ANNEX 2

Feasibility Study

Scaling up Climate Resilient Flood Risk Management in Bosnia and Herzegovina

March 2022

CONTENTS

LIST OF ABBREVIATIONS

AAD	Average Annual Displacement
AFAs	Areas for further assessment
BD	Brčko District
B&H	Bosnia and Herzegovina
BoQ	Bill of Quantity
CCA	Climate Change Adaptation
CO	Country Offices
CP	Civil Protection
DEM	Digital Elevation Model
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DTM	Digital Terrain Model
EbA	Ecosystem Based Approach
EC	European Commission
ECMWF	European Centre for Medium Range Weather Forecasts
EIB	European Investment Bank
EUFD	EU Flood Directive
EWS	Early Warning System
FB&H	Federation of B&H
FFEWS	Flood Forecasting and Early Warning System
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
FS	Feasibility Study
GCF	Green Climate Fund
GEF	Global Environment Facility
GFS	Global Forecast System
GIS	Geographical Information System
GPM	Global Precipitation Measurement
GSM	Global System for Mobile
HDI	Human Development Index
HIS	Hydro Information System
HMI	Hydro Meteorological Institute

HPPs	Hydro power plants
ICPDR	International Commission for the Protection of the Danube River
ICT	Information Communication Technology
IFAD	International Fund for Agricultural Development
IOM	Institutional and Organizational Measures
JP	Joint Programme
KfW	Kreditanstalt Für Wiederaufbau
LED	Local Economic Development
LiDAR	Light Detection and Ranging
M&E	Monitoring & evaluation
MCO	Micro-credit organisation
MoFTER	Ministry of Foreign Trade and Economic Relations
MOUs	Memorandum of Understanding
NAP	National Adaptation Plan
NGOs	Non-Government Organizations
NWP	Numerical Weather Predictions
OM	Operations Manual
PDRNA	Post Disaster Rapid Needs Assessment
PFRA	Preliminary Flood Risk Assessment
PGIS	Participatory GIS
PRFA	Preliminary Flood Risk Assessment
PWS	Public Warning System
QGIS	Quantum GIS
RB	Regional Bureau
RS	Republika Srpska
SDI	Sustainable Development Index
SME	Small and Medium Enterprises
SMS	Short Message Service
SOPs	Standard Operational Procedures
TA	Technical Assistance
TG	Thematic Groups
TNC	Third National Communication
ToR	TERMS OF REFERENCE
ToT	Trainings of the Trainers
TRMM	Tropical Rainfall Measuring Mission

UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USAID	United States Agency for International Development
VAT	Value Added Tax
WAs	Water Agencies
WB	Western Balkans
WBIF	Western Balkans Investment Framework
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

Bosnia and Herzegovina (B&H) is a middle-income country with an estimated 3.531 million inhabitants and total surface area of 51,209.2 km². The 1992-1995 war has had a devastating impact on its human, social and economic resources, leading to enormous challenges of the post-war reconstruction and economic and social recovery. This challenge has been further compounded by the transition towards market economy requiring structural reforms and improved governance.

Bosnia and Herzegovina is particularly vulnerable to extreme precipitation and river basin flooding and results in the highest damages of all natural hazards facing B&H. There have been 49 deaths from floods and floods related events since 1925 in B&H. Flooding in Republic of Srpska accounts for 62% of damages from all natural disasters between 2006 and 2012. In 2010 - the second largest flood on record - damages were US$ 200 million which is approximately 1% of GDP. In May 2014, Bosnia and Herzegovina experienced its worst flooding in 150 years which affected 25% of its territory and resulted in 26 deaths and US$2.7 Billion worth of damages (15% of GDP). The most damaging floods have had devastating impacts on the most vulnerable groups including the rural poor, war returnees and displaced persons. For example, in several municipalities in the Vrbas basin up to 100% of affected households have been identified as war returnees or displaced persons and are least equipped to cope with and recover from floods. This has led to a deepening of poverty in flood affected areas. The 2014 flood was the most extensive, affecting 5 major rivers, compared to previous floods which generally impacted only 1 major river.

Increased intensity and variability of rainfall due to climate change have been causing more frequent and intensive floods on the territory of B&H. The Third National Communication of B&H (TNC) shows that extreme precipitation would intensify under warmer climate conditions. Meteorological observations over the period of 1961–2014 demonstrated continuous rise of the mean annual temperature across the B&H territory in the range of 0.4-1.0°C. The temperature is expected to increase further until the end of the 21st century. Over the period from 1981 to 2014 a slight increase in the amount of annual rainfall was observed, but with significant seasonal and spatial changes. Years with floods have become very common (2004, 2006, 2009, 2010, 2014, 2017, 2018, 2019, 2020). Scenario A1B, A2 and RCP8.5, downscaled for B&H, anticipate further increase in variability of the rainfall regime.

The main flooding sources in B&H are fluvial, pluvial, torrents and groundwater, with high flood risk identified in 5 sub-basin - the Una (in B&H 9,130 km^2), Vrbas (6,386 km^2), Bosna (10,457 km^2), Neretva and Trebišnjica (10,110 km^2), which comprises 75% of the total surface area of B&H. In these basins, under current or baseline conditions, the total number of people affected is 799,445 and 272,811 households, which is 22.5% of the total B&H population and 23.5% of total households in B&H. Under current conditions the expected damages to household assets is US$ 3.2 Billion USD. Under climate change conditions, the total number of people affected is 902,906 and 306,907 households, which is 25.6% of total B&H population or 26.6% of total households in B&H. The total expected damages to household assets is US$ 3.6 Billion USD. The most significant share in total exposure under climate change of about 50% or US$ 1.824 Billion USD, is within the Bosna river basin, followed by the Vrbas river basin with the share of 24% and the Una river basin with 17% of total anticipated damages. Current flood risk to agriculture is expected to increase from 12,896 ha and US$ 3.34 Billion USD in damages to 15,064 ha and damages of US$ 3.7 Billion USD under climate change, most of which is related to the Neretva river basin, with 35% of total damage. 505 public sector buildings/facilities are exposed to flood risk covering sectors including health, education, judiciary, administration and social welfare, police and defence, cultural and historical facilities, with estimated damages of US$ 31,199,798 USD, not considering economic losses from loss of business continuity, loss of income generation, loss of production etc. A total of 2,825 business sector assets of US$ 3.2 Billion USD in total value are currently at risk of flooding and would sustain US$ 550 Million USD in asset damages in an extreme flood event, 57% of which would be in the Bosna River basin.

More frequent and intensive floods on the territory of Bosnia and Herzegovina (B&H), will result in significant impact on people, their property and critical infrastructure assets, with the most important economic sectors such as agriculture, water management, hydropower at risk. In addition to climatic drivers, land use change such as deforestation, is affecting watershed functions - drainage control, erosion processes and landslide susceptibility - that may increase exposure and aggravate consequences of flooding in vulnerable watersheds.

Based on the risk assessment under baseline and climate change conditions, the 5 highest risk basins in B&H – Bosna, Neretva, Trebišnjica, Una-Sana, and Vrbas – have been selected as the target basins for project practical implementation. In addition, Drina basin where flood risk management measures have been undertaken by the World Bank, has also been identified as a target basin.

The project objective is to address increasing vulnerability of B&H communities and livelihoods to intensified climate-induced flood-related disasters. The project will establish an integrated and innovative climate-resilient flood risk management (FRM) approach, strengthen institutional, technical and financial capacity to implement long-term FRM strategies, including a combination of structural and non-structural measures and ecosystem-based approaches. The project will strengthen the use of climate information, flood forecasting, early warning and emergency response systems to enhance adaptive capacity and resilience of at-risk communities. It will scale-up successful FRM solutions and technologies tested through a UNDP/SCCF project in Vrbas River Basin, promote and implement technological, institutional and financing innovations in FRM sector, and will leverage considerable public and private investment into resilient FRM. The latter will be achieved through the development of an FRM investment framework supported with incentives, risk transfer products and private sector partnership models, The willingness of the B&H private sector to engage with the intervention is reconfirmed through the materialized co-financing commitments (Annex 13), surveys and consultations carried out during the project design phase (Annexes 2 and 7).

This GCF project will support the commitment of the B&H governments to avoid losses of lives and to reduce economic and infrastructure losses caused by climate-induced flood disasters, through two outcomes and three outputs. **Outcome 1:** Climate informed impact-based FFEWS and increased generation and use of climate data reduce vulnerability to flood related disasters, is comprised of **Output 1:** Fully integrated impact-based flood forecasting and EWS facilitates timely preparation and response. **Outcome 2**: Vulnerable communities in B&H are better protected from and less exposed to climate induced flood risks through a combination of structural and non-structural flood risk reduction solutions, is comprised of **Output 2:** Non-structural flood risk reduction measures and nature-based solutions mainstreamed in sectoral policies and plans and effectively contribute to protection of people and livelihoods from climate-induced flood risk and **Output 3:** Climate-proof flood protection measures scaled-up through new and improved national and local investment frameworks increasing resilience of the most vulnerable groups to climate induced flooding.

The implementing entity will be UNDP with the key national partners including the GCF NDA, Ministry for Spatial Planning Civil Engineering and Ecology, Ministry of Foreign Trade and Economic Relations, entity hydrometric institutes, water agencies, other relevant ministries and departments.

PART I – SITUATION OVERVIEW

1 COUNTRY CONTEXT

1.1 Study Scope

The climate change impacts that the project is seeking to address are the increased frequency and intensity of floods (fluvial, torrential of flash floods, and groundwater) in B&H. The impact of flood hazards will be reduced across the country for population at risk, and for a number of sectors (e.g. energy, agriculture, critical infrastructure) and ecosystems, which are currently at risk from such hazards.

1.2 Geophysical Context

Bosnia is 51.197 km^2 in area, located in the western Balkans, bordering Croatia (932 km or 579 mi) to the north and west, Serbia (302 km or 188 mi) to the east, and Montenegro (225 km or 140 mi) to the southeast. It has a coastline about 20 kilometres (12 miles) long surrounding the city of Neum. Sarajevo is the capital and largest city. Other major cities are Banja Luka and Bihać in the northwest region known as Bosanska Krajina, Bijeljina and Tuzla in the northeast, Zenica in the central part of Bosnia and Mostar, the largest city in Herzegovina.

Figure 1-1: Locational map of Bosnia and Herzegovina

The country is mostly mountainous, encompassing the central Dinaric Alps. The north-eastern parts reach into the Pannonian Plain, while in the south it borders the Adriatic Sea. The Dinaric Alps generally run in a southeast-northwest direction and get higher towards the south. The highest point of the country is the peak of Maglić at 2,386 metres (7,828.1 feet), on the Montenegrin border. Major mountains include Kozara, Grmeč, Vlašić, Čvrsnica, Prenj, Romanija, Jahorina, Bjelašnica and Treskavica. In the central and eastern interior of the country the geography is mountainous, in the northwest it is moderately hilly, and the northeast is predominantly flatland.

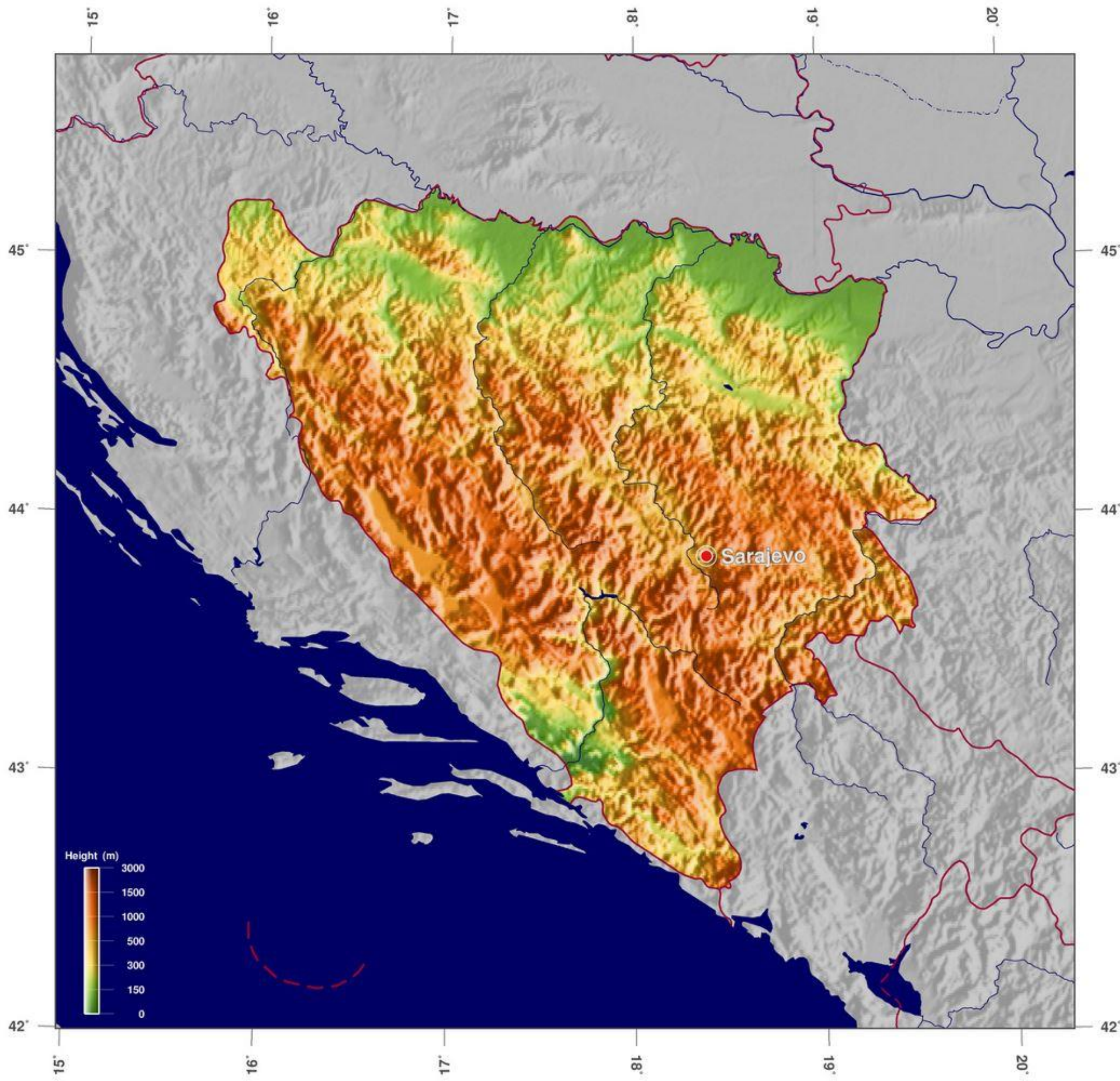


Figure 1-2: Elevation map of Bosnia and Herzegovina

The geological composition of the Dinaric chain of mountains in Bosnia consists primarily of limestone (including Mesozoic limestone), with deposits of iron, coal, zinc, manganese, bauxite, lead, and salt present in some areas, especially in central and northern Bosnia. Herzegovina has a dominant karst topography.

There are two main river basin systems in B&H – Sava (Vrbas, Una-Sana and Bosna and Drina) and Adriatic Sea Basin (Neretva and Trebišnjica rivers). Section 4.1 provides a detailed description of all major sub-basins. Sava river basin is at highest risk of flooding, while Adriatic Sea Basin faces a lower risk of flooding largely due to its karstic geology and heavily modified hydrology from HPP dams. The main flooding sources in B&H are fluvial, pluvial, torrents and groundwater.

There are seven major rivers in Bosnia and Herzegovina (Figure 1-3). The Sava is the largest river of the country and forms its northern natural border with Croatia. It drains 76% of the country's territory into the Danube and then the Black Sea. Bosnia and Herzegovina is a member of the International Commission for the Protection of the Danube River (ICPDR). The Una, Sana and Vrbas are right tributaries of Sava river. They are located in the north-western region of Bosanska Krajina. The Bosna river gave its name to the country, and is the longest river fully contained within it. It stretches through central Bosnia, from its source near Sarajevo to Sava in the north. The Drina flows through the eastern part of Bosnia, and for the most part it forms a natural border with Serbia. The Neretva is the major river of Herzegovina and the only major river that flows south, into the Adriatic Sea.

Figure 1-3: River basins of B&H

Groundwater in Bosnia and Herzegovina is found in three geographically separate areas with special characteristics. In the northern part of the country, the ground water reserves are within alluvial connected sediments along the Sava River and its tributaries at a depth of about 50 m. Artesian water is found at 100-200 m. In the central part of the country, groundwater accumulates in caves and cavities of limestone massifs and emerges on the surface as lime wells in the river basins of Una, Sava, Bosna, Drin and Neretva Rivers. In the Adriatic Sea catchments area in the southern part of the country, where the geology is primarily karst, groundwater is mostly found in wells of the basins of the Cetina, Neretva, and Trebišnjica Rivers[1].

Land use is comprised of agricultural land (42.2%), arable land (19.7%), permanent crops (2%), permanent pasture (20.5%), forest (42.8%) and other (15%) (2011 est.). Most forest areas are in the central, eastern and western parts of Bosnia. Bosnia and Herzegovina can be subdivided into three ecoregions: the Pannonian mixed forests, Dinaric Mountains mixed forests and Illyrian deciduous forests. Of the 2,185,000 hectares of Bosnia and Herzegovina that is forested, 0.1% or roughly 2,000 hectares is classified as primary forest, the most biodiverse form of forest. Between 1990 and 2000, Bosnia and Herzegovina lost an average of 2,500 hectares of forest per year. This amounts to an average annual deforestation rate of 0.11%. Between 2000 and 2005, the rate of forest change decreased by 100.0% to 0.00% per annum. In total, between 1990 and 2005, Bosnia and Herzegovina lost 1.1% of its forest cover, or around 25,000 hectares. Measuring the total rate of habitat conversion (defined as change in forest area plus change in woodland area minus net plantation expansion) for the 1990-2005 interval, Bosnia and Herzegovina lost 4.4% of its forest and woodland habitat. Northern Bosnia (Posavina) contains very fertile agricultural land along the River Sava and the corresponding area is heavily farmed. This farmland is a part of the Pannonian Plain stretching into neighbouring Croatia and Serbia. Natural resources include coal, iron ore, bauxite, copper, lead, zinc, chromite, cobalt, manganese, nickel, clay, gypsum, salt, sand, timber, hydropower.

The climate is characterised by hot summers and cold winters. Areas of high elevation have a moderate continental climate with short, cool summers and long, severe winters. The southern tip has a Mediterranean climate with coastal area characterised by mild, rainy winters.

1 http://web.worldbank.org/archive/website00983A/WEB/OTHER/BEA9848F.HTM?Opendocument&Start=1&Count=5 accessed 3/11/19

1.3 Socio-economic Context

B&H is a sovereign state with a decentralized political and administrative structure. Following the dissolution of Yugoslavia, the country proclaimed independence in 1992, which was followed by the Bosnian War, lasting until late 1995. Today, B&H consists of two Entities and one district: The Federation of Bosnia and Herzegovina (FB&H) and the Republic of Srpska (RS) and Brčko District. The Federation of Bosnia and Herzegovina is sub-divided into 10 Cantons. Decision-making involves the Council of Ministers, the two Entities and Brčko District. The two entities and Brčko District manage environmental issues through laws, regulations and standards. The Bosnia and Herzegovina Ministry of Foreign Trade and Economic Relations (MoFTER) has responsibility for the coordination of activities and harmonizing of plans of the entities' governmental bodies and institutions at the international level, in energy, environmental protection, development and the exploitation of natural resources. The designated UNFCCC focal point is the Bosnia and Herzegovina Ministry of Spatial Planning, Civil Engineering and Ecology.

Bosnia and Herzegovina has a transitional economy with limited market reforms. The economy relies heavily on the export of metals, energy, textiles, and furniture as well as on remittances and foreign aid. Poor coordination among various government levels hampers economic policy coordination and reform, while excessive bureaucracy and a segmented market discourage foreign investment. The economy is among the least competitive in the region. The konvertibilna marka (convertible mark) - the national currency introduced in 1998 - is pegged to the euro through a currency board arrangement, which has maintained confidence in the currency and has facilitated reliable trade links with European partners. In 2016, B&H began a three-year IMF loan program, but it has struggled to meet the economic reform benchmarks required to receive all funding instalments. Bosnia and Herzegovina's top economic priorities are: acceleration of integration into the EU; strengthening the fiscal system; public administration reform; World Trade Organization membership; and securing economic growth by fostering a dynamic, competitive private sector. Interethnic warfare in Bosnia and Herzegovina caused production to plummet by 80% from 1992 to 1995 and unemployment to soar, but the economy made progress until 2008, when the global economic crisis caused a downturn. Since 2013, Bosnia and Herzegovina has posted positive economic growth, though severe flooding hampered recovery in 2014.

The country has been a member of the Council of Europe since April 2002 and a founding member of the Mediterranean Union upon its establishment in July 2008. Bosnia and Herzegovina became a full member of the Central European Free Trade Agreement in September 2007 and is a potential candidate for membership to the European Union.

1.4 Major Development Indicators

1.4.1 Population and demographics

The total B&H population is 3.5 million people or 1.16 million households distributed across 142 administrative units – municipalities, and two entities. 47.9% of the population live in urban areas. Average population density is 68.5 people/sq.km. Population has been decreasing over the past 70 years, with an average value of natural change recorded for the period of 2010-2019 of -1.7, and crude birth rate of 8,3 per 1000 in 2019. Life expectancy has increased over the last decades and reached 77.1 years in 2018. As per age structure the largest group is 25-54 years old, which makes 45.51% of total population. Literacy of population is 98.5%. The population consists of three main ethnic groups (Bosniaks, Croats and Serbs) and several minorities (Montenegrins, Roma, Yugoslavs and Albanians). As a result of the war, B&H still has some internally displaced persons (IDPs) and they are a specific vulnerable group. According to UNHCRs report for Bosnia and Herzegovina, from 2019 there are 96,421 IDPs, 47,000 returnees and 1,354 refugees, asylum seekers etc. which makes total of 144,775 people.

1.4.2 Economic indices

Bosnia and Herzegovina's Gross Domestic Product (GDP) is 41.11 (PPP $ billions). GDP per capita (PPP $) is US$11,717. GDP by sector is as follows: agriculture (6.8%), Industry (28.8%) and services (64.3%). GDP consumption by end user is as follows: household consumption (77.4%), government consumption (19.5%), investment in fixed capital (16.6%), investment in inventories (2.3%), exports of goods and services (38.7%), imports of goods and services -55.1% (2017 est.).

The percentage of the population living below the poverty line is 16.9% (2015 est.). Private sector is growing slowly, but foreign investment has remained low since 2007 (ranked 99th globally). High unemployment remains the most serious macroeconomic problem 20.5%2 (2017 est.) and 25.4% (2016 est.). Agriculture employs 19.1% of the workforce, while industry employs 32.2% and services 48.7% (2017 est.). Successful implementation of a value-added tax in 2006 provided a steady source of revenue for the government (Taxes and other revenues is 44.7% of GDP) and helped rein in grey-market activity, though public perceptions of government corruption and misuse of taxpayer money has encouraged a large informal economy to persist. National-level statistics have improved over time, but a large share of economic activity remains unofficial and unrecorded. Public Debt is 43.2% of GDP (2017 est.).

Index	Value
Population	
Total population (millions)	3.5
Urban population (%)	47.9
Sex ratio at birth	1.06
Life expectancy at birth (years)	77.1
Education	
Literacy rate, adult (% ages 15 and older)	97
Some secondary education (% ages 25 and older)	79.9
Some secondary education, female (% ages 25 and older)	71.7
Some secondary education, male (% ages 25 and older)	88.7
Economy	
Gross national income (GNI) per capita (2011 PPP $)	11,716
Domestic credit provided by financial sector (% of GDP)	56.8
Gross domestic product (GDP) per capita (2011 PPP $)	11,714
Gross domestic product (GDP), total (2011 PPP $ billions)	41.1
Gross fixed capital formation (% of GDP)	16.8
Income index	0.72
Exports and imports (% of GDP)	86.9
Foreign direct investment, net inflows (% of GDP)	2.4
Net official development assistance received (% of GNI)	2.6
Private capital flows (% of GDP)	-1.6
Remittances, inflows (% of GDP)	10.99
Inequality	
Inequality-adjusted HDI (IHDI)	0.649
Coefficient of human inequality	15.3
Income inequality, Gini coefficient	32.7
Income inequality, Palma ratio	1.3
Income inequality, quintile ratio	5.3
Inequality in education (%)	19.8
Inequality in income (%)	20.2
Inequality in life expectancy (%)	5.9
Overall loss in HDI due to inequality (%)	15.5
Gender	
Gender Development Index (GDI)	0.924
Adolescent birth rate (births per 1,000 women ages 15-19)	10
Antenatal care coverage, at least one visit (%)	87
Estimated gross national income per capita, female (2011 PPP $)	7,723
Estimated gross national income per capita, male (2011 PPP $)	15,856
Female share of employment in senior and middle management (%)	24.2
Female share of graduates in science, mathematics, engineering, manufacturing and construction at tertiary level (%)	14.7
Share of seats in parliament (% held by women)	19.3
Total unemployment rate (female to male ratio)	2.09
Women with account at financial institution or with mobile money-service provider (% of female population ages 15 and older)	54.7
Gender Inequality Index (GII)	0.166
Human Development and Poverty	
Human Development Index (HDI), female	0.739
Human Development Index (HDI), male	0.8
Multidimensional Poverty Index (MPI)	0.008
Population in multidimensional poverty, headcount (%)	2.2
Population in multidimensional poverty, headcount (thousands) (for the year of survey)	80
Population in multidimensional poverty, headcount (thousands) (projection for 2016)	77
Population in multidimensional poverty, intensity of deprivation (%)	37.9
Population in severe multidimensional poverty (%)	0.1
Population living below income poverty line, PPP $1.90 a day (%)	0.2
Population vulnerable to multidimensional poverty (%)	4.1
Employment	
Employment to population ratio (% ages 15 and older)	34.7
Employment in agriculture (% of total employment)	19.1
Employment in services (% of total employment)	48.7
Labour force participation rate (% ages 15 and older)	46.6
Labour force participation rate (% ages 15 and older), female	35.2
Labour force participation rate (% ages 15 and older), male	58.7
Old-age pension recipients (% of statutory pension age population)	29.6
Unemployment, total (% of labour force)	25.6
Unemployment, youth (% ages 15–24)	55.4
Vulnerable employment (% of total employment)	20.9
Youth unemployment rate (female to male ratio)	1.23
Working poor at PPP$3.10 a day (% of total employment)	0.2
Skilled labour force (% of labour force)	84.1
Energy	
Fossil fuel energy consumption (% of total energy consumption)	77.5
Renewable energy consumption (% of total final energy consumption)	40.8

1.4.3 Gender and Gender Inequality Indices

Over the last decades B&H has made significant advances in the realization of the gender equality, which is a result of activities taken by all parties (Gender institutional mechanisms, as well as citizens through civil society organizations) responsible for implementing the Law on Gender Equality in Bosnia and Herzegovina. Nonetheless, in spite of these positive changes, there are still a lot to be done. According to the UNDP Gender Inequality Index (GII), measuring inequality in reproductive health, empowerment and labor market, in 2019 Bosnia and Herzegovina has a GII of 0,149 and ranked 38 out of 162 countries assessed.

The GDI reflects gender inequalities against three dimensions: health (measured by female and male life expectancy at birth), education (measured by female and male expected years of schooling for children and mean years for adults aged 25 years and older); and command over economic resources (measured by female and male estimated GNI per capita). The 2017 female HDI value for Bosnia and Herzegovina is 0.739 in contrast with 0.800 for males, resulting in a GDI value of 0.924. In Bosnia and Herzegovina, 19.3 percent of parliamentary seats are held by women, and 71.7 percent of adult women have reached at least a secondary level of education compared to 88.7 percent of their male counterparts. For every 100,000 live births, 11 women die from pregnancy related causes; and the adolescent birth rate is 10.0 births per 1,000 women of ages 15-19. Female participation in the labour market is 35.2 percent compared to 58.7 for men. Please refer to the Gender Assessment and Action Plan (Annex 8 to the Full Proposal) for more detailed information.

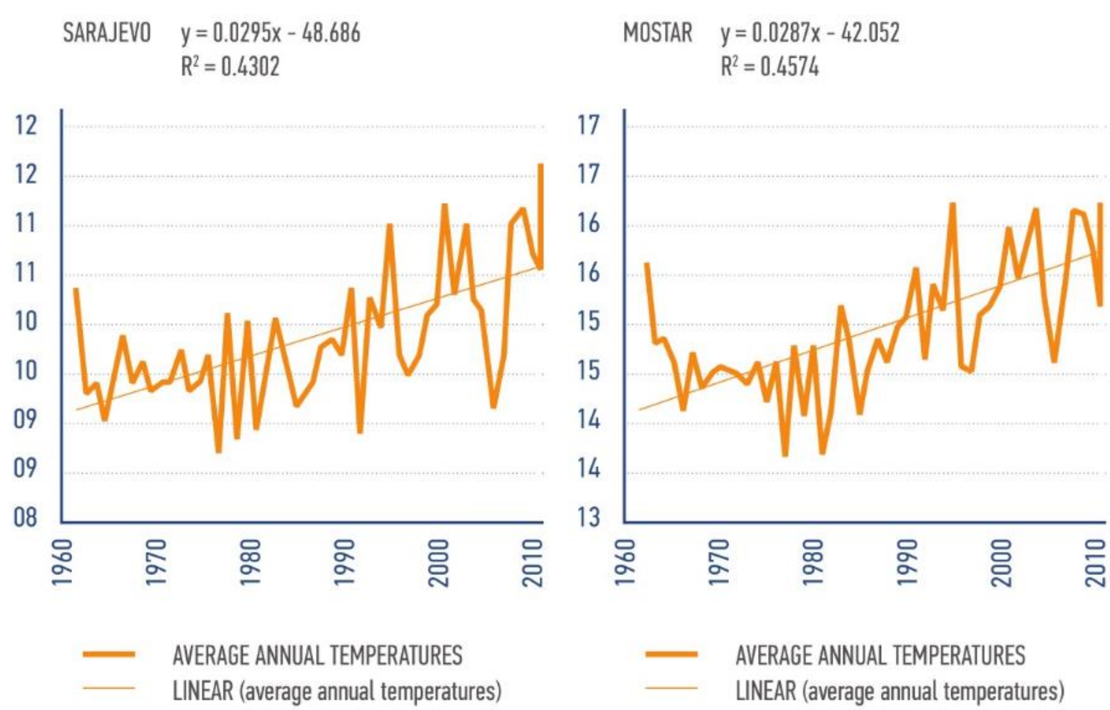
2 CLIMATE CHANGE AND VULNERABILITY CONTEXT

2.1 CLIMATE CHANGE CONTEXT

2.1.1 Observed climate change

2.1.1.1 Temperature trends

According to the TNC, meteorological observations over the period of 1961–2014 demonstrated continuous rise of the mean annual temperature across the entire territory of B&H. Trends in annual temperatures on all analyzed stations were found to be statistically significant, while the changes are more pronounced in the continental part. The increase in annual air temperature ranges from 0.4 to 1.0°C, while the increase in temperature during the growing season (April– September) reaches 1.2°C. Analysis of air temperature during the period 1961-2014 found that all indices of warm temperature extremes have positive trends, while indices of cold temperature extremes have negative trends. The most significant change in this period was observed in the number of cold days (FD) and the number of warm days (SU). In all the meteorological stations the number of cold days (FD) has a negative trend. In the central mountain areas the number of cold days has decreased by 4 days per 10 years, while in the south of the country the decrease is slightly less and it ranges around 2 days per 10 years. The number of warm days (SU) has a positive trend and it is statistically significant. The temperature is expected to increase further till the end of the 21st century.



2.1.1.2 Rainfall trends

The SNC shows that changes in the amount of rainfall are more pronounced by seasons than annually and is spatially varied. In the central part there was a decrease in rainfall during spring and summer (the most pronounced in the area of Herzegovina – up to 20%), while during autumn the increase in rainfall was observed, especially in the north-western and central parts. Due to the increased intensity of rainfall and its greater variability, as well as due to the increased share of heavy rains in the total amount of rainfall, there is the increased risk of flooding especially in the north-eastern part of B&H, where the most disastrous floods in history have been recorded during May 2014.

The historical records show that the number of days with rainfall above 10.0mm has increased. These observations represent a change to the rainfall regime which, when combined with temperature increases, will result in an increased likelihood of floods as the frequency of intense rain events increases. Five out of eight stations marked the decade from 2001-2010 (independently or combined with another) as a period with the largest number of wet summers. All of these impacts have been observed in the project target basins, and reflected in significant damages from flooding.

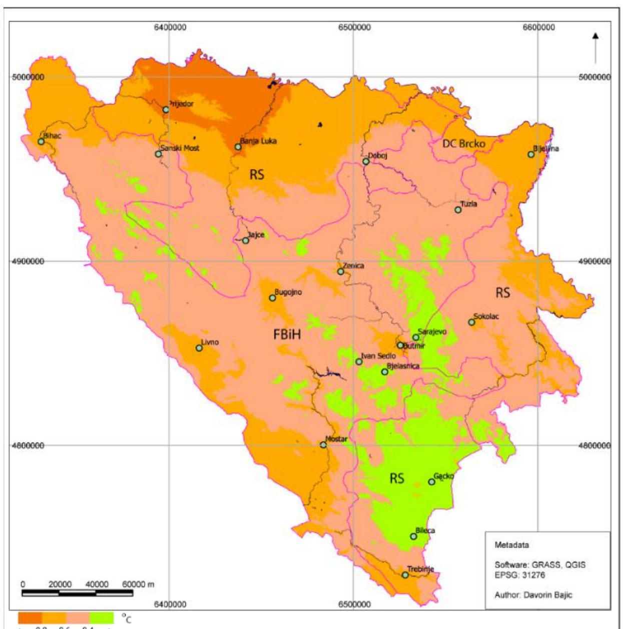


Figure 2-1: Changes in annual air temperature in Bosnia and Herzegovina (during 1981-2010 compared with 1961-1990) Source: Second National Communication of Bosnia and Herzegovina, 2013

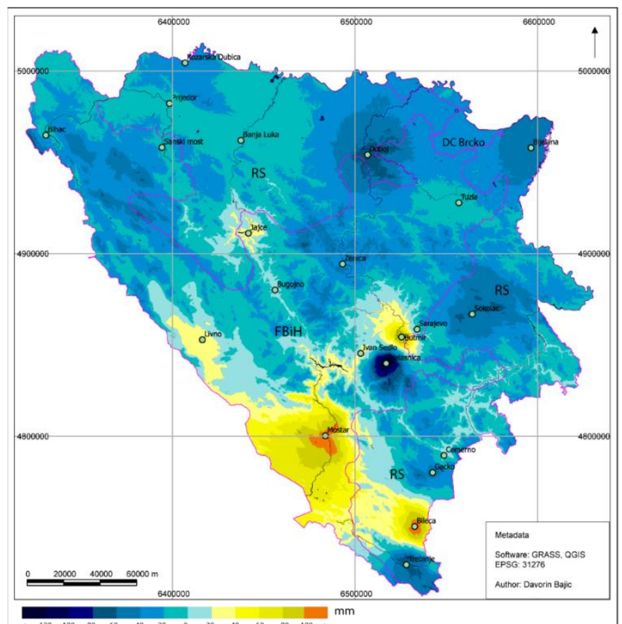


Figure 2-2: Changes in annual precipitation in Bosnia and Herzegovina (1981-2010 compared with 1961-1990) Source: Second National Communication of Bosnia and Herzegovina, 2013

The historical trend analysis has since been updated as part of the FNC (currently draft) based on extended records from HMIs which has been updated since the SNC and TNC. Analysis of rainfall in B&H was made for the two main basin areas, the Sava River Basin (Danube) and the Adriatic Sea watershed area. The available annual data series have been used: for the Sava Basin – data on rainfall from meteorological stations in Bihać, Sanski Most, Sarajevo, Zenica and Tuzla, and for the Adriatic Sea watershed the data were used from the station in Mostar. As Table 2.1 shows, for the Sava Basin the annual maximum rainfall has increased from the period 1961-1990 to the period 1991-2010 by 16.4%, and by 22.5 for the periods

1991-2014 and 1991-2018 (the largest historical flood in the Sava Basin was in 2014). In the Adriatic Basin, the annual maximum rainfall increased from the period 1961-1990 to the period 1991-2010, 1991-2014, and 1991-2018 by 25.04% (the largest historical flood in the Adriatic Basin was in 2004).

Table 2-1: Statistical parameters of the annual rainfall series in B&H, for the periods 1948-2018, 1961-1990, 1991-2010, 1991-2014 and 1991-2018

Statistical parameter[2]	Annual rainfall in Sava River Basin (mm)[3]					Annual rainfall in Adriatic Sea watershed (mm)				
	1948-2018	1961-1990	1991-2010	1991-2014	1991-2018	1948-2018	1961-1990	1991-2010	1991-2014	1991-2018
Mean value	1011.7	990.4	1040.9	1034.3	1037.0	1475.2	1523.8	1456.5	1469.1	1454.5
Median	1005.9	989.3	1033.3	1020.1	1033.3	1468.0	1584	1412.4	1412.4	1394.9
Stand.dev.	134.91	104.38	144.08	172.62	161.09	316.50	282.71	371.1	398.4	370.6
Variance	18199	10896	20759	29795	25950	100174	100174	137749	158692	137358
Kurtosis	1.3070	-0.2116	0.0197	0.5623	0.9503	0.6497	0.6497	1.8350	0.5427	1.1539
Skewness	0.3141	-0.5703	0.1961	0.1349	0.0872	0.2712	0.2712	1.1432	0.8045	0.9586
Range-scope	768.94	406.56	582.66	768.94	768.94	1650.20	1146.7	1594	1618.2	1618.2
Minimum	653.9	754	768.46	653.86	653.86	840.50	841	897	872.5	872.5
Maximum	1422.8	1161	1351.1	1422.8	1422.8	2491.7	1987	2491.7	2491.7	2491.7
% increase in Max			**16.37**	**22.55**	**22.55**			**25.04**	**25.04**	**25.04**

2.1.1.3 Flow Trend analysis

River observations in Bosnia and Herzegovina were interrupted in the decade of the 1990s in the 20th century, due to the war, making the flow trends analysis challenging. Under the FNC, the flow trends of the Bosna River in Maglaj, the Sava River Basin are analysed, whereby the gap in observations in the period 1987-2000 was filled using the hydrological HBV model for the Bosna River Basin, and for the needs of the model, rainfall data from MS in Tuzla, Zenica and Doboj were used. In the Adriatic Sea watershed area, the flows of the Neretva River in Žitomislići were analysed. The report notes that the Neretva River in Žitomislići runs with the artificial regime from 1954. However, since all the reservoirs upstream of Žitomislići operate with equalisation within 1 year, an overview of available flows for the period 1926-2017 is presented in order to compare the average annual flows for different periods.

The results show that the overall change in annual discharge is small, however there are strong changes in seasonal regime and extreme events. Looking at the seasons, there is an increase in discharge in January and February during winter, but the most significant change is the increase in discharge during the spring to summer season. This change is the result of a significant temperature rise, which either results in less snow in the winter months (so more precipitation falls as rain in winter) or to its accelerated melting during the spring. Table 2-2 and Figure 2-3 show that from January to July the maximum discharge has increased in the period 2001-2010 compared to 1961-1990. The % increase in May is 64.4%, while the

2 Variance, flatness, and skewness are dimensionless statistical parameters

3 Series of average values of rainfall from MS Bihać, Sanski Most, Sarajevo, Zenica and Tuzla have been statistically analysed

percentage increase in July is 192%. Figure 2-4 shows that the minimum discharge has also increased, in all months except January and December. The results show that there is a clear trend of increasing flood risk from extreme events due to the increases in maximum discharge particularly in the late spring to summer months. It is also worth noting that the minimum monthly discharge shows increases in all but December and January, indicating that smaller more frequent events, which can be just as damaging as large floods (due to the short recovery times between floods) may also be increasing as well. This is borne out by the observed increase in frequency of flooding in the last two decades, as well as the increases in the magnitude and damages from the extreme floods events, as detailed in Section 2.2 below.

Table 2-2: Bosna River, Maglaj, typical flows for different periods (m3 / s)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	GOD
Mean monthly 1926-1990	131	162	188	210	171	109	73.5	51.6	55.7	77.9	105	145	123
Max monthly 1961-1990	1181	1164	1173	1118	2177	838	766	746	570	1578	1233	1680	2177
Min. monthly 1961-1990	27.5	19.4	38.2	45.8	39.3	27.6	16.0	11.8	11.8	12.2	19.0	29.7	11.8
Mean monthly 2001-2017	139	138	221	210	163	108	64.2	47.9	61.6	74.6	97.7	136	122
Max monthly 2001-2017	1571	1303	1383	1360	3579	1558	2243	1042	729	1044	1177	991	3579
Min monthly 2001-2017	18.9	26.4	50.8	49.0	44.6	32.0	19.7	16.1	15.2	16.1	21.0	22.0	15.2

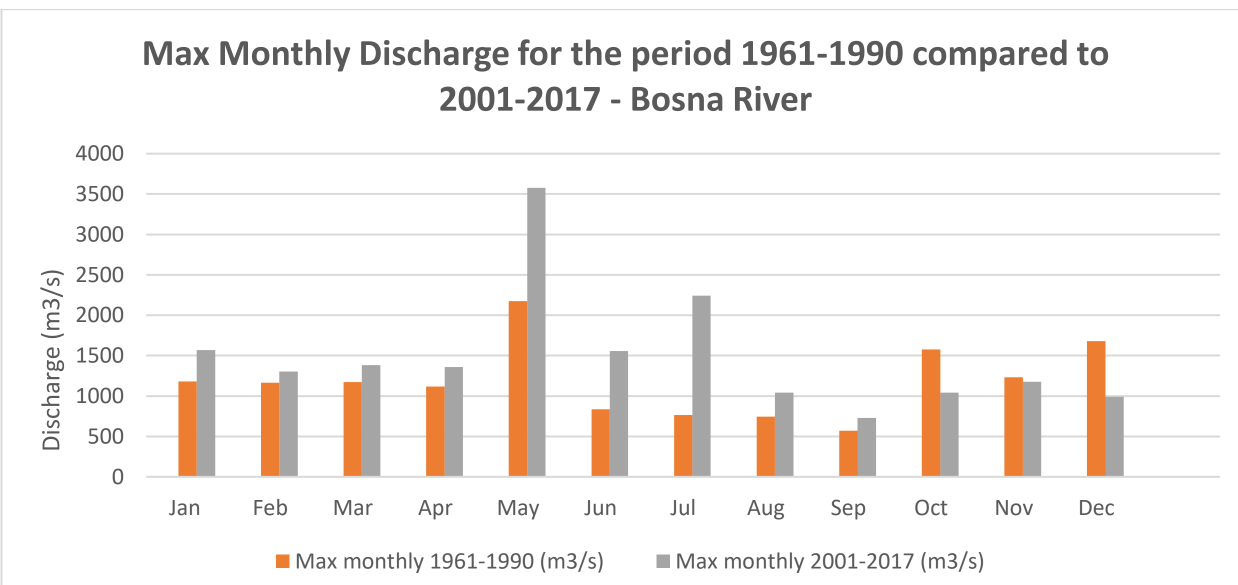


Figure 2-3: Maximum monthly discharge for the period 1961-1990 compared to 2001-2017 for Bosna River

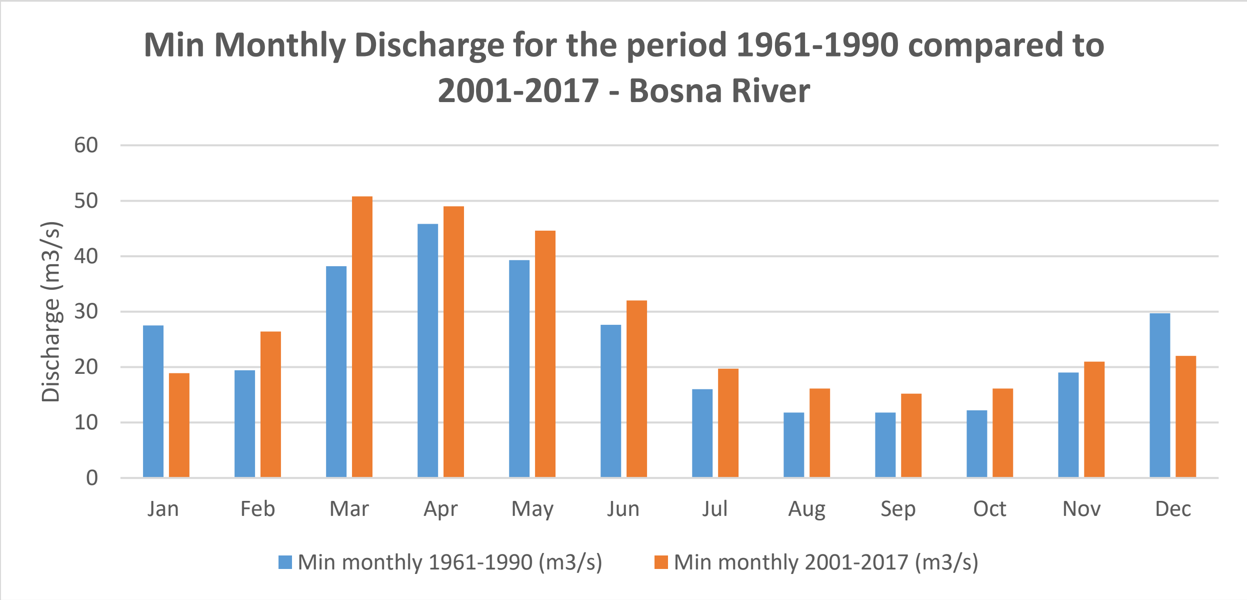


Figure 2-4: Minimum monthly discharge for the period 1961-1990 compare to 2001-2017 for Bosna River

2.1.2 Future climate projections

General Circulation Models (GCMs) enable obtaining results of climate projections at the global level, however, their horizontal decomposition is about 200 km. However, for smaller domains whose size is comparable to the area of Bosnia and Herzegovina (B&H), it is not possible to estimate the spatial change of variables because only a few points of the climate model cover the entire domain (e.g. 2-4 points) and the skill resolution of GCMs is considered even larger. Therefore the results from GCMs are presented only as mean changes for the entire territory of B&H. Regional Climate Models (RCMs), however have significantly better horizontal decomposition, whose size is usually 10 km, so that it is possible to estimate spatial changes over smaller areas, and therefore the results of RCMs are used to show spatial changes in the future.

Forty two (42) different GCMs were taken from the CMIP5 (Coupled Model Intercomparison Project - phase 5) database[4], which was used to prepare the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. This allows for a range of estimates of future changes under different scenarios, indicating the corresponding uncertainties in future projections. Based on the available data, the changes for all four scenarios (RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5), were analysed.

The RCM simulations are taken from the EURO-CORDEX database[5], which is the reference base for climate projections for Europe, and which in recent years has been the basis for many studies on climate change in Europe. Also, this database is the basis for the Copernicus Climate Change Service programme of the European Union, which is dedicated to climate change risk assessment and adaptation to climate change[6]. The horizontal resolution of the downloaded data is 11 km, which allows the spatial changes (maps) of the corresponding climate variables to be displayed. Furthermore, these data have been bias-

[4] https://cmip.llnl.gov/cmip5/
[5] https://www.euro-cordex.net/
[6] https://climate.copernicus.eu/

adjusted, i.e. systematic deviations from the observed climate in the model results have been removed. A quantile-mapping is used to account for the stochastic nature of precipitation and because RCM/GCM rainfall is known to have a "drizzle problem", that is, too many low-magnitude rain events compared to observations[7]. The quantile mapping technique removes the systematic bias in the RCM simulations and has the benefit of accounting for RCM biases in all statistical moments, though, like all statistical downscaling approaches, it is assumed that biases relative to historical observations will be constant in the projection period.

These bias-adjusted data enable the assessment in future projections of climate indices (which are referenced to a particular threshold) to be more realistic. Seven representative RCMs for the three scenarios RCP2.6, RCP4.5, and RCP8.6 were taken from the EURO-CORDEX database (there were no simulations for scenario RCP6.0 which is therefore not used). The 7 RCM-GCM combinations used in the following analysis are:

- CCLM4-8-17_v1 (CNRM-CM5 r1i1p1)
- CCLM4-8-17_v1 (EC-EARTH r12i1p1)
- RACMO22E_v1 (EC-EARTH r1i1p1)
- RCA4_v1 (CM5A-MR r1i1p1)
- CCLM4-8-17_v1 (MPI-ESM-LR r1i1p1)
- REMO2009_v1 (MPI-ESM-LR r1i1p1)
- REMO2009_v1 (MPI-ESM-LR r2i1p1)

2.1.2.1 Changes in future climate - GCMs

According to the RCP8.5 scenario the expected change in mean daily temperature over B&H by the end of the century is 4.8°C, with a range of 4°C to 6°C compared to the 1986–2005 reference period. For the middle of this century, the mean change is higher than 2.5°C, while for the near future (2016–2035) the expected change is approximately 1°C compared to the value from the reference period 1986–2005.

In contrast to temperature, annual average precipitation changes are more heterogeneous, with both positive and negative changes relative to the reference period, especially for periods in the near future, when all four scenarios show that possible changes range from -5 to + 5%. Differences between scenarios are more noticeable for periods at the end of the twenty-first century, with RCP8.5 simulating changes in annual precipitation at the end of the century of -10% with a range from -4 to -15%.

[7] Gutowski, W. J., Decker, S. G., Donavon, R. A., Pan, Z., Arritt, R. W., & Takle, E. S. (2003). Temporal-spatial scales of observed and simulated precipitation in central U.S. climate. *Journal of Climate*, **16**(22), 3841– 3847. https://doi.org/10.1175/1520-0442(2003)016(3841:TSOOAS)2.0.CO;2

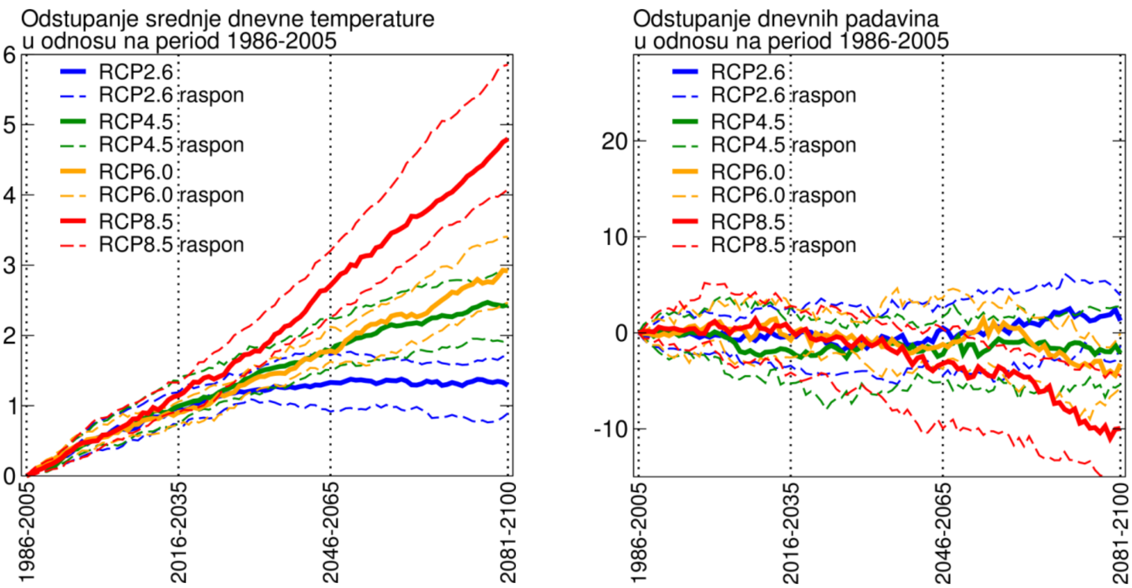


Figure 2-5: Change in the average (over the territory of B&H) annual mean daily temperature (ºC) (left) and annual average daily precipitation (right), shown as the deviation of the 20-year moving average value in relation to the reference period 1986–2005.

Whilst changes in annual average rainfall over B&H are uncertain, changes in measures of rainfall intensity are clearly positive (Figure 2-6). Both the number of rainfall days when > 20mm of rain falls, as well as the annual maximum daily rainfall, are expected to steadily increase during this century, under all 4 simulated scenarios.

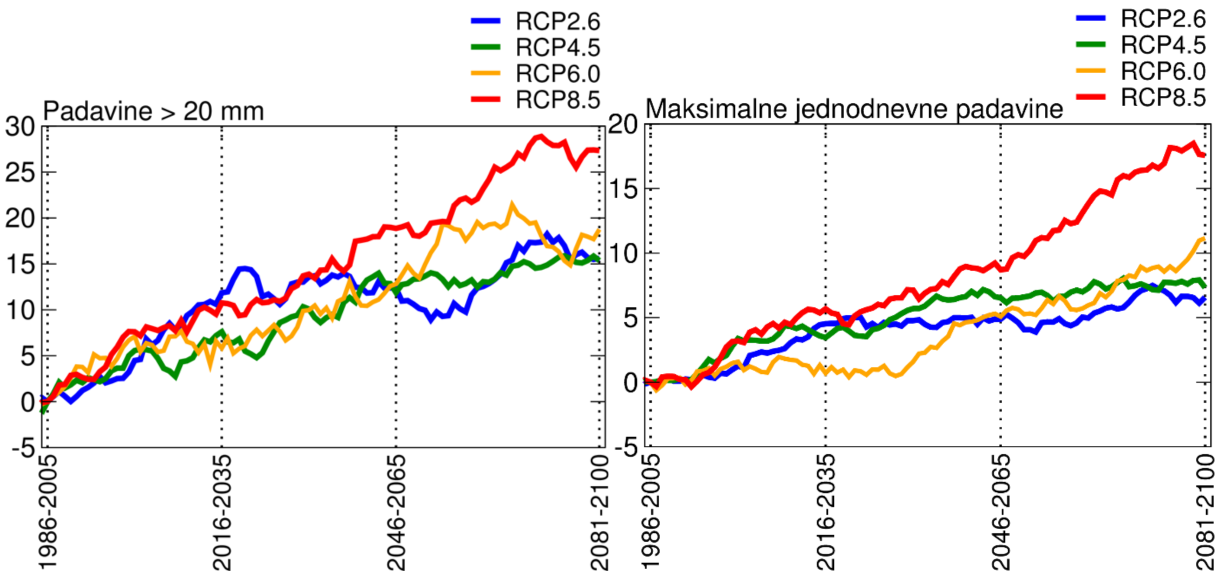


Figure 2-6: Change in the average (over the territory of B&H) number of raindays > 20mm (left) and maximum daily rainfall (right), shown as the deviation of the 20-year moving average value in relation to the reference period 1986–2005.

In turn, whilst rainfall intensity is expected to increase, the frequency of dry days is also expected to increase, as evidenced by increases in the maximum number of consecutive dry days simulated under all 4 scenarios (Figure 2-7).

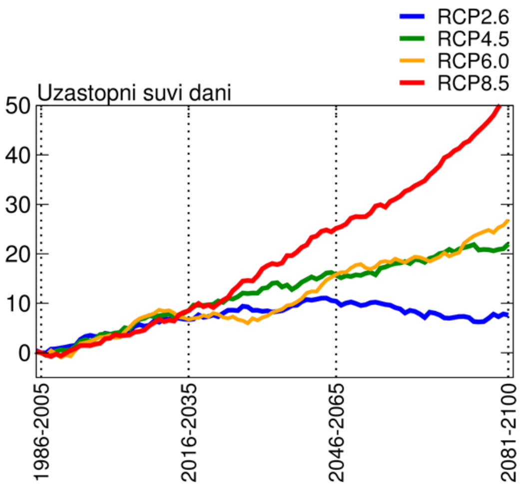


Figure 2-7: Change in the average (over the territory of B&H) maximum number of consecutive dry days, shown as the deviation of the 20-year moving average value in relation to the reference period 1986–2005.

2.1.2.2 Changes in future climate - RCMs

Detailed spatial analyses using the RCM ensemble shows that for the RCP8.5 scenario, changes in mean daily temperature during the near future (2016–2035) range from 0.5 to 1.5°C, by the middle of the century (2046–2065) from 1.5 to 3°C, and for the period (2081–2100) from 2.5 to 5°C. Furthermore, increases of maximum daily temperatures are highest during June-July-August (JJA), when temperature increases in most parts of the country are higher than 5°C. Additionally, temperature changes are highest in mountainous regions, with the smallest increases during the March-April-May season (MAM).

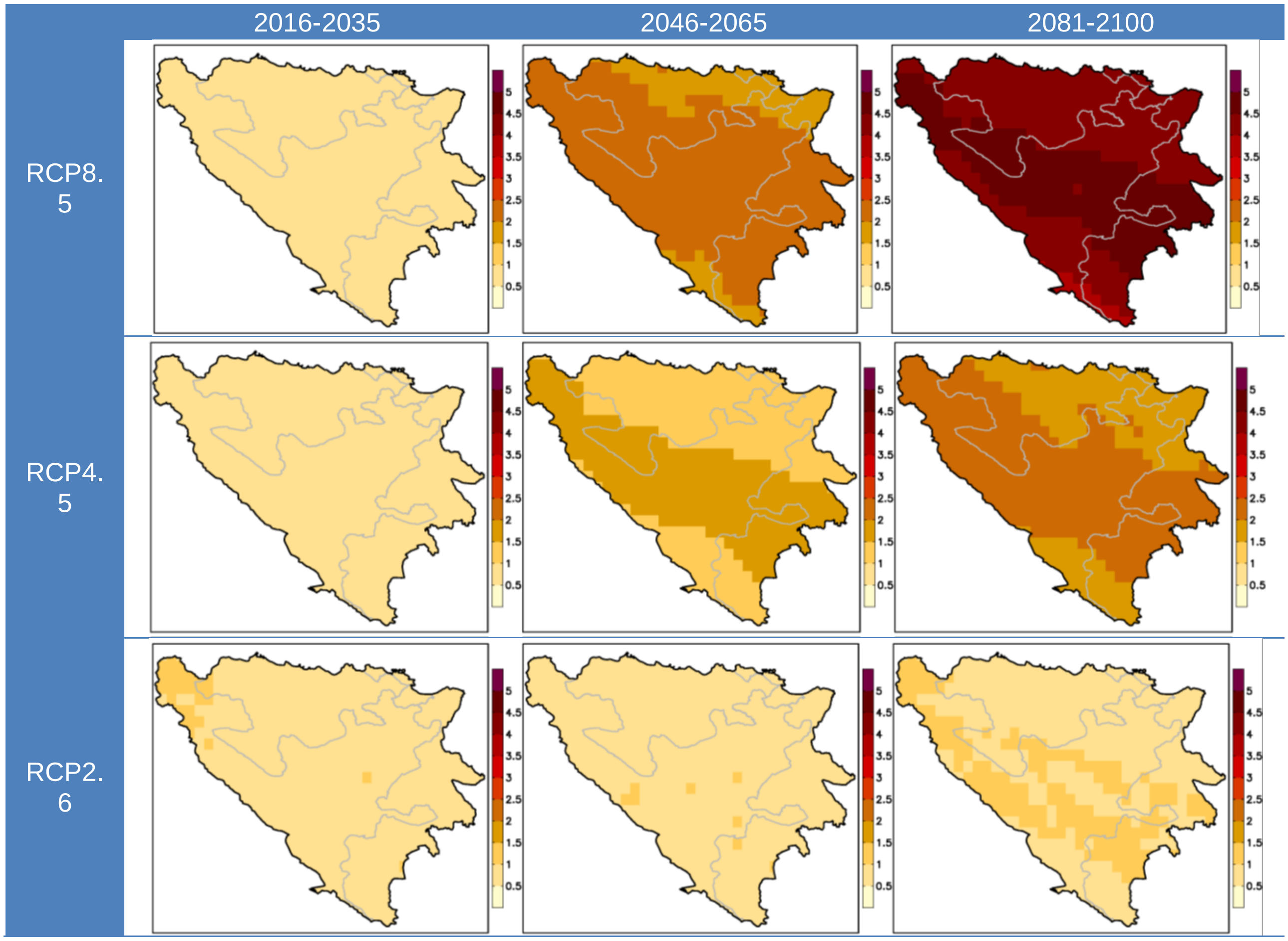


Figure 2-8: Change in mean daily temperature (in ºC) relative to the reference period 1986-2005, for scenarios RCP8.5, RCP4.5 and RCP2.6, on an annual basis, for the three selected future periods 2016-2035, 2046-2065 and 2081-2100

Under RCP4.5 scenario, the change in the near future, ranges from 0.5 to 1.0ºC, whereas by the middle of the century, 2046-2065, the changes range from 1 to 2ºC, whilst for the period 2081-2100 the temperature rise ranges from 1.5 to 2.5ºC. Under the RCP2.6 scenario, increases range from 0.5 to 1.5ºC (as well as the change in minimum and maximum daily temperature), whilst by 2081-2100 changes in minimum and mean daily temperatures is up to 1ºC and maximum temperatures are up to 1.5ºC.

According to all scenarios and for all periods, the number of **icing days** will decrease (Figure 2-9), implying a greater number of days when ice and snow will melt, especially in mountainous areas. In the near future, this will entail approximately -5 days less than at present, with approximately -10 days less under scenarios RCP2.6/RCP4.5 for the period 2046-2065, while for the last time period 2081-2100 the change is up to -20 days. For the RCP8.5 scenario, the change in the number of icing days decreases significantly for further time horizons and for the period 2046-2065 it is up to -20 days, while for the later period the change is most pronounced in the mountainous regions of the country and is up to -30 days, and in some smaller areas up to -50 days less.

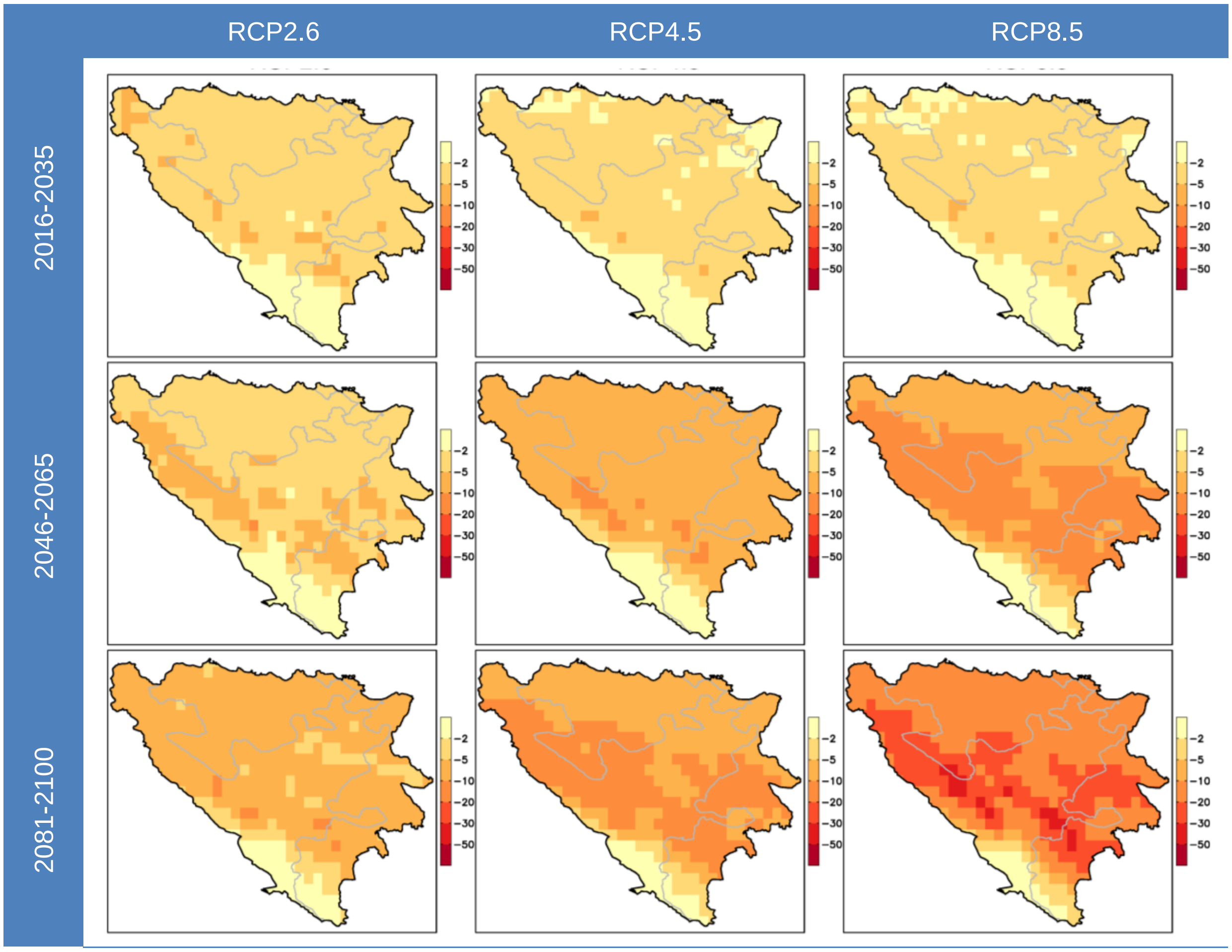


Figure 2-9: Change in the number of icing days (days/year) compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

Figure 2-10 shows future changes in the number of **summer days** in relation to the reference period 1986-2005 for three climate scenarios RCP8.5, RCP4.5 and RCP2.6 and three future periods, 2016-2035, 2046-2065 and 2081-2100. For the near future, the change according to all three scenarios is up to 20 days more in most parts of B&H. In the case of RCP2.6 scenario, this change does not differ significantly for the other two time periods. Under RCP4.5 for the period 2046-2065 this change is up to 30 days more, while for the latter time period 2081-2100 the change is up to 50 days more for certain parts of the country. For the RCP8.5 scenario, the change in the number of summer days increases significantly for further time horizons and for the period 2046-2065 it is up to 40 days more, in some parts up to 50 days more, while for the later period the change is most pronounced and amounts to 60 days more, almost throughout the country.

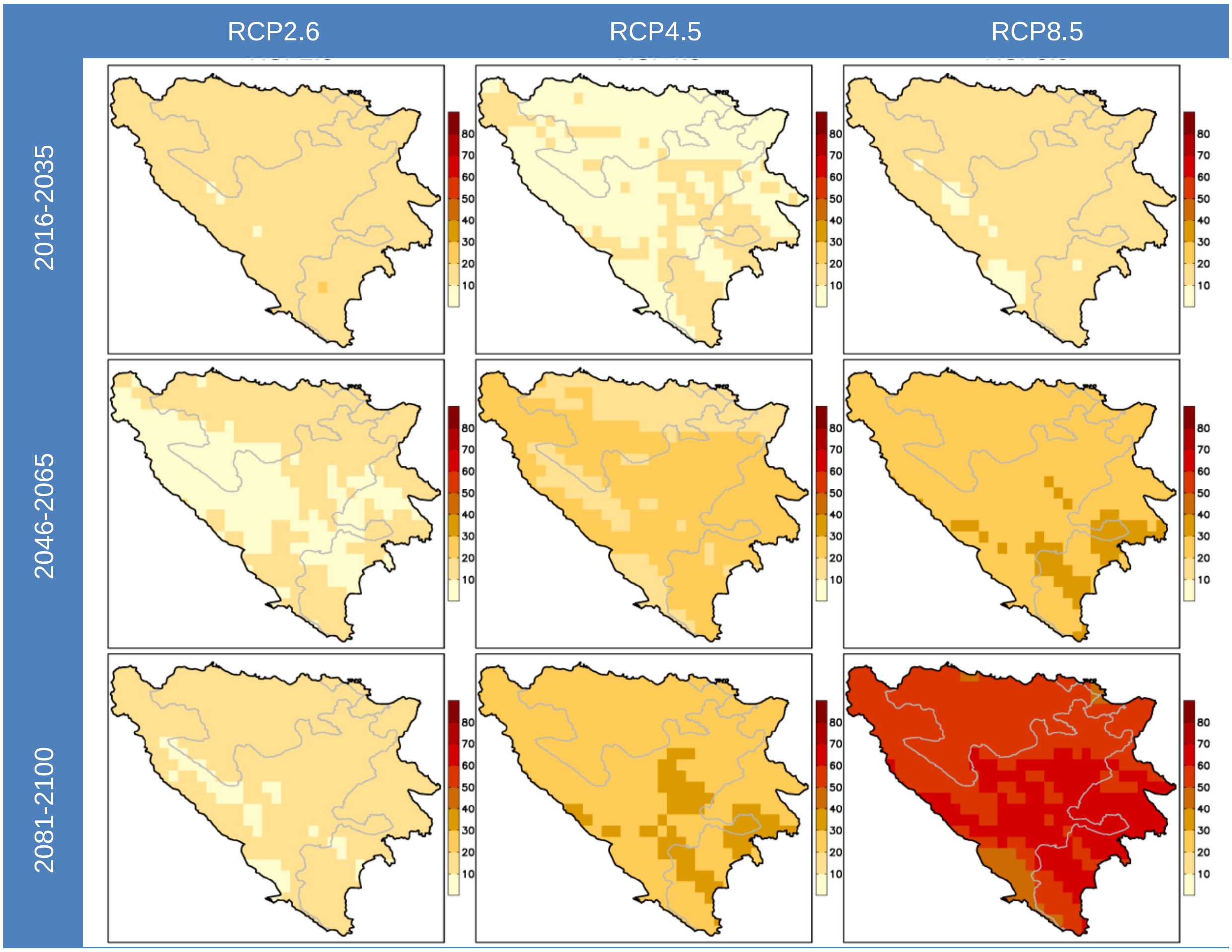


Figure 2-10: Change in the number of summer days (days/year) compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

Changes in annual precipitation from the EURO-CORDEX ensemble, similarly to the GCM results, indicate a range of both positive and negative changes over the territory of B&H. However a breakdown of changes in each season clearly indicates that increases in rainfall particularly during DJF are somewhat offset by decreases in rainfall during JJA (Figure 2-11). Changes during MAM and SON are mostly for increases in rainfall towards the north, with indications of drying in the south.

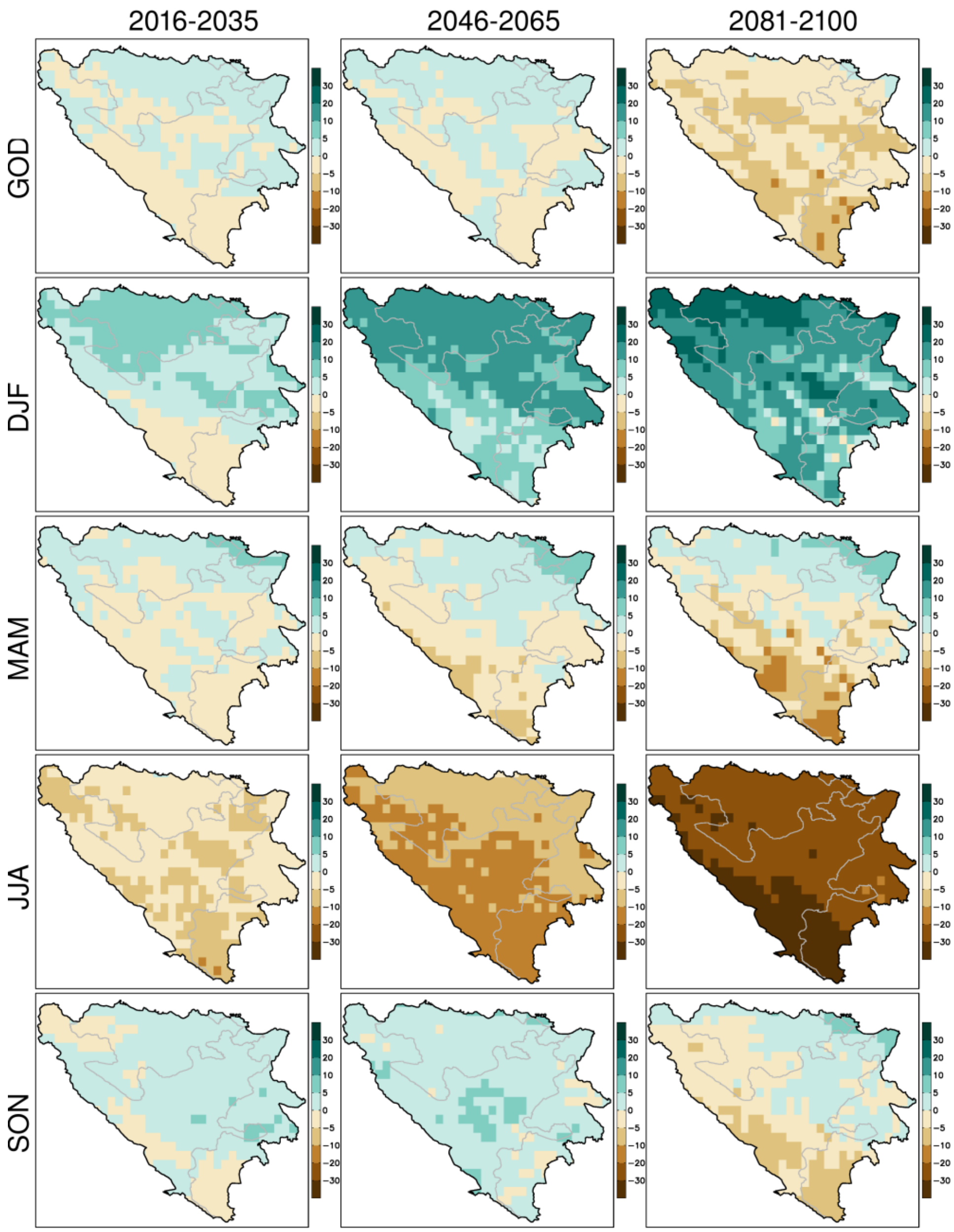


Figure 2-11: Changes in annual and seasonal total rainfall simulated by the EURO-CORDEX ensemble under RCP8.5, for the near future, middle and end of century.

Figure 2-12 furthermore demonstrates that increases in the number of raindays >20mm are simulated over nearly the whole of B&H under all 3 emissions scenarios and for all 3 future periods, suggesting that the number of days with heavy rainfall, which increase the risk of flooding, are expected to increase.

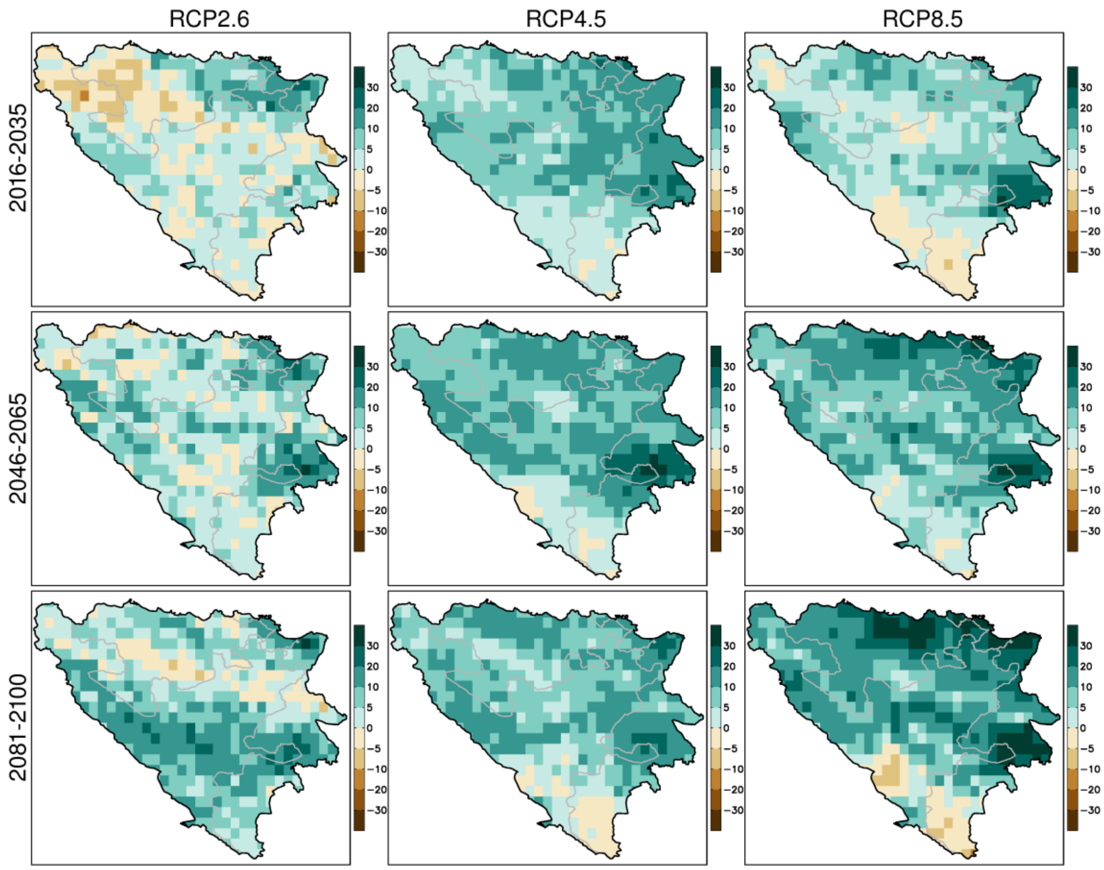


Figure 2-12: Changes in annual number of rain days > 20mm, simulated by the EURO-CORDEX ensemble under RCP2.6, RCP4.5 and RCP8.5, for the near future, middle and end of century.

Figure 2-13 adds further evidence that increases in rainfall intensity are expected across the whole of B&H, indicating that annual daily maximum rainfall amounts will increase more or less everywhere under all three scenarios and for all three future periods.

It is further noteworthy that these increases in temperature and measures of rainfall intensity are consistent between the GCM results (from 42 models) shown above and the 7 models from the EURO-CORDEX ensemble, emphasising that these simulated changes are a robust signal/response to anthropogenic climate change.

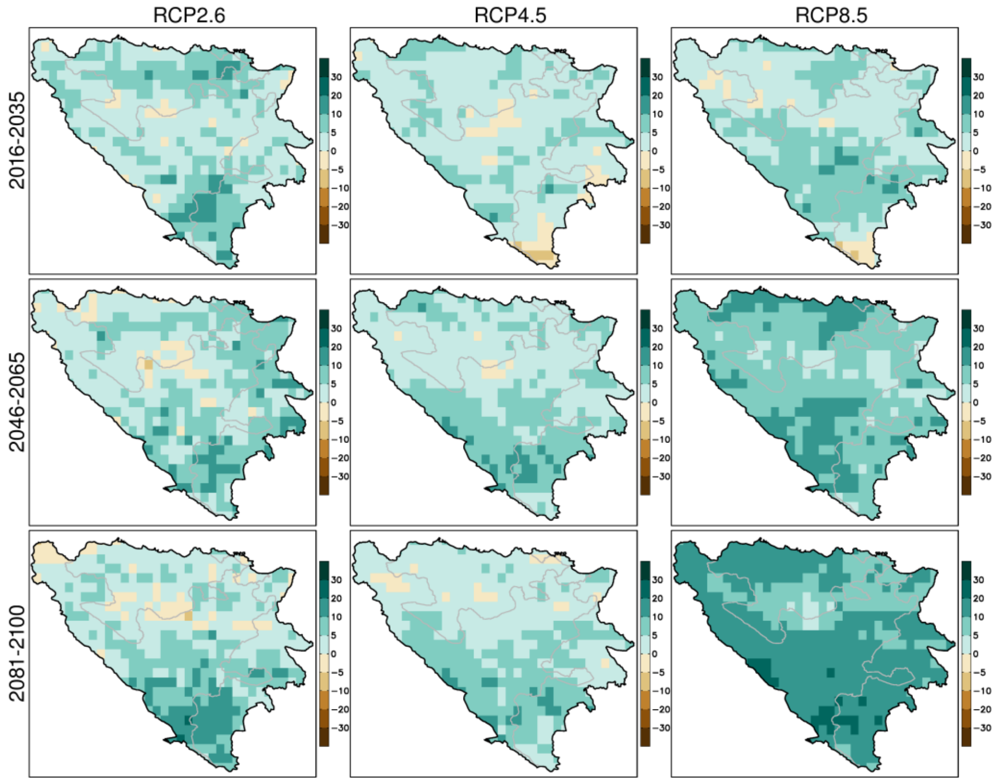


Figure 2-13: Changes in annual daily maximum rainfall, simulated by the EURO-CORDEX ensemble under RCP2.6, RCP4.5 and RCP8.5, for the near future, middle and end of century.

2.1.2.3 Changes in the hydrological regime

Whilst hydrological simulations as yet have not been conducted using the above climate model simulations (which form part of the Fourth National Communication (FNC)), three climate scenarios for the territory of Bosnia and Herzegovina have been used in producing the Third National Communication (TNC). These have been carried out with two different regional models, nonhydrostatic regional NMMB model and related hydrostatic regional model EBU-POM. Regional model NMMB is a nonhydrostatic atmospheric model, while Regional climate model EBU-POM is fully linked atmospheric and oceanic model (Djurdjevic and Rajkovic, 2008; Djurdjevic and Rajkovic, 2010). The atmospheric component of the model is Eta model and oceanic component is the Princeton Ocean Model (POM). With the NMMB Model the regionalization of climate scenario RCP8.5 was made (Moss et al., 2008), as defined in the fifth report of the Intergovernmental Panel on Climate Change (IPCC – AR5), while the EBU-POM model was used for regionalization of the scenarios A1B and A2 (Nakicenovic and Swart, 2000), as defined in the fourth report of the Intergovernmental Panel on Climate Change (IPCC– AR4). Horizontal resolution of the NMMB model was 8 km, and the resolution of EBU-POM model was 25 km. The selected reference period was the period from 1970 to 2000, while the future climate integrations covered the period from 2011 to 2100. For the boundary conditions in the integration of RCP8.5 scenario, the results of global climate model CMCC-CM were used (Scoccimarro et al. 2011), while for the boundary conditions for the scenarios A1B and A2 the results of the global climate model ECHAM5 were used (Roeckner et al, 2003).

According to the Localized Climate Models developed for B&H through the SNC, the mean seasonal temperature changes for the period 2001-2030 are expected to range from +0.8°C to +1.0°C above the previous average temperatures, and further significant temperature increases are expected during the period 2031-2060, of between 1° C to 2° C in coastal areas, and 2° C to 3° C inland.

According to the TNC, for RCP8.5, for the future period 2011-2040 most of the territory has a positive anomaly of annual precipitation, with most of the territory having an anomaly of + 5%. For the scenario A2 for the future period from 2011 to 2040, most of the territory has a positive anomaly of annual precipitation, of +5% (**Error! Reference source not found.** and **Error! Reference source not found.**). Seasons DJF, SON and MAM have qualitatively similar anomalies for the future period from 2011 to 2040 with positive precipitation anomaly on greater part of the territory of Bosnia and Herzegovina (see Section **Error! Reference source not found.** to **Error! Reference source not found.**). For scenario A1B the period from 2011 to 2040 has a negative anomaly of mean annual precipitation compared to the reference period from 1971 to 2000 (**Error! Reference source not found.**).

The Third National Communication of B&H (TNC) shows that extreme precipitation would intensify under warmer climate conditions. Scenario RCP8.5 anticipates a positive anomaly of annual precipitation, in relation to the reference period 1971–2000. Even in case when annual anomalies are negative in relation to the reference climate period, changes of indices of extreme precipitation indicate that there might be an increase in the daily accumulations in the days with precipitation greater than 20 mm or greater than the 95th percentile. In some cases, even the increase of the total precipitation during the day with extreme precipitation can result in a positive anomaly on the significant part of the territory, with a change of up to several dozen percentages for some seasons compared to the reference period. This situation is consistent with the fact that warmer air can carry a greater amount of water vapor, which, under favourable synoptic situations, primarily through convective processes, can be a source of abundant precipitation.

Changes in the hydrological regime in the last decades in B&H are evident in relation to the values and dynamics of the rainfall, and the water levels and river flows. Under the influence of climate change, growing urbanization and other anthropogenic impacts, it can be expected that the adverse effects of spatial and temporal disparities in the hydrological regime will be more and more present in agriculture, water management, hydropower, and urban and rural environments.

In relation to the aforementioned, changes can be expected in terms of time of occurrence, frequency and intensity of extreme events – floods and droughts. The highest air temperature rise is forecasted during the growing season (June, July and August), and somewhat milder rise during March, April and May, which will result in increased evapotranspiration and more pronounced extreme water levels minimums in watercourses. This will result in a general reduction in the availability of water resources in the growing season, when demands are the highest, in terms of water quantity and quality. A significant air temperature rise during the winter season (December, January and February) will result in reduced snowfall, or reduced flow in most watercourses in the spring months. On the other hand, the expected more frequent rainfall of higher intensity will cause more extensive runoff, often accompanied by floods.

2.1.3 Climate change analysis for the Vrbas basin

As part of the Vrbas project (baseline project) climate change analysis was undertaken as input to the flood modelling and mapping that was undertaken. In relation to the reference period, the total accumulated precipitation (RR) was analysed on an annual basis, as well as the change for the seasons: December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON) and individual months. The changes of selected indices of extreme daily rainfall accumulation were analyzed as well, which indicate the frequency and intensity of individual episodes. Definitions of indices and their units are presented in Table 2-3 along with the corresponding index mark.

Indices RR20 and RR20t are defined in relation to the threshold of 20 mm of daily accumulation. Index RR20 is characterized by the frequency of occurrence of certain events, while the index RR20t is characterized by the intensity of rainfall in the days when the daily accumulation exceeded the relevant threshold index, or 20mm. Changes of both indices for extreme precipitation are analyzed on monthly, seasonal and annual basis. Changes in climatology of snow cover (SNO) were analyzed through the change of average daily height of snow cover, on annual basis and for the seasons DJF and November-April, as well as the change of the number of days with snow cover (SNOD).

In the case of temperature changes, the changes in daily mean temperature (TG) were analysed on annual basis, for the seasons: December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON) and for the individual months. In addition, the changes of selected indices of extreme daily temperatures have been analysed, which indicate the frequency and intensity of individual episodes with high temperatures. Definitions of indices and their units are presented in Table 2, along with the corresponding index mark. Indices TX30 and TTX30 are defined in relation to the threshold of 30 °C. Index TX30 is characterized by the frequency of occurrence of certain event, while the index TTX30 is characterized by deviation of temperatures in days with the temperatures exceeding 30°C. Changes of both indices for extreme temperatures are analyzed on monthly, seasonal and annual level.

Table 2-3: Definitions and units of indices used in the analysis of possible change of distribution and the incidence of

Size/Index	Definition	Units
RR	Accumulated precipitation (monthly, seasonal or annual)	mm
RR20	Number of days with daily accumulated rainfall exceeding 20 mm	day
RR20t	Total accumulated precipitation in the days with daily accumulated rainfall exceeding 20 mm.	mm
TG	Mean temperature (monthly, seasonal or annual)	°C
TX30	Number of days in which the temperature during the day was higher than 30°C	Day
TTX30	Daily mean temperature during the days when the temperature was higher than 30 °C	°C
SNO[8]	Average height of accumulated snow	m
SNOD	Number of days with snow cover	Day

daily extreme rainfall in relation to the various scenarios of future climate

RCP8.5

According to the scenario RCP8.5 during the first period from 2011- 2040, we can expect that the annual accumulated precipitation anomaly will remain close to the values observed in the last decades of the twentieth century, and will be positive. During the season DJF, a positive anomaly of accumulated precipitation can be expected, while in the season JJA there is a negative anomaly above -20%. Intensification of rainfall can be expected during the episodes with daily accumulations of more than 20 mm, especially during the colder part of the year and the transitional seasons. The change in the accumulation of precipitation during these episodes for some months exceeds 40%. On the other hand the

[8] Change of SNO and SNOD are shown only for the scenario RCP8.5.

increase in incidence or number of days with intense precipitation is not clearly pronounced, however the colder part of the year and the transitional seasons are those with the anomaly of RR20 index being mostly positive for this period. Changes in climatology of snow cover suggest that according to this scenario drastic changes in average height of snow cover of up to -90% can be expected until the end of the century, as well as decrease of the number of days with snow cover also up to -90% compared to the period 1971-2000. With respect to temperature changes, we can expect further increase in mean annual temperatures by 5.4 °C, which will be mostly pronounced during the colder months of the year, while according to this scenario frequent days of very high temperatures would be most evident during the summer, especially during the month of August.

The maps season and annual for indices RR20t, TG and SNO are presented for RCP8.5 are presented below.

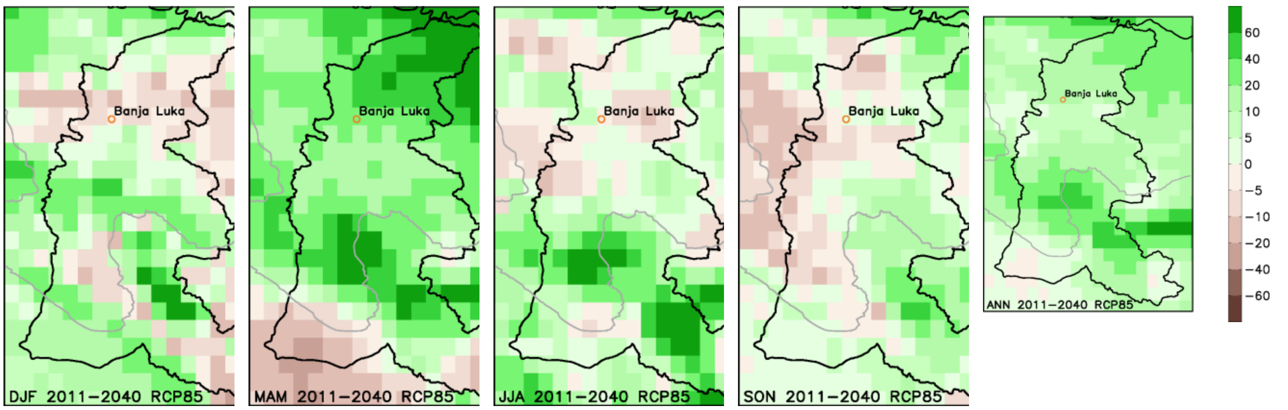


Figure 2-14: Change in accumulated precipitation on days when the accumulation was greater than 20 mm (RR20t), according to the RCP8.5 scenario, for the period 2011-2040, compared to 1971-2000, in %.

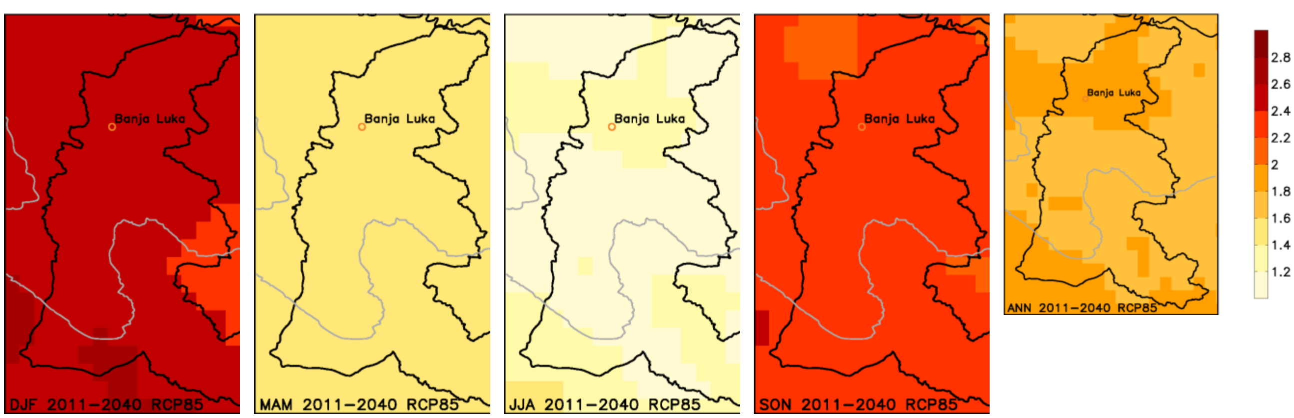


Figure 2-15: Change in serial temperatures (TG), according to the RCP8.5 scenario, for the period 2011-2040, compared to 1971-2000, in °C.

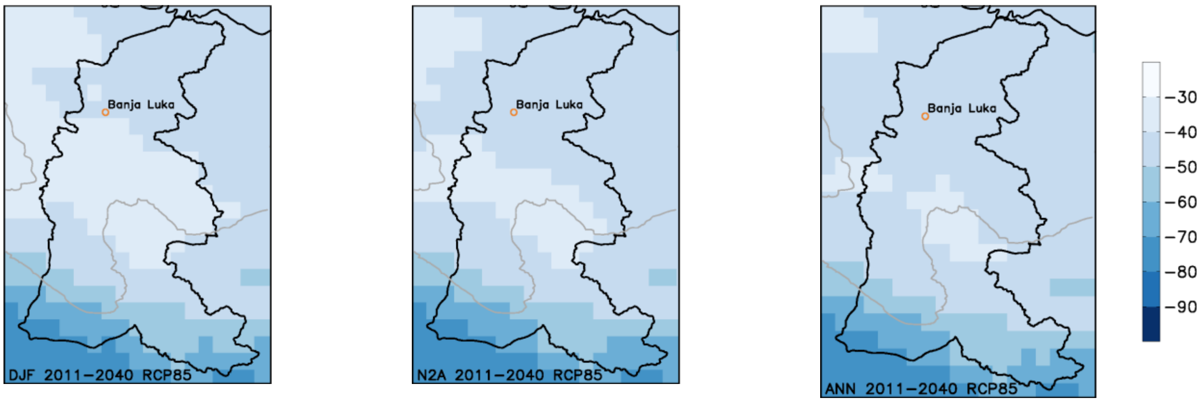


Figure 2-16: . Change in the median height of accumulated snow (SNO), according to the RCP8.5 scenario, for the periods 2011-2040, compared to 1971-2000, in %.

A2

According to the scenario A2 during the first observed period, from 2011- 2040, we can expect that the annual accumulated precipitation anomaly will range from -5 to + 5%. There is a negative anomaly in the JJA season, when the values are greater than -20%. On the other hand in the DJF season in this scenario it can be expected for the anomaly to be positive. Intensification of rainfall can be expected in future, especially during the colder part of the year and the transitional seasons. During these episodes for some months and seasons the anomaly exceeds the value of 40%. On the other hand an increase in the incidence or number of days with intense precipitation is not clearly pronounced, as in the case of scenario RCP8.5, however the colder part of the year and the transitional seasons are those with the anomaly of index RR20 mostly positive. By the end of the century, according to this scenario, further increase in mean annual temperatures can be expected by 4.2 °C, which will be mostly pronounced during the months of June, July and August, during which greater incidence of days with very high temperatures can be expected.

The maps by season and annual for indices RR20t, and TG are presented for A2 are presented below.

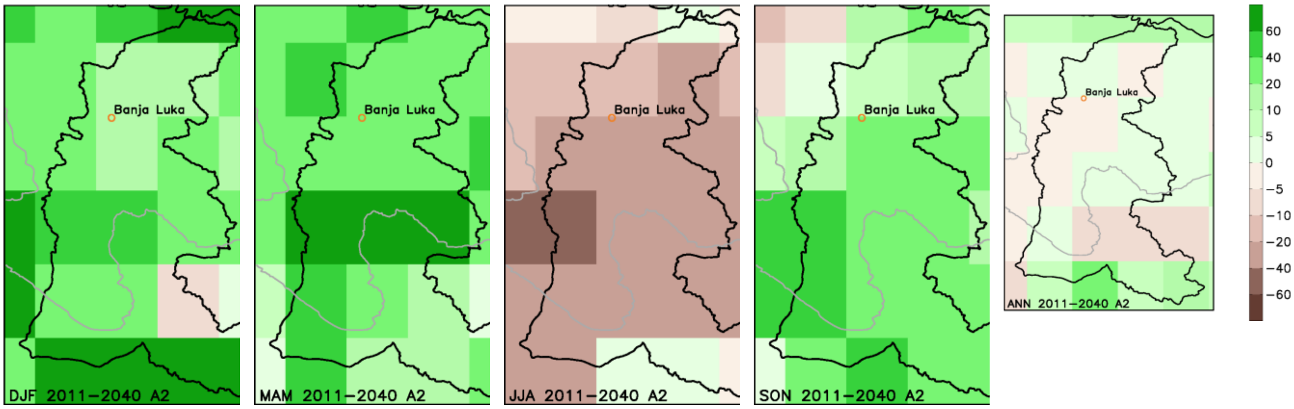


Figure 2-17: Change in accumulated precipitation on days when the accumulation was greater than 20 mm (RR20t), according to scenario A2, for the period 2011-2040, compared to 1971-2000, in %.

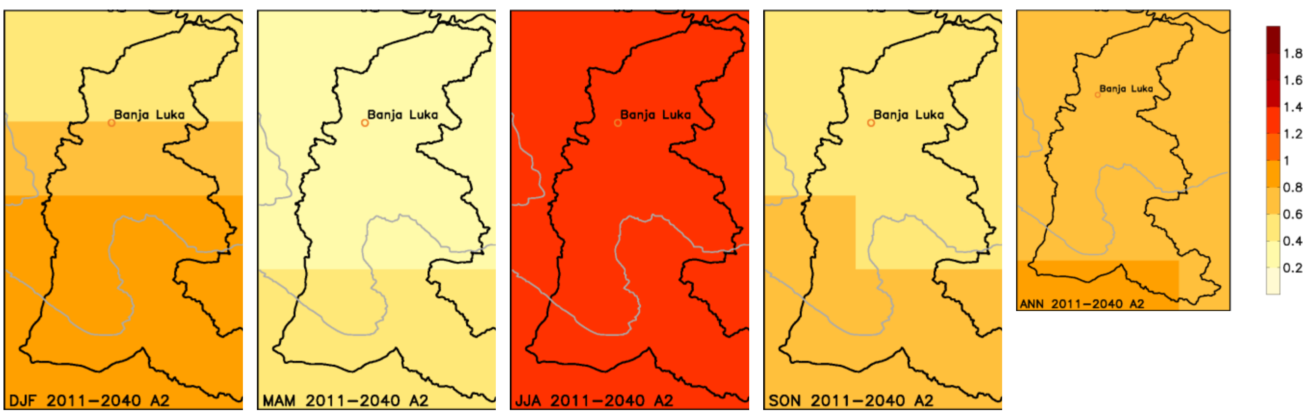


Figure 2-18: Change in serial temperatures (TG), according to scenario A2, for the period 2011-2040, compared to 1971-2000, in °C.

A1B

According to the scenario A1B during the first observed period, from 2011- 2040, we can expect that the annual accumulated precipitation anomaly will be negative within the values of up to -10%. The negative anomaly is particularly pronounced in the JJA season, when the values are greater than -20%. Intensification of rainfall can be expected in future in episodes with daily accumulations greater than 20 mm, especially during the transitional seasons. During these episodes for some months and seasons the anomaly exceeds 40%. On the other hand an increase in the incidence or number of days with intense precipitation is not clearly pronounced, as in the case of scenarios A2 and RCP8.5, however the colder part of the year and the transitional seasons are those with the anomaly of index RR20 mostly positive, for all three observed periods. By the end of the century, according to this scenario, further increase in average annual temperatures can be expected of up to 3.8 °C, which will be mostly pronounced in the months of June, July and August, during which greater incidence of days with very high temperatures can be expected.

The maps by season and annual for indices RR20t and TG are presented for A1B are presented below.

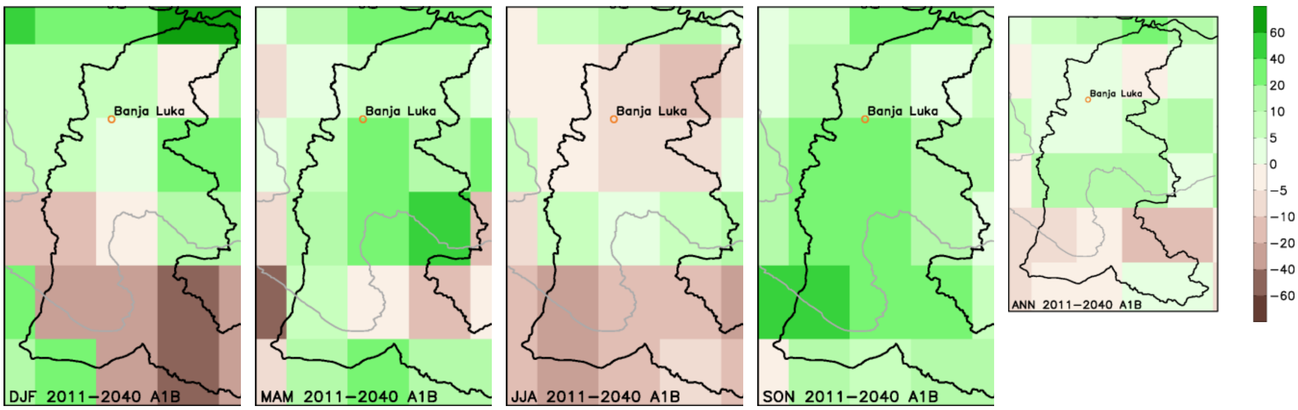


Figure 2-19: Change in accumulated precipitation on days when accumulation was greater than 20 mm (RR20t), according to scenario A1B, for the period 2011-2040, compared to 1971-2000, in %.

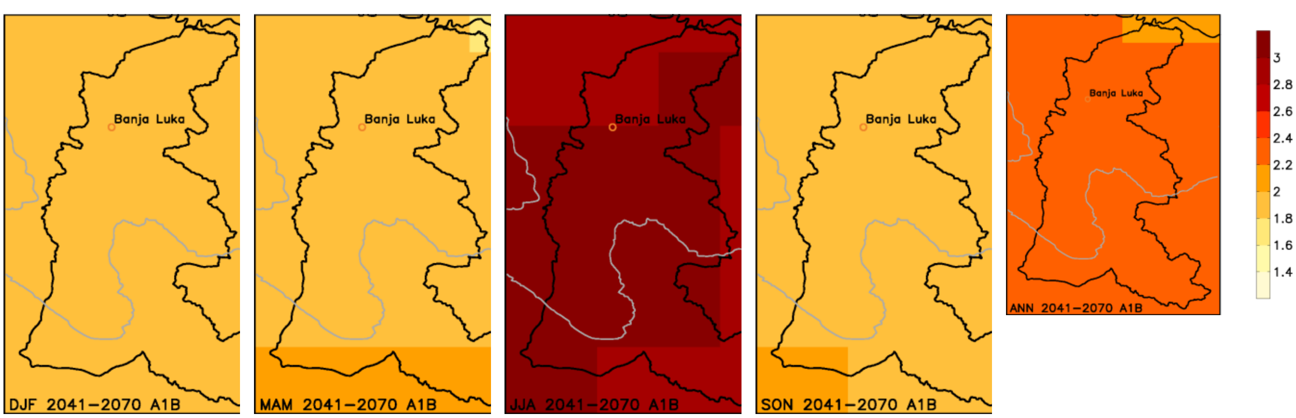


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Figure 2-20: Change of serial temperatures (TG), according to scenario A1B, for the period 2041-2070, compared to 1971-2000, in °C

2.1.4 Modelled Impact of Climate change in Vrbas Basin

The study of impacts of climate change flood risk in the Vrbas basin involved the simulation of a future hydrological regime using the hydrological model and projected GCM climate scenarios as inputs to the NAM hydrological model and then the MikeFlood model. To estimate changes in the hydrological regime, the simulated discharges are compared with those from a reference (baseline) period. Given the uncertainty in the formation of extended climate time series (e.g. precipitation and temperature) and in the climate and hydrological modelling, the discharges from the baseline period are not observed data but the data simulated using the climate data from climate models from the reference period. In this way, we obtained relative changes in the hydrological regime, which are considered more reliable than the absolute values of future discharges. These results provide an insight into the extent of potential impacts of climate change on flood risk at the basin level.

Impact on seasonal Discharge

According to the A1B scenario, an increase in discharge is expected in the spring (MAM) in the near future. According to the A2 scenario, increase in seasonal discharge is possible in winter and spring in the near future, while according to the RCP8.5 scenario an increase of the discharge in the winter and in autumn in the near future. An average increase of discharge of 3.9%is expected in the spring. In the autumn and summer the reduction of discharge is -4% and -9.7% respectively.

Scenario	Future period	DJF	MAM	JJA	SON
A1B	2011-2040	-13.2	7.1	-19.8	-12.6
A2	2011-2040	8.4	23.3	-8.1	-9.2
RCP8.5	2011-2040	4.7	-18.7	-1.2	9.7
Total for all scenarios	2011-2040	0.0	3.9	-9.7	-4.0

Impact on peak flows and the Flood probability curves

As an indicator of flood flows we selected a value of the annual exceedance-probability discharge of 10% and 1% in a given 30-year period. This value is obtained from the a 30-year period (1971-2000, and 2011-2040).

The changes of Q10% per hydrological station in the Vrbas basin show that at most locations an increase of flood flows is possible in the near future.

The results of analysis of the change of more extreme flood flows (Q1%) show that the mean Q1% for all stations shows an increase in the near future (0.9. 12.5 and 6.7% for RCP8.5, A2 and A1B respectively). In addition the For RCP8.5, maximum Q1% increased by 7.1%, A2 increased by 32.5% and A1B increased by 25.6%. Spatial variability of changes in flood flows in the basin is quite large, corresponding to the previously shown results of precipitation and temperature. Changes to the flood probability curve at Banja Luka, the further downstream gauging station are significant with Q1% increasing by 21% for RCP8.5, 87% for A2 and 92% for A1B compared to the reference period.

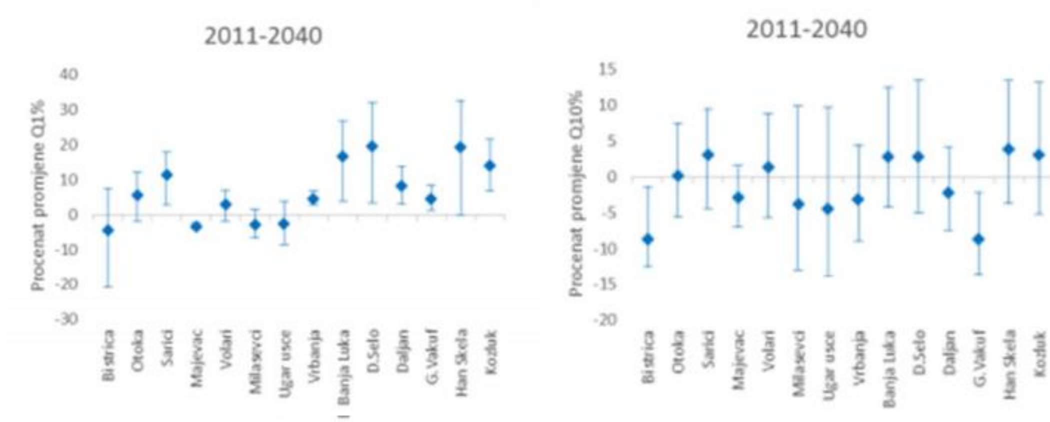


Figure 2-21: Percentage change in Q1% (left) and Q10% (right) for stations in Vrbas

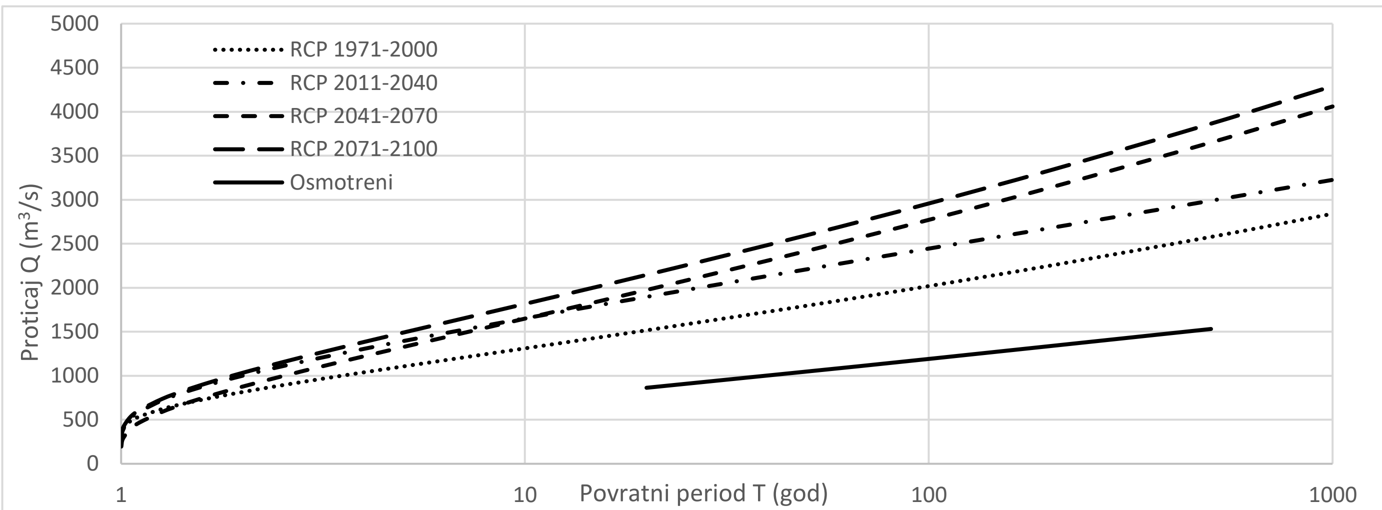


Figure 2-22: Flood probability curve for Banja Luka for RCP8.5

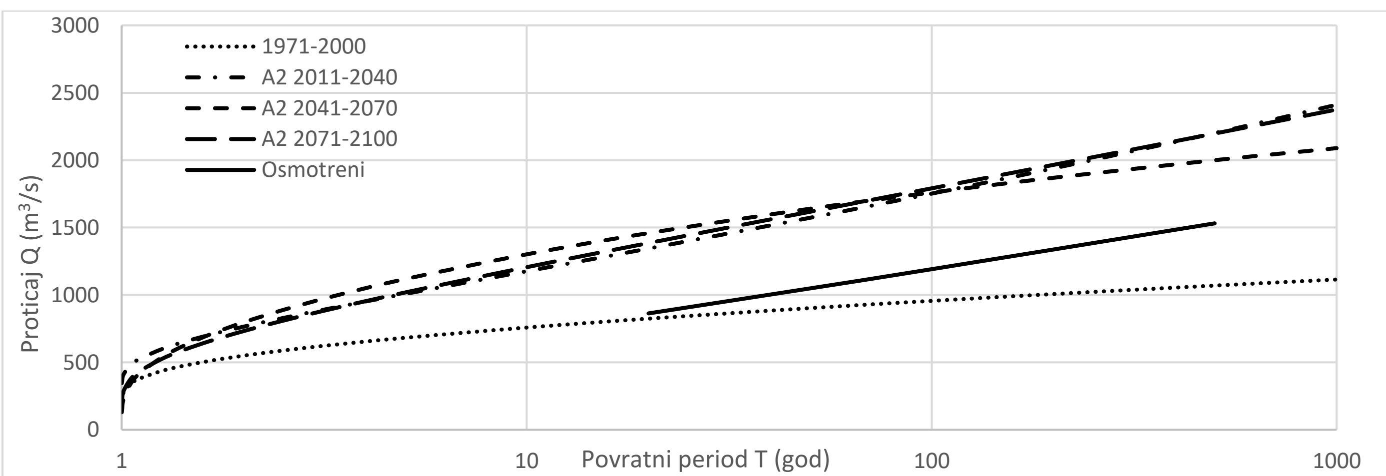


Figure 2-23: Flood probability curve for Banja Luka for A2

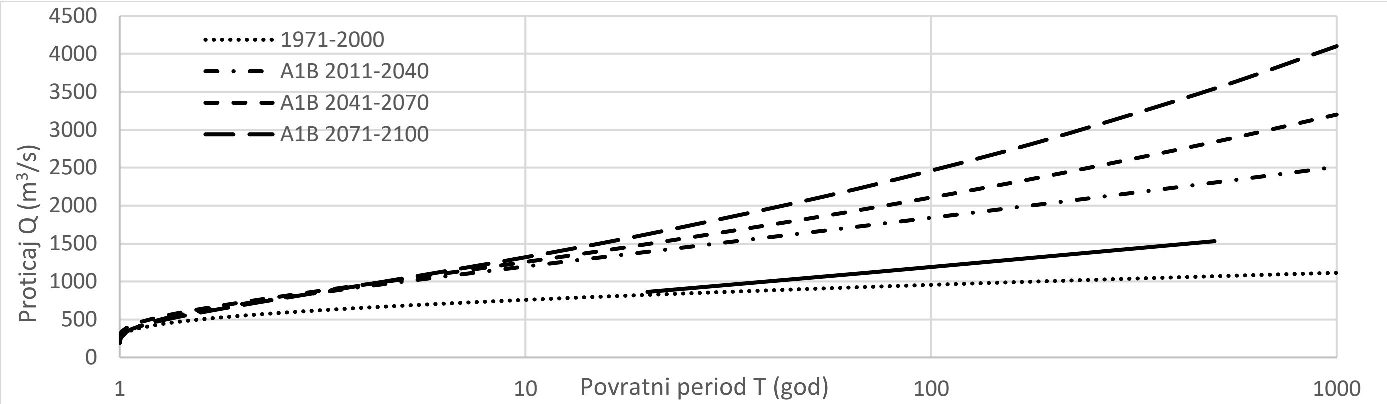


Figure 2-24: Flood probability curves for Banja Luka for A1B

2.1.5 Expected climate change impacts on B&H

Based on the above climate change projections for B&H, by the middle of the century (i.e. by 2050), a significant increase in temperatures accompanied by a decrease of total annual precipitation is expected. Despite this decrease in annual rainfall, rainfall will be concentrated in more intense events and particularly during the winter-spring period; there will be more days with precipitation greater than 20mm (Djurdjevic 2016), maximum daily rainfall intensity will increase, and rainfall during the MAM season increases by up to 40%. These increases in rainfall intensity are expected to lead to increases in extreme discharges, even though temperatures and evapotranspiration increases.The climate change scenarios for Vrbas basin, modelled in detail as part of the EUFD flood hazard and risk modelling, clearly demonstrate these expected increases in discharge (particularly the top 1%) at most locations in the basin.. Modelled changes in discharge for the Vrbas are expected to be indicative of changes in other northern basins given the similar topography, vegetation and consistent changes in climate (particularly increases in intense rainfall) noted above. These changes can be summarised as:

- Change in mean annual temperatures for all scenarios is from 0.7 to 2°C in the near future (2011-2040);
- Change in mean monthly temperatures for all climate scenarios for all months is from -0.1 to 3.2°C in the near future. The biggest increases are expected in the winter and summer months;
- Changes of mean seasonal temperatures range from 0.9 to 1.5°C for the near future, with concomitant expected reductions in snowpack. The greatest increase in temperature is expected in DJF season, then JJA and SON seasons;
- Change in the amount of annual precipitation ranges from -4.6 to 6.8% in the near future, with increases in the number of dry days, particularly during the summer dry period, the main cause of reduced annual precipitation;
- Change in the amount of monthly precipitation is from -27 to 41% in the near future;
- Seasonal changes in precipitation range from -1.7 to 5.8% in the near future. The largest decrease in precipitation is in JJA season, while an increase is expected in the MAM season;
- The changes in mean annual discharge at all 14 stations and for all scenarios are from -10 to 4% in the near future;
- The average monthly discharges change in the range of -15 to 31% for all months in the near future. However, the greatest reduction in mean monthly discharge is in August when discharges are normally low, whilst the largest increases are during December and spring when discharges are normally high already.

Besides the direct impact of climate change on flooding risk elaborated above, climate change is also expected to increase flooding risk through indirect impacts on forest and land cover, as explained in the following section; forest biodiversity and types of trees are likely to change due to increases in temperatures, which reduces the capacity of the land to slow and absorb runoff during high rainfall events.

2.2 Observed Flooding and Vulnerable Sectors

Climate change and climate-induced floods have a significant impact on the most important economic sectors such as agriculture, water management, hydropower, and limit country's already low adaptive capacity.

As outlined above, changes in annual rainfall distribution and increasing rainfall extremes have been driving increased frequency and intensity of floods. Years with floods have become very common (2004, 2006, 2009, 2010, 2014, 2017, 2018) and extreme flood events were especially pronounced during the last 10 years with major floods recorded in 2009, 2010 and 2014, 2017, 2018. 2019. Economic damages from floods have been significant, especially in the water, agricultural and housing sectors. The total economic impact of the 2014 floods is estimated to have reached 2.04 billion EUR, or 15% of B&H's GDP in 2014.

Agriculture employs approximately 20% of total work force and 46% of land use in B&H. It is the most vulnerable sector to climate change. Agricultural losses due to floods can be substantial depending on the timing of the flood during the growing period. In addition, agricultural land suffers from pollution following floods and have to be left uncultivated until rehabilitated. In torrent catchments, the sediment load and debris carried by flash floods to agricultural land result in significant losses and abandonment of productive land. It is expected that climate change will have a positive effect on the yield and quality of winter crops due to the extended growing period. Areas of cultivation of fruit and vines will be expanded due to the disappearance of very cold winters and late spring frosts. However, spring crops will be at risk due to high temperatures and water shortages during the summer months. There will also be a decrease in the yield and the quality of pasture, feed (particularly of spring crops), depletion of pastures due to heavy rains and strong winds. The extension of the growing period due to the increase in the winter and early spring temperatures leads to greater opportunities for the development of diseases and pests. Pathogens of plant diseases, pests and weeds represent a very important segment to which the future climate change have an impact.

Forests in B&H accounts for 53% of land cover. B&H has an extremely high level of diversity of habitats, i.e. the geological diversity. A contributing factor is very specific orography, geological structure, hydrology and "eco-climate". Centuries of coexistence and a broad range of interactivity between biological and geological diversity, adding the anthropogenic impact, are best reflected in the extremely high diversity of landscapes throughout Bosnia and Herzegovina. In terms of composition of the species in the forests of B&H, it is dominated by: beech forests with about 31% of the share, followed by sessile oak forests with the share of 14% and Pedunculate oak with 2%, thermophilic oak forests with 17%, willow, poplar and alder forests with 1%, followed by coniferous forests, mixed coniferous and broadleaves forests with 23%, while pine forests make up around 7%. The others are mostly planted indigenous (4%) or non-native species (1%). Despite the fact that most of the forests are "commercial" in nature, the role played by forests for conservation of biodiversity in B&H is enormous.

Currently, average temperatures in different forest ecosystems in B&H range from beech forests in the Dinaride range (with average annual temperatures of 7.2 to 7.70C) to the stands of downy oak and hornbeam (with average annual temperatures of 12.7 to 13.50C). This range shows that the A2 scenario for the end of this century with its increase of average temperatures from 3.4 to 3.8^{0}C would be close to the currently existing average temperatures for extremely different forest communities. The assumed changes in forest ecosystems indicate that drastic changes would occur even in the mildest scenario. The majority of forests characteristic of the mountainous (Dinarides) regions would evolve into forests of mountainous beech. In the A1B scenario at the end of this century, dominance is expected from the thermophilic forests of the sessile oak with hornbeam, the downy oak and the Holm oak, withthe A2 scenario leading to the loss of the majority of forests.

According to the TNC, climate change represents a threat for all four macro-regions in B&H (ecological-vegetation areas). The Dinarides Region will be under particular threat, as a very important and rich centre of endemic species in Balkans. One of many significant consequences of global warming for ecosystems will be a shifting of water supplies and distribution of agricultural pests and diseases. Threats to this rich flora and fauna by a wide range of different human activities are numerous. The annual increment in the forests is relatively low, because so-called economic forests (forests that can be managed on an economic basis) cover only about 13,000 km^2 (approximately 25% of the B&H territory), and even these forests have low timber reserves (as low as 216 m^3/ha with an incremental increase of timber of almost 5.5 m^3/ha from half of the potential of the habitat). There are about 9,000 km^2 (approximately 17%) of low and degraded forests with a very low incremental increase (approximately 1 m^3/ha) and with no economic value from the timber production perspective. Based on this increment, about 7,000,000 m^3 per year was cut in B&H before the war. The TNC states that to address climate change and the consequences for forestry in Bosnia and Herzegovina, it is possible to implement a wide range of practices, such as improvement in silviculture practices, as well as sustainable management practices, promotion of genetically superior planting material, enlargement of the system for the management of protected areas, substitution of fossil fuels with bio-energy, more efficient protection of forests against fire, diseases and pests, more efficient processing and use of forest products and monitoring of area and growing status of forests, particularly under afforestation practices of bare lands. The TNC advocates: direct increase of the surface on bare grounds and clearways (the areas on which in the past 50 years there were no forests – afforestation) and afforestation of shrubbery, abandoned land, degraded forests and similar (the areas on which in the past 50 years there used to be forest vegetation – reforestation). It states that reforestation practices are important in order to decrease erosion processes and regulate the water regime, apart from the storage of CO2. This practice should take into account which varieties should be used, which are indigenous for that area and how the planted varieties will be affected by future climate regimes, thus selecting the ones that are most suitable. The establishment of forests with varieties and ecotypes more tolerant to higher temperatures and changed regime in precipitation and return of vegetation in degraded and barren areas should imply a planned approach with new or increased funding mechanisms. Promoting carbon sequestration through forestry practices should be increased, especially in areas where there is an extremely low level of carbon in the soil, and where there is the potential for afforestation.

The ***hydropower*** potential of B&H is estimated at 8,000 megawatts (MW), with technical potential of 6,800 MW and economic potential of 5,800 MW, placing the country among the leading hydropower production nations in Southern Europe. More frequent and intense rain events lead to intensive runoff and increased peak river flows and result in reduced power production and damage to hydropower infrastructure. During 2010 and 2014 flood events, hydro power plants (HPPs) didn’t adequately adjust their discharge and as a result largely worsened the flood damage. The Adriatic Sea Basin is particularly heavily modified with a large number of existing and planned hydropower dams and have already experienced an extensive variability in generation due to climate change. While generally designed and licenced to include flood alleviation functions, the HPPs in Adriatic Sea basin require improved management through forecasting to minimize climate change impacts on their operations. Elsewhere in B&H, there is a need to operate HPPs taking climate induced flood risks into account.

Settlements and development activities in the high-risk areas: One of the root causes of increasing vulnerability and damage from floods is increasing exposure. Spatial planning legislation and development control does not take account of flood risk and flood zones with land use and construction rules have not been implemented. As a result, irreversible adverse land use practices in the floodplain and the building of houses and economic activity (including subsistence agriculture) in the floodplain, are common practices which significantly contribute to exposure. Lack of regulatory framework, as well as lack of awareness of the risks and continued uncontrolled adverse practices, will further exacerbate the problem, and will increase the vulnerability and costs from flooding.

2.2.1 Historical Flood events

The table below shows the numbers of significant flood events and fatalities from 1925 to the present. It shows that of the 40 deaths recorded since 1925, 28 occurred since 2010 and 21 in the 95 years before 2010. The 2014 event accounts for 26 deaths, and an average age of 66 years old.

Table 2-4: Historical flooding

Date/Year	Location/River	Number of deaths	Age and Gender	Setting of fatality	Type of flood events
10/11/1925	Mostar/Neretva	1	M	Organized action - catching floating logs	Fluvial flood/extensive rainfall
14-15/11/1925	Bugojno/Vrbas	7	-	-	Fluvial flood/extensive rainfall
15/11/1934	Osijek village/Bosna	1	M	-	Fluvial flood/extensive rainfall
1965	Sarajevo/Miljacka	1	M	-	Fluvial flood/extensive rainfall
13&17/07/1975	Tuzla/Jala	2	-	-	Flash flood
23/07&14/08/1976	Tešanj/ Tešanjka	9	-	-	Flash flood/Landslide
22/06/2010	Šamac/Bosna	1	-	-	Sudden snow melt/extensive rainfall
	Čelinac, Štrbe village/Jošavka	1			Fluvial flood/extensive rainfall
06/12/2010	Drina River basin and in Eastern Herzegovina Cities affected: Goražde, Zvornik and Bijeljina and several smaller settlements	0	-	-	
May, August 2014.	Šamac/Bosna	2	M (76), M	-	Fluvial flood/extensive rainfall
	Doboj/Bosna	11	M(63), M (90), F(88), F (91), F(82), M(53), M(73), M(90), F(76), 2NN	-	Fluvial flood/extensive rainfall
	Vukosavlje/Bosna	1	-	-	Fluvial flood/extensive rainfall
	Modriča/Bosna	2	M (82), F (80)	-	Fluvial flood/extensive rainfall
	Dvorovi/Drina	1	M	-	Landslide caused directly by flood
	Vlasenica/Drina	1	F (70)	-	Landslide caused directly by flood
	Donji Žabar/Sava	1	-	-	Fluvial flood/extensive rainfall
	Domaljevac/Bosna	2	-	-	Fluvial flood/extensive rainfall

	Srbac/Vrbas	1	M (65)	Fell off the boat while trying to rescue	Fluvial flood/extensive rainfall
	Banja Luka/Vrbas	1	M (30)	Victim was swept away from vehicle	Flash flood
	Čelinac, Barakovac village/Crni potok, Jošavka (VRB)	3	M (37) F (42) M (65)	(1,2) Attempted to cross the stream by vehicle (3) Attempted to help a woman with the kids to cross Jošavka river	Flash flood
20-21.03.2017	Approx. 10 municipalities affected: Srbac, Gracanica, Doboj, Derventa, Teslic, Prnjavor, Kalesija, Kakanj, Tuzla, Brcko	**0**		5 regional roads flooded, traffic interrupted Affected minimum 70 houses Flooded approx. 600 ha of agricultural land (Doboj, Kalesija, Gracanica)	Fluvial flood Landslides caused directly by floods
13-14.03.2018	Approx. 11 municipalities affected: Gradiska, Srbac, Kostajnica, Bosanska Krupa, Gracanica, Prijedor, Kozarska Dubica, Novi Grad, Cazin, Sanski Most, Kozarska Dubica	**0**		Flooded at least 120 houses and large agricultural area Prijedor is the mostly affected: flooded 100 houses	Fluvial flood/extensive rainfall
2019 (May/June +Feb/March)	Approx. 35 municipalities affected: Srbac, Laktasi, Banja Luka, Celinac, Kotor Varos, Prijedor, Novi Grad, Kostajnica, Kozarska Dubica, Teslic, Tuzla, Usora, Bihac, Sanski Most, Zepce, Maglaj, Banovici, Gracanica, Gradacac, Tesanj, Celic, Lukavac, Vitez, Novi Travnik, Travnik, Bugojno, Gornji Vakuf Uskoplje, Vitez, Busovaca, Zenica, Hadzici, Kiseljak, Ilidza, Sarajevo Novi Grad	**1**		One death case Flooded almost 1000 houses Bridges: 3 crushed, 8 damaged Roads:damaged/flooded: a dozen roads in at least 10 municipalities Landslides in at least 5 municipalities (2 houses completely damaged) Prijedor the mostly affected:, flooded more than 400 houses, 4 landslides activated	Fluvial flood, extensive rainfall/flash flood/landslides caused directly by flood
2020[9]	No data	**0**		No data	No data
Total		**49**			

In the last two decades, Bosnia and Herzegovina was hit by several extreme floods (2004, 2010, 2014). Non-extreme flood events occur almost every year, so floods were also recorded in 2017, 2018, 2019.

Significant floods were recorded in **April 2004** and they affected 48 municipalities in the basins of Una, Vrbas, Bosnia and Drina. Due to torrential rains in mid-April, the water level of the rivers Pliva, Vrbas,

[9] Data unavailable due to CoVID restrictions

Bosna, Sana, Vrbanja, Josavka, Una, Lasva, Zdena, Drina and Sava rose rapidly. As a consequence, the rivers burst their banks flooding large areas of the Banja Luka, Prijedor, Mrkonjic Grad and Doboj regions, as well as the Una-Sana, Zenica-Doboj, Central Bosnia and Posavina cantons. 5,000 houses were flooded in forty-eight municipalities, while several hundred families had to be evacuated from their homes. In addition, the floods severely affected 20,000 hectares of land with crops and washed away several bridges. The water flooded water-wells and broke into the water network system, which resulted in the water being polluted and thus unsuitable for drinking. It was estimated that the floods affected 300,000 people.

At the beginning of **December 2010**, after heavy precipitation[10], floods occurred, which were particularly pronounced in the Drina River basin and in Eastern Herzegovina. The cities of Goražde, Zvornik and Bijeljina and several smaller settlements were flooded. In the Republika Srpska and in the Federation of Bosnia and Herzegovina, an area of over 240,000 hectares was flooded, predominantly agricultural land, houses were destroyed or damaged, as well as roads and bridges. The army evacuated more than 3,000 people in the north-east of the country after attempts to stop rivers bursting their banks had failed.

Extreme rainfall from between **14th and 19th May 2014**, resulted extreme floods, affecting B&H and the wider region. Floods occurred after multi-day precipitation (the largest precipitation ever recorded since the beginning of the organized measurement, i.e. in the last 120 years), which coincided with snow melting, and which contributed to the extreme increase of water levels in an exceptionally short period, especially on rivers Bosna, Sava, and Drina to a lesser extent, as well as their tributaries. The waters surpassed retention barriers of soil and slopes. The effects were aggravated by pre-existing environmental degradation factors such as deforestation, erosion of riverbeds and construction in hazardous risk exposed areas[11]. The whole of the watershed leading to the River Sava was overwhelmed and peaked, generating flash floods and carrying debris downstream creating a path of destruction and desolation. This accumulated downstream flow of water, mud and debris caused widespread flooding along the plain. Drainage from the plain was made impossible as the River Sava peaked, which caused the retention of water in lowland area for a long period. Thus, in the period 17-18 May 2014, flood defences were breached on several sites along the Sava River and its main tributaries, causing floods and massive damage to property in the areas of Middle Posavina, Odžačka Posavina and Semberija. Additional damages to the basin were caused due to numerous landslides, some of which have completely transformed the environment. A large number of municipalities immediately declared an emergency, while others did so at a later stage. It is estimated that 81 municipalities in B&H suffered damage, losses, social and/or environmental impact of varying degrees. Around 90,000 people became displaced as their houses were affected, either destroyed or damaged, and more than 40,000 took refuge in public or private shelters or moved in temporarily with relatives or friends and were dependant on government support and international assistance. The total economic impact of the disaster (destruction or severe damage to property, infrastructure and goods as well the effects of destruction on livelihoods, incomes and production, among other factors) was estimated to have reached 2.04 Billion EUR. Flooding, erosion, flash floods and landslides marked 2014. Following the floods in May, during **July, August and September 2014**, precipitation caused new flooding problems in areas already devastated by previous floods.

In **October 2015**, Bosnia experienced intense rainfall over a 2 day period. ECHO reported that 120 mm of rain fell in Mostar in 24 hours between 14 and 15 October. Between 14 and 15 October, Livno saw 83.5 mm and Sanski Most 63.2 mm in 24 hours. Elsewhere, in the previous 24 hour Ivan Sedlo saw 73.2 mm. ECHO report that flooding affected parts of Knezica in Kozarska Dubica municipality after rivers overflowed. Una in north-western Bosnia reportedly rose nearly two metres in 24 hours. Overflows from the Una and other rivers flooded dozens of houses and buildings in Prijedor, Novi Grad, Kozarska Dubica, Gradiska and Kostajnica

[10] For example, in November 2010, over 500 l/m^2 to 634 l/m^2 of rain fell in Gacko, and the average for that month is 200-300 l/m^2,/14/.
[11] PDNA, https://ec.europa.eu/fpi/sites/fpi/files/pdna/pdna_bih_2014_-_final_report_0.pdf

Flooding occurred in northern areas of the country, where areas around Bihac and Bosanska Krupa saw flooding after the Una River overflowed. Levels of the river had increased by almost 30 cm in 24 hours from **12 March, 2018**.The Sana river also overflowed, affecting areas around Sanski Most.

In **February 2019**, heavy rain and melting snow caused rivers to burst their banks and cause flooding across Bosnia, damaging houses and blocking roads. A bridge in the capital, Sarajevo, collapsed after the River Zeljeznica overflowed. Milder weather has been witnessed following last month's sub-zero conditions. During a 24 hour period, temperatures increased from 0^0C to 15^0C, causing snow to melt rapidly and trigger floods in central parts of the country. Zenica and Kakanj, towns in central Bosnia, declared a state of emergency as streets in some neighbourhoods were inundated by water and rescue services began evacuating people from their homes on rubber boats. Schools in the most affected areas of central Bosnia were also forced to stay shut on Monday. In Topcic Polje, dozens of homes were evacuated as rescue services built small dams to prevent the further spread of flood waters. Main roads leading in and out of Topcic Polje were damaged by a heavy stream of water which descended from the surrounding mountains. Bosnian rescue services raised security alerts for central parts of the country and evacuated hundreds of elderly residents from their homes. Several landslides were also reported in the south of the country. There were no reports of deaths or injuries.

Figure 2-25: Floods in Bosnia, February 2019, caused by rapid melting of snow and ice, increasing river levels. Photo: Federalna Uprava Civilne Zaštite

After a period of heavy rain from **12 May, 2019**, swollen rivers in Bosnia and Herzegovina caused flooding problems, in particular the Vrbas, Bosna, Sana, Una and Ušora rivers..Bosnia's Civil Protection Agency said on 14 May that a state of natural disaster was declared in Sanski Most, Bosanska Krupa, Cazin, Kljuc, Banovići, Usori, Tešanj and Doboj Jug as result of "abundant precipitation."Hundreds of Civil Protection staff were deployed to the worst affected areas, chiefly Sanski Most, Usora and Doboj Jug. Local media reported that military personnel were deployed to Prijedor in Bosanska Krajina to shore up flood defences along the banks of the Sana river and its smaller tributary, the Milosevac river. Houses and crops were damaged in affected areas, and power and water supply severely disrupted. Flooding and landslides blocked several roads and some schools were closed. Federation hydromet Agency (FHMZ), said that 84 mm of rain fell in Bihać in 24 hours to early 13 May and a further 53 mm the next day. The city of Banja Luka recorded 49mm to 13 May and 62 mm the next day, before peaking at 78mm on the 14th May. FHMZ reported that the River Sana at Sanski Most increased from a level of from 2.22 the previous day to a peak of at 4.23 metres on the 14th. One death was reported.

In **June 2019**, flooding and landslides in northern B&H damaged homes, infrastructure and crops. The city of Tuzla in the north east of the country declared a state of natural disaster on 01 June, 2019 in response to the flooding and landslides triggered by the rain. Tuzla's Civil Protection authorities said that flooding damaged around 50 homes, along with vehicles, roads, two bridges, water infrastructure and agriculture. The city also said that about a dozen landslides have been reported in the area. The rain caused rivers to rise rapidly. On 02 June the Jala River which runs through the city of Tuzla reached 111 cm, jumping from 45 cm in just a few hours. Danger level is 100cm, which had already been surpassed twice that year, once in late April and again in mid-May.

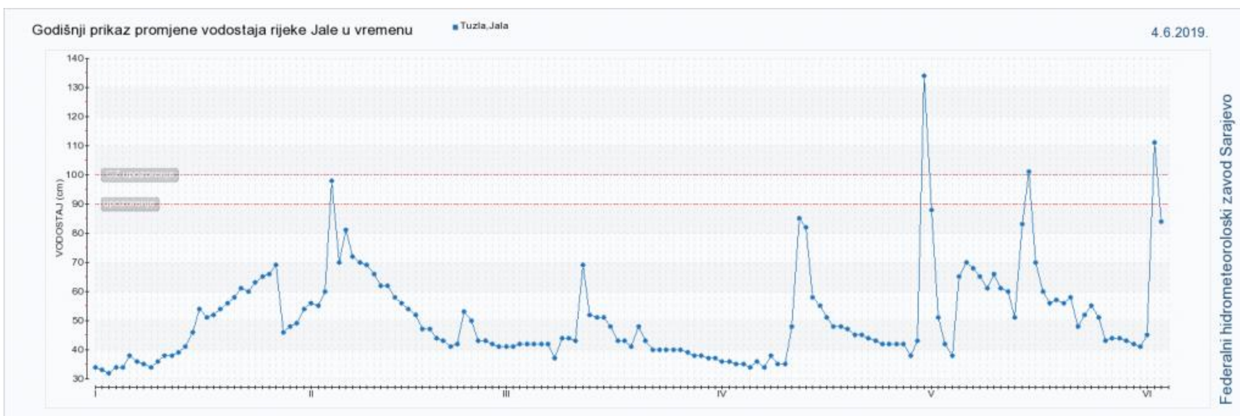


Figure 2-26: Levels of the Jala River at Tuzla in B&H during 2019. Image: Federalni hidrometeorološki zavod B&H

In the Adriatic basin in B&H, where multifunctional water management systems [12] were built, the hydrological regime is affected by the management of these systems. In December 1999, there was a great flood wave of the Neretva River, which caused enormous damage in Mostar, but also in the entire lower course of Neretva. In 2004, when large river overflows were recorded in the Sava River basin in B&H, and in the Neretva River basin, particularly high-water levels were recorded, with sporadic overflows.

The events of the last decades show that in Bosnia and Herzegovina the floods have been escalating, caused by strong regional precipitation, which can even exceed the recorded catastrophic floods. The danger from flooding is also increased due to mild winters with scarce snow, but heavy precipitation, which is persistent for hours, or when there is abundant snow with extreme temperature oscillations. Hence in the last two decades, significant floods have been recorded.

[12] Most of these systems were initiated by the construction of large hydro power plants.

2.2.1 Flash floods

In recent years, in Bosnia and Herzegovina, there is a frequent occurrence of flash floods.

Flash floods generally derive from high intensity and short duration rainfall, which may be caused by heavy rain associated with a severe thunderstorm, hurricane, tropical storm, or meltwater from ice or snow flowing over ice sheets or snowfields. Such rains cause torrents in a short time that destroy everything that is in their way.

The notion of flash floods is much wider than in the case of river floods, so it is often referred to as "flash flood processes", as it is a set of phenomena that take place in the torrential watercourse and coastal area, when the waves of high waters occur. In addition to overflowing of high water from the riverbed, in parallel water carries large quantities of debris, the so-called flash flood lava. The flash flood waves are characterised by great destructive power, when the wave front tears out the trees, undermines the shores, creates debris and landslides. The hydrological regime of the torrential watercourses is also specific. It is manifested by a large range of flux and a characteristic shape of hydrograph of a large flood wave, with a short time base. The flow ratio of high water and low water is Q_{max}/Q_{min} ~ 10^3, unlike large alluvial watercourses where Q_{max}/Q_{min} is ~10. On the other hand, duration of high water is very short, with the order of magnitude of several hours. In the hydrograph of the torrent streams, there is a particularly short rise time (ascending line) due to the rapid formation and sudden escalation of high water. Duration curves of the torrent streams also have a typical shape during the year, with a very short duration of high water (several days a year). Flash floods are accompanied by soil erosion. The erosion processes are hardly noticeable and slow and are most commonly observed only when large areas are exposed. In the relief of Bosnia and Herzegovina there is a typical presence of inclined terrains, and thus, for example, by analysing the individual slope categories in the Federation of B&H, the highest representation of the very steep slope category has been identified, with pronounced erosion processes, with the share of 22.9% of the explored area[13].

In recent years, in B&H, flash floods have been increasing in urban areas – cities; depending on the capacity of the existing sewage system, increase in the intensity of precipitation results in increased overflow and flooding, usually on the roads. This can lead to significant infrastructure problems and damages.

2.2.2 Observed flood damages in B&H

Floods cause great damage in B&H, however, there is no statistical data on the total annual values on the level of Entities and the state, as this type of data is still not collected through the statistical institutions of the Entities and the state. The table below reflects available information which is a combination of estimated losses and the cost of repair after certain floods.

Table 2-5: Data on losses and damage from floods in B&H

Damage from the floods				
Year/average for the period	**B i H**	**F B&H**	**RS**	**BD**
1976	191.788.328 KM[14]			

[13] Multipurpose evaluation of land in the Federation of Bosnia and Herzegovina, 2013

[14] Source: SIZ Vodoprivreda SR B&H - Basic characteristics of water management of SR B&H, 1980. Calculated based on 100 DEM = 766.47 dinars – currency exchange as at 31 December 1976 - Excerpt from the table of the Association of Banks of Yugoslavia 1973-1991.

1976-1980	162 mil. KM /per year (Source: FB&H Government)[15]			
2001		The FB&H Government allocated BAM 6,730,178.00 for repair of the consequences and the damage amounted to more than BAM 50 million[16]		
2004		BAM 23,933,792.86; The flood affected 13,500 hectares of agricultural land[17]		
June 2010		Over BAM 87 million[18] Over EUR 50 million; flooded over 140,100 hectares, of which about 91,360 hectares of agricultural land[19]	Over EUR 26 million; flooded 100,649 hectares of land, destroyed 48, and damaged 1,513 facilities. 15 bridges were destroyed and 40 damaged[20]	
December 2010		Over 15 million BAM of damages. Flooded 315 houses, 59 companies in city of Goražde.	Over 37 million BAM of damages.8000 hectares of land, damaging 1200 houses in cities Zvornik, Visegrad and Bijeljina..	
2014		BAM 1,083,625,000 Flooded area of 30,478 ha of agricultural land; 14,415 residential buildings damaged[21]		
2014 Assessment from RNA document, developed with the assistance of EU, UN and WB[22]	Consequences of natural disaster in B&H: 23 fatalities, total damages EUR 2,037 million	Total consequences of this natural disaster amount to EUR 1,040 million in FB&H	Total consequences in RS amount to EUR 968.30 million	Total consequences in BD amount to EUR 29.6 million

[15] FB&H Government – Assessment of the vulnerability of the Federation of Bosnia and Herzegovina to natural and other disasters, June 2005
[16] FB&H Government – Assessment of the vulnerability of the Federation of Bosnia and Herzegovina to natural and other disasters, June 2005
[17] FB&H Government – Assessment of the vulnerability of the Federation of Bosnia and Herzegovina to natural and other disasters, June 2005 http://fB&Hvlada.gov.ba/fucz/hrvatski/PROCJENA_bos.pdf;
[18] Federal Civil Protection Administration – Assessment of the vulnerability of the Federation of Bosnia and Herzegovina to natural and other disasters, November 2014
[19] ICPDR Report „2010 Floods in the Danube River Basin“
[20] ICPDR Report „2010 Floods in the Danube River Basin“
[21] Information on undertaken activities of the FB&H government, Federal ministries, Federal administrations and Federal administrative organizations on the rehabilitation of consequences of natural disasters in FB&H, August 2014
[22] Action Plan for Flood Protection and River Management in B&H 2014-2021.

2016.		BAM 1.823.601,00 Municipality of Kakanj – floods and landslides, Municipality of Goražde, floods[23]		
2017.	BAM 1.93 Mil BAM	BAM 1.269.550,00 Municipality of Kakanj, Municipality of Doboj East – floods and landslides[24]		
2018.	BAM 22.58 Mil BAM	BAM 6.365.400,00 Municipalities of Maglaj, Kalesija, Tuzla – floods and landslides[25]		
2019	11.77 Mil BAM			

2.3 Analysis of Socio-economic Impact of Floods Under Current and Climate Change Conditions in B&H

Figure 2-38 shows the preliminary flood risk assessment (PFRA) mapping which was undertaken for B&H. In addition, detailed EUFD flood hazard and risk modelling and mapping was undertaken for the Vrbas basin under the Vrbas project for baseline and climate change scenarios. The analysis of socio-economic impact of floods in B&H under current and climate change conditions, was carried out using the PFRA map and the Vrbas detailed EUFD flood mapping as the basis. This section discusses the approach and key findings.

[23] Federal Civil Protection Administration – data on damages reported by municipalities in FB&H
[24] Federal Civil Protection Administration – data on damages reported by municipalities in FB&H
[25] Civil Protection Administration – data on damages reported by municipalities in FB&H

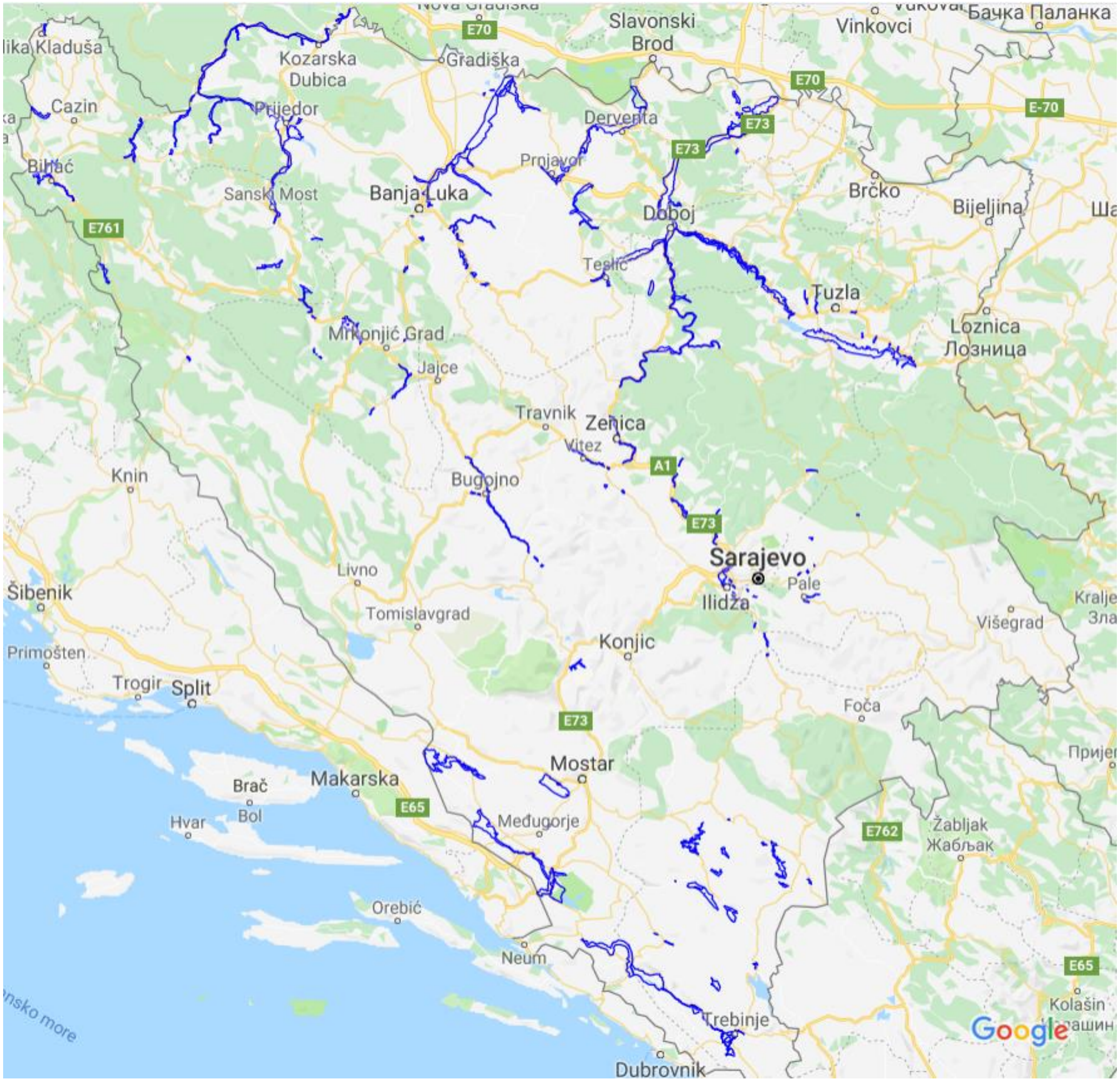


Figure 2-27: PFRA map of historical and existing flood risk for B&H

In the Vrbas basin detailed climate change flood hydrological and hydraulic modelling resulted in the increased flood extent throughout the basin. In other basins (apart from Vrbas), flood plains were defined through PFRA (developed in 2010 and 2012) without hydrologic and hydraulic modelling and without flood probability of occurrence. Having in mind that extreme rainfall and flooding occur in 2014, it can be concluded that extent of flooding in 2014, on whole territory of B&H, represented maximum of future flooding in B&H with regards of topography and river morphology as well as extreme flow in most of the rivers in B&H.

Increase of flood plain for CC scenario represents average increase in range of flood wave due to topography and CC impact. As defined in Vrbas project, CC impact is reflected through the unchanged amount of precipitation during the year, but with higher intensity and shorter duration. This causes significant rainfall over short period of time. Considering that Vrbas river Basin is located on 12% of the territory and that borders with all other basins, it is highly likely that the calculated climate change scenario will be similar in other basins as well. Due to lack of hydraulic and hydrologic modelling, the CC scenario was constructed by increasing flood zones defined in PFRA in order to take into account the impact of rainfall events with high intensity and shorter duration expected under climate change.

An analysis of the socio-economic impact of flooding with and without climate change for the basins of Una (9,130 km²), Vrbas (6,386 km²), Bosna (10,457 km²), Ukrina[26] (1,515 km²), Neretva, and Trebišnjica (for a combined 10,110 km²) was conducted. These basins comprise over almost 3/4 of total B&H surface area. This analysis excludes the river basins of Korana/Glina, Cetina, Drina and direct Sava river basin.

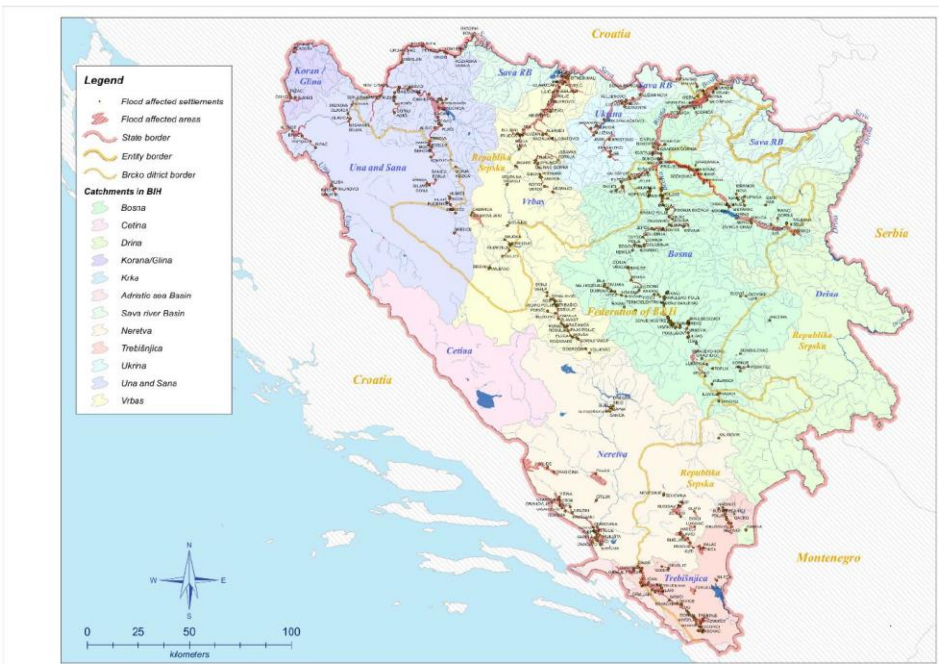


Figure 2-28: Map of flood affected areas without CC

[26] Pending additional analysis, the Ukrina sub-basin was not retained as target project area. It is therefore not included in the discussion below.

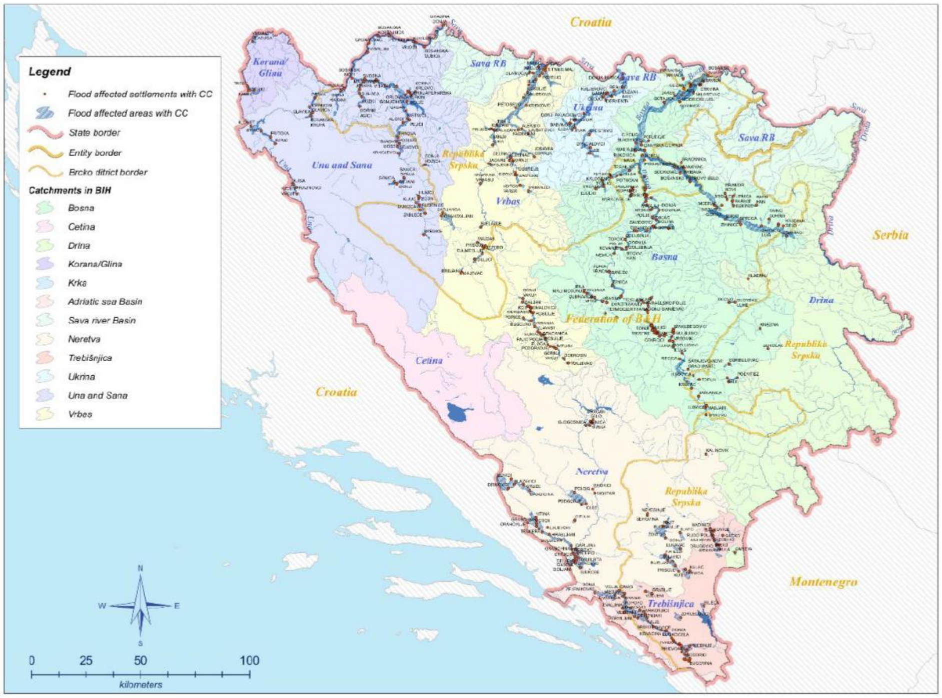


Figure 2-29: Map of flood affected areas with climate change impact

2.3.1 VULNERABILITY OF POPULATION TO FLOODS

The total population of B&H is 3,531,159 distributed across 142 municipalities. Within the analysed basins 79 municipalities (56% of total number of municipalities) are at risk from river flooding (citizens, land, property). In 69 municipalities (49% of total number of municipalities in B&H), the citizens are affected by floods under climate changes, while the citizens of 63 municipalities (44% of total number of municipalities in B&H) are affected by floods under current conditions. Table D1 in Annex D provides a detailed breakdown of impact by municipality within each river basin.

Table 2-6 and Table 2-7 present the affected population per categories and per basins, under climate change and under current conditions.

Under current climate conditions, the number of affected citizens in the 5 modelled basins is 799,445 (representing 272,811 households) across 69 municipalities of the 5 sub-basins. All of these individuals will be exposed to an increasing frequency of more intense flood events. As a result of the estimated extension of flood areas, it is estimated that an additional 103,461 individuals in the 5 sub-basins currently not exposed to floods will become exposed to future floods. The total number of persons impacted by future floods thus amounts to 902,906. This represents 44% of the population of these 69 municipalities. The Bosna river basin alone represents approximately 50% of the affected population.

Women represent 51.7% of the total affected population. The population under 15 years of age and of above 65 years of age represent 15.2% and 13.7% respectively of the affected population.

Table 2-6: Flood-affected population per basin under climate change

Basin	Citizens		Households		Men		Women		Population below 15 years of age		Population over 65 years of age	
	Population number	**% of total population number in B&H**	**No. of households**	**% of total No. of households in B&H**	**No. of men**	**% of total number of men in B&H**	**No. of women**	**% of total number of women in B&H**	**Population number to 15 years of age**	**% of total population number to 15 years of age in B&H**	**Population number over 65 years of age**	**% of total population number over 65 years of age in B&H**
Una	156,973	4.4%	51,477	4.5%	75,701	4.4%	81,272	4.5%	22,004	4.0%	22,223	4.4%
Vrbas	213,740	6.1%	74,220	6.4%	102,139	5.9%	111,601	6.2%	32,390	6.0%	29,963	6.0%
Bosna	450,389	12.8%	155,979	13.5%	215,890	12.5%	234,499	13.0%	69,645	12.8%	58,878	11.7%
Neretva	50,225	1.4%	14,791	1.3%	24,648	1.4%	25,577	1.4%	8,414	1.5%	7,873	1.6%
Trebišnjica	31,579	0.9%	10,440	0.9%	15,451	0.9%	16,128	0.9%	4,947	0.9%	5,295	1.1%
Total	**902,906**	**25.6%**	**306,907**	**26.6%**	**433,829**	**25.1%**	**469,077**	**26.0%**	**137,400**	**25.2%**	**124,232**	**24.8%**

Table 2-7: Flood affected population per basin under current conditions

Basin	Citizens		Households		Men		Women		Population to 15 years of age		Population over 65 years of age	
	Population number	**% of total population number in B&H**	**No. of households**	**% of total No. of households in B&H**	**No. of men**	**% of total number of men in B&H**	**No. of women**	**% of total number of women in B&H**	**Population number to 15 years of age**	**% of total population number to 15 years of age in B&H**	**Population number over 65 years of age**	**% of total population number over 65 years of age in B&H**
Una	138,710	3.9%	45,421	3.9%	66,574	3.8%	72,136	4.0%	19,336	3.6%	19,660	3.9%
Vrbas	192,173	5.4%	66,955	5.8%	91,532	5.3%	100,641	5.6%	28,893	5.3%	27,118	5.4%
Bosna	403,508	11.4%	140,071	12.1%	192,729	11.1%	210,779	11.7%	62,058	11.4%	53,176	10.6%
Neretva	35,590	1.0%	10,609	0.9%	17,384	1.0%	18,206	1.0%	5,882	1.1%	5,581	1.1%
Trebišnjica	29,464	0.8%	9,755	0.8%	14,390	0.8%	15,074	0.8%	4,684	0.9%	4,776	1.0%
Total	**799,445**	**22.5%**	**272,811**	**23.5%**	**382,609**	**22.0%**	**416,836**	**23.1%**	**120,853**	**22.3%**	**110,311**	**22.0%**

2.3.2 Vulnerability of Citizens' Assets and Households

The value of citizens' assets in target area was obtained based on the information on market value of residential and support buildings, methods of heating and fuel used, electrical appliances and devices, household commodities, vehicles and agriculture machinery, agricultural stocks per household and similar. As shown in Table 2-8, the total value of assets exposed to future floods reach in excess of $21 billion. Utilizing the mean value of damage function, given a flood it is estimated that damages to household assets reach approximately $3.6 billion up from $3.2 billion under current climate conditions. The Bosna basin alone represents 50% of these damages to household assets. Table D2 in Annex D presents a detailed breakdown of impact by municipality within each river basin

Table 2-8: Damages to flood-affected households in target basins under climate change

Basin	*No. of households*	*Total value of assets of the affected households per basins (USD)*	*Damages on household assets (USD)*	*% of damage per basin against total damage*
Una	51,477	3,685,806,604	602,260,799	17%
Vrbas	74,220	5,314,228,999	868,345,018	24%
Bosna	155,979	11,168,258,219	1,824,893,393	51%
Neretva	14,791	1,059,050,945	173,048,924	5%
Trebišnjica	10,440	747,514,831	122,143,923	3%
TOTAL	**306,907**	**21,974,859,598**	**3,590,692,058**	**100%**

Table 2-9: Damages to flood-affected households per in target basins in B&H, under current conditions

Basin	*No. of households*	*Total value of assets of the affected households per basins (USD)*	*Damages on household assets (USD)*	*% of damage per basin against total damage*
Una	45,421	3,252,190,722	531,407,964	17%
Vrbas	66,955	4,794,047,462	783,347,355	25%
Bosna	140,071	10,029,228,916	1,638,776,005	51%
Neretva	10,609	759,615,406	124,121,157	4%
Trebišnjica	9,755	698,468,120	114,129,691	4%
TOTAL	**272,811**	**19,533,550,626**	**3,191,782,172**	**100%**

2.3.3 Vulnerability of the Agricultural Sector

Total flood damages in agriculture in the analysed basins include damages in flood area to the following crops: wheat, corn, barley, potato, apple, plum and pear. By multiplying the losses due to flood-related yield decrease presented in USD/ha and size of land under the crops in the flooded area (ha), the total flood damages are obtained. Under current climate conditions, it is estimated that 12,896 ha of farmland is exposed to flood and experiences agricultural losses and damages a result. All of these hectares of land will experience in the future an increasing frequency of more intense floods. An additional 2,168 ha will become exposed to floods as a result of the projected increase in flood areas. Total farmland exposed to floods is projected to reach 15,064 ha and that losses in presence of floods would reach approximately $3.5 million.

Table D3 in Annex D presents a detailed breakdown of impact by municipality within each river basin.

Table 2-10: Total damages to agriculture per basins under climate change

Basin	Land size in ha of flooded agriculture crops	Hazards for agriculture (USD)								
		Wheat	Corn	Barley	Potato	Apple	Plum	Pear	Total	% damage per basin
Una	3,598	39,008	181,668	17,502	50,703	23,248	25,946	6,716	344,792	9%
Vrbas	2,890	43,798	301,134	19,192	170,250	19,081	48,577	12,277	614,309	17%
Bosna	6,801	119,900	622,737	30,866	260,899	23,586	69,804	4,439	1,132,230	30%
Neretva	1,428	38,435	24,584	28,561	1,077,189	100,998	32,998	1,530	1,304,295	35%
Trebišnjica	347	17,848	8,694	15,574	149,527	112,112	11,053	2,132	316,940	9%
TOTAL	**15,064**	**258,989**	**1,138,816**	**111,695**	**1,708,567**	**279,025**	**188,377**	**27,095**	**3,712,565**	**100%**

Table 2-11: Total damages in agriculture per basin under current conditions

Basin	Land size in ha of flooded agriculture crops	Hazards for agriculture (USD)								
		Wheat	Corn	Barley	Potato	Apple	Plum	Pear	Total	% damage per basin
Una	3,236	35,177	164,370	15,703	43,939	20,503	24,032	6,369	310,093	9%
Vrbas	2,318	35,348	248,292	15,265	133,021	14,351	36,788	9,656	492,722	15%
Bosna	5,588	99,237	526,064	25,663	204,202	17,161	54,394	3,568	930,290	28%
Neretva	1,415	36,882	24,374	27,363	1,065,479	104,005	32,906	1,411	1,292,421	39%
Trebišnjica	339	16,813	8,304	14,046	142,432	115,558	10,476	2,003	309,633	9%
TOTAL	**12,896**	**223,458**	**971,404**	**98,041**	**1,589,073**	**271,579**	**158,597**	**23,007**	**3,335,159**	**100%**

2.3.4 Vulnerability of public sector

In this study, public sector includes public buildings/facilities where the following institutions are located: health, local administration, judiciary, city administration, police and army, civil protection, social welfare, fire brigades, associations of citizens, culture, information, sport, culture-historical heritage, as well as public infrastructure such as water supply, waste water disposal, heating and similar. All mentioned categories are divided into 7 groups, as follows: Health, Education, Judiciary, administration and social welfare, Police and defence, Culture, information and sport, Culture – historical heritage and Public infrastructure.

As shown in Table 2-12, a total of 505 public sector buildings are exposed to floods in the 5 basins, experiencing damages in excess of $31 million under climate change. Table D4 in Annex D presents a detailed breakdown of impact by municipality within each river basin. Of the total number of affected buildings, 66 are educational facilities (e.g. schools), 72 are used for purpose of the implementation of judiciary, public administration, and social welfare.

Table 2-12: Flood-affected public buildings and institutions within the target basins in B&H

Basin	Number of affected buildings/facilities per sectors							
	Health	Education	Judiciary administration and social welfare	Police and defence	Culture information and sport	Culture – historical heritage	Public infrastructure	Total
Una	1	11	11	3	27	27	6	86
Vrbas	9	7	19	2	40	30	13	120
Bosna	5	33	21	6	42	55	22	184
Neretva	1	11	14		12	18	12	68
Trebišnjica		4	7		11	13	12	47
Total	**16**	**66**	**72**	**11**	**132**	**143**	**65**	**505**

Table 2-13: Damages on public buildings/facilities per sectors

Basin	Damages on public buildings/facilities per sectors USD							
	Health	Education	Judiciary, administration and social welfare	Police and defence	Culture, information and sport	Culture – historical heritage	Public infrastructure	Total
Una	61,782	679,600	679,600	185,345	1,668,108	1,668,108	370,691	**5,313,233**
Vrbas	556,036	432,472	1,173,854	123,564	2,471,271	1,853,453	803,163	**7,413,813**
Bosna	308,909	2,038,799	1,297,417	370,691	2,594,835	3,397,998	1,359,199	**11,367,847**
Neretva	61,782	679,600	864,945	0	741,381	1,112,072	741,381	**4,201,161**
Trebišnjica	0	247,127	432,472	0	679,600	803,163	741,381	**2,903,744**
Total	**988,508**	**4,077,597**	**4,448,288**	**679,600**	**8,155,195**	**8,834,794**	**4,015,816**	**31,199,798**

2.3.5 Vulnerability of Business Sector

The damages in business as well as in public sector are given only for the current condition, excluding the floods under climate changes[27]. Within the mentioned basins, significant number of businesses are affected. The following table shows the number of affected businesses per basin. Table D5 in Annex D presents a detailed breakdown of impact by municipality within each river basin.

Table 2-14: Businesses affected by floods per basins in B&H.

Basin	No. of businesses	Total value of assets of the affected businesses per basins (USD)	Damages on business assets (USD)	% of damage per basin against total damage
Bosna	1,613	2,112,269,979	359,085,896	65.55%
Neretva	284	329,051,436	55,938,744	10.21%
Trebišnjica	91	199,554,269	33,924,226	6.19%
Una	394	434,938,935	73,939,619	13.50%
Vrbas	443	146,337,426	24,877,362	4.54%
Total	**2,825**	**3,222,152,045**	**547,765,848**	**100%**

Of 2,825 affected businesses in the target basins, the majority are located in Bosna river basin (57%), followed by the basins of Vrbas (16%) and Una (14%). Total value of assets for 2,825 businesses amount US$ 3.2 billion, while the damage on assets of businesses totals US$ 548 million. The most significant share in total damages, of about 66% or US$ 359 million, is within the Bosna river basin, followed by the Una river basin with the share of 13% and the Neretva river basins with 10% of total anticipated damages.

2.3.6 Summary of socio-economics analysis

The above analysis of socio-economic impact of flood risk was undertaken specifically for this project formulation and is based on existing flood maps which includes PFRA maps of historical flooding for all basins other then Vrbas for which detailed EUFD flood maps have been developed, receptor data, which is primarily based on mapping of all properties, critical infrastructure agriculture, businesses etc., and socio-economic data which is based on national census data and more detailed socio-economic surveys undertaken for Vrbas basin. During project implementation, detailed flood hazard and risk maps to be developed will ensure improvements to the socio-economic analysis.

While the project will have national remit and will therefore reduce flood risk in all basins, based on the above flood risk assessment under baseline and climate change conditions, the 5 highest risk basins in B&H – Bosna, Neretva, Trebišnjica, Una-Sana, and Vrbas – have been selected as the target basins for project practical implementation. In addition, Drina basin where flood risk management measures have been undertaken by the World Bank, has also been identified as a target basin.

[27] Due to the lack of georeferencing, it was not possible to map all business and public sector units under climate change flood risk. The business and public sector baseline risks are based on units manually identified during PFRA as being at risk. It should be noted that excluding damages to business and public sectors under climate change underestimates the overall impact of climate change in B&H.

3 EXISTING LEGISLATIVE, POLICY AND INSTITUTIONAL FRAMEWORK RELATED TO WATER AND FLOOD RISK MANAGEMENT IN B&H

Bosnia and Herzegovina is politically decentralized and comprises two governing Entities, the Federation of Bosnia and Herzegovina (FB&H) and the Republika Srpska (RS), with Brčko District (BD) as a de facto third entity. The State of Bosnia and Herzegovina is the central authority but has only limited and specific powers with regard to the water sector and environmental protection: The Ministry of Foreign Trade and Economic Relations (MoFTER) has water-related competencies at the level of Bosnia and Herzegovina. Due to the lack of a State-level framework and the constitutional character of B&H and its entities, the current state of affairs is complex and heterogenic, and the responsibilities for water management rest with the Entities (Ministry for Agriculture, Forestry and Water Management of RS and Ministry for Agriculture, Water Management and Forestry of FB&H). An analysis of the B&H constitutional and legal framework indicates that it does not contain specific and clear principles that should guide the constitutive elements of the State in their management of shared water resources (i.e. those intersected by entity or district borders). The State-level authorities therefore have no responsibility for regulating these inter-entity relations.

The legal framework is not unified across the country and there are certain discrepancies in legislation between Entities (FB&H and RS) and even among Cantons within FB&H. The two Entities and the Brčko District have relevant political, administrative and legal jurisdiction in their own territories, but the level of coordination and cooperation among them is not as strong as it should be. Furthermore, the Federation of Bosnia and Herzegovina is divided into 10 Cantons which have their own authorities (ministries) with responsibilities in the water sector, including adoption of their own relevant laws. This complex administrative structure results in a number of different institutions in charge of water management issues and increases the need for coordination at the B&H level.

The Law on Water of Republika Srpska was aligned with the EU Floods Directive in 2017 to provide the legal basis for better flood risk management. It defines the method of flood risk assessment and management in order to reduce the harmful effects that floods pose to humans, economic activity and the environment, and includes definition of preliminary risk assessment requirements, development of flood hazard and risk maps, establishing forecasting and early warning systems, as well as regulating the development of Flood Risk Management Plan.

This amendment has catalysed and identified a need for a whole series of the necessary amendments of the entire Law on Waters in order to fully regulate the area of water management and to align the legislation with the remaining requirements and the EU Directives governing this area.

Following adoption of the amended Law in July 2017, a number of bylaws/regulatory documents have been created and adopted in order to make the Floods Directive fully incorporated into national legislation. One of the most important is the Decree on Content and Key Elements of Flood Risk Assessment and Management which is adopted in December 21017. This document regulates content and procedure for Preliminary Flood Risk Assessment (PRFA), process of flood hazard and risk mapping, content and appearance of the maps, goals of flood risk mapping and measures for their achievement, programme of activities for preparation of Flood Risk Management Plan (FRMP), content of the Plan and necessary elements for its update and other issues related to flood risk assessment and management. Based on new regulation the first FRMP in B&H has been developed for Vrbas basin.

In Federation of Bosnia and Herzegovina (FB&H) the situation is slightly different. Draft Amendment of the Water Law FB&H is officially submitted to the FB&H Parliament at the end of 2017. Also, it is known that drafting phase started in 2013 and generally, the process of regulative changes has been slow. One of the goals of the proposed amendment is ''additional improvement of protection from harmful effects of waters based on experiences of 2014 floods and requirements of the EU Flood Directive''. Proposed legislative changes put attention to the financial aspects of water sector management, issuing of water licenses and harmonization with EU Water Framework and Flood Directive. However, legislative development in FB&H requires additional efforts and support in order to achieve full alignment with EU Flood Directive.

3.1 WATER MANAGEMENT

The reform of the water sector has led to the adoption of new water legislation. According to the new Water Laws, Entity Ministers (Federal Ministry of Agriculture, Water Management and Forestry in the Federation and Ministry of Agriculture, Forestry and Water Management in the Republika Srpska) are responsible for the preparation of Entity strategies for water management. The entity River Basin District Agencies are in charge of water management and monitoring, as well as the preparation of water management plans.

In terms of flood protection, some steps have been taken in preparing strategic documents and plans. For example, IPA project “Support to Water Policy in B&H (Dec 2009 – Dec 2011)” supported development of a Sub-strategy for the implementation of the EU Flood Directive (2007/60/EC). Full implementation of the EU Directive 2007/60/EC on the assessment and management of flood risks was expected by 2017, but its implementation is severely delayed, as flood hazard and flood maps have not been completed as yet, except for Vrbas river basin.

The main documents in the field of water management are the Water management Strategy in FB&H (2010-2022, adopted 2011) and the Republika Srpska Strategy for Integral Water Management (2014–2024). Although these strategies acknowledge climate changes, there are no concrete data nor adaptation measures identified. These entity strategies should be coordinated and harmonized, as much as possible, in order to provide an aligned B&H-wide strategy.

Within EU IPA IPA 2007 – 2011, Water management plans 2016-2021 were developed for Sava river basin for Republika Srpska and for Federation Bosnia and Herzegovina in 2015, but were adopted in only Feb 2018 for Republika Srpska and in May 2018 for FB&H.

These plans, among other issues, will deal with protection against the detrimental effects of water, protection from erosion, defence against ice, and drought control. They are to be revised and updated every six years. Within International Sava Commission, water management plan for direct Sava watershed has been developed (http://www.savacommission.org/srbmp/en/draft) and has been in public consultation phase since 2014.

The water management institutional framework is fragmented and lacks vertical and horizontal cooperation (see Figure 3-1).

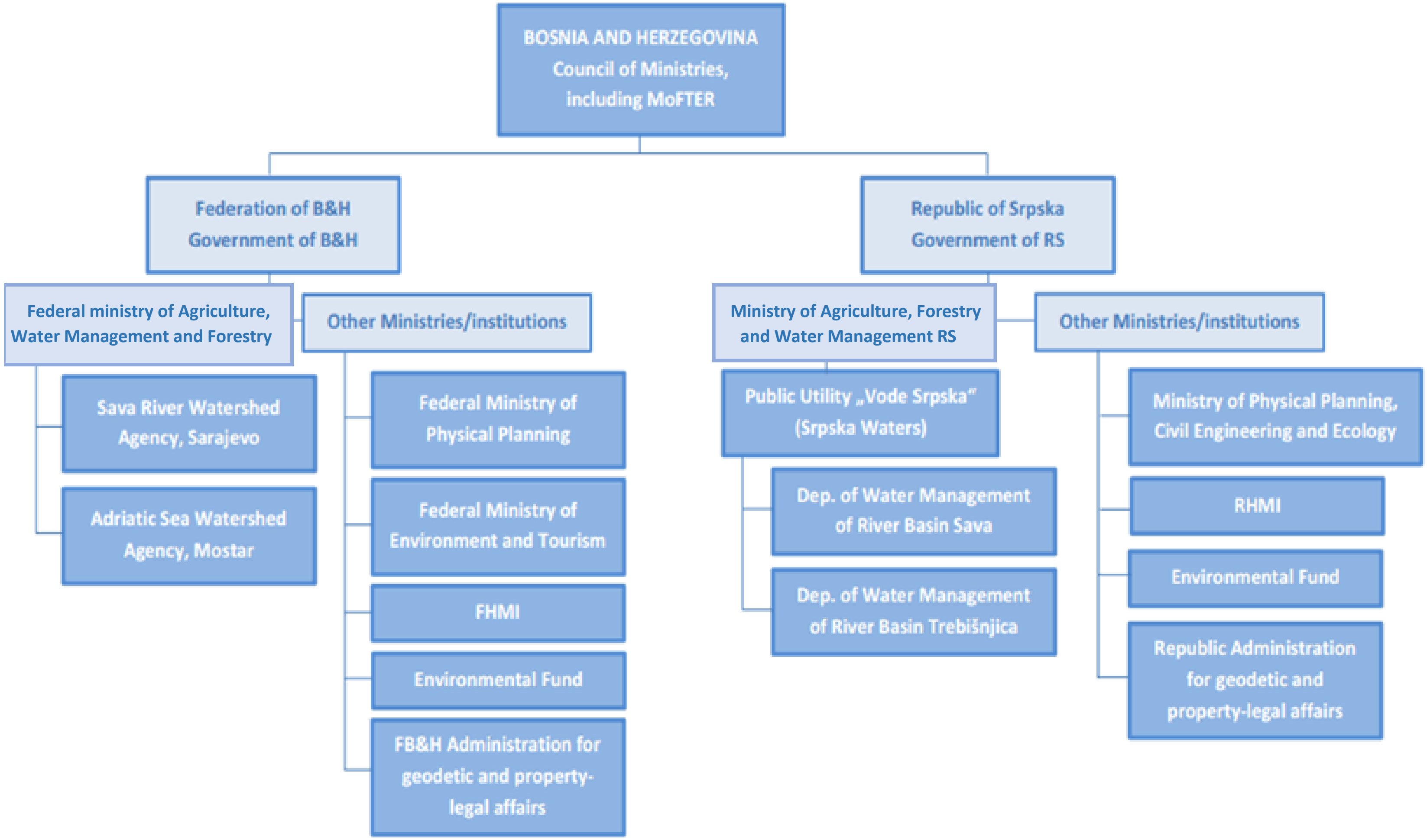


Figure 3-1: Institutional framework for water management in B&H

3.2 Sectoral and Spatial Development Policy

In addition to direct water management and flood protection legislation, several other sectors that have a direct impact on flood risk management, or are impacted on by flooding, also need to be considered. A detailed analysis of existing sector-specific legislation, policies and plans for the spatial planning, agriculture, energy and forestry sectors, has been taken. Spatial planning legislation and development control does not take account of flood risk or the use of zoning to reduce flood impact. Poor enforcement of existing weak development control rules has resulted in development in the floodplain. Flood defences strategies are based on traditional hard measures and do not consider combined structural and non-structural measures to manage floods. Spatial planning does not effectively deal with sediment management particularly riverbed and bank mining practices which exacerbates flooding. The agricultural sector is the heaviest flood impacted sector, yet it does not include flood risk consideration in the zoning of agriculture. Agricultural infrastructure is at risk of flooding and missing the opportunity to provide attendant benefits to flood protection by considering flood risk in irrigation and drainage planning. For the energy sector, the main issue of the policies related to HPP dams in terms of planning, and operation which do not take account of flood risk under climate change. Strategic plans of forestry do consider adverse effects of degraded forests which cause reduced positive hydrological role of forests (reduction of erosion). However, in reality, water and physical planning sectors and forest sector are often in conflict due to lack of legislation / regulation enforcement as well as lack of efficient inspection. Therefore, it is necessary to establish mechanisms for active cooperation of these sectors in legislation and inspection enforcement and in harmonization of their objectives

In general, there is a lack of cross-sectoral policies, strategies and plans and this is a key barrier to effective flood risk management. Furthermore only a few of these sector plans currently takes account of climate change in their formulations. Thus, the legislative framework does not enable effective flood risk management.

The special attention is to be paid to watersheds which are part of inter-entity line, which is separating two B&H Entities, such as Spreca and Usora where one bank belongs to Republika Srpska and the other to FB&H. Due to different regulatory framework and different priorities set by water agencies, flood risk management in these watersheds is especially difficult.

3.3 Disaster Risk Reduction and Early Warning

The early warning and disaster risk reduction (DRR) system is also fragmented. Different administrative units (entities and cantons) develop their own laws, strategic documents and policies regarding civil protection. DRR priorities are rarely outlined specifically. Rather, they are included in various sectoral mandates at various levels. The Federation of Bosnia and Herzegovina issued several laws related to DRR, such as the Law on Spatial Planning and Land Usage (which requires the inclusion of data about areas prone to natural and/or man-made disasters/catastrophes in spatial plans but does not mention risk assessments or vulnerability mapping as prerequisites). Amongst others, Republika Srpska has strengthened its enabling environment for DRR through the Law on the Regulation of Space issued by the Ministry of Spatial Planning Construction and Ecology, and the Law on Water, which outlines preventive measures to be taken to protect people and material goods from potential damage caused by floods or erosion of water surfaces, including a risk and vulnerability assessment of the relevant areas.

The Early Warning System (EWS) in practice is, however, fragmented and inefficient. When a flood has been forecasted, data are submitted to Sava water agencies by both water agencies (Water Agency for Sava River in FB&H and JU "Vode Srpske in RS) on a daily basis from all stations. When water levels reach the predefined threshold level for which emergency state has to be declared, the data are submitted every four hours until the emergency has ended.

When there is no emergency situation, Federal Hydro-meteorological Institute is obliged to report weather forecasts on a monthly basis, based on statistical data and models like WRF-NMM 3.5. In contrast, when an emergency situation arises, data on water levels in the reservoirs, including inflow and outflow of the reservoirs is available on a daily basis, and/or every four hours. In addition, within their operating licenses, for the purpose of flood management, all HPPs have set water levels in reservoirs for the various seasons. So, in wet periods when rain is expected water reservoirs should provide sufficient available storage to be able to receive expected flood volumes. If users of a reservoir possess their own hydrologic and/or meteorological stations and remote-sensor information system, they are obliged to the agencies with access to such data in case of emergency.

After receiving the information, the centre forwards the information to the relevant authority or to the appropriate agencies (e.g. water agencies) and institutions. In case of cross border situations, the information is transmitted to the corresponding centres in the other entity or Brcko District and in case of an international event, to the Operational and Communicational Centre in the Ministry of Security B&H, responsible for further early warning communication with neighbouring countries. For cross-border flood events with the possibility of negatively impacting B&H, the flow of information goes through the same channels, but in the opposite direction.

In accordance with the Framework Law on the Protection and Rescue of People and Property in the Event of Natural or Other Disasters in B&H Operations and Communications Centre-112, which works 24 hours/7 days a week, was established within Ministry of Security of Bosnia and Herzegovina to continually collect the data on all types of phenomena and hazards that may lead to a natural or other disaster. The Centre-112 should act as an operations-and-communications connection hub in the international protection and rescue communications system and is linked with the centres in neighbouring and other countries, international institutions and organizations. The Centre is equipped with modern IT and other equipment, creating all the necessary preconditions for performance of the functions. However, due to lack of identified authorities between entities, implementation of the aforementioned legal obligations of information sharing is not adequate and must be improved. In addition, this communication route for early warning is too long and could be detrimental to providing the early warning in time. During the May 2014 flood the operating centre played a very important role but was not able to assess the level of emergency. This process could be enhanced with centralized, computerized systems that link automatic hydrometric observations and forecasts to a forecasting model and disseminates automated warning information across entities and other boundaries, in real time. Civil protection organization in B&H consists of four established organizational and managerial levels, namely:

- State level (Ministry of Security - Sector for Protection and Rescue);
- Entity level and Brcko District (Federal Administration of Civil Protection, Administration of Civil Protection of Republic Srpska and Department of Public Safety of Brcko District);
- Cantonal Administrations of the Civil Defence; and
- Municipal Administrations of the Civil Defence.

There is no civil defence headquarter as a management body at the state level, but the Coordinating Body of B&H which is responsible for coordination of the civil protection activities. An additional obstacle in coordination between entity civil protection units is the fact that Federal Administration of Civil Protection has a coordinating role for the 10 cantonal civil protection units, while in the RS it is centralised.

RS developed a plan of protection and rescue in 2003, while the Federation of B&H adopted its plan of protection and rescue in 2008. Brcko District does not have its own plan, yet various measures can be found in laws issued by individual ministries, e.g. the Law on Food, the Law on Healthcare, etc. The Civil Protection Plans of the Federation of B&H and RS contain similar elements in mobilisation and operational plans and preparedness measures. According to studies conducted by the Ministry of Security of B&H, inter-agency plans conducted at lower levels of organisation (entities, cantons and municipalities) are dysfunctional. The Sector for Prevention and Rescue within the Ministry of Security is making efforts to create a unified methodology for the preparation of planning documents at the state level and to provide adequate guidance on their content, in order to establish a coordinated system of plans for preparedness and activities at the interdisciplinary multi-organisational level. There is a potential here to embed climate change considerations into this unified methodology at state level, including the use of hazard maps based on climate change considerations in the development of emergency response plans.

The Vrbas project developed a fully integrated flood forecasting and early warning system for Vrbas basin. In addition, a review of the institutional arrangements for FFEWS was undertaken and recommendations made. In addition, the technical specification for the implementation of FFEWS in any basin in B&H was developed. This would serve as the basis for development of a fully integrated national FFEWS.

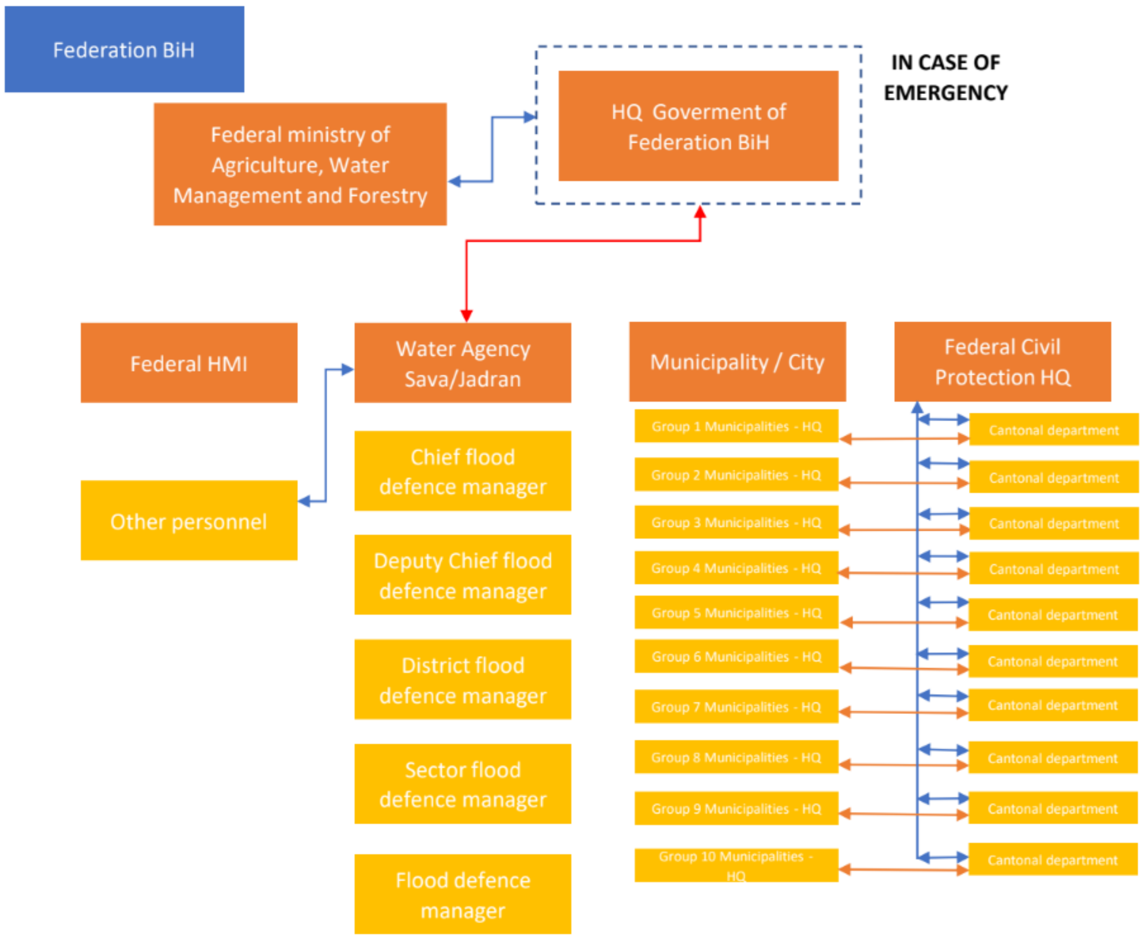


Figure 3-2: : Civil Protection Organizational Structure for FB&H

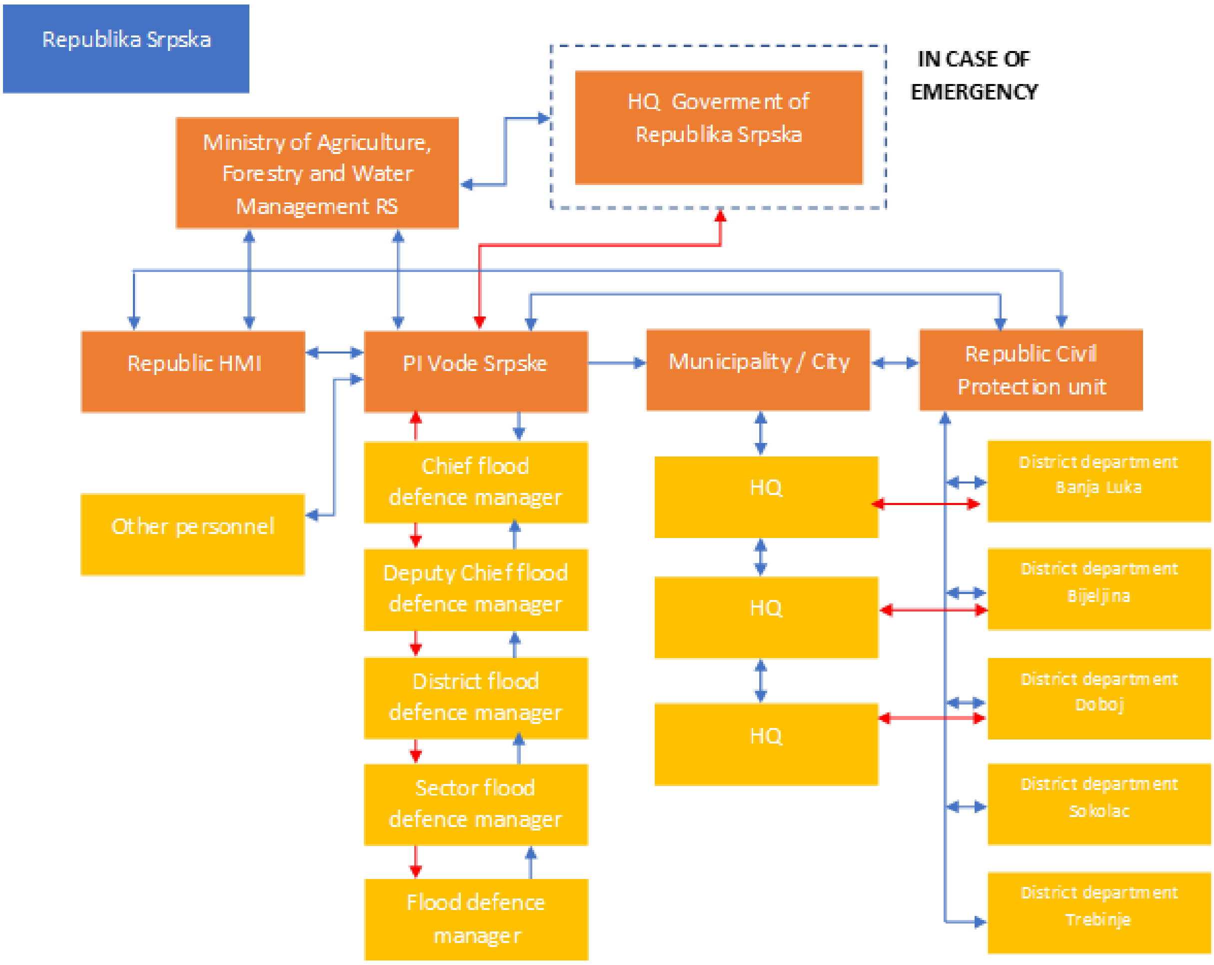


Figure 3-3: : Civil Protection Organizational Structure for RS

At the state level, the system for civil protection is headed by the Ministry of Security through the Sector for Protection and Rescue. It leads policy design. However, because of the decentralized nature of the system, the brunt of the responsibility for measures taken to deal with protection and rescue is placed on the entities and Brcko District. The Ministry of Security and the Coordinating Body of B&H (composed of the Council of Ministers, five representatives from the Federation of B&H, five from RS and two from Brcko District) take the leading role only in the event of a large-scale accident with trans-boundary effects or which cannot be resolved at the entity level. Local governments lack capacity and resources to fulfil even basic DRR functions.

Civil protection centres are organised on municipal, cantonal and entity levels. There is an emergency warning centre being organised on B&H (country) level, but it is still not in operation. Split responsibilities in the past have already led to artificially triggered floods (e.g., Neretva 1999 when lack of coordination among various electricity agencies provoked confusion resulting in unwanted opening of the gates on some dams).

3.4 Non-governmental organisations

State level: Society of Red Cross (RC) B&H is registered as non-profit organization and is financed by state institutions on a regular basis. Main body is The Presidency consisting of members of Red Cross of RS, FB&H and Brcko district, which has only overall coordination role, with competences derived from international agreements and in case of emergency for coordination of international cooperation and support.

Sub national-entity level:

• Red Cross of Republika Srpska (RS): registered as nongovernmental organization, even though it is financed by Ministry of Health of Republika Srpska on an annual basis. It is a voluntary, humanitarian organization that operates on the territory of Republika Srpska. It is defined as a subsidiary body of public authorities in humanitarian areas. It has coordination role over 64 Red Cross organizations registered as legal entities in local communities in RS, and 9 coordination boards (with no legal status) especially during the emergency/crisis situations.

• Red Cross of Federation of B&H (FB&H): registered as association of citizens, a voluntary, humanitarian organization that operates on the territory of Federation B&H. It is financed by Federal Ministry of Labor and Social Policy, by grant on an annual basis (just for salaries and basic needs). Additional funding is for trainings on first aid (for drivers) and small amount from lottery. However, main source of financing is through different project activities. It has coordination role over 79 Red Cross organizations registered as legal entities in local communities in FB&H and 10 cantonal organizations.

Cantonal level: RC in 10 cantons of FB&H, registered as nongovernmental organizations

Local level: local Red Cross organization exists in each local community in B&H: 64 in RS and 79 in FB&H. They are also registered as nongovernmental organizations which are independent but also financed by local administrations by annual grant, within the local Department of Social Affairs, mostly.

Even though the Red Cross organizations are financed by some of the governmental structures (at state, entity, canton, municipality/city level) they act mostly independently and in cooperation with these structures, with recognized status of organization of special significance. Also, Red Cross acts in accordance with the principles of humanity, impartiality, neutrality, independence, voluntary service, unity, and universality.

The network of local Red Cross organizations is well developed and active in local communities and they are supported and well-coordinated by higher levels (cantonal or subnational). They have small number of full-time employees but also a significant number of volunteers. One of the roles of Red Cross is to protect and improve health of population in community and to respond effectively to disasters but also, to develop capacities for timely and adequate response to disasters, and to raise awareness and improve knowledge on different subjects important for human health and wellbeing. In the case of declared natural disaster, representative of Red Cross is member of Crisis Board, together with representative of Civil Protection and other important institutions. From the aspect of natural disasters, the both, Civil protection as well as Red Cross are the ''First Responders''. Especially important is active role of Red Cross in elementary and high schools where they have permission to work with the pupils and usually have established ''Red Cross Corner'' that is very active in the most of schools in B&H.

Comparing to Civil Protection, that in the context of natural disasters have role in preparedness, protection and rescue, Red Cross is more focused on human health, safety, and provision of help in terms of food, hygiene, first aid and psychosocial support, which was proved to be especially necessary in the conditions of the COVID 19 pandemic and during the natural disasters.

From the aspect of natural disasters, it can be concluded that Red Cross has equally important role in society as Civil Protection, but with slightly different focus. Thus, it can be recommended that Red Cross should be engaged in the new GCF initiative on the similar way and at all levels as Civil Protection, especially within:

3.5 Climate Change Policies and Priorities

B&H's Climate Change Adaptation and Low Emission Development Strategy is of key importance to defining and planning adaptation action. The Strategy was adopted by the B&H Council of Ministers on October 8, 2013 and utilized the then available observed and projected climate change impacts on key sectors in the country including agriculture, water, hydropower, human health, forestry, biodiversity/ sensitive ecosystems and tourism. The Strategy is based on four specific outcomes covering climate change risks, vulnerabilities and opportunities supporting evidence-based policy development, effective institutional and regulatory framework, mainstreaming CCA approaches into decision making, and effective resourcing with timely and effective implementation. As one of the worst impacts of climate changes the Strategy identifies more frequent and severe floods, along with more frequent flood related damage to HPP and damage to agriculture and forest eco-systems caused by changes in rainfall and weather extremes. It is also recognized in the Strategy that adaptation approaches were limited by a lack of reliable data, which needed to be addressed urgently. Infrastructural improvements (both flood protection and water storage infrastructure) have also been identified as needed, along with mechanisms for better water management.

Hydrological modelling and flood mapping are identified as key research project. Strengthened hydro-meteorological monitoring, establishment of the early warning system, water information system, natural disaster data bases are activities identified as priority in the Strategy. However, its implementation has slowed mainly due to lack of knowledge and institutional capacity to project, attract finances and undertake adaptation measures.

The Government has initiated the development of the National adaptation plan, which should lay out specific activities with timeframes, indicative costs and implementing entities, necessary to combat climate change consequences in the most vulnerable sectors: water management, agriculture, forestry, biodiversity, hydro-energy, human health and tourism. It is anticipated that the National adaptation plan will be ready for UNFCCC submission by the end of 2020.

Some of the key strategic documents in Bosnia and Herzegovina such as water management strategies, rural development strategies etc. point out that climate changes affect their sectoral operations, but these documents do not propose measures how to mitigate future and adapt to existing climate changes. The water management institutional framework is fragmented too and lacks vertical and horizontal cooperation (see Figure 5). At the state level, the system for civil protection is headed by the Ministry of Security through the Sector for Protection and Rescue. It leads policy design. However, because of the decentralized nature of the system, the brunt of the responsibility for measures taken to deal with protection and rescue is placed on the entities and Brcko District. The Ministry of Security and the Coordinating Body of B&H (composed of the Council of Ministers, five representatives from the Federation of B&H, five from RS and two from Brcko District) take the leading role only in the event of a large-scale accident with trans-boundary effects or which cannot be resolved at the entity level. Local governments lack capacity and resources to fulfil even basic DRR functions.

Civil protection centres are organised on municipal, cantonal and entity levels. There is an emergency warning centre being organised on B&H (country) level, but it is still not in operation. Split responsibilities in the past have already led to artificially triggered floods (e.g., Neretva 1999 when lack of coordination among various electricity agencies provoked confusion resulting in unwanted opening of the gates on some dams).

3.6 Public Sector Financing of Flood Risk Management

Government investment in flood risk management is scarce and is mainly focused on ongoing maintenance of very old flood defence structures. The condition of flood control facilities is very poor as a result of wartime damage, many years without maintenance, and minefields around some facilities (TNC). The total annual budget for climate adaptation and resilience activities in B&H related to flood risk management averages US$40 Million comprising mainly donor grants (40%) and loans (60%). Although after the 2014 floods, flood risk management has been undertaken through many donor-funded projects implemented by or in partnership with relevant ministries, most of the baseline projects, elaborated in Chapter 4 of this report, are focused on post-event recovery only and do not take integrated approach (see also barriers section) and climate change into consideration. The proposed GCF project is scaling up the successfully implemented UNDP/SCCF project “Technology transfer for climate resilient flood management in Vrbas River basin” (Vrbas project, 2015-2020) and extending its many achievements to the rest of B&H.

3.6.1 Climate Change Adaptation Funding

According to the TNC, the RS Law on the Fund for Environmental Protection (2002) and the FB&H Law on the Fund for Environmental Protection (2003) established funds to collect and distribute funds for environment protection, but these have not brought any expected effects yet. A new Law on the Fund for Environmental Protection and Energy Efficiency has been adopted in November 2011 in RS; it sets a new schedule for allocating funds for energy efficiency projects and modifies the name of the fund. Changes in the laws on environmental funds in FB&H and Brčko District are forthcoming.

B&H lacks the necessary human and financial resources to adapt to climate change. The main sources of international funding for Climate change adaptation as so far been, the European Union, which has committed itself to strengthening dialogue on climate change with candidate countries and potential candidate countries (the current status of B&H). However, this also represents a general message of all strategies tackling expansion issues, hence it is no surprise that in several key joint policies of EU and the budgets of EU and country members, there are significant resources allocated for sustainable development (including direct and indirect investments in the climate change mitigation measures.) Scientific research shows that climate change may significantly impact water resources, agriculture, forest and forest ecosystems, coastal areas, tourism, energy, land use and buildings, transport infrastructure conditions, natural ecosystems, human health, socioeconomic status and demographic trends in the countries of South-eastern Europe. Potential financial sources for adaptation include the Global Environmental Facility, including the Adaptation Fund; the Special Fund for Climate Change; and the Green Climate Fund. Other funders include the World Bank, the European Bank for Reconstruction and Development (EBRD) and FAO, the European Union (including pre- accession instruments, the EU Seventh Framework Program, and EIB funds), the WMO Technical Cooperation Program, the South East Initiative for Disaster Relief and Adaptation administered by the World Bank, and bilateral donors (UK, Spain, Switzerland, Sweden, and others)28.

3.6.2 Water Management Funding in the Federation of B&H

Funding sources for water management activities are defined by the legal regulations in effect. The Law and the regulations set out the types of water use, the amount of charges, as well as the circle of beneficiaries and identifies payers of special water charges. In the Federation of Bosnia and Herzegovina, the following legislation applies to funding of water management activities:

- Law on Water (Official Gazette of FB&H, 70/06);
- Decision on the amount of special water charges (Official Gazette of FB&H, 46/07, 10/14 and 3/16);
- Rulebook on the content and manner of keeping records and submitting data on quantities of abstracted water (Official Gazette of FB&H, 83/08);
- Decree on requirements for releasing waste waters into environment and public sewage system (Official Gazette of FB&H, 4/12, 101/18),
- Rulebook on the method of payment of public revenues of budget and extra budgetary funds in the Federation of Bosnia and Herzegovina (Official Gazette of FB&H, 29/06, 46/06, 8/07, 30/07, 51/07, 82/07, 35/13, 53/13, 63/13, 93/2013, 103/13, 11/14, 19/14, 46/14, 60/14, 65/14, 105/14, 20/15, 44/15, 53/15, 73/15 and 96/15);
- Rulebook on the content and manner of keeping records and submitting data on quantities of abstracted water (Official Gazette of FB&H, 83/08);
- Rulebook on the method of calculation, procedure and deadlines for accounting and payment and control of settlement of obligations based on general water charges and special water charges (Official Gazette of FB&H, 92/07, 46/09, 79/11 and 88/12).

The main provisions of water management funding are laid down in the Law on Water, specifying types of water charges, bases for charging, as well as water charges payers.

Article 168 of the Law on Waters of the Federation of B&H states the sources of water management funds as follows: Funds to carry out the activities and tasks defined by this Law shall be provided by means of the following:

- general water charges;
- special water charges;
- revenue generated by lease of the public water property;

[28] TNC

- the Federation, cantonal, town and municipal budgets;
- credit facilities;
- funds provided for in special legislation;
- donations and other funds in accordance with the law.

In relation to the general water charges, the Law on Water stipulates that the payers are “physical or legal persons registered for a particular activity”. They “shall pay the general water charge at a level of 0.5% of the basis consisting of a net salary of an employee in permanent or temporary employment and fees paid on the basis of service contracts”.

Special water charges

In relation to the special water charges, the Law on Water stipulates the payment of the following five types of water use:

- Abstraction of surface waters and groundwater;
- Water use for electricity generated by hydropower.
- Wastewater discharge;
- Extraction of materials from watercourses;
- Flood protection.

Special water charges are collected for surface water and groundwater abstraction for:

- water for public water supply,
- water and mineral water used for water bottling,
- irrigation water,
- water for fish production at fish farms,
- water for industrial processes, including thermal power plants,
- water for other purposes.

The aforementioned charges are calculated on the basis of the volume of water abstracted in m^3. The level of these charges may vary, depending on the purpose and quality of the water.

A special water charge is collected for water used for electricity generation by hydropower. This charge is calculated on the basis of the energy generated in kWh.

Payers of special water charges

The payment of special water charges for water protection is defined for the following cases:

- Owners of vehicles using oil and oil derivatives as fuel. This charge is calculated on the basis of the level of water pollution expressed in terms of the population equivalent (PE);
- Wastewater discharge. This charge is calculated on the basis of the level of water pollution. The basis for calculation of the charge is pollution expressed in terms of the PE;
- Fish farming. This charge is calculated per 1kg of fish produced;
- Use of artificial fertilizers and plant protection chemicals. This charge is calculated per 1 kg of manufactured or imported artificial fertilizer or plant protection chemical.

Charge for the extraction of material from watercourses is calculated per $1m^3$ of extracted material;

Flood protection charges for:

- Agricultural, forest or building land protected by flood protection structures. The definitions of agricultural, forest or building land adopted in the tax regulations shall apply. This charge is calculated per 1 ha of protected land. The level of this charge may vary, depending on the type of land protected;
- Residential, business and other buildings or structures that are protected by flood protection structures. This charge is calculated per 1 m^2 of usable area of the building or structure.

Payers of special water charges

The Law on Water clearly defines the payers of special water charges. In principle, payers of special water charges include physical or legal persons who use or discharge waste water, for which, in most cases, they are obliged to obtain water authorisations.

Owners of vehicles using oil derivatives, producers or importers of fertilizers and pesticides are not obliged to obtain any water authorisations and in such cases the payers of charges are identified as follows:

- Payers of special water charge related to owners of vehicles using oil and oil derivatives is a physical or legal person in whose name the vehicle has been registered, or the owner of a construction machine for which registration is not required.
- Payers of special water charge related to artificial fertilizers and plant protection products is a physical or legal person who produces or imports these products.

It should be emphasized that the current level of special water charges was established in 2007 and that since then there were no changes in unit values. This resulted in a situation that the water sector funding sources were not adjusted in view of the development of their tasks.

In accordance with Article 177 of the Law on Water of the FB&H, the water charges and revenues generated by the lease of public water property on Category I surface waters are distributed as follows:

1) 40% to the competent River Basin District Agency,
2) 45% to the budget of cantons and
3) 15% to the FB&H Environmental Protection Fund

Revenues from the lease of public water property on Category II surface waters are fully allocated to the cantonal budget.

In accordance with Article 178 of the Law on Water of FB&H, revenues allocated to the competent River Basin District Agency are used for:

1) the activities and tasks referred to in Articles 29 and 156 of the Law on Water of FB&H,
2) maintenance of the water protection structures in the ownership of the Federation,
3) other tasks and activities entrusted to the River Basin District Agency under this Law, and
4) financing of operations of the River Basin District Agency.

The revenues allocated to cantonal budgets are used for co-financing of the construction and maintenance of the water structures referred to in paragraph 1 of Article 14 of the Law on Water, with the exception of the structures referred to in indentations 2, 4, 5 and 6 of point 3 of that Article, and also of other activities related to water management (preparing technical documentation, base proposal for the issuance of concessions and similar activities) in accordance with the annual plan and program of the cantonal ministry in charge of water management.

The revenues allocated to the Environmental Protection Fund of the FB&H are exclusively used for the implementation of tasks entrusted under this Law to the Federal ministry in charge of the environment and for the co-financing of the water protection infrastructure of significance for the Federation.

3.6.3 Water Management Funding in Republika Srpska

This section provides an overview of the current situation in the Sava River Basin and the Adriatic Sea Basin in Republika Srpska and it is focused on the following key aspects:

- Legal framework for water management funding
- Current level of special water charges
- Regulating reporting and payment of water charges
- Water revenues from water charges
- Action Plan and costs of the Public Institution/JU Vode Srpske

Legal Framework for water management funding

Sources of water management funding are defined in accordance with the system of regulations. These regulations determine the types of water use, the amount of charges, as well as the circle of beneficiaries and identified payers for the use of water. In Republika Srpska, the following regulations apply:

- Law on Water (Official Gazette of RS, 50/06, 92/09 and 121/12),
- Decision on rates of special water charges (Official Gazette of RS, 53/11 and 119/11),
- Rulebook on the manner and methods for determining the level of pollution of waste waters as a basis for determination of water charges (Official Gazette of RS, 79/11 and 36/12),
- Decree on the manner, procedure and deadlines for charging and payment and delaying payment of special water charges (Official Gazette of RS, 7/14).

Fundamentals of water management funding are prescribed in the Law on Water of Republika Srpska, specifying types of water charges, charging bases, and payers of water charges.

Article 188 of the Law on Water of Republika Srpska states sources of funds for water management as follows: “Funds for performing duties and tasks in accordance with this Law, operation and maintenance of real estates and water facilities of general importance, preservation of the value of constructed water facilities and systems, undertaking public investment measures and capital construction of water facilities under this Law shall be provided from:

- Special water charges,
- Revenues generated by lease of the public water property,
- The general part of the Republika Srpska budget and local governments,
- Donations.

Special water charges

In relation to special water charges, the Law on Water specifies the type and basis for calculating the following types of water use:

a) Charges for abstraction of surface and ground water. The basis for the calculation is one cubic meter of the abstracted water. The rate to be applied for calculation of this charge may vary, based on the prescribed professional and scientific basis, depending on the purpose and quality of the water. This category of special water charges includes the following types of abstraction:

- Drinking water for public water supply,
- Water and mineral water used for bottling water,
- Water for irrigation,
- Water for fish farming,
- Water for industrial processes, including thermal power plants,
- Water for other uses and other cases for human use.

b) Charges for electricity generated by hydropower. The basis for calculation of this charge is 1 kWh (one kilowatt hour) of electricity generated.

c) Water protection charges:

- Water protection charge paid by owners of means of transport using oil or oil derivatives. The basis for calculation is the power unit of the drive unit;
- Charge for wastewater discharge. The basis for calculation of the charge is the pollution expressed in terms of the PE (population equivalent),
- Charges for fish farming in submersible cage-farms in surface water. The basis for calculation of the charge is 1 kg of fish produced,
- Charges for the use of artificial fertilizers and plant protection chemicals. The basis for calculation of the charge is 1 kg of produced or imported artificial fertilizer or plant protection chemicals.

d) Charges for the extraction of material from watercourses. This charge is calculated per 1 m^3 of extracted useful material.

e) Flood protection charges:

- Flood protection charges for agricultural, forest or building land protected by flood protection structures. The definitions of agricultural, forest or building land adopted in the regulations governing spatial planning shall apply. This charge shall be calculated per 1 ha of protected land and 1 m2 for smaller areas. The rate to be applied for this charge may vary, depending on the type of land protected;
- Flood protection charges for residential, business and other buildings or structures that are protected by flood protection structures. The definition adopted in the regulations governing spatial planning shall apply. The basis for calculation of this charge is 1m2 of the facility.

Payers of special water charges

The Law on Water clearly defines who is obliged to pay water charges. In principle, payers of special water charges include physical or legal persons who are obliged to obtain prior water permit (or water authorisation) for adequate water use.

Furthermore, the Law on Water defines determination of the rate of special water charges prescribed by the Government, at the proposal of the Ministry, except for the cases referred to in point e), sub-points 1) and 2), which represents the revenue of the local government on the territory of which the land is located, and as such these are defined by that particular administration.

Article 194 of the Law on Water of RS, the water charges and revenues generated by the lease of public water property are monitored by the Ministry for each river basin district separately, and the competent authority, allocates the charges, other than those referred to in point v), sub-points 1), 2) and 3) , paragraph 1, Article 189, as follows:

a) 70% on a special purpose account for water,

b) 30% on a special purpose account for the budget of a local government.

The charge referred to under point c) sub-points 1), 2) and 3), paragraph 1, Article 189 are distributed by the competent authority in the following manner:

a) 55% on a special purpose account for water,

b) 15% on a special purpose account for the protection of the environment of Republika Srpska, and

c) 30% on a special purpose account for the budget of a local government.

Revenues from special water charges are used for: professional and technical tasks related to the application of the provisions of the Law on Water of RS and its implementation, in particular for:

1) preparation of provisional water management plans,

2) preparation of water management plans,

3) monitoring of the state of water,

4) establishment and operation of the Information system,

5) maintenance of facilities owned by the Republika Srpska, local governments or third parties, if they are of general interest,

6) implementation of intervention activities in the water sector on the territory of the Republika Srpska,

7) costs of operation and functioning of water agencies,

8) costs of operation and functioning of public water companies,

9) costs of development, establishing and managing the Information system, scientific and professional work,

10) support in establishment and development of qualified institutions or entities, relevant for the water sector,

11) development of the sector through financing the construction of water facilities and systems, improvement of technical, material, personnel and other capacities.

3.6.4 Water Management Funding in Brčko District B&H

Brčko District has not yet adopted its Law on Water, therefore general and special water charges are not implemented.

3.6.5 Setting Water Prices in Strategic Water Management Documents

The water management strategies in effect in both Entities are paying particular attention to the economic framework of water management. In addition to defining water services cost recovery as the guiding principle when setting prices, they pay special attention to financing of defined measures. Brčko District B&H does not have a water management strategy.

Water Management Strategy of the Federation of Bosnia and Herzegovina 2010-2022

“Cost recovery” is presented in the Strategy as a key strategic commitment of the economic framework. The following is stated: “All costs must be recovered if water management, particularly in the water supply sector, is to be cost-effective and sustainable. In this area of water use, subsidies for special groups, most often the poorest ones are considered desirable and necessary. Whenever possible, the extent of such subsidies and the answer to the question who will benefit from such subsidies should be transparent”.

The objectives of the Strategy emphasize the need for financial sustainability in water management and the reform of water pricing system with gradual introduction of economic water prices. “The underlying idea of water pricing is to facilitate the recovery of costs and to rationalize, i.e. reduce the consumption. If the water system of setting water prices is adequately defined, all consumers will be using water more rationally and reduce the quantities of consumed water to the necessary minimum.”

The Strategy envisages the following measures under the reform of setting water prices:

- Establishment of pricing system which reflects actual, economic, organisationally and technologically justifiable costs related to water supply and sanitation,
- Harmonization of unit prices collected from households and legal entities for services of water supply and sanitation, if water of the same quality is being considered.
- Analysis of the possibilities of establishment of a regulatory body(-ies) responsible for service pricing;
- Promoting the establishment of public-private partnership in providing water supply and sanitation services.

The Strategy defines “Financial Resources” as another strategic commitment of the economic framework: “It will be necessary to mobilize increasingly larger financial resources for the purpose of achieving sustainable development. Demonstrating that the existing resources are being used efficiently will to a large extent help mobilizing additional financial resources from national and international sources, both public and private”.

According to the Strategy, sources for financing infrastructural development should include:

- Budget funds (the Federation, Cantons and Municipalities);
- Environmental Protection Fund
- Water prices sufficient for cost recovery (economic water price)
- Donations (EU Pre-Accession Funds);
- Loans

The following is emphasised in the Strategy: “The development components of economic water price should be promoted through adopting appropriate legal regulations, in case they have not been adopted yet:

- development charge – local public funds that are charged to the users of water supply and drainage services in the service area;
- water use charge and water protection charge– public funds that are charged to the users of water supply and drainage services on the entire territory of FB&H and
- a portion of value added tax that is charged on the municipal services. If, for any reason whatsoever, the budget funding is insufficient, the latter component (VAT on water services) should be insisted on, because it is an integral part of the economic water price”.

Integrated Water Management Strategy of Republika Srpska 2014-2024.

The Strategy emphasizes the “cost recovery” obligation, whereby all costs of water services should be paid off, including the costs of environmental protection and protection of water resources as a whole (applying the “polluter-pays” principle for water protection, and “user-pays” principle for water abstraction).

In the context of water services, the Strategy emphasizes that “the water prices should provide full cost recovery of all simple reproduction costs, for recovery of investment and ongoing system maintenance costs, as well as full protection of sources, and in addition certain portion of expanded reproduction, pertaining to research and planning of new systems ... “

When the Strategy envisages rationalization of water consumption, the proposed measures include:

- Introducing economic water prices;
- Introducing water pricing policy to promote water saving;
- Reduction of losses in the distribution network and in the households’ installations;
- Upgrading the monitoring function in water supply systems.

According to the Strategy, economic price of water is the most important condition for the normal operation of water utilities. Price must be affordable and cover all costs. Pricing policy should ensure self-financing of the water sector through adequate collection of charges for water supply and all other water services. In addition, economic price of water is the most efficient instrument to rationalize water consumption; therefore, it is one of the most efficient measures of water protection, both in terms quantity and quality.

The Strategy emphasizes the availability of adequate sources of funding in the water services sector. In that context, the following measures are envisaged:

- Assess the actual financial needs of the water sector and identify the lack of financial resources;
- Identify sources of additional funding;
- Consistently apply the polluter-pays and user-pays principles;

Ensure gradual introduction of economic price of water services, particularly in water supply area, wastewater discharge and processing.

3.7 CURRENT STATE OF FLOOD RISK MANAGEMENT PRACTICE IN B&H

Following the devastating 2014 floods, B&H Council of Ministers adopted in November 2015 an Action Plan for Flood Protection and River Management for the period 2014-2017. The Action plan focuses on the following activities: repairment of the existing infrastructure damaged in 2014 floods, transposing of EU flood directive, establishment of the flood forecasting system, adoption of new technologies, capacity development and coordination among institutions. However, due to very low implementation of this Action plan, in Mar 2018, its implementation period was extended till the end of 2021. Part II of this feasibility study provides detailed analysis of all elements current flood risk management in B&H. A summary is provided in this section.

3.7.1 Flood hazard and risk mapping, flood risk monitoring and warning

There has been significant investment in rehabilitation of the hydrometric network in B&H through current and future projects, but only for the main watersheds (funds already committed. See baseline investment section below). The UNDP-GEF Vrbas project has rehabilitated the network for the Vrbas river basin and is developing a long-term maintenance plan. However, the ongoing upgrades to the network - a more effective flood monitoring, management, forecasting and early warning - have not yet been realized at the appropriate spatial and temporal scale. Chapter 5 provides a detailed review of the hydrometric network and identification of additional needs and includes a review of the existing HPP hydrometric network. Chapter 5 discusses existing arrangements for, and opportunities to strengthen/formalize data sharing between HPPs, hydro-meteorological institutes and water agencies to maximise the network. The existing flood forecasting and early warning system (FFEWS), for most of main watercourses is currently under development and improved FFEWS institutional arrangements and communications protocols are yet to be implemented. Interagency communications during and after natural disasters are cumbersome and inefficient. FFEWS does not exist at all for tributaries and torrents. UNDP-run Vrbas project is establishing the first FFEWS platform in B&H which will be run by local water agencies and will cover Vrbas main river, without tributaries. Chapter 6 discusses the existing FFEWS in more detail and Chapter 10 discusses the proposed GCF project interventions to improve and establish a fully functioning, state-of-the-art impacted based national FFEWS.

WBIF project is developing EUFD flood hazard and risk maps for all basin in B&H (except Vrbas which is already done) and is expected to be completed by end of 2020. These flood hazard and risk maps will only cover category 1 rivers and will not include detailed hydrological modelling, which will be required for future flood forecasting and undertaking strategic flood risk management in the future. Category II rivers pose a significant risk to populations, particularly where torrential flash flooding is significant. There is currently no hazard or risk mapping of torrents, expect for Vrbas basin. In addition, the IPA2016 has allocated funds for development of flood risk management plans for all basins in B&H, and this work is expected to be completed by the end of 2021. Section **Error! Reference source not found.** discusses how the GCF project will build upon these efforts and contribute to the development of comprehensive, definitive flood hazard and risk maps for B&H under Output 1.

3.7.2 Flood protection structures

Throughout B&H, flood defences were severely damaged during the war and have remained in a poor state of repair due to limited budgets for maintenance. Many structures now fail to meet their design standards of protection due to the increased magnitude and frequency of large flood events in the last 10 years. However, through various loans, by 2022 more than 100 Million would be invested in the upgrade of flood protection structures in B&H. This level of investment is not sufficient and does not cover all basins. In addition, there is no unified guidance on the design and construction of new flood defence infrastructure, and no requirement or methodology to include climate change considerations in the development of new structures. Annex B discusses the current approach to flood defence design and construction in B&H, while Section **Error! Reference source not found.** provides details of the significant EiB co-financed flood defence programme of works that will be undertaken as part of/in parallel with this GCF project, under Output 3. Section 10.2 discusses non-structural and Eco-system based measures which the project is introducing under Output 2, which will complement non-structural approaches to flood protection and prevention.

3.7.3 Flood Hazard Assessment, Modelling and Mapping in B&H

3.7.3.1 Overview of methodologies and models for flood hazard modelling and mapping in B&H

By adopting the Decree on the types and contents of protection plans against harmful effects of water (FB&H Official Gazette, 26/09), FB&H legislation fully incorporated the EU Directive 2007/60/EC on flood risk assessment and management with all of its activities. One of the goals defined by the aforementioned Decree is the development of a flood risk management plan. As a first step in the development of the flood risk management plan in FB&H, activities were initiated at the beginning of 2009 on preparation of the Preliminary Flood Risk Assessment (PFRA). The preliminary flood risk assessment for the Sava River Basin was completed by 2012, and then it was updated after flood events in 2014. On the Trebišnjica River Basin, which belongs to the Adriatic Sea Basin, the Preliminary Flood Risk Assessment was carried out at the end of November 2016.

3.7.3.2 PFRA in Federation of B&H

Preliminary flood risk assessment was developed for the FB&H (for watercourses of category I and II) by mid-2013 in three steps. The first step consisted of data collection. Municipalities were provided with *Flooding Questionnaire Survey* and thus a database on past floods was created (historical floods). All flood lines of design high water of major watercourses in the FB&H were collected, which were the subject of processing of the planning documentation from the water protection segment as future floods (floods that may occur in the future).

The second step implied the development of the methodology. The basic criteria for the methodology for assessing significant flood risks were defined. The methodology for flood risk assessment is expressed through the index (I), which is obtained by adding up all negative impacts, taking into account the surface of floodplain and the four impact categories required by the EU Floods Directive (human health, environmental protection, cultural and historical heritage and economic activities). Certain criteria of importance are assigned to the relevant impact categories. All negative impacts are aggregated and if a total number of points for a single floodplain is 100 points or greater, then the flood is considered relevant. Floodplains, which have over 500 index points are assessed with very relevant risk of flooding. Based on the aforementioned formulations, the floods are classified into four categories as shown in the following table:

Table 3-1: Flood indexes for PFRA

Index	Relevance
0-50	Not relevant
50-100	Moderately relevant
100-500	Relevant

> 500	Very relevant

In the third step, the Preliminary Flood Risk Assessment in FB&H was performed, i.e. floodplains on watercourses of category I and II were identified, which are under significant flood risk (APSFR). The areas for which the risk was assessed as significant and extremely significant were designated as APSFR areas. In the Sava River Basin in FB&H, 69 APSFR areas on the category I watercourses are defined, and 28 APSFR areas on the category II watercourses. Since some of these areas partially overlapped or were adjoined, they were merged into one area. Thus, the final number of APSFR areas for the Sava River Basin in FB&H is 84. For these areas, the activities were undertaken on the next steps defined by the EU Directive on the assessment and management of flood risks – drawing up of flood hazard and risk maps.

3.7.3.3 PFRA in Republika Srpska

3.7.3.3.1 Sava River Basin

Overall in the Sava River Basin in the territory of the Republika Srpska (which includes: direct Sava River Basin, Drina River Basin, Bosna River Basin, Ukrina River Basin, Vrbas River Basin and Una River Basin), on the basis of the aforementioned surveys and field data collection through the Flooding Questionnaire Survey, within the total catchment area of 21,607 km^2, the floods covered 88,986 ha, with the following data recorded:

- Number of flooded residential buildings 35,331
- Number of flooded communal housing 361
- Number of flooded individual housing buildings 33,548
- Number of flooded auxiliary facilities 66,845
- Number of residents in the flooded area 116,090
- Number of evacuated households from the flooded area 12,476
- Number of evacuated residents from the flooded area 33,880
- Number of casualties from floods 16

According to the data obtained from the field through the Flooding Questionnaire Survey, in Republika Srpska, flood waters of the Sava River and its tributaries threaten a total of 88,986 ha of agricultural and construction land. The values are the following divided by the sub-basins of Sava River: direct Sava River Basin District (29,486 ha), Drina River (17,718 ha), Bosna River (17,919 ha), Ukrina River (6,363 ha), Vrbas River (9,839 ha) and Una River (7,661 Ha).

3.7.3.3.2 Trebišnjica River Basin

Overall in the Trebišnjica River Basin (which includes: Trebišnjica River Basin and Neretva River Basin in Republika Srpska), and based on the aforementioned surveys and field data collection through the Flooding Questionnaire Survey within the total catchment area of 4,058 km^2, the floods covered 7,404.60 ha, whereby the following data are recorded:

- Number of flooded residential buildings 254
- Number of flooded communal housing 51
- Number of flooded individual housing buildings 203
- Number of flooded auxiliary facilities 489
- Number of residents in the flooded area 3,274
- Number of evacuated households from the flooded area 116

- Number of evacuated residents from the flooded area 460
- Number of casualties from floods 0

According to the data obtained from the field through the Flooding Questionnaire Survey, in Republika Srpska, flood waters of the Trebišnjica and Neretva Rivers and their tributaries threaten a total of 7,404.60 ha of agricultural and construction land. The values are the following, divided by the sub-basins of Trebišnjica and Neretva rivers: Trebišnjica River (5,187 ha) and Neretva River (2,217.60 ha).

3.7.4 Detailed Flood Hazard Modelling for Each Basin

Based on the results of the Preliminary Flood Risk Assessment, a Methodology was developed for developing the detailed flood hazard maps and risk maps in FB&H and Republika Srpska. The methodology has been developed for areas at a significant flood risk, in compliance with all provisions of the EU Flood Directive governing these maps.

For each of the three defined flood scenarios (1/20, 1/100 and 1/500 years), the hazard map should contain flood extent, water depth, flow velocity and water level. The flood hazard is defined as the function of depth and water velocity and is divided into four categories.

Flood risk maps will show the potential adverse consequences associated with flood scenarios and expressed in terms of the following:

- the indicative number of inhabitants potentially affected;
- type of economic activity of the area potentially affected;
- installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control which might cause accidental pollution in case of flooding and potentially affected protected areas.

A significant challenge in defining the methodology was the selection of adequate weight factors for each of the endangered categories. In order to test and verify all the parameters and factors and visualize flood hazard maps and risk maps defined by the methodology, a certain number of hydraulic models of floodplains along the watercourses of the Sava River Basin in the FB&H was prepared, which served as the basis for drawing up flood hazard maps and risk maps. Hydraulic models were developed covering the floodplains as follows:

- Hydrodynamic model, hazard and risk maps of the sub-basin of Una river – floodplains on the rivers Sana and Sanica,
- Hydrodynamic model, hazard and risk maps of the sub-basin of Una river – Municipalities of Bihać and Bosanska Krupa;
- Hydrodynamic model, hazard and risk maps on the floodplain of Drina river in FB&H and Vrbas River in FB&H;
- Hydrodynamic model, hazard and risk maps on the floodplain of Usora River in FB&H.

It should be noted that hazard maps and risk maps for these floodplains served as the pilot maps. They were utilised for updating the floodplains in the technical annexes of the Federal Flood protection Operational Plan (FOP).

For the purpose of preparing high quality topographic surveying maps, i.e. digital terrain model (DTM) for testing methodology of development of hydraulic modelling for the needs of flood hazard maps and risk maps, digital models of the inundation terrain and watercourse riverbeds were prepared using several different methods.

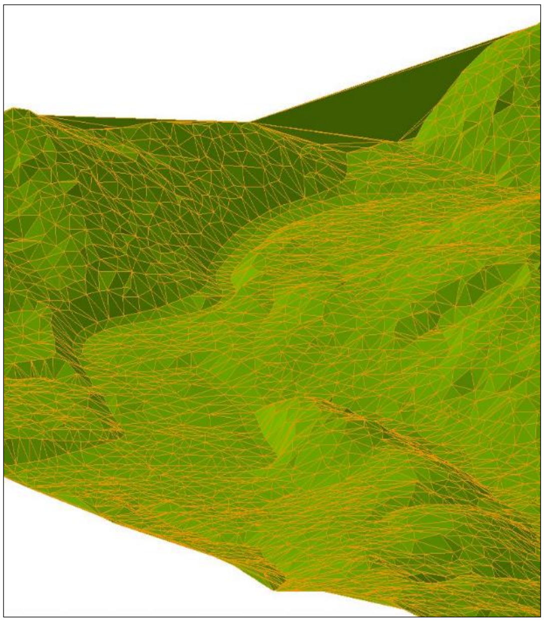
Field geodetic surveying of riverbeds and bank sections of watercourses was performed by using all available technical and technological equipment, so that the obtained data could be properly prepared and processed. For the purpose of obtaining a certain number of geodetically surveyed points, a watercourse riverbed was surveyed under the water level.

Cross-section positions have been agreed prior to the start of on-site works. The cross-section positions represented characteristic places of changes in the width of the riverbed, directions, curves and similar, with an average distance of about 200-300 m. Areas between cross-sections were surveyed in the highest possible number of points, so as to minimise subsequent processing of data and interpolation between the surveyed cross-sections.

Producing of a digital terrain model in the inundation area required some other ways since the Lidar surveys were not available at that time, therefore the methods were used to improve the existing "rough" terrain models by classical geodetic surveying of the terrain and densifying through "removal" of geodetic points from the available geodetic plans and maps. In this way, the existing DTM would be improved in places where it was necessary and linked to the terrain model of the watercourse riverbed.

Another method of preparation and creation of the DTM of the inundation area is the selection of methodologies of development based on satellite stereo recordings with the appropriate resolution.

In this way, a DTM (hybrid model) was obtained in the selected floodplain area, which would contribute to development of hydrodynamic flow model through consolidation with hydrological data. The method of DTM overview can be seen on the following photos.



In the first half of 2017, flood hazard and risk maps on the Vrbas River Basin in B&H were completed, in accordance with the Methodology for drawing up flood hazard and risk maps adopted by the competent Agencies and PI "Vode Srpske".

Hazard maps are determined based on two parameters: modelled water depth in the floodplain and water velocity. The methodology sets out map resolution of 10 x 10 m. The developed flood hazard and risk maps on the Vrbas River Basin represent Pilot project of flood risk mapping in B&H, which is based on detailed hydrological and hydraulic modelling using extensive geodetic surveys of the main riverbed of the Vrbas river and its major tributaries, through which the flood hazard was considered in continuity. LIDAR surveying of the river valley was performed for the area over 300 km^2 on the basis of which flood hazard mapping was carried out and, in combination with socio-economic activities, flood hazard maps were developed for the obtained floodplains.

3.7.4.1 WBIF national flood hazard modelling and mapping

Currently, the activities are ongoing throughout Bosnia and Herzegovina on the development of detailed flood hazard maps and risk maps, which are implemented through the WBIF project. What is important to note is that these are being developed in accordance with the methodology defined in 2013, which has been verified for the entire Bosnia and Herzegovina through the UNDP's project *Technology transfer for climate resilient flood management in Vrbas River Basin*.

As part of the WBIF project, LIDAR survey of the terrain along the watercourses was carried out with a precision of +/- 10 cm. The results of this survey, together with the classic geodetic survey of the cross-section of water courses, enable the production of a high-quality digital terrain model, as a basis for hydraulic modelling for the development of flood hazard maps and risk maps. In addition, for the purpose of development of these maps, statistical processing of the existing hydrological stations will be used, based on which the design major high water with the probability of occurrence of 1/20, 1/100 and 1/500 years will be defined. Activities for the development of these maps for the entire territory of B&H are expected by the end of 2020. Thus, Bosnia and Herzegovina will have the best quality and modern flood hazard maps and risk maps in the region.

Producing flood hazard maps and risk maps is a prerequisite for initiating development of the Flood Risk Management Plan for the Sava River Basin in the FB&H. In order start with implementation of this Plan immediately after the development of these maps, the funds for its development have been provided under the EC IPA 2016 fund. These funds will be used for producing Flood Risk Management Plans for both basins in B&H (Sava River and Adriatic Sea) and for all administrative units (Federation of B&H, Brčko District B&H, Republika Srpska), as well as a unified plan for the entire territory of B&H.

Based on the aforementioned, it is planned that in 2021 the first Flood Risk Management Plan will be implemented in B&H. The Flood Risk Management Plan will define a program of structural and non-structural measures aimed at reducing the risk of flooding in the Sava River Basin in the Federation of B&H.

Currently, the lack of flood hazard maps and risk maps as well as the Flood Risk Management Plan is a major barrier to the effective management of flood risk in all sectors.

The following recommendations have been given:

- Flood hazard maps and risk maps should be published when they are finalised, and they should be disseminated to local communities and the general public for information;
- Once developed, flood hazard maps should be shared with the civil protection structures at all levels so that they can use them as the basis for preparing Population Evacuation Plan within floodplains;
- When developing Flood Risk Management Plans, all interested parties and the general public should be involved.

After development of flood hazard maps and risk maps for the whole of the Vrbas basin, further activities continued resulting in completion of the first Flood Risk Management Plan for the Vrbas River Basin in Republika Srpska in July 2019. Having in mind that part of Vrbas river basin in the Federation of B&H is under significantly lower flood risk than the downstream part in Republika Srpska, FB&H opted not to develop FRMP for its part of the basin, but rather to wait until FRMP for the rest of the country is developed. Hence, the Plan was prepared only for the territory of the Vrbas River Basin in Republika Srpska.

After conducting the final expert and public hearings, all beneficiaries of the river basin agreed that the developed Flood Risk Management Plan for the Vrbas River Basin in Republika Srpska is represents the first pilot project of a kind both in Republika Srpska and B&H, as well as in most countries of the region. The Plan was developed in a very detailed and high-quality level, harmonized with the beneficiaries throughout, the Ministry and the PI Vode Srpske. The Plan took into consideration the key components of sustainable flood risk management at the Vrbas River Basin in Republika Srpska. Methodology used for development of the FRMP for the Vrbas River Basin in Republika Srpska has been agreed upon and will be used for rest of the country.

3.7.4.2 Torrents modelling and mapping

Under the Vrbas project a methodology was developed for the modelling and mapping of torrential flood hazard for B&H. This method which was agreed among the entities will be the basis for all torrent hazard mapping in the future and is briefly described in this section.

3.7.4.2.1 Methodological framework for developing erosion maps

In the last few decades significant progress has been achieved in understanding, modelling and mapping of erosion processes and the transport of sediment, where the emphasis was on relatively small spatial units, and the process in different spatial dimensions and time scales. The ability to model and map sediment production and transportation processes is important for predicting quantities of produced erosion material at the level of the basin, but also to predict quantities which will potentially clog certain reservoirs and other hydraulic structure, or significantly change river when deposited profiles and impact flood processes. It is important to choose the most appropriate modelling methods and tools.

A large number of different erosion methods was developed with the intention to understand laws of erosion process, prediction of transport of sediment and with different spatial and time basis which represents their conceptual basis. The emphasis was on development and research of three main groups of methods. These are: empirical, conceptual and methods based on physical laws of erosion process. Typically, the majority of these methods are of reduction type and more or less focused on particular genetic forms of erosion or on "on-site" or "off-site" effects of erosion process.

The significant difference between empirical, conceptual and physics-based methods is based on their focus to "on-site" or "off-site" effects of erosion process. Methods CORINE, EHU and FKSM are focused more to "on-site" effects of erosion process and with emphasis on problem of erosion without reviewing of transport and accumulation of sediment. Different from that, PSIAC, FSM, VSD, CSSM, WSM, Gavrilović empirical model (MPE) and synthetic method by R. Lazarević, include into consideration the production, transport and accumulation of sediment and they represent some form of holistic model.

Empirical models are more focused to modelling of erosion and transport of sediment at the basin level, than the smaller surfaces like methods based on physical laws of erosion process. Therefore, when the goal of research is the intensity of erosion process and transport of sediment at small surface or some topographical surface with certain angle of slope/decline, certainly it is better to use physically based or conceptual methods, but if we want to determine production and transport of sediment from certain basin surface, more acceptable is the use of empirical methods since they have shown far better accuracy and reliability in defining of final results.

The Method of potential of erosion (MPE) by S. Gavrilović with changes and amendments done by R. Lazarević – synthetic method, which has been successfully implemented for several decades, is of long standing in scientific and expert practice, and it was selected and used in the final processing of the Erosion Map of SR Bosnia and Herzegovina, during making of Erosion Map of RS and Erosion Map of river basin of Vrbas in Federation B&H, and is the basis of the nationally accepted methodology.

3.7.4.2.2 Methodology for development of the cadastre of torrent basins

Institutions of Bosnia and Herzegovina competent for water sector or institutions in Federation B&H, Republika Srpska and District Brčko B&H do not have official Cadastre of torrent flows (torrent basins), or module ISV which is an integral part of entity water management information systems. In spite of the fact that flash floods have extremely destructive impact to socio-economic sector, they are poorly documented and very often the monitoring of it is missing, and especially the work in torrent basins and torrent riverbeds. The lack of data imposes a specific methodological approach in identifying and defining and torrent basins and making of Cadastre of torrent basins. Since there are no relevant data on torrent flows (basins) and flash floods, in practice the most often is used field (expedition) work on examining and collecting of data on torrent basins.

Field researches of torrent basins include:

- studying and collecting of data on factors which have impact to forming of flash flood
- mapping of erosion in order to define zones and sources of sediment – central points of erosion
- studying of hydrographic network through which is achieved transit of torrent mass
- studying of zones of settling of torrential sediment – studying of silted up material at the confluence into local erosion base
- identification of hydraulic traces of high waters created during passing of torrential flood waves
- analysis of frequencies and volume of previous torrential flood waves
- analysis of type of torrential rising
- analysis of parameters of torrential flood wave (depth, width, hydraulic traces)
- analysis of the cause of occurrence of torrential flood wave (rain shower, long-lasting rain, sudden snow melting, etc.)
- analysis of weather data (length of event)
- reviewing of destruction power of torrential flood wave - (types of caused damages)

- separation of torrent basins – mapping by GIS/GPS device
- making of cadastre of torrent basins – creating of geo-spatial data base

By desk work routes of visiting of basins are defined, thematic topographic layers/bases are prepared and integrated into GIS/GPS device. In the field in basins and riverbeds of analysed watercourses, indicators of torrential regime are reviewed, determined and documented (cadastral sheet).

3.7.4.2.3 Classification of torrents

Classification of torrent flows is conducted according to the origin of drawn sediment:

Undermining – torrential flows passing through topographic surface which is easily undermined under the impact of devastating power of water, so that there are intensively developed processes of deep and lateral erosion;

washing-off – torrential flows which flow in the bed which is rocky, so that it is not expressed vertical erosion, but in which are transported huge quantities of sediment which has come in the bed by process of washing-off (surface erosion – denudation work of water in the basin);

mixed torrential flows – characterized by undermining of the bed, but also by transport of material originated from surface erosion.

In the above classification, torrential flows are classified also in VI hydrographic classes (Hk).

3.7.4.2.4 Method for development of torrential cadastre maps

In order to make Cadastre of torrent basins (flows) it is necessary to undertake the following activities:

- Collecting of archive documentation - projects, water management plans, spatial-planning documentation, etc.
- Preparation of topographic bases/layers and defining of routes of field recognition.
- Preparation of partial DOF surveys/records and integration of it into GIS/GPS device.
- Field work – analysis of erosion processes in the basin, analysis of characteristics of sediment in the bed, analyses of silted up material on riverbanks, analysis of preserved traces of torrential waves, survey of local population, etc.
- Collecting of data by GIS/GPS device – field work in basins of torrential flows.
- Processing of data collected in the field – digitalisation of water partings of separated torrent basins, defining of attribute features of separated basins, etc.
- Making of geo-spatial data base – Cadastre of torrent basins (flows).

3.7.4.2.5 Method for development of Sensitivity Model to occurrence and development of flash floods

Methodological procedure of making of Sensitivity Model to occurrence and development of flash floods (Torrent Flood Susceptibility Model – TFSM) includes several phases:

- Making of Cadastre of torrent basins
- Analysis and selection of factors which determine sensitivity,
- Creation of the sensitivity model,
- Calibration and validation of obtained sensitivity model to occurrence and development of flash floods.

Due to specifics in geological-geomorphological composition (karst), hydrology and pedological and vegetation characteristics of basins in B&H, there were selected 7 factors which have important role in the process of running-off of water down the topographic surface.

Factors used in making of Sensitivity Model to occurrence and development of flash floods are: angle of the slope (S); decline and length of slope (LS) which are generated from digital altitude model (DEM); CN number determined based on the pedological map, reference pedological profiles and types of land use; density of river network (GRM) determined based on existing watercourses from maps 1:25.000; type of land use (NKZ) determined based on the CORINE - Land use Land cover_2012 (Coordination of Information on the Environment - EEA) with amendments using digital orthophoto (DOF); categories of erosion (KE) determined using Erosion Map and density of vegetation (FD) obtained based on the Global Forest Change 2000-2014 data.

Collecting and preparation of data of mentioned factors is conducted using GIS software. All data for analysis are in vector format, re-classified depending on type of data and on histogram of distribution of analysed data.

Defining and separation of adequate determination factors of flash floods is the first step in the procedure of developing Sensitivity Model of flash floods, or procedure of separation of certain surfaces and areas, which have different sensitivity (prone – suitable) to the occurrence and development of flash floods. One of the methods which is most often used in physical-geographical, geological and geo-morphological research today is the Matrix Method. This is a quantitative method which in essence is using statistical analysis for establishing of the model of sensitivity to this phenomenon within certain observed area. Although with this model cannot reliably predict sensitivity through absolute probability, it can predict relative potential sensitivity, which is calculated for total observed surface, where several measurable relevant factors of this phenomenon are used.

GMM - GIS Matrix Method, the procedures of which are completely performed in GIS environment, is based on calculation of three matrixes: (1) Matrix of torrent basins (MBS), (2) Matrix of determination factors of flash floods of the total surface of observed area (MOFBPUP) and (3) Matrix of occurrence and development of flash floods (MPRBP). This model is based on determination of all possible combinations between different types of factors, which have impact on the occurrence and development of flash floods. The final result is a spatially disaggregated surface area, comprising a combination of determination factors within that area. Every determination factor is weighted to provide the combination in relation to total observed area.

By using this method of classification in GIS environment (natural-breaks method or other) results are obtained which can be further re-classified and visually presented as different levels of sensitivity of area to occurrence and development of flash floods (very weak 0-2, weak 2-10, medium 10-30, strong 30-50, very strong 50-100).

Validation of the model is conducted by using of method of Degree of fit - DoF which consists of estimation of the relation between surfaces of torrent basins (sample from Cadastre of torrent basins which was not used in making of previous model) and obtained Sensitivity Model to occurrence and development of flash floods. Quality of the obtained model is assessed by the technique of spatial autocorrelation and measuring of degree of fit between validation group of data and obtained sensitivity model.

3.7.4.2.6 Torrents modelling and mapping in Federation of B&H

A major issue with regard to torrential floods in the Sava River Basin in FB&H is the lack of data on torrents and torrential floods that could be applied. Namely, no erosion map has been developed so far, no systematization of flows has been carried out, and no vulnerability has been identified with respect to occurrence and development of torrential floods in this area. There no developed methodology for forecasting this type of flood.

The exception is the sub-basin of Vrbas river, for which the UNDP's project *Technology transfer for climate resilient flood management in Vrbas River Basin* covered the mentioned activities on the entire territory of the Vrbas River Basin in the FB&H and RS. In order to overcome the aforementioned shortcomings, the listed activities are nominated through the EU funds – IPA 2016 which will become operational in 2019.

Torrents are watercourses that generally have specific characteristics that differentiate them from other river flows, especially in terms of the flood hazard. They vary significantly in terms of the flow in high and low water. The relationship between these two flows is marked as 'torrent factor'. There are different subjective criteria that determine whether a stream is 'torrential' or not, based on this value. In the practice applied in B&H, various authors are trying to adopt different values of the relation as a norm, often in the range of 100-200. Floods develop rapidly after the precipitation, thus forming flash floods – with a time of concentration of Tc <6 hours.

If their basin surfaces cover land with high erosion potential, the torrents carry a large amount of sediment. Floods filled with sediments pose a greater risk to people and property, as already experienced in B&H (example of Željezno Polje location during the May 2014 floods).

Land erosion results significant and long-term damage, threatening many sectors: agriculture, forestry, water regime, transport, communications, utility infrastructure, settlements, economic activities and so on. So far, only partial protection measures were implemented, which were of interests for the institution which implements such measures. Far more favourable effects would be achieved if the mentioned actions would be coordinated and if a multidisciplinary approach to the problem would be taken. It is necessary to draft and acknowledge the Strategy and the Program of protection against erosion under the coordination of the competent Ministry of Agriculture, Water Management and Forestry of FB&H, the Ministry of Environment and Tourism and the Ministry of Physical Planning.

In order to reduce potential damages from flash floods, it is necessary to carry out general anti-erosion measures. Regardless of the local conditions, general anti-erosion measures include: legislative measures, producing of erosion state cadastre, erosion processes monitoring, training of population, mainstreaming of issue of protection from erosion into: spatial plans, forest management plans and, obviously, in the water sector planning documentation. Erosion can be significantly reduced by proper soil treatment and conservation of plant cover.

When addressing erosion damage remediation, it should be emphasized that the approach to remediation measures needs to be thoroughly analysed with emphasized priorities, so as not to disrupt the natural balance of watercourses and basin areas. The protection from erosion should be carried out according to the established criteria, which are depending on: importance and priorities of the water protection facility, the degree of a threat of backfilling with deposits, the degree of susceptibility to backfilling with deposits, the degree of feasibility of works (rates of profitability).

Susceptibility analysis of the basin surface or the development of a flash flood susceptibility model is of crucial importance because if we take a timely consideration of the potential hazard, socio-economic and ecological disasters can be prevented to a certain extent or substantially mitigated.

Methodological approaches to flash floods are different. There are several generally accepted methodologies that are very successful in forecasting and preventing disastrous impacts of flash floods. They are primarily based on factor analysis of rainfall as the main factor that generates flash flooding (trigger) along with other factors (hydrological, geomorphological, lithological and other factors).

The methodological process of developing the Flash flood susceptibility model includes several phases:

- Development of torrential basins cadastre,
- Analysis and selection of factors that determine susceptibility,
- Development of a susceptibility model,
- Calibration and validation of the obtained Flash Flood Susceptibility Model.

Given the specificity of the geological-geomorphological, hydrological and pedologic and vegetation characteristics of the basins in B&H, 7 factors were selected through UNDP’s project that play an important role in the process of the water runoff through the topographic surface.

Factors used in the design of the Flood Susceptibility Model include: slope camber angle; decline and length of the decline generated from the digital terrain model (DEM); CN number determined on the basis of the pedological map, reference pedologic profiles and the manner of land use; river network density; land use method determined based on CORINE - Land use Land cover_2012 with supplements using digital orthophoto (DOF); erosion categories were determined using Erosion map and the vegetation density was obtained on the basis of Global Forest Change 2000-2014 data.

Since the torrential floods are characterized by big declines of the terrain, significant kinetic energy of the flow, short time of concentration, the content of the flood wave that more resembles a pulp and where more than 80% of the material is run on these watercourses, the forecasting model and early warning system must be very fast and expedite. The general approach to this problem is that classical water measuring stations are incorporated with radars and satellites that are very expensive so that on the basis of meteorological forecasts and cloud movements, the intensity of expected rainfall and activation of a torrential flow on a watercourse with adverse consequences could be estimated.

With regard to the need for economic and financial analysis of the funds invested and possible damage to the torrential watercourses, it would be more beneficial to act preventively in the upper sections of the basin in order to reduce the potential damages from flash floods. These measures include arranging and remediation of forest land in combination with anti-erosion works and afforestation of the surfaces.

Another important measure is the construction of partition profiles on which the interruption of longitudinal fall of watercourse will be performed and ensure the disposal of sediment. This obviously also implies regular cleaning and draining of storage space.

The existing hydrometric network partially covers torrential flows, but it is more concentrated on the locations of the confluence of these flows into larger watercourses, while the upper sections of the basin are insufficiently included. Through development of erosion maps, systematisation of torrential flows and identification of flash flood susceptibility, it will be possible to estimate and give recommendations for the expansion of the hydrometric network in order to adequately monitor and model the hazards and risks in the torrential basins.

3.7.4.2.7 Torrents modelling and mapping in Republika Srpska

Republika Srpska, unlike Federation of B&H, has an updated Erosion map on the entire territory in the scale of 1:25 000. In reference to this, opportunities have been created to continue with the development of: flash flood cadastre and a flash flood susceptibility model, independently from conducting activities on development of Erosion map in FB&H, all in line with the positive practice defined within the development of a flash flood susceptibility model on the Vrbas River Basin.

In the forthcoming period, it would be particularly useful to produce the aforementioned documentation on the Ukrina river basins (which almost entirely belongs to Republika Srpska) and on the Una River Basin with Sana, in the territory of Republika Srpska in the following way:

<u>Ukrina River Basin</u>

Except foreseen infrastructural measures that will significantly contribute to reduction of the flood risk, non-structural and eco-system based measures are also important as part of systematic approach in river basin organization. Combined structural and non-structural approaches provides the basis for reconsidering required interventions on the basin that will contribute to the flood risk mitigation, through the reduction of erosion process intensity and reduction of quantities of deposit which is transported from the basin.

For the purpose of implementation of such measures, it is necessary to reconsider the status of erosion processes by development of Map of Erosion (implemented for the territory of Republika Srpska, but for some areas with extensive erosion it should be updated) to perform Cadastre Register of torrential basins and establish Model of sensitivity/susceptibility to torrential floods. Map of erosion, Cadastre register of torrential basins and Model of sensitivity/susceptibility to torrential floods represents initial base for planning of anti-erosion measures on individual river basins.

Proposals for future anti-erosion measures are defined by analysing status of erosion in the basin, number and spatial distribution of torrential basins, maximum discharge values, quantities and structure of deposit on certain river courses profiles, as well as spatial distribution of sensitivity/susceptibility categories to the occurrence and development of torrential floods. Those measures mean: technical measures-construction of torrent barriers on critical partition profiles; bio-technical measures-development of (single and double) wattle check dam which create support for vegetation growth on bare hillsides; other anti-erosion measures- economic measures (adjusted land cultivation) and administrative bans. By terrain prospection using indicated maps, necessary scope of anti-erosion interventions is defined, as well as list of measures and assessment of required funds.

Considering defined status in the basin, proposal of measures for planning and systematic organization of the basin is divided into two groups: 1) anti-erosion measures on the surface where processes of excessive and heavy erosion are present (torrential basins) which are erosion cores in the basin, 2) basic measures of systematic organization of the basin, i.e. organization of forest and agricultural areas with light erosion processes.

<u>Una River Basin with Sana</u>

It is necessary to plan non-investment measures such as those indicated for the Ukrina River basin in Republika Srpska, throughout development of the following documents:

- Maps of erosion (implemented for Republika Srpska territory, but for some areas with extensive erosion process it should be updated),
- To develop Cadastre of torrential basins and
- Create Model of sensitivity to torrential floods occurrence and development,
- Organization of the river basin- forest and agricultural land and planning of anti-erosion measures on individual river basin areas.

3.7.4.2.8 Hydropower plant models and representation of HPP operations in FEWS models in B&H

The power system in B&H was divided into three vertically integrated companies split along geographic/ethnic lines. The three state-owned electric power generation and distribution companies are: Elektroprivreda B&H (EPB&H), Elektroprivreda Republika Srpske (EPRS), and Elektroprivreda Hrvatske Zajednice Herceg-Bosna (EPHZHB). Early post-war international assistance provided hundreds of millions of dollars between 1996-2001 for the reconstruction of the physical infrastructure, facilities and networks that were destroyed. Since 2001, international financing continues for physical improvements and on the institutional strengthening and restructuring of the electricity market.

Under a project financed by the Global Environment Facility (GEF), the development of an optimal management system for multi-purpose reservoirs in the river basins of Neretva and Trebišnjica was undertaken by EPTISA (2013). The project developed a Model for Hydrological Predictions, Forecasting, and Decision-making, and Preparation of a Plan, Guidelines, and Training Program for the Optimal Management of Multi-purpose Reservoirs in the River Basins of Neretva and Trebišnjica, which aimed to strengthen the integrated management of water resources in Bosnia, in accordance with the EU Water Framework Directive. In particular, the project focused on supporting the management of the river basins Neretva and Trebišnjica by the provision of decision support instruments and guidelines to achieve the maximum economic effects in respect to the operational rules and constrains of hydropower plants (HPPs) in various hydrological conditions.

The models developed by EPTISA did not cover the whole basin nor did they include consideration of groundwater hydrological processes which are important in this basin, nor flood risk under climate change. Forecasting model for Adriatic Sea basin does not include water level predictions and needs to include water level and flood extent downstream.

In addition, while HPP specific model existing for operational forecasting, HPPs and their operations are not currently incorporated into Flood Forecasting System for any of the basins in B&H, which limits the ability of basin flood forecasting models to accurately represent the impact of HPP operations on potential flooding downstream, and also limits the potential benefits to dam safety and optimisation of generation for the HPPs operators during flooding periods.

3.7.4.3 Datasets available for flood hazard modelling

Activities 9 and 10 of the project *Development of Flood Hazard Maps and Risk Maps in Bosnia and Herzegovina* involve preparation and calibration of hydraulic models of the watercourse sections within APSFR/AFA. The Inception Report confirmed the total number of 181 APSFR/AFA for hydraulic modelling, and the design maximum flows with the return period Q20, Q100 and Q500 as the input parameters for each APSFR/AFA were confirmed in the hydraulic working document. Topographic data required for modelling are available in the form of new DTMs and cross-sections of watercourses and characteristic floods in each APSF /AFA, made during LiDAR and geodetic surveys of 2200 km^2 during spring and summer of 2018 (Phase I). During Phase II, in the autumn of 2018, an additional 3300 km^2 was surveyed. The key step before modelling is the establishment of the criteria that will determine where 1D modelling is needed, and where 2D modelling. Such Technical concept represents the criteria proposed by the Consultant in order to facilitate the decision for each modelled section of the watercourse. The criteria were tested and revised on a preliminary model of the Neretva River.

It is expected that WBIF project will meet only the minimum requirement for EUFD flood hazard mapping, particularly if only AFAs[29] will be modelled in some basins. In addition, hydrological modelling will not include derivation of full design hydrographs but will instead use only design peak flows. Groundwater modelling will not be included in the WBIF hazard modelling even for basins where it is the biggest flood

[29] AFAs are based in previously flooded areas only. Hence areas that may flood in the future (e.g. due to climate change) will not be represented in the model.

risk, nor will HPP reservoir operation be included. These shortcomings will pose a problem where the full basin model is required for flood forecasting, emergency response, reservoir operation optimisation and climate resilient spatial planning. Hence GCF project will need to address these shortcomings in the WBIF modelling by integrating more detailed hydrological and hydraulic into river basin models, developing and incorporating groundwater modelling and undertake and incorporate HPP reservoir operation. Such integration will require additional data for each basin beyond that collected and processed by the WBIF project.

A potential problem is that the expansion of the hydrological station network to provide better and more detailed input data for flood modelling and mapping, flood forecasting and early warning systems, has not been addressed (see above for planned network expansion). In addition, there is a problem of lack of data from smaller, unexplored basins where input data on the flows were obtained by various empirical methods, which ultimately resulted in significantly different outputs. In order to improve the existing hydrological and meteorological models, in addition to hydrological data, it is necessary to significantly improve the input geomorphological data (digital terrain model, cross-sections of riverbeds, etc), which is necessary for better modelling of flood events. The previous models relied on the existing geometry of riverbeds that only met the minimum requirements for modelling floods and flood events. Therefore, any improvement in terms of input parameters, riverbed geometry and hydrometeorological data will result in better quality flood risk maps. With these know issues in mind, the following is a review of the data that would is available for detailed flood hazard modelling.

3.7.4.3.1 Review of data requirements and availability for inclusion of groundwater flood risk modelling and mapping

Flooding caused by groundwater is characterized by a negligible water velocity (≈0) and a long duration of flooding which has an impact on the value of the occurred damage. In order to be able to consider the possibility of modelling and developing forecasting models for flooding caused by groundwater, an adequate level of groundwater monitoring should be established as a first step, the results of which will be used as model input data.

Federation of B&H

The Program of Measures, prepared within the Water Management Plan for the Sava River Basin in the Federation of Bosnia and Herzegovina 2016-2021, defines the need for establishing adequate groundwater monitoring in order to monitor the regime and the quantitative and qualitative state of these waters.

In the territory of Bosnia and Herzegovina, as well as in the Sava River Basin in FB&H and Republika Srpska, groundwater monitoring is not currently in place to the extent necessary. Very few sources and aquifers are regularly observed, and existing observations cannot be considered representative for more precise analyses and for making appropriate conclusions.

In the phase I of the establishment of groundwater monitoring, water bodies with intergranular porosity and free groundwater level are covered, considering the equitable spatial distribution of springs. The monitoring of groundwater levels in water bodies will be carried out in natural (undisturbed) conditions, outside the radius of the impact of wells or other objects that disturb the natural groundwater regime.

After purchasing equipment for the establishment of quantitative monitoring of groundwater levels in 2017, eleven locations were designated on which the piezometers drilling was performed during 2018.

An overview of the sites with the installed piezometers on which the groundwater will be monitored is shown on the following map:

In the phase II of the establishment of groundwater monitoring, activities started on establishing the monitoring of groundwater bodies in karstic–porous aquifers, i.e. the quantitative and qualitative monitoring of representative karst springs in certain groundwater bodies of this type.

In this respect, a Study was prepared, which covered 20 major springs and defined all necessary prerequisites in order to establish the measurement profiles that will be used to assess the groundwater state in accordance with the EU Water Framework Directive.

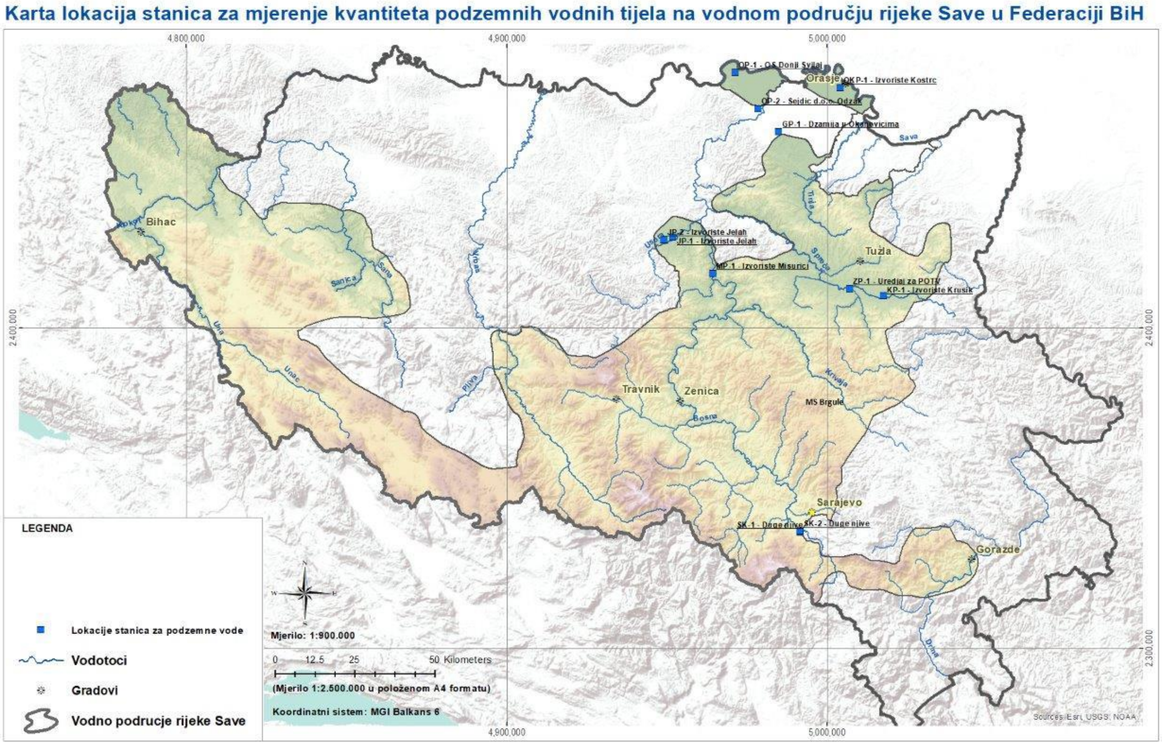


Figure 3-4: Map of sites with stations for measuring quantities of groundwater on the Sava River Basin in FB&H

It should be emphasized that in most of groundwater bodies in the Sava River Basin in the FB&H the groundwater levels are in functional dependence and conditioned by water levels of surface watercourses. Because of this, the surface flooding is mainly caused by the water pouring from the main riverbed. Cases that are specific to karst fields in the Adriatic Sea watershed, where terrain flooding caused due to groundwater level rise is almost negligible. In the coming years AVP Sava plans to expand the network of measurement profiles of groundwater monitoring with its own resources and with the help of the funds of international financial institutions, ensuring that all the groups of groundwater bodies in the Sava River Basin in FB&H are included.

Republika Srpska

The methodology of calculation and development of karst field risk maps were tested through the FB&H Methodology and showed logical results when applied in Mostarsko blato. In the Republika Srpska the methodology has not yet been tested but its potential use will be analysed for Republika Srpska as well. One of the critical paths for a proper implementation of hazard and risk maps in the karst fields is the insufficient observation network, as well as inadequate determining of underground flow connections at different hydrological and hydraulic scenarios on the basin. As noted, having in mind that these fields are uninhabited and the fact that they are regularly flooded due to limited drains, the methodology should be based on key data related to the period of flooding, duration and depth of water in temporary reservoirs.

In order to be able to fully implement the methodology, the hydrometric monitoring network needs to be strengthened, and in particular, the necessary financial investments need to be made to densify the groundwater monitoring network in Republika Srpska.

3.7.4.3.2 Data requirements and availability for inclusion of HPP operations in flood hazard models.

Development of flood hazard maps does not envisage analyses of potential impact of hydropower plant operating regime on generation and mitigation of flood events by transformation of flood waves in the reservoirs of hydropower plants. Consideration of the impact of hydropower plant operating regime is planned in the framework of the development of forecasting models.

Federation of B&H

For all major HPP facilities in the Sava River Basin in FB&H (Jajce I and II, Kostela, Modrac), in addition to including their impact in the framework of the aforementioned forecasting models of the sub-basins, it would be necessary to develop local forecasting models related to these facilities aimed at defining the relevant levels and the appropriate procedure in accordance with their operating plan. Generally, it can be stated that in the reservoir areas of the mentioned facilities the necessary volumes of space for the successful implementation of flood protection measures are not envisaged. The existing storage space of these facilities needs to be analysed and optimized from the point of view of flood protection of downstream areas.

This is especially important for Modrac reservoir. It is the most important water resource in the territory of Tuzla Canton. The dense hydrographic network upstream from the reservoir, the problems related to reducing the storage space due to the disposal of tailings from the surrounding mines, the multifunctional use of the reservoir space, the problems of flooding of downstream areas in the areas of municipalities of Lukavac, Gračanica and Doboj Istok with significant economic development, resulted in a need for creation of a separate forecasting model. Development of the forecasting model is also recommended within the new plan of operation of the Modrac HPP. As part of the model, it should be considered whether it is necessary to expand the network of hydrological monitoring on the watercourses entering the reservoir; define the priorities in the plan of operation of the HPP, as well as the relevant levels at which a certain action is activated; link the plan for water discharge from the reservoir with the downstream area exposed to extreme flood risk, i.e. with the relevant water level at which the notification to the pertaining water station Karanovac is triggered so as to prevent flooding or decrease the duration of the flood wave downstream the reservoir. This is of particular importance until regulation of the Spreča riverbed downstream of Modrac is finalised.

Artificial reservoirs in the Adriatic Sea watershed are:

- Rama
- Jablanica
- Grabovica
- Salakovac
- Mostar
- Buško blato
- Mandor

Artificial reservoirs on rivers Neretva and Rama

The reservoirs built in series, depending on their possible impact on floods, can be considered through two aspects: (1) potential positive and (2) potential negative impacts.

- More significant positive impacts can be achieved (due to reservoir size) in the reservoirs of Rama and Jablanica. Namely, having adequate and synchronized plan of operation in place both of these and the downstream reservoirs (hydropower plants) it is possible, thanks to the size of these reservoirs, to achieve (already achieved) a significant reduction in the height of the flood wave downstream from Mostar and thus reduce the costs of construction of the dikes downstream.
- In the absence of such a plan for any of the aforementioned reservoirs, independent or joint interaction can cause a significant increase in downstream flood waters, instead of decrease, due to the condition of the system for high water transmission.

  One such case occurred in December 1999, after which the competent bodies and organizations took the necessary steps so as to avoid such events in the future.

A particularly positive segment of these activities is the start of development of the Neretva River Basin Management Plan, facilitated by the Public Enterprise for the "Adriatic Sea Watershed", and without such plan in place it will not be possible to implement measures of efficient flood management.

At a time, from 1976 to 1980, according to the available data, considerable attention was paid to the problem of propagation of the water wave in the event of dam demolition.

Through scrutiny of the available studies: 1) Demolition of dam Jablanica, (2) Demolition of dam Grabovica and (3) Analysis of the Mostar reservoir drainage, it was indicated that these calculations should be considered as part of the already mentioned Neretva River Basin Management Plan and implemented through modern software packages that represent an integrated whole with the basin management package.

Artificial reservoirs of Buško blato and Mandor

Reservoirs of Buško blato and Mandor are part of the system of water resources utilization of the so called "Livno Horizont" and, together with the corresponding part of the facilities, as explained in considerations of flood protection measures in the Livno Karst Field, they practically solved this problem.

Republika Srpska

The Flood Risk Management Plan of the Vrbas River Basin in Republika Srpska provides for a detailed analysis of the possibilities of flood mitigation by transforming the waves in the reservoirs of the hydropower plants on the basin. It has been concluded that by proper management and preparation of the reservoirs prior to the occurrence of flood waves, significant effects of mitigation of flood waves downstream the hydropower plant or reservoir can be achieved.

Taking into account that in the project target basin areas in Republika Srpska in the part that drains towards Sava River there are not many reservoirs (Drenova on the Ukrina river basin) that can transform the flood waves, the most probable tendency in the forthcoming period will be to dedicate attention to the inclusion of new reservoirs on the basin for the purpose of active protection from floods. Hydropower plants on Trebišnjica have their own reservoir management plans defined in the document: Management of reservoirs and hydropower plants of the Trebišnjica system.

3.7.4.4 Data requirements and availability for enhanced flood hazard modelling

Table 3-2: List of available data and information available for enhanced flood hazard modelling and mapping[30]

No.	Data
1	**Previous Studies**
1.1	Any existing flood management strategy, policy and plan documents
1.2	All previous flood management studies for each sub-basin
1.3	All previous hydrological studies for the basins including climate change studies
1.4	Local and/or regional hydrological assessment guidance/standards
1.5	Records of flooding (post event community surveys, info from newspapers, disaster registers, aerial photos etc.)
1.6	All previous flood risk modelling reports
1.7	Design Manual and relevant reports for all hydraulic structures
1.8	As-built drawings of the all hydraulic structures
1.9	All previous socio-economic studies
1.10	All previous environmental studies (EIA)
1.11	All previous geotechnical surveys/studies (including geomorphological or landslide surveys)
1.12	All previous site investigations for the catchment
1.13	All previous sedimentation surveys (systematic soils samples, riverbed profile surveys over time)
1.14	All previous groundwater studies for the catchments
1.15	All relevant policy/legislative documents for the area (land use, water resources management, climate change, DRR etc.)
1.16	Records of past structure failures (dates, locations, size of breach, possible cause of failure)
1.17	National and local Development plans
2	**Mapping/Topo data (in GIS format)**
2.1	Base maps at 10k and 50 covering the whole catchment
2.2	LiDAR DEM data for the floodplain area
2.3	Other DEM data (e.g. SRTM, ASTER or Contour data) for catchment delineation and derivation of hydrological parameters
2.4	Land cover maps in electronic GIS format
2.5	Geology maps of the area in GIS format
2.6	Soil and sub-soil maps in GIS format
2.7	River network centreline
2.8	GIS map showing location of all gauges (rainfall, flow, level, borehole) in the study area and in the study catchments
2.9	Aerial photos for study area during or after flood events
2.10	Previous historical flood extent maps (e.g. EUFD PFRA maps)
2.11	Channel cross-section surveys including all hydraulically significant structures (historical surveys datasets are useful for comparison of sedimentation)
2.12	Receptor data (property by type (e.g. residential, commercial etc.), agriculture, industry, land use) with physical and socio-economic attributes
2.13	All other individual mapping of relevance (e.g. maps showing agricultural holdings, forestry etc.) which may be held by individual government departments
2.14	Map of all existing and planned flood defences in the catchment.
3	**Hydrometric data**
3.1	Sub-daily (e.g. hourly) flow and level record for all gauges within the sub-catchments (i.e. records for any automatic gauges in the catchment)
3.2	Mean daily flow and level record for all gauges within the sub-catchments
3.3	Annual maximum flow values derived from appropriate flow record
3.4	Flood level records (if exist) for as many flood events as possible
3.5	Rainfall records for all rain gauges within the study catchments
3.6	Rainfall depth-duration-frequency curves for study area

[30] All necessary datasets are available for the target basins or will be collected as part of project implementation.

3.7	Rating equations and spot gauges (if available) for all flow and level gauges within the catchment.
3.8	Temperature data
3.9	Precipitation
3.10	Snow cover
3.11	Snow water equivalent
3.12	Solar radiation data
3.13	Wind speed data
3.14	Relative humidity data
3.15	Soil moisture data
4	**Geologic data**
4.1	Geologic Mapping, 1:50,000 scale surficial geologic mapping of sub-basins
4.2	Geologic Cross Sections, 1:50,000 scale geologic cross section of sub-basins
4.3	Geophysical Profiles, 1:50,000 scale deep geophysical profile of sub-basins
4.4	Geologic Boring Logs any scale geologic boring log of deep wells
4.5	Regional Geologic Map, 1:500,000 scale regional geologic map of sub-basins
5	**Groundwater Data**
5.1	Groundwater Map - Basin, 1:200,000 or larger contours of groundwater levels
5.2	Groundwater Levels - Wells, location, elevation of wellhead, depth to water
5.3	Locations Well Fields, locations of field, number of wells, production
5.4	Average Annual Withdrawal - Wellfields average annual withdrawal - each well field
5.5	Average Decline in Groundwater Level average annual groundwater decline in sub-basins
5.6	Locations of Large Municipal Wells locations of wells, number of wells, production
5.7	Average Annual Withdrawal - Municipal average annual withdrawal, major municipal wells
6	**HPP Reservoir Operation Data**
6.1	Map showing location of all existing dams and HPP installations in the sub-basins
6.2	map showing location of all proposed dams and HPP installations in the sub-basins (with details of their intended size, capacity etc.)
6.3	Any information of storage capacity of each dam (design capacity and current capacity)
6.4	Any information related to the management of dams' safety from a government perspective
6.5	Any previous studies related to flood risk from dams
6.6	Historical record of reservoir water level
6.7	Historical record of reservoir discharge
6.8	Reservoir operation rules and operating curves
6.9	HPP maintenance and emergency response plans (floods/dam breach)
6.10	Hydrological assessment of inflows from upstream catchments taking account of all precipitation types, magnitude etc., what is the standard flood return period used for the design for dam spillway capacity for dams of different categories (PMF, 1 in 10,1000 year, 1 in 1,000 year etc.) to prevent overtopping
6.11	Calculation of the routed design flood hydrograph through a representation of the reservoir (using Depth-volume relationship of the proposed reservoir), with the outflow structures (sluice gates, weirs etc.) fully represented
6.12	Assessment of the ability of the dam outflow structure to pass floods of different sizes without overtopping
6.13	Assessment reports of dam geotechnical stability
6.14	Assessment of risk of breaching and associated inundation
6.15	Climate Change consideration used in dam operations and risk assessments
6.16	National technical standards for dam design and risk assessment
7	**Torrents Modelling Data**
7.1	Maps of erosion
7.2	Cadastre of torrential basins

3.7.5 Damage and Loss Accounting for Flood Risk in B&H

3.7.5.1 Existing damage and loss data collection methods and procedures

Current damage loss and data collection methods in B&H are based on Law on Protection and Rescue defined in both entities, RS and in FB&H. The both laws on similar way prescribe Instruction on Unique Methodology for Damage Assessment Caused by Natural Disasters. The methodology defines direct and indirect damage assessment, and assessment of the damage caused due to implementation of the activities of protection and rescue of the population. Damage assessment is implemented by the federal, cantonal and municipal commissions (in FB&H) and by republic and municipal commissions (in RS). These commissions are proposed by civil protection at level of governance unit (entity, canton, municipality). Also, methodology defines methods and principles of damage assessment in details including prices, forms and reports. (official form for damage assessment in FB&H http://fucz.gov.ba/download/procjenesteta/obrasci/obrascisauputstvom.pdf). It is important to note that water depth in flooded facilities is not anticipated to be recorded during the damage assessment.

The common procedure of damage assessment anticipates that citizens claim damage to their local administration, with precondition that mayor has proclaimed state of natural disaster for the specific event(defined by law). Local community forms the commissions that assess damage in accordance to received claims. Based on data collected the commission prepares summarized report and inform local assembly on specific damage. The assembly than can decide to provide financial support to most vulnerable, poor citizens that suffered damage. Damage compensation is usually funded by local budgetary reserves that are usually very minimal, but also it happens that local community is not able to compensate damage, even to the poorest. In the case of catastrophic events of larger scale, the local community can request support for damage compensation from higher governance units such as cantons and entities' governments. The information on assessed damage is not systematically provided to higher government level nor civil protection HQs or statistic agencies.

The most systematic damage assessment in B&H in recent years, has been implemented after floods 2014. Commissions entitled for damage assessment where systematically trained to apply defined methodology, for the first time in some parts of B&H. The data collected and damage reports where used for damage compensation by local governments, funds collected from donors, or loans.

3.7.5.2 Existing damage and loss accounting data base

In B&H does not exists unique data base of loss and damage caused by natural or other disasters. After floods in 2014 Government of Republika Srpska designed very simple data base at entity level that accounted damage of individual households after May and August floods. The data base has not been updated since then, but it is operative.

3.7.5.3 Planned activities for damage and loss accounting

In 2018 the Council of Ministers of B&H adopted ''Information on the beginning of the process of implementation, reporting and monitoring of the Sendai Disaster Risk Reduction Framework 2015 – 2030''. Within this information the Council of Ministers entitled relevant B&H institutions and bodies to ensure the implementation and monitoring of the Sendai Disaster Risk Reduction Framework. The Ministry of Security of Bosnia and Herzegovina is obligate to coordinate all activities, specifically harmonization/alignment of risk assessment methodologies in Bosnia and Herzegovina, methodology of damage assessment, introduction of DesInventar database for loss and damage data collection and risk mapping through the regional atlas and nominate focal points for reporting, in cooperation with the competent entity institutions and Brčko District.

At this moment there is no information that implementation of defined activities started.

4 DETAILED DESCRIPTION OF THE STUDY AREA – River Basins of B&H

4.1 River Basins of B&H

Bosnia and Herzegovina is divided into two entities – Federation of B&H, Republika Srpska - and one self-governing administrative entity – Brcko District which is part of both entities. The Federation is further divided into 10 cantons, which are then subdivided into municipalities while Republika Srpska is divided directly into municipalities. There are two major river basins – Sava and Adriatic Sea river basin. 75.7% of the overall area of B&H (38,719 km^2), drains to the Sava River Basin (shared with 5 other countries - Slovenia, Croatia, Serbia, Montenegro and Albania), while the remaining 24,3% (12,410 km^2) drains to the Adriatic Sea basin. 45% of the Sava River Basin in B&H (17,506 km^2) belongs to the Federation of B&H, and 21,213 km^2 (55%) to Republika Srpska. 68% of Adriatic Sea basin in B&H belongs to Federation of B&H, while 32% belongs to Republika Srpska.

The target sub-basins of the two main river basins are Vrbas, Una-Sana, Bosna and Drina rivers in the Sava basin and Neretva and Trebišnjica rivers in Adriatic Sea Basin.

4.1.1 Sava watershed and sub-basins in B&H

The Sava River Basin in B&H accounts for ca. 38,288 km^2 or 74.9 % of the total B&H area, and 39.2% of the total Sava River Basin (97,713 km^2). The Sava River Basin in B&H is created by the main river basins of Una, Vrbas, Ukrina, Bosna Rivers and the direct Sava River Basin.

Danube Basin	Basic basins in B&H	Distance from Sava mouth [rkm]	River basin area [km^2]	Sava RB area in B&H [km^2]	Sava RB area in B&H [%]
Sava River	Una	507	9,368	8,137	8.33
	Vrbas	419	6,274	6,274	6.42
	Ukrina	373	1,500	1,500	1.54
	Bosna	306	10,810	10,810	11.06
	Drina	175	19,570	7,068	7.23
	Direct Sava Basin	-	3,786	3,786	3.87
	Korana and Glina (Kupa)	-	-	713	0.73
Total basins in B&H		332	51,308	38,288	39.18
Other basins in Sava RB		-	46,405	59,425	60.82
Grand Total:		-	**97,713**	**136,001**	**100.00**

The following maps show the Sava sub-basin outlined as dark blue polygons. Where there is a hashed shading over the basin, it denotes the portion of the basin in FB&H as can be seen from the entity lines.

Figure 4-3: Overview of Ukrina River Basin

Figure 4-4: Overview of Bosna River Basin

Figure 4-2: Overview of Una-Sana River Basin

Figure 4-1: Overview of Vrbas River Basin

Figure 4-5: Overview of Drina River Basin

4.1.1.1 Direct Sava River Basin in B&H

The **Sava River** enters B&H at the Una River mouth (507 km from the Sava mouth) and exits at the Drina river mouth (175km from Sava mouth), measuring a total of 332 km. Sava River forms a natural border with Croatia, Serbia on the left river bank, and border with B&H on the right river bank. Hence all B&H tributaries of Sava River are right tributaries. Along its entire course through B&H (332 km), it creates the state border between B&H and Croatia and B&H and Serbia.

Along the Sava River in B&H there are 175km (52.7 % of the total river course length), of dikes for protection against Sava River flood waters to protect the most fertile agricultural RS and FB&H land in this area. There are significant flood protection systems against external (upland) and inland waters, comprised of dikes, canal network and drainage systems for protection against external and inland waters and systems of 23 pump stations (Total capacity of 135.25 m^3/s) for pumping the external and inland waters out to the Sava River. On the right bank of the Sava River, the flood zones are divided into seven polders, so called „kazete": Dubiĉka ravan, Lijevĉe polje, Srbaĉko-Noţiĉka ravan, Ivanjsko polje, Odţaĉka Posavina, Srednja Posavina and Semberija. The polders are independently protected against floods by levees. The sections without protection are still inundation zones with a limited retention function. The 23 pump stations and the system of canals (main boundary canals for external waters and the network of the main canal for collecting inland waters) support the drainage and the flood protection. Una, Vrbas and Bosna Rivers are all protected streams, up to the backwater limit of the Sava river, but many settlements on the tributaries are not protected. Drina River has smaller flood prone areas due to its steep topography and reservoirs. The construction of the Mratinje reservoir on the Piva River (tributary of the Drina in Montenegro) had a positive impact of decreasing the flood risk of the settlements along the Drina.

The main right tributaries of Sava River in B&H, the Drina River (175 km from the mouth of the Sava River), Bosna River (306 km), Vrbas River (419 km) and Una River (507 km) and Ukrina are discussed below.

4.1.1.2 Bosna River Basin

The river **Bosna** is the third longest river in Bosnia and Herzegovina and is considered one of the country's three major internal rivers (catchment area of 10,457 km^2). The Bosna River Valley is the country's industrial centre and home to close to a million people, as well as the location of several major cities. The river's biggest tributaries are the Željeznica, Miljacka, Fojnička, Lašva, Gostović, Krivaja, Usora, and Spreča rivers.

Bosna originates from karst springs in village Vrutci nearby Ilidţa in Igman mountain plinth on 494.7 m a.s.l. Its source is at the spring Vrelo Bosne, at the foothills of the Mount Igman, on the outskirts of Sarajevo, capital of Bosnia and Herzegovina. Significant tributaries in upper Bosna River course are Ţeljeznica, Miljacka, Zujevina, Dobrinja, Stavnja, Fojnica and Lašva River. Total area of upper Bosna River course is 4,120 km^2. The entire upper Bosna River course is 77.5 km long, with total fall of 174 m. Bosna riverbed slope varies in range of 1.5 – 2.2 m/km. In the heavily populated valleys in this part of the river course, the towns Sarajevo, Visoko, Kakanj and Zenica have been developed. Ţeljeznica River, that is considered as the Bosna River main course extension, is performing drainage of Jahorina, Treskavica and Bjelašnica Mountain. In its middle course, Bosna River is characterised by rapids at several points. Average slope is 1.45 m/km. Significant Bosna River tributaries in the middle course are: Gostović, Krivaja and Usora River. The largest towns in this part of the river basin are: Zavidovići, Ţepĉe and Maglaj. The lower course of Bosna River is the section from Doboj to the mouth into the Sava River, with total length of 76.3 km. On the territory of Republika Srpska, Bosna River is a large lowland river. Total difference in elevation from the left tributary Usora River mouth (139 m a.s.l.) to the Bosna River mouth is ca. 62.6 m, and average riverbed slope is ca. 0.82 m/km. The following towns with important industrial capacities have been developed on this part of the Bosna River course: Doboj, Modriĉa and Šamac. The section from Modriĉa to Šamac is a natural retention for Sava and Bosna River flood waters. Due to that fact, the flood protection dikes were constructed along the entire river course - a length of 40 km on the both banks of the Bosna River. Inland waters are being pumped into the Bosna and Sava River. The Bosna flows through a number of cantons. From its starting point in the Sarajevo Canton, it flows through Zenica-Doboj Canton, Doboj Region, and Posavina Canton, in that order.

Geologically the basin is extremely diverse, with distinct karst areas in its western part resulting in undefined catchment borders. The Bosna River headwaters are defined by the Vrelo Bosne spring with its karst setting and with small surface stream. Downstream, the Fojnica River and the Lašva River are its left-bank tributaries, while the Krivaja River joins it from the right at Zavidovići. At Doboj, the Usora River flows into the Bosna from the left side, and the Spreča River from the right. In the section between the Miljacka and Krivaja tributaries, there are many small streams flowing into the Bosna from the right with catchment areas of up to 200km^2, and a total catchment area of approx. 1700km^2. The river basin is 56% forested.

4.1.1.3 Drina River Basin

The **Drina** River Basin extends from the central part of the Dinaric Mountains to the Pannonian plain. The Drina river - the largest right tributary of the Sava River, with the total river basin surface of 19,570 km^2 in B&H- originates at the border of Bosnia and Herzegovina and Montenegro where the Piva and Tara rivers converge, near the town of Šćepan Polje, flows northwards, and terminates at the confluence with the Sava river. The length of the Drina River is 346 km, of which 220 km define the border between Bosnia and Herzegovina and Serbia. The basin's surface area of 20,320 km^2 is almost evenly distributed between three of the four riparian countries, covering the northern half of Montenegro (32% of the river basin), part of the east of Bosnia and Herzegovina (36% of the river basin), part of the west of Serbia (31% of the river basin) and a very small part of the North of Albania (less than 1% of the river basin).

4.1.1.4 Vrbas River Basin

The **Vrbas** River basin has a total area of the VRB is 6,386 km^2 which is 12.5% of the entire B&H territory, 63% of which is located in the Republica Sprska (RS) and 37% in the Federation of Bosnia and Herzegovina (FB&H). The headwater of Vrbas belongs to the highest range of the Dinaric Mountains. The rest is mostly developed on the north-eastern slope of the Dinaric Mountains. The Basin is typified by mountainous relief, accounting for 90% of land area mainly located in the upper and middle sections. The remaining 10% of a lower, more mature river plain mainly located at Lijevče Polje and the Skopaljska Valley. There are relatively little lowlands (about 600 km^2) and they are located mainly in the northern part of the basin, at the mouth of Vrbas to River Sava, and in smaller part in narrow valleys along the main stream and tributaries. The most important tributaries are: Pliva, Ugar, Crna Rijeka and Vrbanja which are in the central part of the basin and which drain significant karstic plateaux. In the upper and central part of the basin there are a larger number of karstic springs suitable for water supply, and the most important among them are the springs of Pliva and Janj. The karstic geology of these major tributaries means that flooding could be triggered by a combination of long-duration rainfall filling up groundwater stores which will eventually result in soils having low rainfall acceptance capacity, resulting in flooding.

The Upper course of spring to Han Skela (km 145.1) has an average riverbed slope of 7.8 m/km. This section is characterized with big falls and low water quantities. Middle Vrbas River course is the section from Jajce to Banja Luka, with total length of 72.5 km, total difference in elevation of ca. 165 m, with average longitudinal slope of the riverbed of ca. 2.27 m/km. There are HPP Boĉac (RS), HPP Jajce I (FB&H), and HPP Jajce II (FB&H). Those accumulations have a significant impact on the hydraulic regime of the water course. Lower Vrbas is the section from Banja Luka to the Vrbas River mouth (Srbac), in total length of ca. 70km, with total difference in altitude of ca. 65 m and average riverbed fall of 0.9 m/km. At this section, Vrbas has all characteristics of a large lowland river. In this area, several towns developed, as follows: Banja Luka, Laktaši and Srbac (mouth) with significant industrial structures. Section from Povelić – Razboj tributary mouth (15 km) to the Vrbas River mouth in the Sava River is used as natural retention for flood waters of Vrbas and Sava River, so that dikes are constructed at this section on the both river sides. At the Vrbas River right bank, at this section the reclamation system Srbaĉko-Noţiĉka Ravan is constructed for protection against inland and external waters (6,100 ha). Inland waters are partially pumped by pump station Povelić into the Vrbas River and partially by the Ina pump station into the Sava River.

The annual average precipitation is 1050 mm, the total precipitation volume is 6704.3x106 m^3 and the total runoff is 4062x106 m^3. This gives an average runoff coefficient for the entire basin of 0.60 and an average discharge of 128.8 m^3/s. The upper streams of the Vrbas have extremely torrential regimes, with a very short time of concentration of the flood wave and extremely large runoff modules (1–1.5 m3/s km^2.

4.1.1.5 Una-Sana River Basin

Una River has a catchment area of 9,368 km^2, and is the third biggest Sava River tributary in B&H. Una River spring is in the Suvaja mountain plinth, 214.7 km, with spring level at 420 m a.s.l. Total difference in elevation from the spring to the mouth is 335 m (85.0 m.a.s.l), and average river bed slope is 1.56 m/km. Main left Una River tributaries are: Klokog and Ţirovac. Main right Una River tributaries are: Unac, Krušnica and Sana, Mljeĉnica and Moštanica River. Ca. 35.7 % of the Una River Basin (3,346 km^2) is located on RS territory, ca. 49.3 % (4,613 km^2) on FB&H territory and ca. 15.0 % (1,409 km^2) on HR territory. Una River Basin has a moderate continental climate with average annual precipitation of 1,245-1,400 mm, total precipitation of 11,663 hm^3 and average runoff of 6,824 hm^3.

The spring area of Una River consists of several springs in karst formations. Main springs are Unsko Vrelo and springs Velika Neteka and Mala Neteka, in the area south from the Suvaja Mountain. First important tributary is Srebrenica River with mouth immediately under Suvaja Mountain. Downstream of the waterfalls at Martin Brod lies the mouth of the right Una River tributary - Unac River. From Martin Brod to Bihać, Una River has no significant tributaries, except for springs in karst area, nearby Kulen Vakuf. At this section, Una River is characterised by several natural cut-off trenches, thus forming waterfalls and cascades of various sizes e.g. Strbacki Buk which is a big waterfall. The upper course (from the spring to Bihać) is characterised by very steep slopes. Total fall from the spring to the water meter station Bihać is 151.8 m, and the length of this section is 66.8km. On the middle course, from Bihać to Novi Grad, Una River is an upland-lowland river with a significant riverbed slope. Total slope from Bihać to Novi Grad is 104.0 m at the length of 71.0 km. North of Bosanska Krupa, Una River has its right tributary, Krušnica. From Novi Grad to the mouth into the Sava River, Una River has all the characteristics of a lowland river, with total fall of 29.3 m at the length of 71.5 km; average slope is 0.41 m/km. The largest right tributary to the Una River - Sana River discharges in Novi Grad, and a little lower from Novi Grad, there is a left tributary Ţirovac. From Dubica to the Una River mouth into the Sava River, represents a part of reclamation system Dubiĉka ravan, so that flood protection dikes are being constructed on the both rivers banks, at the length of ca. 12.5 km, for protection against Una and Sana River flood waters.

The **Sana** originates from four springs gushing into a karst plateau of the Bosanska Krajina, near the villages of Pečka and Mrkonjić Grad, not far from the city of Šipovo. After a length of about 1.5 km, these streams meet to form the Sana, which then passes near the town of Ključ in a south-north direction that the river maintains for many kilometres. The river later combines with the waters of its main tributary, the Sanica River and then passes through Sanski Most and combines with the river Zdena. The Sana goes through the city of Prijedor, where the Sana combines with the Gomjenica river. The Sana then directs its course to the west until Novi Grad where it flows into the Una river as a tributary. Between Prijedor and Novi Grad, the river serves as a natural border between the two towns of Potkozarje and Podgrmeč.

4.1.1.6 Ukrina River Basin

Ukrina River is formed by the merging of the Mala Ukrina (Small Ukrina) and Velika Ukrina (Great Ukrina). The length of Ukrina of origin Great Ukrina (Lukavac) is 119.3 km, and the surface area of the basin is 1504 km². Its mouth is 3 km north from settlement Koraće and 10 km southwest of Brod.

4.1.2 Adriatic Sea watershed in the Federation of B&H

Figure 4-6: Overview of Adriatic sea Basin

4.1.2.1 Neretva River Basin

The Neretva is the largest karst river in the Dinaric Alps in the entire eastern part of the Adriatic basin. The total length is 230 km, of which 208 km are in Bosnia and Herzegovina (the upper part of the basin), while the final 22 km are in the Dubrovnik-Neretva County of Croatia (the lower part and river mouth). The upper course of the Neretva river, called the Upper Neretva (Bosnian: Gornja Neretva), includes vast area around the Neretva, numerous streams and well-springs, three major glacial lakes near the river and even more scattered across the mountains of Treskavica and Zelengora in the wider area of the Upper Neretva, mountains, peaks and forests, flora and fauna of the area. Upper-Neretva is considered to be rich in natural and cultural heritage representing rich and valuable resources of Bosnia and Herzegovina as well as Europe.

Neretva is a river with significant hydropower potential, and it is also an important water source for water supply, irrigation and flood protection.

The predominant karst geology of Neretva River basin makes it very difficult to determine the exact boundaries of the river basin. The length of the river is 240 km, and the catchment area covers the surface of about 11,800 km^2. The river has numerous tributaries, affecting the main basin either directly on the surface or indirectly through groundwaters. The main level of the river basin is at about 250 meters above sea level.

The climate characteristics of the river basin vary with the distance from the sea. The climate is Mediterranean in the lower parts, closer to the sea, while the middle part has a continental climate, and the upper part has the mountain climate. The average rainfall is 1.650 l/m^2 and varies between 1500 and 1800 l/m^2. The highest rainfall is in November, and the lowest is during the summer, in July. The temperatures vary between -29 and +43 °C, and annual evapotranspiration is 500-900 mm.The average runoff is 269 m^3/s, while the minimum runoff is 44 m^3/s and the maximum runoff is 2179 m^3/s.

The main features of this river include large basin surface, extremely heterogeneous basin, large number of tributaries, strong impact of karst on the entire basin, causing a significant difference between the orographic and hydrogeological basin drainage area and the pronounced deterministic influence on the flow caused by numerous hydropower plants.

Neretva River is created by several strong springs in Republika Srpska, and not far away from there, downstream from the settlement Ulog, Neretva river enters the territory of the Federation of B&H. The main tributaries of the Neretva until Konjic are the rivers: Ljuta, Rakitnica, Šištica (rises from Boračko Lake), Bijela and Trešanica rivers after which Jabaničko lake gets formed. In its upper stream, all the way to Konjic, the course of the Neretva River is a stochastic process, which starts changing directly downstream the town of Konjic.

In the middle course of the Neretva River, the flow is a stochastic-deterministic process, caused by hydropower plants: HPP Jablanica, HPP Rama, HPP Grabovica, HPP Salakovac and HPP Mostar. The low water regime is conditioned by the operating regime of the hydropower plants. The impact of the hydro powerplants is reflected in the fact that low flows are higher than in the natural flow regime (which is important for the dry season of the year), and the waves of high water are significantly reduced by the influence of artificial reservoirs or by proper use of the storage space.

The tributaries of Neretva River are watercourses: Kraljušnica, Baštica, Neretvica, Rama, Doljanka, Bijela, Drežanjka, and the lakes Jablaničko and Rama (artificial lakes) and Blidinje Lake (natural).

The lower course, downstream from Mostar, is under the strong influence of karst. Characteristics of this part of the basin are a significant number of strong karst springs (on the tributaries and in the riverbed of Neretva), water inflow to the springs from the karst fields by underground flow, additional deterministic influences of HPP Čapljina (Krupa), HPP Peć Mlini (Trebižat) and numerous irrigation canals. All tributaries of the Neretva River in this part of the basin come from the karst fields on the left and right sides of the Neretva River flow. The tributaries include: Jasenica (these are the waters of Lištica River and the waters of smaller watercourses ending in the Mostarsko Blato), the tributary Buna (water from Nevesinjsko polje), the tributary Bregava (water from Dabarsko polje and one part of Fatničko polje), tributary Trebižat (originates from Imotsko polje). In addition, there are strong karst springs along the tributaries: Klokun, Vrioštica, Grudsko vrilo, Lištica spring, Buna and Bunica springs.

4.1.2.2 Trebišnjica River

Trebišnjica River has a total length of 187 km, of which 96.5 km flows above the ground and the remaining length, flows underground. It is one of the longest sinking rivers in the world.

The Trebišnjica originates as two streams from the Lebršnik and Čemerno mountains - the Mušnica, which flows from the eastern to the western border of the Gatačko Polje ("Field of Gacko") (from the mountain Lebršnik to Bjelašnica, through Lake Klinje and several settlements before it sinks into the karst in the

Cerničko Polje ("Field of Cernica", west of Baba Mountain at the village of Cernica under the name of Ključka rijeka (River of Ključ), and the Gračanica, which flows from the Čemerno mountain also into the Gatačko Polje, next to the villages of Bahori and Gračanica, before it meets the Mušnica near Srđevići. Both streams are characterized by very sharp, almost erratic bends and changes of direction. The river briefly re-appears in the Fatničko Polje (Field of Fatnica) under the name of Fatnička reka (River of Fatnica), only to sink again after a short flow above the ground.

After a total underground flow of some 30 km, the waters of the sinking *Fatnička reka* re-appear as a series of very powerful cave springs near the town of Bileća, converge to form the Trebišnjica, the most important river in eastern Herzegovina. The river flows to the south, through the depression of Miruša. On the southernmost part of the depression, the river is dammed by the Grancarevo Dam at the village of Gornje Grančarevo and completely flooded upstream by the artificial Lake Bileća. Nearly all of the eastern bank of the lake belongs to Montenegro.

The Trebišnjica turns west between the villages of Donje Grnčarevo and Lastva into the Trebinjsko polje (Field of Trebinje), being dammed again at Gorica, with a small reservoir. The river continues to the west following the southern slopes of Bjelasnica mountain, through the town of Trebinje and villages of Dražin Do, Tvrdoš, Gornja Kočela and Donja Kočela, and enters the largest karst field in the Balkans, Popovo Polje (Priest's Field).

In Popovo Polje, the Trebišnjica used to sink right after the city of Trebinje. In the field, the river turns northwest, next to the villages of Staro Slano, Đedići, Dobromani, Žakovo, Tulje, Sedlari, Grmljani and Zavala, near the Vjetrenica cave, the largest in Bosnia and Herzegovina. The river then turns north, curves between the villages of Dvrsnica, Orašje, Čavaš and Turkovići and in the lower Popovo Polje, near the Croatian border, sinks into the several big sinking holes (most notably, the Doljašnica and Ponikva holes).

The waters of the Trebišnjica from the Popovo Polje, re-appear as three separate outflows – 1) The powerful spring of Čapljina, in the area of the lower Neretva river, in Hercegovins; 2) a series of underwater springs (called vrulje, "boiling water") near the small sea harbor of Slano in Croatia, northwest of Dubrovnik, and 3) after some 20 km of underground flow, the Trebišnjica re-emerges as the powerful spring in the great cave near Gruž, in the western part of Dubrovnik where it is called the Ombla River (Umbla; or Dubrovačka rijeka, "River of Dubrovnik"), is only 30 m long but very wide and powerful (average discharge is 24 m3/s (850 cu ft/s). The lower part of the river is flooded by the sea (Croatian: draga), 30 m deep and navigable for 3.7 km. Several suburbs of Dubrovnik (Mokošica, Komolac, Rožat, Prijevor, Lozica) are located alongside the river. Water from the river has been used by the Dubrovnik waterworks since 1437.

The total drainage area of the Trebišnjica covers 4,926 km^2, of which 600 km^2 is shared with the Neretva drainage area (the spring of Čapljina). The drainage area of the central, longest part of the river covers 2,225 km^2.

Significant regulatory works on the Trebišnjica were established during the former Yugoslavia. In 1965 the river was dammed at the village of Gorica, creating artificial lake as an auxiliary water basin for the future hydro-electrical power station (HE) Trebinje. The water of the lake is conducted by two parallel, 16 km long, hydro-energetic tunnels into the Croatian village of Plat, on the Adriatic coast, near the Cavtat, where HE Dubrovnik is constructed. In 1967 the dam for HE Trebinje (or Grnčarevo) was constructed, creating the large Lake Bileća (or Lake Miruša; area 33 km^2, altitude 400 m, depth 104 metres, volume 1,300,000,000 m^3 (4.6×1010 cu ft)). The old Arslanagić bridge was deconstructed and moved to Trebinje. Together with HE Dubrovnik, two power stations have a power of 422 MW and capacity for production of 2.19 billion kWh yearly.

In 1979 the HE Čapljina was completed, after an 8 km long hydro-energetic tunnel and two reservoirs (with volume of 12,500,000 m^3) began operating. The power station has a power of 430 MW (two aggregates of 215 MW) and capacity for 619 million kWh yearly. In 1979, to prevent the sinking of the water through the smaller sinking holes in the Popovo Polje, the riverbed was concreted for a length of 67 km.

5 HYDROMETRIC MONITORING NETWORK

5.1 INTRODUCTION

5.1.1 History of hydrometric monitoring network in FB&H

5.1.1.1 Hydrometric Network Pre-war (pre-1992)

The hydrometric network in the Sava River Basin in FB&H and Republika Srpska has a long history as it was established in the middle of the 20th century as part of the hydrometric network introduced at the level of the former Republic of Bosnia and Herzegovina. The measurement profiles are defined on the most important watercourses and their main tributaries on which quantitative data were monitored – through water level markers, limnographs, cable cars, as well as qualitative water data.

Observation, collection and analysis of water level data at that time was carried out by the Hydrometeorological Institute of Sarajevo of the Republic of Bosnia and Herzegovina, and the results were published through yearbooks and thus were available to a wider public. According to the data from the Water resources management framework of Bosnia and Herzegovina of 1994, until 1992 there were 66 hydrological and 28 meteorological stations throughout B&H. Groundwater monitoring, except for Semberija, as well as standing water (lakes and reservoirs) was not covered by the program of regular control. In the period 1992-1995 the aforementioned hydrometric network was completely destroyed and disabled for carrying out any kind of monitoring.

5.1.1.2 Hydrometric Network Post-war (post 1992)

In the B&H, right after the end of the war, the activities were initiated on the reconstruction of the hydrometric network and the establishment of monitoring. The starting point was almost from the scratch, so the establishment of water monitoring also had to start from the beginning. There was a clear lack of adequate maps, lack of field observations and measurements.

Activities were initiated on organising field observations (on certain profiles), water level meters have been gradually renewed, and the very basic monitoring started – water level monitoring. With the help of international donors, the relevant institutions - "Water Agency for Sava River Basin" Sarajevo (AVP Sava) and Federal Hydrometeorological Institute in Sarajevo as well as Public Institution Vode Srpske, Bijeljina and Republic Hydrometeorological Institute in Banja Luka – gradually re-established intensive monitoring although with still limited networks. On all major profiles (watercourses) the water level monitoring systems were established, and the first automatic stations (for water level measurement) were established as well.

5.1.1.3 Current situation

AVP Sava, together with other water sector institutions, started the activities in 2003 aimed at modernising the existing monitoring system. It initiated the development of a new data collection system from remote locations, monitoring surface water levels both quantitatively and qualitatively.

Within the project of the Spanish Government, the hydrological network was partially restored on the sub-basin of the Bosna River. Further reconstruction was continued through a series of projects and it expanded across the entire water Sava River basin in the FB&H (EC, the Government of Switzerland, the Agency through its Annual Plans and Financial Plans). The priority of reconstruction of water measurement stations was given to the sites on which the water measurement stations were already installed and from which the hydrological parameters were monitored for a number of years. The reconstruction was carried out following the latest technical advancements in hydrometric monitoring, i.e. automatic hydrological stations were installed which provide data on water levels to the Water Information System in real time.

In addition, in order to meet the requirements of B&H aimed at its accession to the European Union, surface water monitoring is also being adapted and developed in order to respond to these requirements. It is important to mention that B&H became part of international monitoring systems (network) with the aim of data and information exchange, such as EIONET network, TNMN network and recently the EuroWaterNet water monitoring network as well.

In addition to data exchange through international monitoring networks, data exchange is performed at international, regional and national level for the needs of early warning system and flood forecasts. Delivery of measured hourly data is done in EFAS, Sava FFWS, Danube HIS systems.

This kind of automated monitoring allows data access to a wider range of users through internet technology. By developing the web portal www.voda.ba in 2004, the Agency has enabled, through various applicative solutions, access to the server with a central database to different users of the system, as well as to the general public.

5.1.2 Institutional arrangements for hydrometric monitoring in B&H

5.1.2.1 Hydrological monitoring overview

Hydrological monitoring of watercourses includes water measurement – water level, flow speed, flow rate, geometry of measuring profile and water temperature measurement. The monitoring network is designed to provide a coherent and comprehensive overview of the surface water quantitative status and other hydrological parameters (e.g. water temperature), as well as to provide forecasts for long-term changes and trends, based on the data.

Continuous data collection through automatic stations is of paramount importance for providing continuous insight into water level changes, including continuous monitoring of high flows as well as for the registration of extremely low water levels in watercourses. The collected data are used in a number of ways, in real time, for monitoring and analysis of high flow waves during floods, and subsequently for numerous hydrological analyses, water regime definition, water balance, definition of environmentally friendly flows, etc.

Hydrological monitoring of surface waters in the Sava River Basin in the FB&H is performed pursuant to Article 156, paragraph 1, item 2 of the FB&H Water Law (FB&H Official Gazette,70/06), Rulebook on the establishment and management of the water information system (FB&H Official Gazette, 77/09), as well as the EU Water Framework Directive (WFD) – Monitoring Guide, within the Water Information System and Monitoring Unit, Water Management Division of the *Water Agency for Sava River Basin* Sarajevo (hereinafter: AVP Sava). Competence of AVP Sava regarding hydrological monitoring is linked to all watercourses of the Sava River Basin in FB&H through monitoring of hydrological parameters and performing necessary analyses.

At the moment monitoring network in Republika Srpska consists of 33 automatic hydrological stations. 15 stations are under the RHMS RS, 6 PI Water Srpska agency and 12 in Trebišnjica river basin under the HPP Trebišnjica. In Federation of B&H at the moment there is cc 100 automatic hydrological stations. Most of them are under the jurisdiction of the Agency for water management for Sava river basin and Adriatic sea.

From all automatic hydrological stations in RHMS RS data transmission is via GPRS, automatically, every 30 minutes. On some stations is defined emergency water level and data logger has possibility to automatically generate and send warning SMS to person in charge about water level. Regarding data exchange, RHMS RS is one of the signed parties on “Policy on the data exchange in Sava river basin”. Regarding that document was developed Sava Hydroinformation System (Sava HIS) under the “International Sava river basin commission. Through that system via FTP data for entire Sava river basin from all stations except HPP is exchanged in real time available via username and password.

5.1.2.2 Meteorological Monitoring overview

The Federal Hydrometeorological Institute oversees meteorological/weather monitoring in FB&H. It should be noted that AVP Sava, within its own monitoring network, also owns a number of meteorological/weather stations, however with a smaller number of parameters under observation. These are precipitation stations with the following parameters: precipitation, temperature and humidity. Meteorological/weather stations also exist within certain legal entities such as hydropower plants, farms, forest management administrations, etc.

In Republika Srpska, Republic Hydrometeorological Institute in Banja Luka is responsible for collecting and dissemination of all activities regarding monitoring of meteorological data. All data is gathered from precipitation stations that measures precipitation, air temperature and relative humidity), as well as from meteorological stations (Precipitation, air temperature and relative humidity, pressure, solar radiation, wind speed and direction 2m and 10 m high).

5.1.3 Long-term strategic for hydrometric monitoring management in B&H

5.1.3.1 Sava River Basin in Federation of B&H

Although there has been significant improvements in hydrometric monitoring since the 1990's there is still work to be done to establish the optimised hydrometric network in all river basins.

With regard to monitoring in sub-basins of the Sava River Basin in FB&H the main identified shortcomings are provided below, as well as recommendations for their overcoming:

- Water monitoring activities are not yet sufficiently aligned at the level of the Entities, at the level of institutions involved in monitoring in the water sector and other institutions that are in need of monitoring outside the water sector (e.g. electrical utility companies), which should be resolved by signing the protocol on data exchange;
- Insufficiently developed groundwater monitoring, which is currently comprised of 11 measuring gauges, while a study identified that 20 measuring profiles of the most significant karst springs is required. Lack of financial resources to optimise groundwater network which requires investment value for their establishment of an estimated BAM 400,000);
- Lack of financial resources for maintenance of the equipment and continuous functioning of the established monitoring system. As an example, it is stated that AVP Sava annually allocates funds in the amount of BAM 500,000.00 for maintenance of the monitoring stations in its ownership, while the FB&H Hydrometeorological Institute, which is a institution with no possibility of collecting extra-budgetary fees such as water fees, has no possibility of securing funds for maintaining its monitoring stations;
- Lack of operational and specialized expert staff;
- It is necessary to improve the spatial coverage of meteorological stations, i.e. to increase the number of these stations on the main sub-basins;
- Ensure that meteorological stations provide data in real time on hourly basis;
- It is recommended to increase the number of profiles for flow rate measurement, including the establishment of Q-H curve, so that water level measurements can also be used to calculate the flow rates;
- For the purpose of considering the effects of climate change it is necessary to extend the time series of water measuring stations for the period from 1992 until the rehabilitation (on average 10-15 years), when the stations didn't work, by supplementing and expanding data from hydrological similar basins using correlations with water measuring stations from neighbouring countries (Croatia and Serbia).

Through the development of hydrological forecasting model, forecasting and decision making and preparation of the plan, guidelines, training programs for optimum management of multi-purpose reservoirs in the Neretva and Trebišnjica river basins, EPTISA, 2014[31], suggestions are provided for improving the monitoring and data exchange system.

In the present document a proposal was made to improve the monitoring system, which consists of a network of automatic meteorological stations in the Neretva River Basin. The density of the network of automatic meteorological stations is proposed, taking into account the currently existing stations. For the density of the networks, two phases are proposed depending on their importance. They are considered as new, important meteorological stations for inclusion in the automatic network, and therefore those that are located in the areas with the low density of the stations and with high rainfall are included in the first phase.

5.1.3.2 Republika Srpska

The needs for strengthening monitoring network in the catchment areas of Republika Srpska are defined in the Integrated Water Management Strategy of Republika Srpska. The most important conclusions under the Strategy pertaining to the establishment and strengthening of the monitoring network include:

- The collection, processing and data management system should be significantly improved until 2024. Inadequate organization and discrepancies between some applications within the system has resulted in automated data exchange from databases being disabled. In addition, there is a malfunction or incompatibility of equipment, specifically automatic measuring stations (although this situation has been greatly improved in the period since 2014 it requires further improvement). On the other hand, irregular maintenance of automatic measuring stations causes a gradual cessation of work of the remaining stations that are operating, which leads to a reduction in the volume, reliability and timeliness of watercourse monitoring data. Another problem in managing collected information is a complex and non-automated data exchange, or poor "communication" between the existing system applications.
- Based on the identified difficulties, it can be concluded that, in the collection, analysis and management of information, there is a need for constant updating in terms of hardware and software in order to monitor the development of information technology. In addition, it is extremely important that the installed measuring equipment and the accompanying systems are adequately maintained and serviced so that they can function properly. In this regard, it is necessary to pay more attention until 2024, both to maintenance and modernization of monitoring system and related applications in the information system.

5.2 Mapping, Overview and Detailed Analysis of the Gaps of the Existing Hydrometric Network

5.2.1 Existing hydrometric network

5.2.1.1 Meteorological monitoring in Republika Srpska

RHMZRS has a total of 18 automatic stations for measuring meteorological parameters (of which 11 are on the Vrbas river basin) while in the area of other sub-basins of Sava and Adriatic Sea which are in RS, there are 7 stations.

[31] Management of Systems under High Waters, EPTISA, 2014

Figure 5-1: Meteorological stations RS

Table 5-1: Existing Precipitation Stations

Ref. No.	Location/Name	Ownership	Basin
1	Šipovo	RHMZ	Vrbas Basin
2	Majevac (source of Pliva)	RHMZ	Vrbas Basin
3	Mrkonjić Grad	RHMZ	Vrbas Basin
4	Manjača	RHMZ	Vrbas Basin
5	Krupa on Vrbas	RHMZ	Vrbas Basin
6	Srbac	RHMZ	Vrbas Basin
7	Čelinac	RHMZ	Vrbas Basin
8	Kotor Varoš	RHMZ	Vrbas Basin
9	Donji Borojevići (Kneževo)	RHMZ	Vrbas Basin
10	Banja Luka (PMF)	RHMZ	Vrbas Basin
11	Krupa on Una	RHMZ	Una Basin
12	Mjecanica	RHMZ	Una Basin
13	Prijedor	RHMZ	Una Basin
14	Ribnik	RHMZ	Una Basin
15	Doboj	RHMZ	Bosna Basin
16	Kalinovik	RHMZ	Bosna Basin
17	Pale - Stambolčić	HPP	Bosna Basin

Table 5-2:

Existing Meteorological Stations

Ref. No.	Location/Name	Ownership	Basin
1	Banja Luka	RHMZ	Vrbas Basin

Table 5-3: Precipitation stations – in progress

Ref. No.	Location/Name	Ownership	Basin
1	Derventa	RHMZ	Bosna Basin
2	Prnjavor	RHMZ	Bosna Basin
3	Borja-Hajdučke vode	RHMZ	Bosna Basin
4	Modriča	RHMZ	Bosna Basin

Table 5-4: Meteorological stations – in progress

Ref. No.	Location/Name	Ownership	Basin
1	Sokolac	RHMZ	Bosna Basin
2	Han Pijesak	RHMZ	Bosna Basin
3	Banja Vrućica	RHMZ	Bosna Basin

5.2.1.2 Meteorological monitoring in FB&H

There are 14 classic meteorological stations that were established after the World War II. Currently, several international projects are underway working on strengthening the weather network. Trough Vrbas project 11 new automatic precipitation stations have been established. During 2019 trough IPA II project within Bosna river basin an additional 21 automatic weather/precipitation measuring stations has been installed.

Quality control of data collected on meteorological stations in the FB&H and filling of the time series is done by FHMZ. These data are published in meteorological yearbooks prepared by FB&H Hydrometeorological Institute in cooperation with water agencies.

The table below provides an overview of the meteorological stations in the Sava River Basin in the FB&H managed by Water Agency for Sava River Basin and the FB&H Hydrometeorological Institute.

Figure 5-2: Meteorological stations Sava basin in FB&H

Table 5-5: Meteorological stations in Sava River sub-basins in FB&H

No.	Station Name	Basin	Station Owner
1	CAZIN	Kupa	AVPS
2	VELIKA KLADUŠA	Kupa	AVPS
3	DRVAR	Una	AVPS
4	MARTIN BROD	Una	AVPS
5	BOSANSKI PETROVAC	Una	AVPS
5	KLJUČ	Una	AVPS
7	SANSKI MOST	Una	AVPS/FHMZ
8	LUŠCI PALANKA	Una	AVPS
9	BIHAĆ	Una	AVPS/FHMZ
10	BOS. KRUPA	Una	AVPS
11	RIPAČ	Una	FHMZ
12	SANICA	Una	FHMZ
13	GORNJI KAMENGRAD	Una	FHMZ
14	BOROVA RAVAN	Vrbas	FHMZ
15	PIDRIŠ	Vrbas	FHMZ
16	VOLJICE GAJ	Vrbas	FHMZ
17	DOBROŠIN	Vrbas	FHMZ

18	GORNJI VAKUF	Vrbas	FHMZ
19	GRAČANICA	Vrbas	FHMZ
20	RAT	Vrbas	FHMZ
21	BUGOJNO	Vrbas	FHMZ
22	ROVNA	Vrbas	FHMZ
23	ŠEHERDŽIK	Vrbas	FHMZ
24	ŠIPOVO	Vrbas	FHMZ
25	JAJCE	Vrbas	FHMZ
26	DIVIČANI	Vrbas	FHMZ
27	KUPRES	Vrbas	FHMZ
28	DELIJAŠ	Bosna	AVPS
29	BJELAŠNICA	Bosna	FHMZ
30	SARAJEVO	Bosna	FHMZ
31	FOJNICA	Bosna	AVPS
32	OLOVO	Bosna	AVPS
33	ZENICA	Bosna	FHMZ
34	ZAVIDOVIĆI	Bosna	AVPS
35	MAGLAJ	Bosna	AVPS/FHMZ
36	TUZLA	Bosna	FHMZ
37	MODRAC	Bosna	AVPS
38	KARANOVAC	Bosna	AVPS
39	BRGULE	Bosna	AVPS
40	BILA	Bosna	AVPS
41	KAKANJ	Bosna	FHMZ
42	TRAVNIK	Bosna	FHMZ
43	KISELJAK	Bosna	FHMZ
44	GRAČANICA	Bosna	FHMZ
45	ŽEPČE	Bosna	FHMZ
46	TEŠANJ	Bosna	FHMZ
47	MOŠČANICA	Bosna	FHMZ
48	SREDNJE	Bosna	FHMZ
49	VLAŠIĆ	Bosna	FHMZ
50	VAREŠ	Bosna	FHMZ
51	VISOKO	Bosna	FHMZ
52	BABIN DO	Bosna	FHMZ
53	GRADAČAC	Sava	FHMZ
54	GORAŽDE	Drina	AVPS/FHMZ
55	BIJELE VODE	Drina	FHMZ
56	BUDIM POTOK	Drina	FHMZ
57	USTIKOLINA	Drina	FHMZ
58	SAPNA	Drina	FHMZ
59	SNJEŽNICA	Drina	FHMZ

60	KLADANJ	Drina	FHMZ

5.2.1.3 Hydrological monitoring network in Republika Srpska

The adopted Integrated Water Management Strategy of Republika Srpska defines strategic guidelines towards improving surface water and groundwater monitoring and its use for flood forecasting and improving the management of existing and planned hydrotechnical facilities. The prerequisite for modernizing a management system is the modernization of the measurement-information system (monitoring) and putting into operation the key measuring stations, with the aim of obtaining remote data acquisition using an on-line system – continuously during the operational management period.

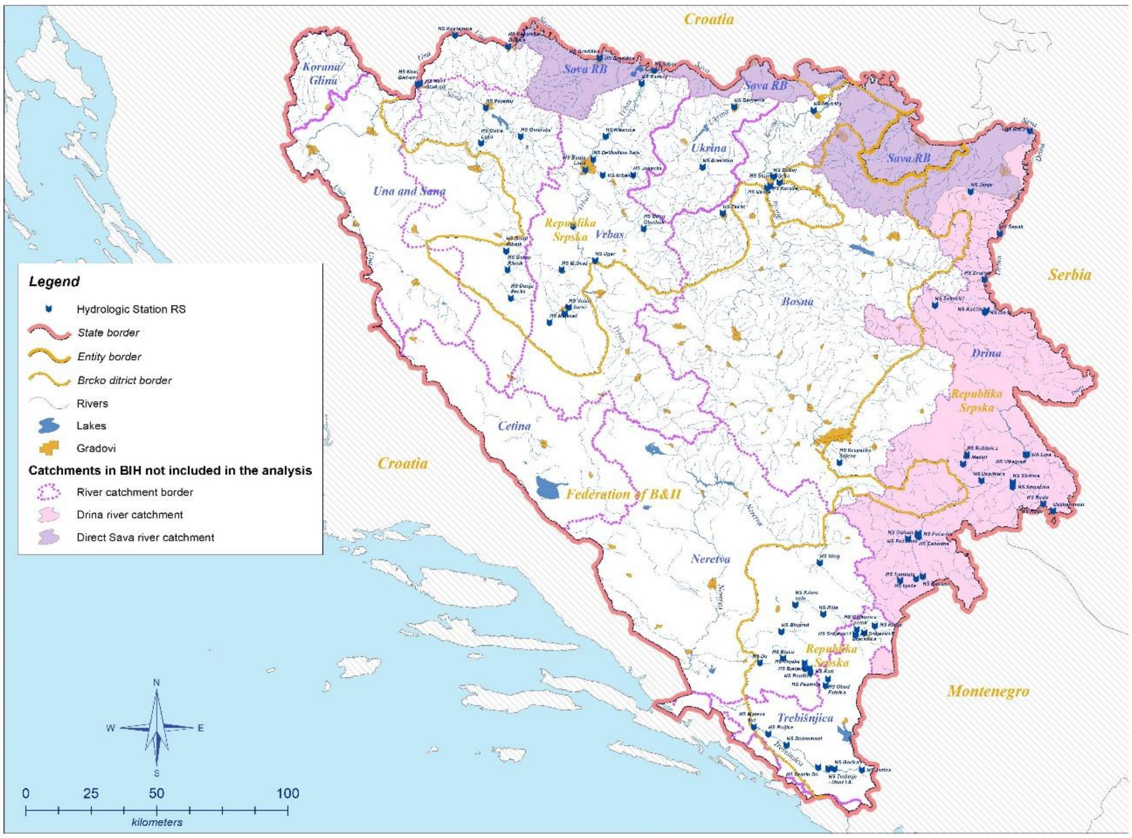


Figure 5-3: Hydrologic stations in RS

The hydrological monitoring network of the Republika Srpska the project's target basins currently consists of 17 hydrological stations installed by the RHMZRS, 5 hydrological stations installed by the PI "Vode Srpske" and 12 hydrological stations under the monitoring of HPP Trebišnjica.

Table 5-6: Automatic hydrological observation network in the RHMS system in RS

Ref. No.	Location/Name	Ownership	River	Basin
1	Sarići	RHMZ	Janj	Vrbas Basin
2	Majevac	RHMZ	Pliva	Vrbas Basin
3	Volari	RHMZ	Pliva	Vrbas Basin
4	Bočac	RHMZ	Vrbas	Vrbas Basin
5	Banja Luka	RHMZ	Vrbas	Vrbas Basin
6	Delibašino selo	RHMZ	Vrbas	Vrbas Basin

7	Klašnice	RHMZ	Vrbas	Vrbas Basin
8	Donji Obodnik	RHMZ	Vrbanja	Vrbas Basin
9	Vrbanja	RHMZ	Vrbanja	Vrbas Basin
10	Jošavka	RHMZ	Jošavka	Vrbas Basin
11	Oštra Luka	RHMZ	Sana	Una Basin
12	Omarska	RHMZ	Gomjenica	Una Basin
13	Doboj	RHMZ	Bosna	Bosna Basin
14	Modriča	RHMZ	Bosna	Bosna Basin
15	Novi Grad downstream	PI "Vode Srpske"	Una	Una Basin
16	Prijedor	PI "Vode Srpske"	Sana	Una Basin
17	Donji Ribnik	PI "Vode Srpske"	Sana	Una Basin
18	Klinje	PI "Vode Srpske"	Mušnica	Trebišnjica & Neretva Basin
19	Gojkovića potok	PI "Vode Srpske"	Zalomka	Trebišnjica & Neretva Basin
20	HPP Bočac	HPP	Vrbas	Vrbas Basin
21	HPP Trebisnica	HPP	on 12 locations	Trebisnica Basin

Table 5-7: Existing Hydrological stations with manual reading

Ref. No.	Location/Name	Ownership	River	Basin
1	Mrkonjić Grad	RHMZ	Crna rijeka	Vrbas Basin
2	Gornji Ribnik	RHMZ	Sana	Una Basin
3	Ulog	RHMZ	Ulog	Neretva Basin

Table 5-8: Automatic Hydrological stations – in progress

Ref. No.	Location/Name	Ownership	River	Basin
1	Teslić	RHMZ	Usora	Bosna Basin
2	Stanić rijeka	RHMZ	Spreča	Bosna Basin
3	Derventa	RHMZ	Ukrina	Ukrina Basin

The most challenging situation in terms of observation and hydrological processing is in the Ukrina River basin (Vijaka and Ukrina) because in the current monitoring there are no hydrometric and meteorological observations, and in this part of the basin there is Drenova reservoir, which can have significant effects on transformation or propagation of flood waves in the Vijaka River Basin.

One of the significant issues to take into account is the location of existing and planned hydrological measuring stations on watercourses. These locations must be aligned with hydraulic and other conditions of construction (stabilization of measuring points, locations outside of bridge slowdown and other facilities, outside of bends, and so on).

In general, on the part of the river basin which is the subject of the Terms of Reference in Republika Srpska, the monitoring status is as follows:

5.2.1.4 Hydrological monitoring in the Federation of B&H

Hydrological monitoring of surface waters in the Sava River Basin in the FB&H consists of:

- continuous, 24-hour (using automatic hydrological stations),
- daily (visual monitoring of water levels by readings from water level markers).

Implementation of hydrological monitoring of watercourses in the Sava River Basin in the FB&H, under the competence of AVP Sava, has been carried out since 2002, when the first 3 automatic stations were established for the continuous, 24-hour monitoring of hydrological parameters, as well as through the restored hydrological stations (water level markers) for daily monitoring through the engaged observers, which were established before 1992 by the Hydrometeorological Institute of Republic of B&H. Since then until today, hydrological station network has been constantly increasing in the number of locations, and currently it encompasses about 100 sites on which hydrological observations and measurements are performed. In extraordinary hydrological conditions such as floods and droughts, hydrometric operations with extraordinary measurement plan may be expanded beyond the aforementioned scope.

Figure 5-4: Equipment on automatic stations –radar water level sensor

Figure 5-5: Water level gauge boards

Figure 5-6: Display of data through LED display

A certain number of automatic hydrological stations was also established for continuous data collection needs by AVP Sava and within the hydropower systems by JP Elektroprivreda B&H and JP Elektroprivreda HZHB – *Electric Utility Companies*. The data from these stations are available according to the available technical capabilities of users. In the FB&H water management information centres in water agencies are "linked" with hydrological stations owned by electric utility companies and have the possibility of "on-line" data collection. The map below shows an overview of hydrological stations network on the Sava River Basin in FB&H.

Data from automated stations are collected on an hourly basis in real time via GPRS and GSM networks and delivered to the hydrological monitoring system. After real-time data collection, the data is verified, processed, and stored in the central database (HIS – Hydrological Information System). Various tools and applications allow the experts and the general public to have an insight into the collected data, as well as for various needs. In addition to the publication of the processed data and results in hydrological yearbooks, these data are also used in real time for the development of early warning systems for floods such as the EFAS system, Sava FFWS, the forecasting and warning system on river basins of Una and Vrbas rivers.

Timeseries water level data that predates the network of automatic water measuring stations is included by extending the timeseries (especially for high flows) to cover 1960-1990, following WMO rules for data infilling and hindcasting. Hence data from 1960 to 1990 and as well as automatic station data is available within the HIS for operation, calibration and verification of hazard and forecasting models, and for the definition of the design flows. The infilling of HIS for the sub-basins of Una and Vrbas has been completed, and the extension of HIS for the sub-basins of Bosna and Drina is underway. There is a long series of systematic hydrological monitoring of water levels and flow measurements, from numerous hydrological stations across the entire Neretva River Basin, making the Neretva River basin well-studied in hydrological terms.

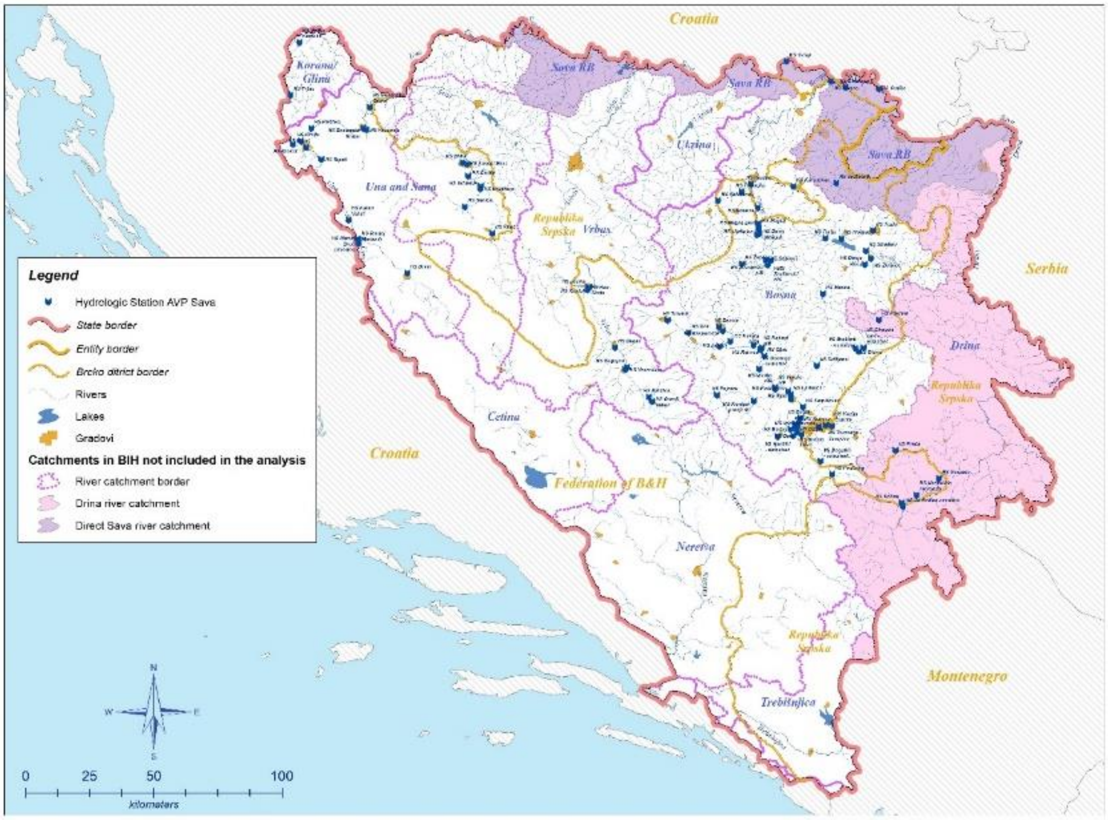


Figure 5-7: Hydrological monitoring network for Sava basin in FB&H

The management of hydrological stations in the Sava River Basin District of the FB&H, falling under the competence of Water Agency for Sava River Basin (AVP) are shown in Figure 5-7 listed in Table 5-9.

Table 5-9: Hydrological stations in Sava sub-basin in FB&H

No.	Station Name	Watercourse	Owner
1	SVILAJ	SAVA	AVPS
2	GREBNICE	SAVA	AVPS
3	ORAŠJE	SAVA	AVPS
4	TRŽAC	MUTNICA	AVPS
5	VELIKA KLADUŠA	KLADUŠNICA	AVPS
6	MARTIN BROD	UNA	AVPS
7	MARTUN BROD upstream	UNA	FHMZ
8	KULEN VAKUF	UNA	AVPS
9	RIPAČ	UNA	AVPS
10	BIHAĆ	UNA	AVPS/FHMZ
11	KRALJE	UNA	AVPS
12	KOSTELA	UNA	AVPS
13	BOSANSKA KRUPA	UNA	AVPS
14	BOSANSKA OTOKA	UNA	AVPS

15	KRUŠNICA	KRUŠNICA	AVPS
16	DRVAR	UNAC	AVPS
17	RMANJ MANASTIR	UNAC	AVPS
18	KLOKOT	KLOKOT	AVPS
19	KLJUČ	SANA	AVPS
20	SANSKI MOST	SANA	AVPS/FHMZ
21	VRHPOLJE	SANA	FHMZ
22	ČAPLJE	SANA	EP B&H
23	HRUSTOVO	SANICA	AVPS
24	SANICA	SANICA	AVPS
25	BLIHA	BLIHA	AVPS
26	GORNJI VAKUF	VRBAS	AVPS
27	BUGOJNO	VRBAS	AVPS
28	DALJAN	VRBAS	AVPS
29	KOZLUK JAJCE	VRBAS	AVPS
30	BISTRICA	BISTRICA	AVPS
31	VESEOČICA	VESEOČICA	AVPS
32	HAN SKELA	VRBAS	EP HZHB
33	JOŽIKA	PLIVA	EP HZHB
34	VRELO BOSNE	BOSNA	AVPS
35	RIMSKI MOST	BOSNA	AVPS
36	OTES	BOSNA	AVPS
37	OSJEK	BOSNA	AVPS
38	BUTILE	BOSNA	AVPS
39	RELJEVO	BOSNA	FHMZ
40	LJUBNIĆI	BOSNA	AVPS
41	VISOKO	BOSNA	AVPS
42	DOBRINJE monitor	BOSNA	AVPS
43	KAKANJ	BOSNA	AVPS
44	RASPOTOČJE	BOSNA	AVPS
45	ZENICA	BOSNA	FHMZ
46	VRANDUK upstream	BOSNA	EP B&H
47	VRANDUK downstream	BOSNA	EP B&H
48	JANJIĆI	BOSNA	EP B&H
49	ŽEPČE	BOSNA	AVPS
50	ZAVIDOVIĆI	BOSNA	AVPS
51	DONJI ULIŠNJAK	BOSNA	AVPS
52	MAGLAJ GRAD	BOSNA	AVPS
53	MAGLAJ POLJICE	BOSNA	AVPS
54	KOSOVA	BOSNA	AVPS
55	ŠAMAC	BOSNA	AVPS
56	ILIDŽA	ŽELJEZNICA	AVPS

57	PODTELJIG	BIJELA	AVPS
58	BOGATIĆI monitor	CRNA	AVPS
59	HADŽIĆI monitor	ZUJEVINA	AVPS
60	BLAŽUJ monitor	ZUJEVINA	AVPS
61	DOGLODI	DOBRINJA	AVPS
62	KOZIJA ĆUPRIJA	MILJACKA	AVPS
63	SARAJEVO	MILJACKA	FHMZ
64	VODOPRIVREDA	MILJACKA	AVPS
65	BUTILE	MILJACKA	AVPS
66	SEMIZOVAC	LJUBINA	AVPS
67	ILIJAŠ	MISOČA	AVPS
68	PODLUGOVI	STAVNJA	AVPS
69	FOJNICA	DRAGAČA	AVPS
70	VISOKO	FOJNIČKA RIJEKA	AVPS
71	OBRE	TRSTIONICA	AVPS
72	KAKANJ	ZGOŠĆA	AVPS
73	TRAVNIK	LAŠVA	AVPS
74	MERDANI	LAŠVA	AVPS
75	STIPOVIĆ	GOSTOVIĆ	AVPS
76	BILA	BILA	FHMZ
77	OLOVO	KRIVAJA	AVPS
78	MAOČA	KRIVAJA	AVPS
79	ZAVIDOVIĆI	KRIVAJA	AVPS
80	BIOŠTICA monitor	BIOŠTICA	AVPS
81	OLOVSKELUKE monitor	STUPČANICA	AVPS
82	LIJEŠNICA	LJEŠNICA	AVPS
83	KALOŠEVIĆ	USORA	AVPS
84	TEŠANJKA	USORA	AVPS
85	KARUŠE	USORA	AVPS
86	STRAŠANJ	SPREČA	AVPS
87	KARANOVAC	SPREČA	AVPS
88	DONJA VIŠĆA	OSKOVA	AVPS
89	ŽIVINICE	GOSTELJA	AVPS
90	TURIJA	TURIJA	AVPS
91	TUZLA	JALA	FHMZ
92	MODRAC	SPREČA	AVPS
93	SREBRENIK	TINJA	AVPS
94	HAZNA monitor	J. HAZNA	AVPS
95	VIDARA monitor	J. VIDARA	AVPS
96	GORAŽDE	DRINA	AVPS
97	USTIKOLINA upstream	DRINA	EP B&H
98	PRAČA	PRAČA	AVPS

99	KOLINA	KOLUNSKA RIJEKA	AVPS
100	KLADANJ	DRINJAČA	AVPS

5.3 DETAILED ANALYSIS AND CHARACTERIZATION OF EXISTING O&M PROCEDURES

Given the complexity of the system of collection, transmission and processing of data it is necessary to provide systematic maintenance to ensure continuous operation of measuring equipment and data transfer, the systematic quality control of data to ensure accuracy, and availability of data for all users.

The minimum maintenance conditions that must be met, and the way which they are met, related to each component (Stations) are as follows:

Maintenance of Hydrological, Meteorological and precipitation stations include ensuring continuous operation of hydrological and for measuring water level and temperature, and the continuous operation of meteorological and precipitation stations for the measurement of all meteorological variables being measured. In both cases this includes the installed equipment (power supply, battery, solar panel with charge controller and voltage protection device for data collection, data modem, and measuring sensors). This includes continual monitoring of the work of the Hydrological, meteorological and precipitation station from the operational center and monthly reporting on maintenance of each station. Preventative visiting includes the regular maintenance of outdoor spaces and the control of operation of each station. For example, refilling fluids against freezing rain gauge is an integral part of the maintenance program for meteorological and precipitation stations. Such visits are supposed to be done on a monthly basis.

The accuracy of the device is determined by reviewing the datalogger, sending the data to hydro-meteorological institutes and comparing the current data in the datalogger readings with reliable instruments, like water gauging strips, portable thermometer, etc. Each datalogger has the ability to detect and identify a series of errors that can occur on the measuring device. In the event of irregularities in the work of the measuring device, identification error code will be displayed on the datalogger and sent to the user along with other data. Depending on the error, recalibration, repairing of device or replacement of device may occur. In case of malfunction of station or specific device, on-site intervention must be performed within maximum of 72 hours.

Additional redundancy measures are procurement of spare devices so they can be replaced and installed in case of failure. Also, in order to verify long-life accuracy of measurement station parameters, it is advised to install additional station in immediate vicinity of existing one and carry out comparison of data for a certain period of time.

Standard activities on maintenance of automatic stations (hydrological, meteorological and precipitation) are:

- Inspection of the automatic station components - cabinet and sensors (Visual and physical overview of the basic components of the automatic station).
- Testing of data sending, storing and display (checking all parameters trough connecting datalogger OTT netDL 1000 with computer).
- Testing of GMS Signal strength, with difficulties in data transmission, through datalogger or mobile phone.
- Testing of remote communication – overview of incoming data on server (communication with service center or directly on field).
- Cleaning of Pluvio2 Precipitation gauge from leaves, dirt, branches, etc.
- Pluvio2 chamber must be emptied after excessive rainfall (maximum volume is 30 l).
- Grass in station perimeter must be mown several times through vegetable season
- Replacement/refill of antifreeze in pluvio2 chamber (additional antifreeze must be placed in required amount during winter season to keep pluvio2 working).
- Cleaning of solar radiation sensor- (sensor is mounted on top of multisensor Lufft WS501 which is sometimes birds resting place)

- Voltage checking of backup battery (regular procedure for batteries exposed to extreme temperatures and weather. Batteries are prone to weakening of their nominal capacity which leads to their reduced capacity).
- Replacement of empty acu-battery if needed (during maintenance, regular checking of backup battery is mandatory and replacement is needed if battery is empty).
- Cleaning of water level probe – OTT PLS (after muddier or higher water it is necessary to clean the head of water level probe, which must be performed by authorized personnel).
- Scaling water level – measurement of water level with water level gauge and datalogger (after muddier or higher water it is necessary to scale water level to ensure water level are recorded properly).
- Cleaning of water level gauge is necessary after muddier or higher water
- Cleaning of vegetation around water level gauges (in locations where water level gauges are located in vegetative areas, it is necessary to remove vegetation that obscures them during the vegetative season).

5.3.1 Cost of Maintenance of hydrometric network

5.3.1.1 Cost of Maintenance of hydrometric network in Republika Srpska

In the project target basins within the Republika Srpska, the estimated annual cost of maintenance for the existing and planned monitoring network based on management cost of the relevant institutions as well as estimated annual maintenance costs of the equipment is as follows:

Table 5-10: Annual maintenance of existing automatic hydrological stations

Existing Automatic Hydrological stations					
Ref. No.	**Location/Name**	**Ownership**	**River**	**Basin**	**Annual maintenance (BAM)**
1	Sarići	RHMZ	Janj	Vrbas Basin	2000
2	Majevac	RHMZ	Pliva	Vrbas Basin	2000
3	Volari	RHMZ	Pliva	Vrbas Basin	2000
4	Bočac	RHMZ	Vrbas	Vrbas Basin	2000
5	Banja Luka	RHMZ	Vrbas	Vrbas Basin	2000
6	Delibašino selo	RHMZ	Vrbas	Vrbas Basin	2000
7	Klašnice	RHMZ	Vrbas	Vrbas Basin	2000
8	Donji Obodnik	RHMZ	Vrbanja	Vrbas Basin	2000
9	Vrbanja	RHMZ	Vrbanja	Vrbas Basin	2000
10	Jošavka	RHMZ	Jošavka	Vrbas Basin	2000
11	Oštra Luka	RHMZ	Sana	Una Basin	2000
12	Omarska	RHMZ	Gomjenica	Una Basin	2000
13	Doboj	RHMZ	Bosna	Bosna Basin	2000
14	Modriča	RHMZ	Bosna	Bosna Basin	2000
15	Novi Grad downstream	PI "Vode Srpske"	Una	Una Basin	2000
16	Prijedor	PI "Vode Srpske"	Sana	Una Basin	2000
17	Donji Ribnik	PI "Vode Srpske"	Sana	Una Basin	2000
18	Klinje	PI "Vode Srpske"	Mušnica	Trebisnica & Neretva Basin	2000
19	Gojkovića potok	PI "Vode Srpske"	Zalomka	Trebisnica & Neretva Basin	2000

20	HPP Bočac	HPP	Vrbas	Vrbas Basin	2000
21	HPP Trebisnica	HPP	on 12 locations	Trebisnica Basin	24000
TOTAL:					**64000**

Table 5-11: Annual maintenance costs for existing manual hydrological stations in RS

Existing Hydrological stations with manual reading					
Ref. No.	**Location/Name**	**Ownership**	**River**	**Basin**	**Annual maintenance (BAM)**
1	Mrkonjić Grad	RHMZ	Crna rijeka	Vrbas Basin	500
2	Gornji Ribnik	RHMZ	Sana	Una Basin	500
3	Ulog	RHMZ	Ulog	Neretva Basin	500
TOTAL:					**1500**

Table 5-12: Annual maintenance for existing precipitation station in RS

Existing Precipitation Stations				
Ref. No.	**Location/Name**	**Ownership**	**Basin**	**Annual maintenance (BAM)**
1	Šipovo	RHMZ	Vrbas Basin	3500
2	Majevac (Izvor Plive)	RHMZ	Vrbas Basin	3500
3	Mrkonjić Grad	RHMZ	Vrbas Basin	3500
4	Manjača	RHMZ	Vrbas Basin	3500
5	Krupa na Vrbasu	RHMZ	Vrbas Basin	3500
6	Srbac	RHMZ	Vrbas Basin	3500
7	Čelinac	RHMZ	Vrbas Basin	3500
8	Kotor Varoš	RHMZ	Vrbas Basin	3500
9	Donji Borojevići (Kneževo)	RHMZ	Vrbas Basin	3500
10	Banja Luka (PMF)	RHMZ	Vrbas Basin	3500
11	Krupa na Uni	RHMZ	Una Basin	3500
12	Mjecanica	RHMZ	Una Basin	3500
13	Prijedor	RHMZ	Una Basin	3500
14	Ribnik	RHMZ	Una Basin	3500
15	Doboj	RHMZ	Bosna Basin	3500
16	Kalinovik	RHMZ	Bosna Basin	3500
17	Pale - Stambolčić	HPP	Bosna Basin	3500
TOTAL:				**59500**

Table 5-13: Annual maintenance costs for existing meteorological stations in RS

Existing Meteorological Stations				
Ref. No.	**Location/Name**	**Ownership**	**Basin**	**Annual maintenance (BAM)**
1	Banja Luka	RHMZ	Vrbas Basin	5000
TOTAL:				**5000**

Table 5-14: Capital costs and annual maintenance costs for planned automatic hydrological stations in RS (to be implemented before start of GCF project)

Automatic Hydrological stations – in progress								
Ref. No.	**Location/Name**	**Ownership**	**River**	**Basin**	**Unit price**	**Construction works**	**Total BAM (VAT excl.)**	**Annual maintenance (BAM)**
1	Teslić	RHMZ	Usora	Bosna Basin	7000	2000	9000	900
2	Stanić rijeka	RHMZ	Spreča	Bosna Basin	7000	2000	9000	900
3	Derventa	RHMZ	Ukrina	Ukrina Basin	7000	2000	9000	900
TOTAL:					**21000**	**6000**	**27000**	**2700**

Table 5-15: Capital cost and annual maintenance costs for planned precipitation stations in RS

Precipitation stations – in progress							
Ref. No.	**Location/Name**	**Ownership**	**Basin**	**Unit price**	**Construction works**	**Total BAM (VAT excl.)**	**Annual maintenance (BAM)**
1	Derventa	RHMZ	Bosna Basin	14000	2000	16000	1600
2	Prnjavor	RHMZ	Bosna Basin	14000	2000	16000	1600
3	Borja-Hajdučke vode	RHMZ	Bosna Basin	14000	2000	16000	1600
4	Modriča	RHMZ	Bosna Basin	14000	2000	16000	1600
TOTAL:				**56000**	**8000**	**64000**	**6400**

Table 5-16: Capital cost and annual maintenance costs for planned meteorological stations in RS

Meteorological stations – in progress							
Ref. No.	**Location/Name**	**Ownership**	**Basin**	**Unit price**	**Construction works**	**Total BAM (VAT excl.)**	**Annual maintenance (BAM)**
1	Sokolac	RHMZ	Bosna Basin	22000	4000	26000	2600
2	Han Pijesak	RHMZ	Bosna Basin	22000	4000	26000	2600
3	Banja Vrućica	RHMZ	Bosna Basin	22000	4000	26000	2600
TOTAL:				**66000**	**12000**	**78000**	**7800**

5.3.1.2 Cost of Maintenance of hydrometric network in Federation of B&H

In the FB&H AVP Sava annually allocates funds (from water fees collection) in the amount of BAM 500,000.00 for maintenance of the monitoring stations in its ownership. However, the FB&H Hydrometeorological Institute, which is a budget institution, has no possibility of securing funds for maintaining its monitoring stations and does not receive maintenance budget. This lack of consistency in the allocation of financial resources for maintenance of the equipment and continuous functioning of the established monitoring system results in discrepancies in the level of maintenance of the hydrometric network in FB&H.

5.4 Planned Hydrometric Network

5.4.1 Planned hydrometric network in Federation of B&H

Lack of financial resources and insufficiently developed groundwater monitoring: currently, 11 measuring profiles are being established, while a recent study suggested that 20 measuring profiles are required for the most significant karst springs, which would require an investment of approximately **BAM 400,000.00** value for their establishment.

It is necessary to improve the spatial coverage of meteorological stations, i.e. to increase the number of these stations on the main sub-basin, but this requires a study based on WMO procedures and expert recommendations and EU countries experience, to define the optimised network including required number and optimal locations for new meteorological stations which would represent an adequate basis for flood forecasting, flood hazard modelling and emergency planning.

It is recommended to increase the number of profiles for flow rate measurement, including the establishment of Q-H curve, so that water level measurements can also be used to calculate the flow rates;

Table 5-17: Monitoring network requirements in FB&H

	Quantity	Unit price (BAM)	Construction works (BAM)	Total Capital Cost (BAM)	Cost USD
Groundwater Monitoring network in other Sava river sub-basins in FB&H:					
Groundwater monitoring stations for measuring profiles of the most significant karst springs in FB&H required.	9.00	18,000.00	12,000.00	270,000.00	135,000.00
Hydrometric network requirements for Sava basin in FB&H					
For entire river basin on FB&H territory (including Drina river basin as well and direct Sava river basin) the missing investments works in sense of upgrading hydrological and meteorological observation stations needs to be performed with following specifications of equipment: <u>GMS program</u> Measurement: Temperature (t, tmin, tmax, tmin5), Humidity, Wind, pressure, precipitation, insulation, snow depth, soil temperature per depth:(2 cm, 5 cm, 10 cm, 20 cm, 30 cm, 50 cm, 100 cm) <u>AMS sensors:</u> precipitation, temperature, wind, humidity, pressure, global radiation, snow depth, percentage of water in snow. <u>AAS sensor:</u> Soil temperature up to 1m of (5 cm, 10 cm, 50 cm i 100 cm) Humidity of soil up to 1 m (5 cm, 10 cm, 50 cm i 100 cm) humidity of leaves					
Meteorological Stations:	16.00	22,000.00	4,000.00	416,000.00	208,000.00

5.4.2 Planned hydrometric network in Republika Srpska

Based on the analysis of the strategic documents of the water sector of Republika Srpska, it was concluded that the hydrometric network requires planned reconstruction, upgrading and modernization of hydrological stations on surface watercourses. The goal is to gradually and systematically establish monitoring on all major watercourses in Republika Srpska, i.e. to put in operation major automatic hydrological stations on the watercourses in order to create prerequisites for adequate operational water management, especially in case of protection from floods. This also implies putting into operation weather stations and measurements on hourly basis.

According to the Integrated Water Management Strategy of Republika Srpska it is necessary to reconstruct, modernize or construct new automatic water measuring stations in the until 2024. It is proposed to complete installation of a total of 37 stations in the Sava River Basin (of which 22 in the basins of Bosna, Ukrina, Vrbas and Una) and 23 in the basin of Trebišnjica and Neretva rivers. Due to the extremely complex flow conditions in the karst, when it comes to monitoring of surface waters in the Trebišnjica and Neretva areas, it is necessary to plan a more dense water measuring station network so as to provide for a more reliable monitoring of all components of the water balance. Stations in the river basin of Trebišnjica will be distributed according to the competence of RHMZRS and PI Vode Srpske and the Hydropower plants on Trebišnjica river.

Compared to the situation before 2014 and the catastrophic floods, the hydrometric observation network has been improved, although until 2024, there are extensive tasks ahead in the sense of expanding the observation network and renewing hydro and meteorological stations that have been in use until 1990.

Until 2024, it is necessary to make an upgrade of hydro and weather observation network by means of harmonising competences (RHMZ RS, PI "Vode Srpske" and HPP Trebišnjica), and the remaining activities on improving surface water and meteorological monitoring.

Moreover, in the Trebišnjica river basin, it is necessary to put in operation around 10 major piezometers in order to be able to follow the oscillation processes of underground water levels because they are very important for the creation of water balances. The most challenging situation in terms o observation and hydrological processing is in the Ukrina River basin (Vijaka and Ukrina) because in the current monitoring there are no hydrometric and meteorological observations, and in this part of the basin there is Drenova reservoir, which can have significant effects on transformation or propagation of flood waves in the Vijaka River Basin. One of the significant issues to consider is the location of existing and planned hydrological measuring stations on watercourses. These locations must be aligned with hydraulic and other conditions of construction (stabilization of measuring points, locations outside of bridge slowdown and other facilities, outside of bends etc.).

For entire river basin on Republika Srpska territory (including Drina river basin as well and direct Sava river basin) the missing investments works in sense of upgrading hydrological and meteorological observation stations needs to be performed as follows:

- Automatic Hydrological stations:
    - Quantity – 23
- Meteorological Stations:
    - Quantity – 10

Regarding development of the Ground Water Monitoring System in Trebišnjica HPS, two development phases can be planned, as follows:

1. Installation of the appropriate measuring equipment into existing piezometers which are out of function or never were installed with measuring equipment-24 pc– first – urgent phase:
    - Fatničko polje edges 3 pcs
    - Dabarsko polje edges 4 pcs
    - Jasen and Ljubomirsko polje 3 pcs
    - Cerničko polje 4 pcs
    - Gatačko polje 2 pcs
    - Nevesinjsko polje 8 pcs

2. Performing piezometer 100 and 200 m deep, with installation of equipment on following locations, average depth of 180 m x 18 pcsx - drilling and casing construction + equipping – second short-term phase, for following locations:
    - Bileća reservoir edges 4 pcs
    - Bilećko polje 3 pcs
    - Bijela Rudina area 3 pcs
    - Meka Gruda area 2 pcs
    - Ljubomirsko polje and Jasen 4 pcs
    - Trebinjsko polje 2 pcs

For the other Sava river sub-basins in Republika Srpska (Una with Sana river basin, Vrbas river basin, Bosna river basin and Ukrina river basin) it is necessary to establish ground waters monitoring network where it is necessary to perform drilling, casing and installation of equipment for measurements.

Table 5-18: Monitoring network requirements in RS

	Quantity	Unit price	Construction works	Total capital Cost	Cost USD
Hydrometric network requirements in Republika Srpska					
For entire river basin on Republika Srpska territory (including Drina river basin as well and direct Sava river basin) the missing investments works in sense of upgrading hydrological and meteorological observation stations needs to be performed as follows:					
Automatic Hydrological stations: The level and depth of the water,pressure,temperature.	23.00	7,000.00	1,000.00	184,000.00	92,000.00
Meteorological Stations: GMS program Measurement: Temperature (t, tmin, tmax, tmin5), Humidityt, Wind, preasure, precipitation, insulation, snow depth, soil temperature per depth:(2 cm, 5 cm, 10 cm, 20 cm, 30 cm, 50 cm, 100 cm) AMS sensors: precipitation, temperature, wind, humidity, preasure, global radiation, snow depth, percentage of water in snow. AAS senzori: Soil temperature up to 1m of (5 cm, 10 cm, 50 cm i 100 cm) Humidity of soil up to 1 m (5 cm, 10 cm, 50 cm i 100 cm) humidity of leaves	10.00	22,000.00	4,000.00	260,000.00	130,000.00
Ground Water Monitoring System in Trebišnjica HPS:					
Installation of the appropriate measuring equipment into existing piezometers which are out of function or never were installed with measuring equipment – first – urgent phase:					
Fatničko polje edges	3.00	12,000.00		36,000.00	18,000.00
Dabarsko polje edges	4.00	12,000.00		48,000.00	24,000.00
Jasen and Ljubomirsko polje	3.00	12,000.00		36,000.00	18,000.00
Cerničko polje	4.00	12,000.00		48,000.00	24,000.00
Gatačko polje	2.00	12,000.00		24,000.00	12,000.00
Nevesinjsko polje	8.00	12,000.00		96,000.00	48,000.00
2. Performing piezometer 100 and 200 m deep, with installation of equipment on following locations, average depth of 180 m I– second short-term phase, for following locations:					
Bileća reservoir edges	4.00	18,000.00	12,000.00	120,000.00	60,000.00
Bilećko polje	3.00	18,000.00	12,000.00	90,000.00	45,000.00
Bijela Rudina area	3.00	18,000.00	12,000.00	90,000.00	45,000.00
Meka Gruda area	2.00	18,000.00	12,000.00	60,000.00	30,000.00
Ljubomirsko polje and Jasen	4.00	18,000.00	12,000.00	120,000.00	60,000.00
Trebinjsko polje	2.00	18,000.00	12,000.00	60,000.00	30,000.00
Groundwater Monitoring network in other Sava river sub-basins in Republika Srpska (Una with Sana river basin, Vrbas river basin, Bosna river basin and Ukrina river basin):					
boreholes with average depth up to 50 m, with casing and installation of equipment	10.00	5,000.00		52,000.00	26,000.00
boreholes with average depth up to 30 m, with casing and installation of equipment	30.00	3,000.00		90,000.00	45,000.00

5.4.3 Identification of long-term O&M requirements for optimised hydrometric network

Equipment	Quantity	Total capital cost (USD)	O&M Activities	Annual maintenance (USD)	Total maintenance for 20 years (USD)
Supply of groundwater monitoring stations for measuring profiles of the most significant karst springs	9	163,800.00	O&M for purchased groundwater	16,380.00	**327,600.00**

			monitoring stations		
Supply of Meteorological Stations: GMS program Measurement: Temperature (t, tmin, tmax, tmin5), Humidity, Wind, pressure, precipitation, insulation, snow depth, soil temperature per depth:(2 cm, 5 cm, 10 cm, 20 cm, 30 cm, 50 cm, 100 cm) AMS sensors: precipitation, temperature, wind, humidity, pressure, global radiation, snow depth, percentage of water in snow. AAS sensor: Soil temperature up to 1m of (5 cm, 10 cm, 50 cm i 100 cm) Humidity of soil up to 1 m (5 cm, 10 cm, 50 cm i 100 cm) humidity of leaves	16	248,000.00	O&M for purchased meteorological stations	24,800.00	**496,000.00**
Automatic Hydrological stations: Measurement: level and depth of the water,pressure,temperature.	23.00	121,900.00	O&M for purchased hydrological stations	12,190.00	**243,800.00**
Meteorological Stations: GMS program Measurement: Temperature (t, tmin, tmax, tmin5), Humidity, Wind, pressure, precipitation, insulation, snow depth, soil temperature per depth:(2 cm, 5 cm, 10 cm, 20 cm, 30 cm, 50 cm, 100 cm) AMS sensors: precipitation, temperature, wind, humidity, pressure, global radiation, snow depth, percentage of water in snow. AAS sensor: Soil temperature up to 1m of (5 cm, 10 cm, 50 cm i 100 cm) Humidity of soil up to 1 m (5 cm, 10 cm, 50 cm i 100 cm) humidity of leaves	10.00	155,000.00	O&M for purchased stations	15,500.00	**310,000.00**
Ground Water Monitoring System in Trebišnjica HPS: Installation of the appropriate measuring equipment into existing piezometers which are out of function or never were installed with measuring equipment: Fatničko polje edges, Dabarsko polje edges, Jasen and Ljubomirsko polje, Cerničko polje, Gatačko polje, Nevesinjsko polje	24	172,800.00	O&M for purchased equipment	17,280.00	**345,600.00**
Ground Water Monitoring System in Trebišnjica HPS: Performing piezometer 100 and 200 m deep, with installation of equipment on following locations, average depth of 180 m: Bileća reservoir edges, Bilećko polje, Bijela Rudina area, Meka Gruda area, Ljubomirsko polje and, Jasen, Trebinjsko polje	18.00	327,600.00	O&M for purchased equipment	32,760.00	**655,200.00**
Groundwater Monitoring network in other Sava river sub-basins in Republika Srpska (Una with Sana river basin, Vrbas river basin, Bosna river basin and Ukrina river basin): boreholes with average depth up to 50 m, with casing and installation of equipment	10.00	34,000.00	O&M for purchased equipment	3,400.00	**68,000.00**
Groundwater Monitoring network in other Sava river sub-basins in Republika Srpska (Una with Sana river basin, Vrbas river basin, Bosna river basin and Ukrina river basin): boreholes with average depth up to 30 m, with casing and installation of equipment	30.00	63,000.00	O&M for purchased equipment	6,300.00	**126,000.00**

6 FLOOD FORECASTING AND EARLY WARNING

6.1 OVERVIEW OF EXISTING FLOOD FORECASTING SYSTEMS IN B&H

6.1.1 Detailed description of flood forecasting models by basin

Establishment of the flood forecasting and early warning system is a key non-structural flood risk management measure which is increasing important as a climate change adaptation measures, given that climate change will further increase the frequency, intensity and variability of floods. Throughout the world flood forecasting and early warning systems are becoming increasingly important to reduce the damage and human life losses. By obtaining timely information, activities to mitigate or avoid potential consequences of these events can be implemented.

Before the flood event in May 2014 there was no established forecasting model for floods in B&H. Hydrological data from the network of automatic hydrological stations were collected on an hourly basis in real time, transmitted by telemetry system via GPRS and GSM network to the Water Information System where they were verified and processed and then forwarded to the competent institutions and to the general public. The "Water Agency for Sava River Basin" Sarajevo currently has about 90 automatic meteorological and hydrological stations at disposal in the Sava River Basin in FB&H. Data from all stations are collected systematically and regularly, and such data are validated and processed within the Water Information System.

One of the recommendations of the regional conference for the southwestern Balkans held in late November 2014 was the necessity of setting up a forecasting model and early warning system. The need to address this activity at the regional level was underlined, with full respect for the specificities of each country, relying on existing structures and institutions (ICPDR, Sava Commission).

Accordingly, intensive cooperation with Croatia and Slovenia started. Namely, during 2014, representatives of the relevant water institutions of Bosnia and Herzegovina met the Slovenian and Croatian forecasting models (Sava and Kupa, up to Sisak). Active cooperation was established with the Environmental Agency of the Republic of Slovenia (ARSO), aimed at defining the preliminary model of the runoff of the Bosna river. The outcome of this cooperation is the development of a study "Analysis of the May 2014 flood event in Bosnia and Herzegovina for the Bosna River Basin". In the course of the project, the representatives of the B&H institutions were introduced to the activities performed on forecasting models implemented in Slovenia, their cooperation and bilateral contacts with Hrvatske vode and DHMZ on the modelling of the design of international watercourses (Kupa, Sava), as well as in relation to the exchange of meteorological and hydrological data in real time. As the expansion of the forecasting model for the Sava River in the Republic of Croatia was planned up to the border with the Republic of Serbia, the importance of preparing the forecasting models of the right tributaries of the Sava River in the territory of B&H (Una, Vrbas, Bosna and Drina) was considered. The text below provides an overview of the current state of implementation of each of these sub-basins in the FB&H watershed.

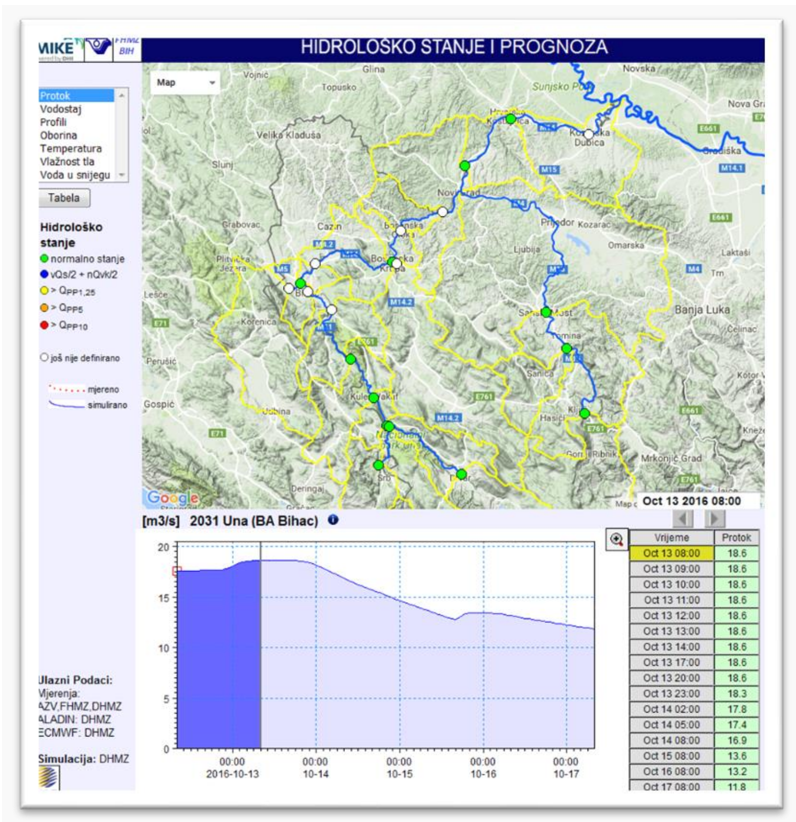
6.1.2 Forecasting model for sub-basin of Una River

Flood forecasting system for sub-basin of Una river is already operational. The system was developed following the same methodology as the Slovenian and Croatian real-time flood forecasting system used by the Slovenian Environmental Protection Agency, Hrvatske vode and the National Hydrometeorological Institute. This system includes real-time data exchange that allows forecasting of flow, water levels and rainfall data on an hourly basis.

As a first step, the combined hydrological and hydrodynamic model MIKE 11 was developed partially based on existing hydrodynamic sub-models (HecRas) and the watercourse cross-sections, as well as on the existing upstream model of the Sava River in Croatia. After the finalisation, calibration and verification of the MIKE 11 model, a forecasting model was developed. The model is used within the Flood Forecasting Operating System, which uses measured and forecasted data. Two rainfall forecast sources are used in order to extend time series for model simulations for 4 days in advance, as well as a network of rainfall stations with real-time data transmission.

The forecast is automatically prepared on an hourly basis for four days in advance. The Flood forecasting system is installed with the end users where additional scenarios, flood control and analysis can be done.

Combined hydrological and hydrodynamic model for the modelled area was developed to simulate flow and water levels over a period of six days starting from two days back and continuing with four days in advance. The Hydrological NAM model, which is a semi-distributed hydrological model, was developed for the entire basin so as to allow the inflow from the sub-basin to river branches in the hydrodynamic model. The overall hydrodynamic model was developed based on available geometry data and DTM data on the modelled surface.



6.1.3 Forecasting model for sub-basin of Vrbas River

Flood forecasting system for Vrbas River Basin is under development as part of the project *Technology transfer for climate resilient flood management in Vrbas River Basin* implemented by UNDP B&H, the design of which was described above. The version based on Mike NAM and the 1D hydraulic model is implemented in the system. The model actually consists of two separate NAM and HD models (covering the two entities).

In establishing this model two key objectives are defined:

- Establishment of the operational model of the mathematical forecasting for the sub-basin of Vrbas river, i.e. the development and hydrological and hydraulic model of the sub-basin of Vrbas river, linking them to the existing forecasting model of the sub-basin of Una river basin forecast on the common web platform. The model must operate on an hourly basis.
- Development of institutional capacity for flood forecasting using the established operational forecasting model.

In the previous, first phase of this project, a hydrological model of Vrbas river was developed, which is bas

ed on a very small number of measuring stations and as such is not adequate for use at this stage of the project. Therefore, the new hydrological model of Vrbas will be created for the purpose of establishing the forecasting model. The hydrodynamic 1D model of Vrbas will form the basis for the Vrbas river hydrodynamic model for operational forecasting of floods in the basin.

6.1.4 Forecasting model for sub-basin of Bosna River

Activities have started on the development of forecasting system elements for the sub-basin of Bosna river (including sub-basins of the rivers Ukrina, Tinja and Brka – tributaries of Sava river) in Bosnia and Herzegovina. The sub-basin of Bosna river was the area most affected by the floods in May 2014 inflicting the major damage. This forecasting model should be integrated with the forecasting model of sub-basins of the rivers Una and Vrbas.

6.2 Description of Flood Early Warning in B&H

6.2.1.1 Republika Srpska

Real-time Flood Forecasting System on the Vrbas River and Una River basins, *inter alia*, is practically applied through the development of the alert, early warning and evacuation system.

In the Early Warning System, it is very important to introduce clear expert guidance in response to dangerous situations, to define competences and procedures. Based on this, through the development of the Flood Risk Management Plan in Vrbas River Basin, a working proposal was provided on the possible hierarchical network of action and the responsibilities, which should be clearly defined in the forthcoming period in accordance with the operational capacities of the relevant institutions and organizations.

Definition of a detailed Plan of action and responsibilities in the early warning system should be elaborated in a separate document "Development of Flood Early Warning System, Alert and Evacuation on the Vrbas River Basin", which will define all the technical, communication and legal aspects that need to be established, all in order to mitigate damaging consequences from floods on the Vrbas River in Republika Srpska.

In the forthcoming period, legal and technical capacities of PI "Vode Srpske" should be strengthened, which should be a key factor (together with the relevant Ministry and RHMZ of RS) and the partner of the RS Civil Protection Administration in the Early Warning System. In the current system, PI "Vode Srpske" has limited legal and technical capacity to carry out key tasks in its area of competence, which may be a limiting factor for the future functioning of the flood forecasting system in real time and subsequent flood early warning system.

A functional flood early warning system requires a prompt and decisive response of the competent authorities. This requires proper cooperation, as well as timely information and coordination. In addition, communication and coordination with the relevant civil protection agencies is also very important in the part of the basin in the FB&H, in accordance with the legal provisions and regulations.

Signals for alerting population and procedures in cases of danger are stipulated in the Rulebook on alerting citizens and procedure in case of emergency (RS Official Gazette, 53/13), which was issued pursuant to the Law on Protection and Rescue in Emergency Situations. The issuer is the Minister of the Interior. In reference to this regulation the issue regarding response of stakeholders and persons in flood protection regarding those activities remains open.

6.2.1.2 Federation of B&H

Implementation of flood early warning system in FB&H involves all of the aforementioned conclusions as in the case of Republika Srpska, with additional recommendations aimed at prevention of flood events on the basin.

In addition to the aforementioned, the following recommendations are also given, which refer to forecasting models for flash floods, groundwater and HPP facilities:

- Development of high-resolution model/radar. Currently, there is no source for providing short-term (2-6 hours in advance) rainfall forecasts or current forecast. It is recommended to invest in the development of radar/satellite-based systems covering the Sava River Basin in FB&H so as to improve precision of forecasting with shorter time (at this moment there are no plans to purchase this sophisticated equipment). This is particularly significant for adverse weather conditions such as storms with the occurrence of thunderstorms and floods; the spatial and temporal distribution of these phenomena is difficult to predict without radar/satellite;
- Expand the network of groundwater monitoring measurement profiles in the Sava River Basin in FB&H;
- For the HPP facilities with the pertaining reservoir space, create separate forecasting models in order to consider the possibility of better and more functional use of these facilities for the purpose of implementation of flood protection measures and their plan of operation – the best example is the Modrac reservoir.

Through the project Optimization of the hydropower plants' operations on the Neretva River, which was completed at the end of 2014, an application was developed for forecasting of the Neretva River water level on certain profiles downstream the Mostar hydropower plant.

For the needs of developing this application, an analysis of the coverage of the basin with meteorological and hydrological stations was carried out, as well as analysis of data series from these stations. The conclusion of the analysis is that 36 meteorological stations meet the conditions for use of data in this application, of which only 7 refer to the upper stream of the Neretva River. As a spatial problem, it emerged that measuring stations are not produced by one manufacturer and as such do not provide data in the same format, and it was necessary to find a way of how to harmonize the data and enter such data into a single database.

6.3 EXISTING FLOOD FORECASTING MODELS AND PLATFORMS IN NERETVA AND TREBIŠNJICA TO BE DEVELOPED.

Flood forecasting models for most basins are either already developed, or are being developed by other projects, with the exception of Neretva and Trebišnjica basin. Flood forecasting models of Una-Sana and Vrbas were developed under the Vrbas project and forecasting models planned within other financial lines (World Bank – Drina River Basin; IPA Funds – basins of rivers Bosna, Ukrina, Tinja and Brka). It is the intention of the GCF project, to develop the flood forecasting for Neretva and Trebišnjica basin, in order to ensure complete national coverage. The activity described under Activity 1.3 will include the integration of all FFEWS models into a common platform.

Annex C describes the existing flood forecasting models of Neretva and Trebišnjica basin and the need developments to align with the Vrbas protype and all other flood forecasting models.

6.4 Recommendations for the Improvements of FFEWS in B&H

Recommendations given aimed at establishing adequate flood forecasting models and early warning systems are based on the experience gained in the work on the forecasting model of the sub-basin of Una river, which has been operational for some time, and which can be classified as technical and institutional recommendations, as follows:

Technical recommendations

- Continuously update forecasting models with the cross-sections where they are not currently available in order to increase the quality of water levels forecasting. Additional cross-sections and structures should also include tributaries;
- Increase the number of automatic (on-line) stations for rainfall monitoring. The current number of ombrographic stations needs to be enriched with new rainfall monitoring stations in order to ensure the best possible results of river runoff forecasts;
- Improve communication with ombrographic stations in order to provide hourly data;
- Use meteorological inputs to the model with better spatial resolution (Aladin, EMCWF);
- Perform calibration of forecasting models for a long period, including high and low flow rates and pay special attention to snow (snow water equivalent);
- Perform hydrometric flow measurements during the occurrence of high water so as to improve the extrapolation of the rating curve (Q-h ratio) for extreme events;
- For the needs of real-time flood forecasts, besides the rainfall model – runoff, it is also necessary to produce hydraulic non-stationary 2D flood forecasting models, which should serve for different ‘what if’ scenarios, along with the development of the spatial flood coverage.

Institutional recommendations

- Perform quality control of all automated (on-line) data;
- Forecasters need to be continuously trained in maintenance, use and calibration of the system;
- Active cooperation with forecasters in the region (Sava River Basin);
- Ensure support for maintaining and upgrading used software packages, tools, and applications;
- Define communication, exchange and cooperation protocols between FB&H/B&H institutions and within the region.

6.5 INSTITUTIONAL ARRANGEMENTS FOR FFEWS IN B&H

Flood forecasting and early warning (FFEWS) is defined into different components.

1) Risk Knowledge: risk assessment exercise for the provision essential information in order to set priorities for mitigation and prevention strategies and designing flood early warning systems.
2) Monitoring and forecasting: systems with monitoring and forecasting capabilities to provide timely estimates of the potential risk faced by communities.
3) Dissemination: communication systems are needed for delivering warning messages to the potentially affected locations. Messages need to be reliable, synthetic and simple to be understood by authorities and the public.
4) Response: coordination, good governance and appropriate action plans are key points in effective early warning. Likewise, public awareness and education are critical aspects of disaster mitigation.

6.5.1 Risk Knowledge Institutional Arrangement

6.5.1.1 Risk Knowledge Existing Institutional Arrangement

The main national government institutions and agencies involved in vulnerability, hazard and risk assessments are the Ministry of Security in B&H, the Civil Protection Units in the two entities and the different Water Agencies in B&H. The Water Agencies are under the responsibility of Water Ministries in each entity and thus they are responsible for flood vulnerability, hazard and risk assessments. Under this responsibility, and in accordance with the EC Flood Directive, Water Agencies have started to develop flood risk studies in B&H.

It should be noted that all Institutions dealing with risk knowledge (Ministry of Security, Civil Protection Units and Water Agencies) follow their own methodologies, standards and rules prescribed by their respective regulation. Methodologies are similar but in the absence of standards which determine necessary type of data and information, way of analysing and presenting results, responsible institutions for collecting and delivering specific type of data, this leads to the production of a significant amount of documentation for different areas and different sectors, which need to be further evaluated and upgraded in order to be a base for risk assessment and management of risks which meets EUFD requirements.

Also, national standards and protocols for the systematic collection, sharing and assessment of hazard and vulnerability data do not exist. There is no strategy either for engagement of communities in analysing local hazards and vulnerabilities.

Analysis of the characteristic of key natural hazard are performed within the Studies on vulnerability assessment from natural disasters, which need to be performed for the territory of B&H, entities, cantonal and municipal or city territories. The studies asses each natural disaster individually which might occur at specific territory including information on intensities, frequencies, probability, historical data, possible causes as well as on areas which might be vulnerable and affected and on possible adverse effects on people, material goods at the specific area. However, in practice, various types of natural hazards and adverse effects are not elaborated at the same level within different studies, due to different quantity of available data for specific hazards, or different sources of data on the same hazard which provide different outputs.

6.5.1.2 Risk knowledge - Key Recommendations

There are some key recommendations, not necessarily within the institutional framework, for this component:

1) Flood hazards maps for the whole B&H should be developed. These maps should be based on international practices. This would require:
   a. Collection of required datasets, including high resolution DEM data.
   b. Hydrological assessments, implementation of hydrological models.

c. Implementation of hydraulic models.

It should be noted that within the framework of the WBIF project, flood hazards maps are being developed for the whole B&H Territory. Procedures should be implemented to ensure that this process is revisited periodically.

2) Develop risk maps for the whole B&H territory. In order to accomplish this, elements at risk and vulnerability information should be collected. This process should be revisited periodically too. It should be noted that this process will also be undertaken for the Vrbas Basin within the framework of this project. This involved the collection of extensive socio-economic, land-use, infrastructure and cadastral datasets to integrate with the flood maps derived from hydrology and hydraulic modelling exercises. Also, within this project, a framework model for this type of risk and vulnerability assessment has been provided and thus this assessment can be extended to other basins within B&H.
3) Improve the existing meteorological and hydrological database. Within the framework of this project data within the Vrbas Basin was digitised. A more significant effort should be undertaken to enhance the exploitation of these data and to digitise the whole dataset within B&H.

6.5.1.3 Proposed Institutional Arrangements for the Risk Knowledge Component

There are some key requirements from an institutional point of view in order to ensure that the risk knowledge component is fully implemented.

- *Clarification of responsibilities*: The responsibilities regarding flood risk knowledge should be clarified.
- *Cooperation:* an enhanced collaboration should be organised among the different organisations with responsibilities on flood risk knowledge, both research organisations and governmental ones. Two different objectives can be defined for this collaboration, in order to bring technical expertise into the system and in order to gather the necessary information.
- *Technical expertise*. Some local research centres have expertise regarding required for the proper flood risk assessment. The agency responsible of undertaking flood risk assessments should benefit from this expertise. This is especially the case regarding the role of the Water Institutes.
- *Information.* Water Agencies needs more information in order to improve the proper assessment of the flood risk in B&H. The proper management of that information should be planned. Institutional arrangements with relevant organisations should be planned in order to gather some of this information. The acquisition of this information should not be a one-time exercise, and periodical information updating should be undertaken (justifying the institutional arrangement):
    - Reservoir Information: information about the reservoir operation and characteristics is highly important for the flood risk knowledge. Power companies in both entities have information about this and it would be highly important to get this data for the risk knowledge component. It should be noted that this information will be paramount for the monitoring and warning component too.
    - Cadastral Information: cadastral information is vital for the development of the risk knowledge component. Up to date information from several sources, including the Geodetic Institutes of both entities will be required.
    - Flood Events: information about previous past events from different sources will be required for the implementation of the flood risk component. This information should be gathered from Hydro-meteorological Institutes, Civil Protection Units (at all levels) and regional and local authorities.
    - Hydro-meteorological data: the coordination between the Hydro-Meteorological Institutes and the water agencies in the flood risk knowledge component (and in most components for this matter) will be very relevant. Water Agencies should collect all the required data from the Hydro-Meteorological Institutes such as precipitation and water level/flow records. Also, Hydro-Meteorological Institutes have undertaken studies about the hydrology or groundwater in the catchment that are very relevant to the flood risk knowledge assessment.

    - Climate Change: information about climate change should be included in the flood risk assessment. This information can be collected from relevant ministries and research centres.
- *Capacity building:* capacity building activities should be planned in order to enhance the technical expertise within Water Agencies. These activities should focus on risk assessments and flood mapping and modelling. Guidelines about how to carry out flood risk assessment should be produced in Water Agencies in order to systematise the assessment process and to inform any interested organisation or person about the procedure followed in these assessments. The capacity building should not be restricted to Water Agencies. Hydro-meteorological institutes, local research and academic centres would benefit for capacity building in this component from international organisations.
- *Maintenance:* several mechanisms should be implemented in order to ensure that the risk assessment exercise is updated periodically. Hazards, element at risk and vulnerability in B&H will change in the future. Water Agencies should be responsible for undertaking this activity and an annual revision is recommended.
- *Risk knowledge dissemination:* Water Agencies should provide the necessary means to disseminate the results of the flood risk assessment periodically. This information should be disseminated to both public bodies and to the general public. The preferable mean of dissemination for the latter would be a dedicated webpage with flood mapping and risk information. The results of the risk analysis should be integrated into the design of communication and disaster preparedness strategies.

Therefore, an institutional arrangement for the flood risk knowledge would include links between all the different organisations listed above (Figure 6-1). The nature of these links would depend on the organisations concerned. It is suggested that links with universities and research centres could be through internships, in order to build national capacity, and also to provide relatively cheap human resources to some relevant organisations. The collaboration of Water Agencies and other organisations with PhD programmes could also be considered.

Regarding data links, most of the national and entity organisations involved in these links are governmental ones. Different type of links could be established in order to ensure both, the initial provision of this information and the periodic update of this. Also, the type of link would depend on nature of the data. For instance, reservoir information could be supplied in a daily basis (by electronic/digital means) whereas some other information such as the cadastral information could be supplied in an annual basis. Digital communication means are preferable. It should be pointed out again that it is advisable that Water Agencies maintain the main responsibility regarding flood risk knowledge in B&H.

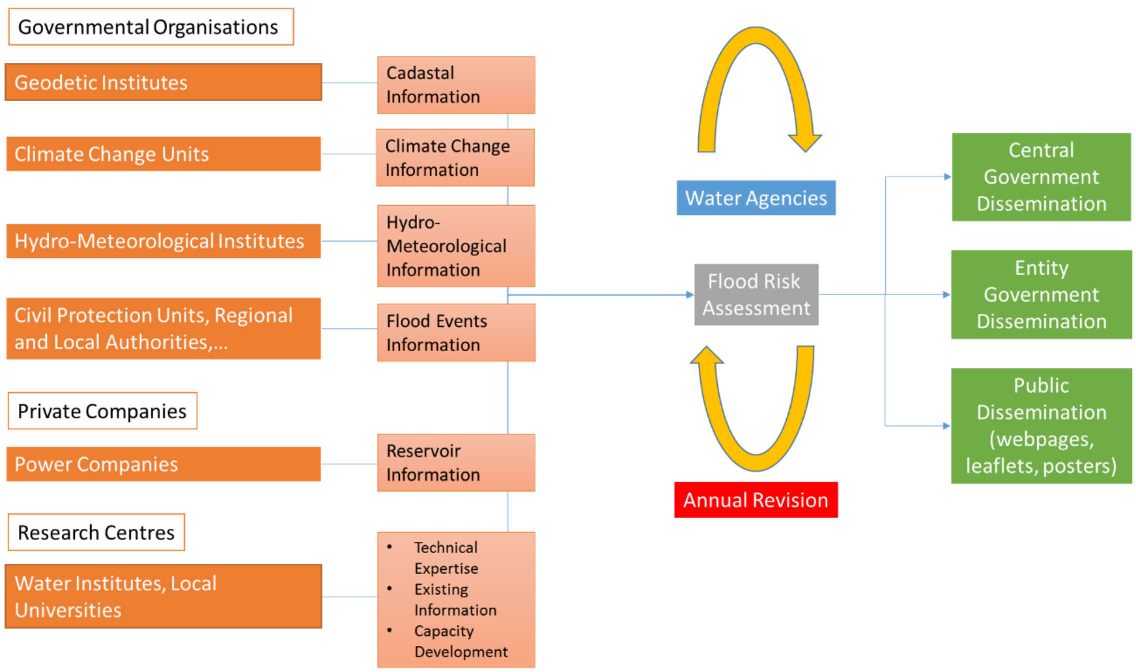


Figure 6-1: Institutional arrangement for risk knowledge component.

6.5.2 Monitoring and Forecasting Institutional Arrangements

6.5.2.1 Monitoring and forecasting Existing institutional arrangements

The existing flood early warning system was reviewed under the Vrbas project. The key recommendations for improved institutional arrangements were as follows:

The proposed institutional arrangement for the monitoring and forecasting component for the Federation of B&H and for the Republic of Srpska are shown in Figure 6-2 and Figure 6-3 respectively.

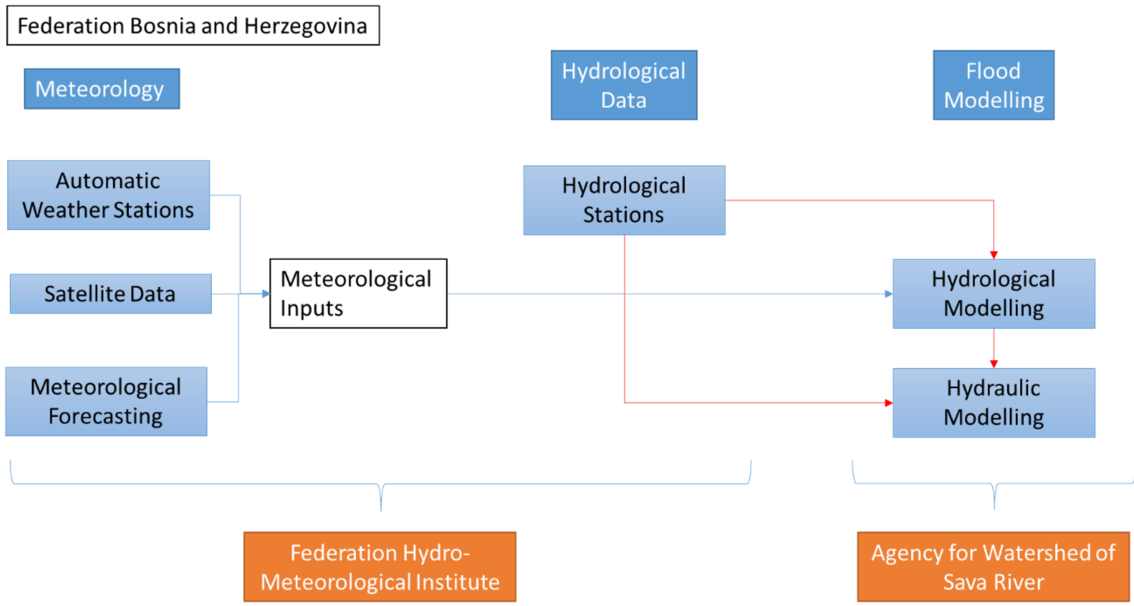


Figure 6-2: Proposed institutional arrangement for the monitoring and forecasting component in the FB&H

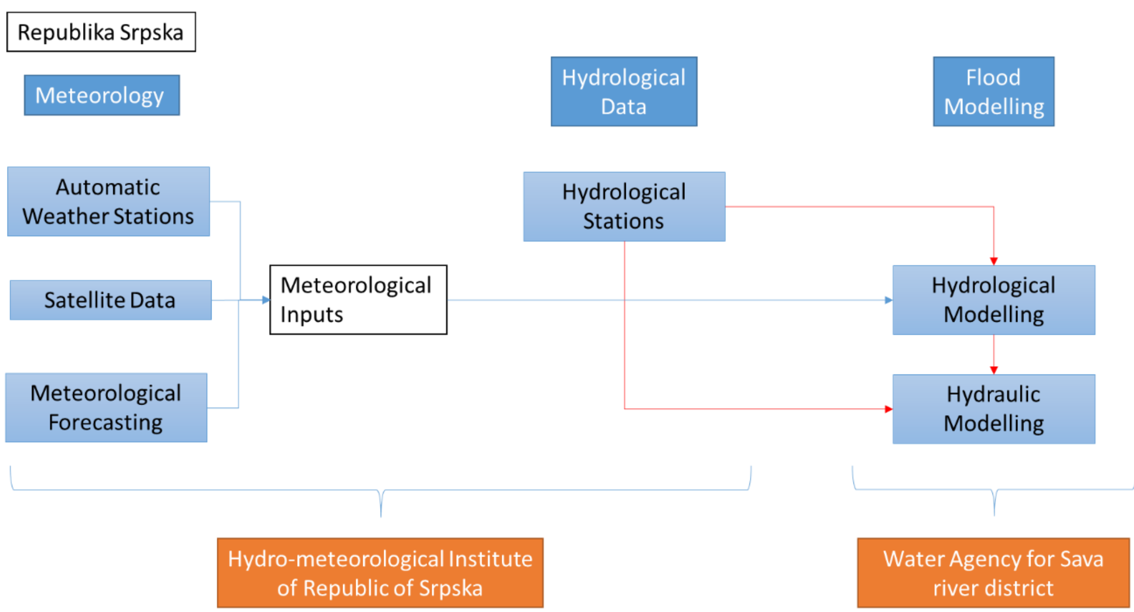


Figure 6-3: Proposed institutional arrangement for the monitoring and forecasting component in RS

The proposed institutional arrangement is identical in both entities at this stage of the institutional planning.

6.5.3 Dissemination and Communication Institutional Arrangement

6.5.3.1 Dissemination and Communication - Existing Institutional Arrangement

There are different key organisations at different levels with competences regarding dissemination and communication for flood warnings. The B&H Ministry of security formed and established a system for early warnings, the Operational and Communication Centre (BH-112), following the single European number for emergency situations approach. This Operation and Communication Centre-112 functions 24/7 and is constantly collecting any data that may lead to any type of disaster. There are also operational centres in each of the entities. These three operational centres, however, are not linked with each other. There seems to be a lack of information flow definition, and the different centres are not aware of what information has to be submitted to whom.

It should be added that in each of the entities there are operational centres at entity level, regional level (cantonal level in the Federation) and at municipal level.

The warnings produced by FHMI or RHMS are available to the public through internet pages. Currently also SMS, phone, email, paper copy, fax are all available for dissemination of warnings. FHMI disseminates warnings to public media and State Information Organizations by SMS and Internet. RHMS produces regular bulletins 3 times a day and warnings up to 5 days in advance. RHMS also produces special reports during extreme meteorological condition, such as floods, cold and warm wave, fires, thunderstorms and strong wind situations, sent to the civil protection administration and to the Operational Centre 112.

Also, in B&H early warning can be initiated by citizens or the private sector (in particular water management companies that perform the monitoring of rivers and waterways) by calling the competent bodies and government institutions (the municipality, fire department, police or local centre for warning), which will launch the initial phase in the overall EWS operation. Local institutions do have plans that prescribe the dissemination of information to the competent authorities and the standard operating procedures for reporting.

The whole communication and dissemination of flood warnings is shown in Figure 6-4: Current institutional arrangement for the Communication component. In general terms, in both entities, Hydro-Meteorological Institutes send weather warnings to different organisations regarding meteorological parameters. In the RS, the Hydro-Meteorological institute also send warning based on water level measurements whereas in the Federation of B&H is the Water Agencies issuing water level warnings. In both entities these warnings are sent to different Civil Protection Units and also to the Media and other organisations.

When a natural disaster occurs in most cases the communication is two-ways and interactive between the different levels.

It should be noted that warning alerts and messages are currently not tailored to the specific needs of those at risk. They are more or less typical in all areas in B&H and universal for all population categories.

Cantonal and municipal civil protection units have developed guidelines for public (available on the internet) with specific instructions on type of alerts (by siren and its meaning) and what to do in case of different natural disasters.

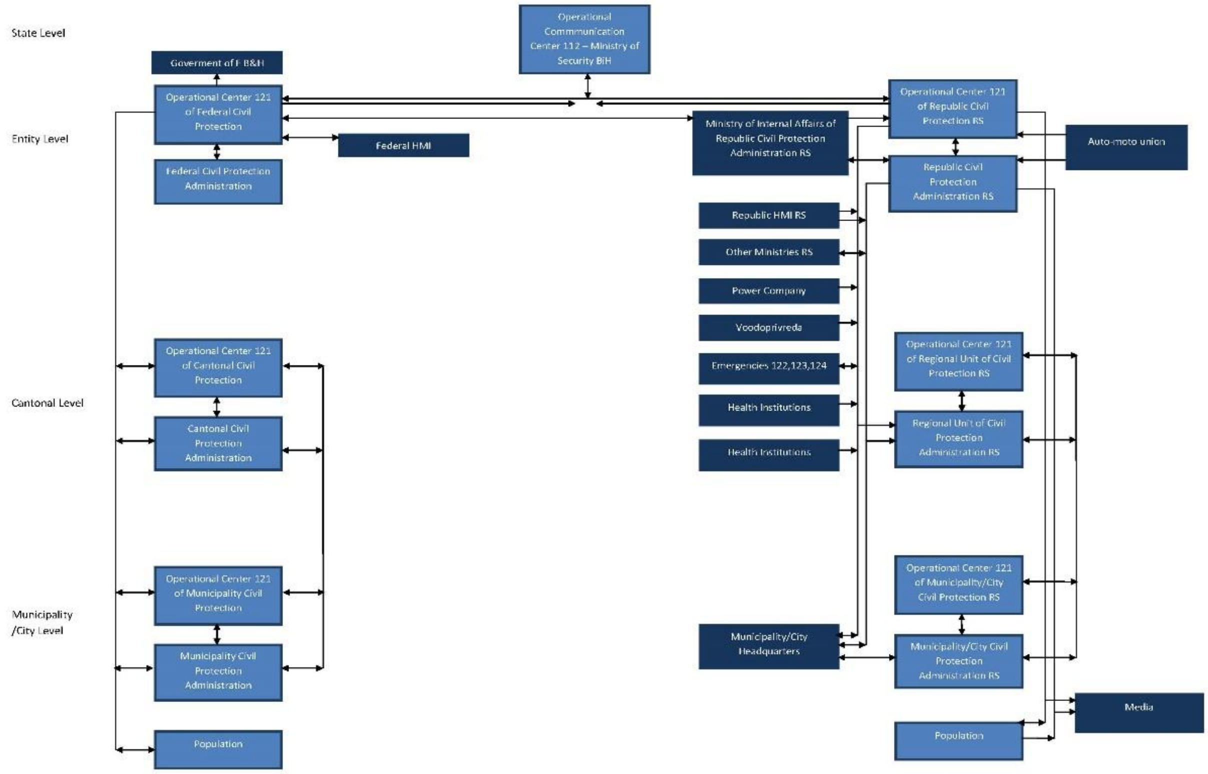


Figure 6-4: Current institutional arrangement for the Communication component

At a municipal level, there are municipal plans for protection and rescue developed by municipal departments for civil protection, including installed sirens, radio and TV stations and public address stations to be used for informing and alerting the population. There are several municipalities where problems are obvious regarding this planning and the communication equipment is not fully functional.

6.5.3.2 Dissemination and Communication - Key institutional recommendations

There are some key institutional recommendations at this stage:

- Institutional responsibilities within this component should be clarified.
- Communication means between the different organisations should be improved, and redundancy means should be implemented.
- Communication with communities should be enhanced.
- The distinction between warning levels for different events should be properly established. The criteria for this distinction should also be defined. This distinction and criteria should be agreed by all the major stakeholders. Thresholds for different variables and areas of influence for this distinction should be agreed by Water Agencies and Hydro-Meteorological Institutes in both entities. It is highly recommended that this same threshold approach is agreed also between the different organisations between the two entities. It is recommended that in the whole Vrbas River Basin the threshold approach and the different threshold levels (when not local) should be the same independently of the entity.
- On the other hand, Civil Protection Units at different levels should be involved in the definition of the response size and resources to be deployed depending on the size of the event. The opinion and feedback of any other stakeholder, especially local and regional ones, should also be considered for the definition of this criteria and distinction.
- It is highly recommended that institutional procedures are set up to describe:

- The meaning of the different level of warning. Also, the criteria for the definition of the different levels should be established.
- The information to be communicated. This has to be clear and easy to understand by the receiver, therefore different standard type of messages should be devised depending on the organisation to receive the message.

6.5.3.3 Dissemination and Communication - Proposed Institutional Arrangement

The suggested arrangement is shown in Figure 6-5 and Figure 6-6 for the Federation of Bosnia and Herzegovina and the Republic of Srpska respectively. In both cases the proposed arrangement is very similar. It is suggested that in both scenarios any flood warning is issued centrally from the Water Agencies. This implies that meteorological and observational water level warnings identified by the Hydro-Meteorological Institutes in both entities would be sent to the Water Agencies and from there distributed to the different operational centres and Civil Protection Units at different levels. The reason behind this suggested approach is twofold:

- A single organisation issuing external flood warnings will help to avoid any issues and misunderstandings regarding warnings.
- The relationship between the Hydro-Meteorological Institutes and Water Agencies should be very intensive and cooperative. The communication of data should be in a sub-daily basis and in most cases the communication flow should be from the Hydro-Meteorological Institute to the Water Agency, and therefore the communication of warnings would follow the same communication channel.

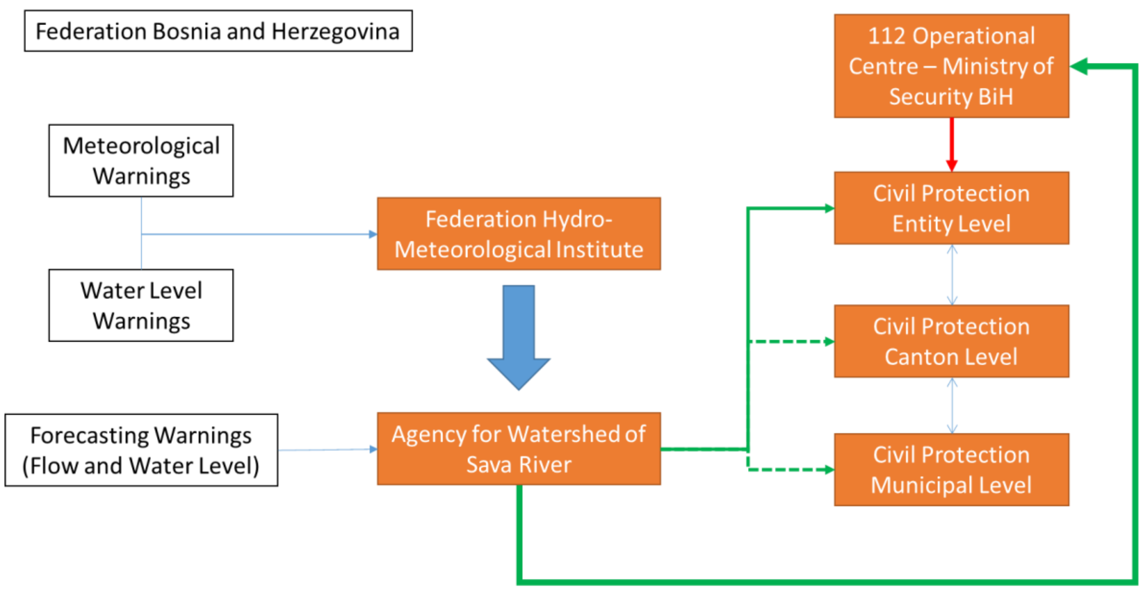


Figure 6-5: Proposed institutional arrangement for the Communication component - FB&H

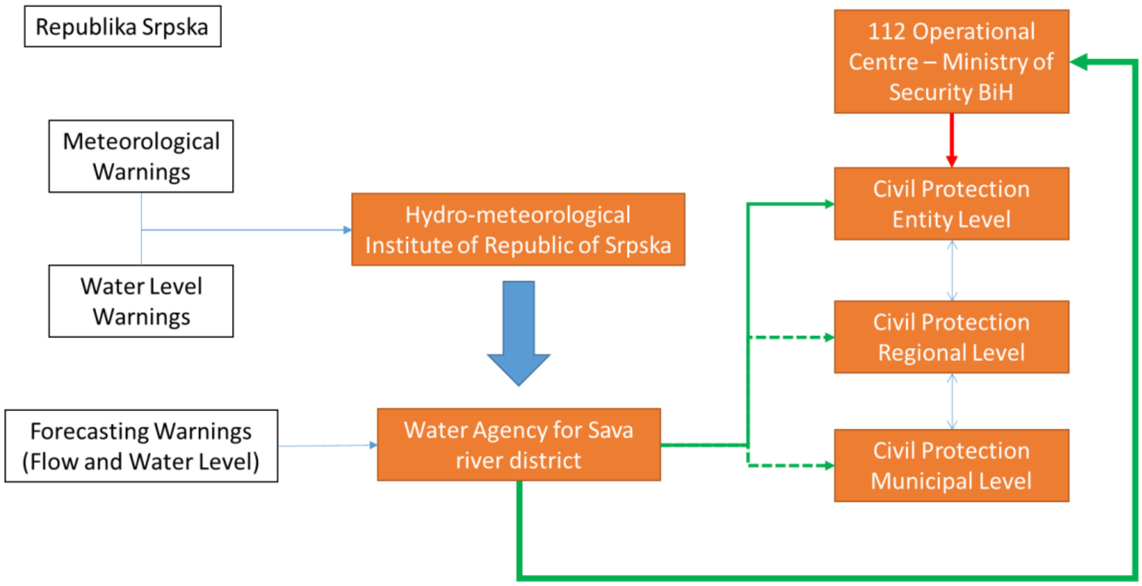


Figure 6-6: Proposed institutional arrangement for the Communication component - RS

It should be noted that both the Hydro-Meteorological Institutes and the Water Agencies could be (and should) considered as an Operational Centre for Flood Forecasting, and the relationship between these two types of organisations should be strong and functional.

The main communication link between the Flood Forecasting Operational Centre and any other organisation would be between Water Agencies and Civil Protection Units (Figure 6-7 and Figure 6-8). Water Agencies should communicate primarily with the Civil Protection Units at Entity level. The Civil Protection Unit at Entity level should then communicate any warning to the Cantonal or Regional one, and this latter one should communicate with the Civil Protection Unit at municipal level. It is recommended that more communication chains are established in order to ensure redundancy, but the main one should be from the Water Agencies and the Civil Protection Unit at Entity level.

Also, Water Agencies should communicate any warning to the State Operational Centre (112) and they should liaise with the different Civil Protection Units too. This is because the Vrbas River Basin crosses the two entities, and any warning within this basin may affect the two entities. Therefore, the State Operational Centre should be involved and aware of any warning within the Vrbas River Basin. It is recommended that Water Agencies from the two different entities communicate with each other too. The whole arrangement at this level is shown in Figure 6-7, where the communication between Water Agencies and the different Operational Centres and Civil Protection Units is displayed.

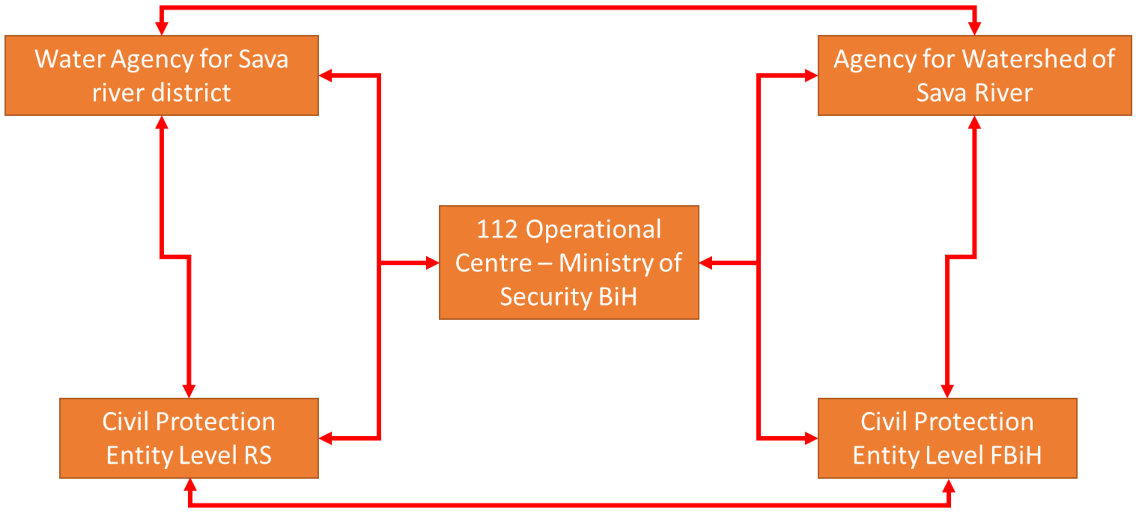


Figure 6-7: Proposed institutional arrangement for the Communication component

Once both the State Operational Centre and the Civil Protection Unit at Entity level has been notified of a likely impending event (warning), they should liaise with the different Civil Protection Units, with the other Entity and also with the different relevant organisations within its entity. Figure 6-8 shows an example of this arrangement for the Republic of Srpska. A similar approach should be followed in the Federation.

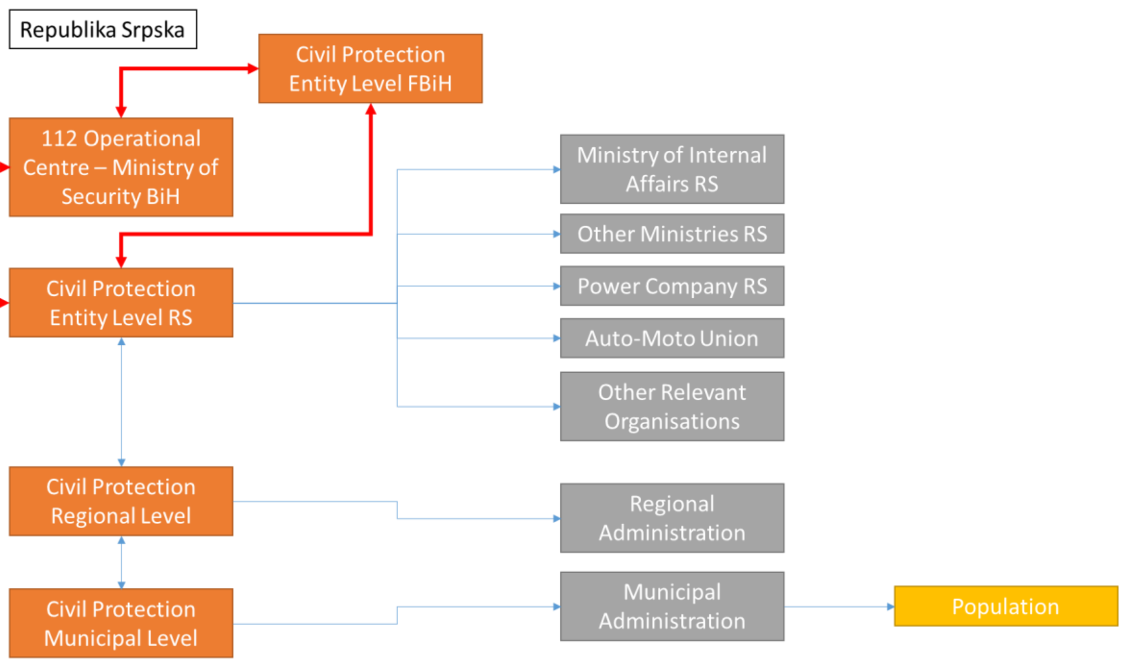


Figure 6-8: Proposed institutional arrangement for the Communication component

6.5.4 Response Institutional Arrangement

6.5.4.1 Response Existing Institutional Arrangement

As previously noted, civil protection headquarters exist and function at entity, cantonal (in FB&H) and regional (in RS), municipal and sometimes at the level of local communities, in both B&H entities. Generally, these civil protection headquarters at all levels manage preparatory and operational activities: before natural disaster and after proclamation of state of natural disaster.

It should be noted that in order to start any operational activity (such as usage of material goods and people, implementation of rescue and protection activities), civil protection headquarters, a proclamation of state of natural or other disaster must be declared beforehand.

The fact that problems have been reported for the coordination, and request of humanitarian aid in B&H should be highlighted. The current institutional arrangement has led to more effort and some duplication that was identified by humanitarian organizations responding to flood disasters.

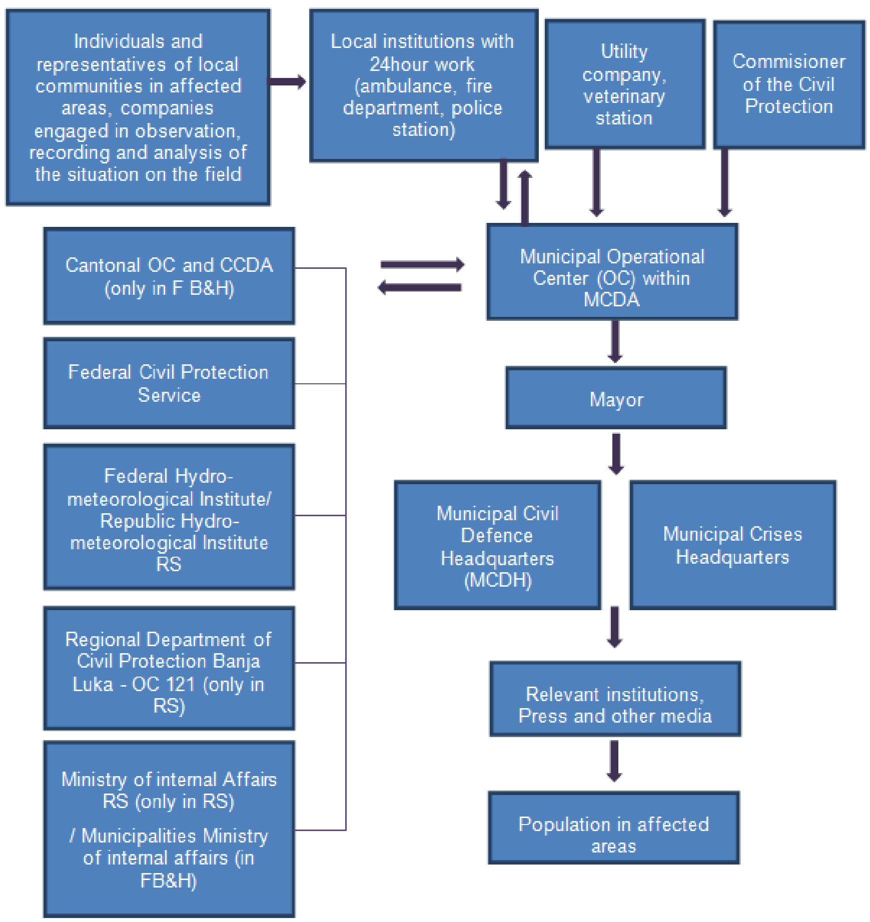


Figure 6-9: Existing Response Component at local level

On local level, the early warning response correspond to the municipal operational centre, the municipal administration, the municipal civil defence headquarters, the Fire Department, the Health department, the Police Units and also to private companies engaged in observation, recording and analysis of the situation on the field (Figure 6-9).

Most communities have not defined evacuation routes or centres, although in practice the population is most cases evacuated to relatives or neighbours. In some communities, Community Response Plans identify schools and sport halls for evacuation purposes, although it is not always clearly defined.

Current community practices during flood events are the monitoring of meteorological conditions, declare the state of natural disaster, organisation of Crisis Committee meeting, supervision, surveillance, proposition of measures and activation of municipal services for protection and rescue.

It should be noted that at local level, the Civil Protection Units works in a voluntary basis in most cases. There are issues regarding the commitment and the training of the voluntary members of these units.

6.5.4.2 Response - Key institutional recommendations

There are some recommendations regarding this component:

- Clarify institutional responsibilities.
- Response plans for relevant institutions at all levels should be developed
- Undertake public awareness campaigns to promote disaster risk reduction at all levels
- Education and awareness-raising, including networking among universities with programmes of excellence in the field of the emergency management.
- Improve involvement of local communities in the response process component. It is also recommended that every community develop its own response plans.
- Training of Civil Protection Units at all levels should be developed in order to enhance the response component.
- As previously noted in the dissemination component, Civil Protection Units at different levels should be involved in the definition of the response size and resources to be deployed depending on the size of the event.
- Private companies and/or NGOs should be involved in the response component

6.5.4.3 Proposed Institutional Arrangements for the Response

The institutional arrangement for the response component would depend on the magnitude of any specific warning. Preparation and response should be considered whenever a flood warning at local level. Depending on the severity of the event, the involvement of external organisations (private companies or NGOs) or organisation at a higher level (at regional/cantonal, entity or state level) should be considered.

7 PAST AND ONGOING FLOOD RISK MANAGEMENT PROJECTS

7.1 Baseline Projects

- **Technology Transfer for Climate Resilient Flood Risk Management** – USD 5 mil SCCF funded UNDP implemented project. The SCCF funds are used to enable the communities of the Vrbas basin (12% of B&H) to adapt to flood risk through the transfer of adaptation technologies for climate resilient flood management, upgrade and rehabilitation of the hydrometric monitoring network, development of a flood forecasting system and early warning system, development of emergency response plans, and provision of training in flood-specific civil protection. Importantly, the project provides targeted training on climate-induced Flood Risk Management to over 100 practitioners and decisions makers and develops an institutional capacity development plan for the long-term development of capability and capacity in FRM. The proposed GCF project is scaling up the successfully implemented “Technology transfer for climate resilient flood management in Vrbas River basin” (Vrbas project) and extending its many achievements to the rest of B&H. In addition, GCF project will collaborate with ongoing projects.
- **Emergency Flood Relief and Prevention Project** - EIB Loan. The total value of this project is 55 million Euros with implementation period 2012-2017. The purpose of the project is to safeguard the agriculture, industrial and housing areas prone to flood impacts and to enable a stable basis for future development. The main focus of this project is construction of hard engineering structures, mainly along the Sava River. The project also makes an inventory of damages to flood protection infrastructure within the RS's main Danube tributaries
- **B&H Floods Emergency Recovery Project** – WB Loan - The objective of this USD 100 mil loan is to meet critical needs and restore functionality of infrastructure essential for public services and economic recovery in floods affected areas. There are three components to the project, the first component being emergency disaster recovery goods. The second component is the rehabilitation of key public infrastructure. The third component is the project implementation support and capacity building.
- Advance the National Adaptation Plan (NAP) process for medium-term investment planning in climate sensitive sectors in Bosnia-Herzegovina - USD 2.56 mil GCF funded, UNDP implemented project (2018-2021) - is to advance adaptation planning in B&H with a focus on sectoral approaches, upgrading the knowledge base for adaptation, prioritising adaptation interventions for the medium term, building institutional capacities for integrating climate change adaptation and demonstrating innovative ways of financing adaptation at the sub-national/local government level. Proposed activities will result in the compilation of a NAP and implementation strategy focused on scaling-up adaptation in key sectors for the medium-term; develop municipal level investment financing instruments with public/private sector engagement; and build national, sub-national and sectoral capacity to integrate and mainstream risk informed planning and budgeting.
- **UN Floods Recovery Programme "Danas Za Nas"**: started in July 2014, right after the humanitarian response phase, aiming to reestablish normal living conditions, preserve jobs, support local economies and increase disaster resilience in more than 60 communities most affected by the floods. Financed by 28 bilateral donors, this USD 22,6 million worth programme is coordinated by UNDP and implemented by the UN agencies: UNDP, UNFPA, FAO, UNICEF and UNESCO.
- **EU flood recovery program** - following 2014 floods in B&H, EU launched its EU Floods Recovery Programme for Bosnia and Herzegovina worth 43.52 million Euro, out of which the EU’s contribution is 42.24 million Euro. The Programme aims to rehabilitate 4,000 dwellings for approximately 14,000 people, 100 local roads and bridges, 90 educational institutions (including pre-school facilities), 10 water and sanitation facilities, three municipality buildings, four Centres for social welfare, and four healthcare facilities. The EU Flood Recovery programme is aligned with the Recovery Needs Assessment, which was conducted by domestic authorities with

assistance provided by the European Union, the United Nations and the World Bank. The Programme was implemented through UNDP, INICEF and IOM until February 2016.

- **West Balkans Drina River Basin Management Project (GEF)**- World Bank project to assist the countries of Bosnia-Herzegovina, Serbia and Montenegro to achieve improved planning and implementation for integrated, cooperative management of the trans-boundary Drina River basin. Started in 2017.
- Capacity Development for the Integration of Global Environmental Commitments into National Policies and Development Decision Making (GEF)- for facilitating cross-sectoral and participatory approaches to natural resource management planning and implementation; Including developing individual and institutional capacities to better adapt and apply global environmental management indicators as a monitoring tool to assess the intervention performance and institutional sustainability
- **Flood Hazard and Flood Risk Maps of B&H**, a project of the Western Balkans Investment Framework (WBIF). The overall objective of this project is to prepare the expert basis needed to ensure protection against floods for existing and future facilities and raise the level of knowledge on flood hazard and flood risk in the most prone-to areas of Bosnia and Herzegovina. It will be achieved via development of flood hazard and flood risk maps. Started in 2017.
- **Floods and Landslides Housing Risk Assessment** – EU launched the EU Flood Recovery Programme for B&H, in order to support recovery efforts after the floods of May 2014. The Programme aims at assisting people in the flood affected areas and communities in the 24 most affected municipalities to normalize their lives. Furthermore, the Programme recognizes the importance of investing in future risk informed decision making and it thus initiated the development of a Flood and Landslide Risk Assessment for the Housing Sector in B&H (Assessment). The Assessment focuses on the flood and landslide risk for the housing sector in Bosnia and Herzegovina, prioritizes locations based on risk ranking and makes recommendations for risk reduction.

7.2 DESCRIPTION OF BASELINE PROJECT BEING SCALED UP

The **Technology Transfer for Climate Resilient Flood Risk Management in Vrbas River Basin** project is a 5-year project US$5 million project with the objective to transfer technologies for climate resilient flood management in order to increase resilience of highly exposed rural poor, returnee and displaced persons communities in Vrbas River Basin. Adaptation technologies for climate resilient Flood Risk Management (FRM) include the development of state-of-the-art hydrological and hydrodynamic models and GIS tools for the Vrbas River Basin incorporating climate change predictions and producing flood hazard maps as the basis for spatial planning and long-term strategic FRM. The project includes the upgrade and rehabilitation of the hydrometric network, and the harmonisation and centralisation of the hydrometric database. The project also developed the flood forecasting system and enhanced the existing early warning system within the VRB. Emergency response is being enhanced through the development of emergency response plans, and provision of training in flood-specific civil protection are provided. Further, an institutional capacity development plan for the long-term development of capability and capacity in FRM is developed. The project works closely with affected communities to introduce climate resilient community-based non-structural measures and provides training to local communities in climate resilient FRM. The project has three components as follows:

Component 1: Enabling environment for climate risk sensitive water and flood management

Output 1. Key relevant development strategies/policies/legislation integrate climate change-resilient flood management approaches

Activity 1.1: At least two priority sectoral policies and plans (e.g. agriculture, hydropower, water resources) updated to include climate change modelling results;

Activity 1.2: Floodplain management and spatial planning regulations and policies updated to include climate change risks (revision of land use regulations, stricter policy on construction permits in the areas prone to flooding, etc);

Activity 1.3: Appropriate adaptation technology solutions for climate resilient flood management in B&H codified and disseminated.

Component 2. Technical and institutional capacity for transferring climate resilient flood management technologies and approaches

Output 2. Climate resilient flood risk management is enabled by transferring modern technologies and strengthening institutional capacities

Activity 2.1: Improved hydrological and hydrodynamic model for the VRB incorporating climate change predictions, developed to produce flood hazard inundation maps for spatial planning and emergency response planning, and for the long-term strategic flood risk management of the VRB;

Activity 2.2: GIS-based vulnerability, loss and damages assessment tool and database established and institutionalized to record, analyse, predict and assess hydro-meteorological and other hazard events and associated losses;

Activity 2.3: Hydro-meteorological monitoring system in the VRB upgraded and harmonized into a central hydrometric system;

Activity 2.4: Institutional capacity strengthening plan developed and targeted training on climate-induced flood risk management provided to at least 100 practitioners and decision-makers;

Component 3. Climate resilient flood management technologies for vulnerable communities in VRB

Output 3. New technologies and approaches for enhanced flood risk management applied to increase resilience of vulnerable communities in VRB

Activity 3.1: Integrated land use and flood risk management plan for the VRB developed and non-structural measures implemented by local communities (through Output 3.2.), government and/or private sector;

Activity 3.2: Participatory community-based adaptation strategies, technologies and practices implemented in priority flood risk areas (e.g. community afforestation scheme on the flood plains; establishing locally controlled and managed flood zones; watershed rehabilitation works, etc);

Activity 3.3: Local communities (particularly women and refugees) trained to implement and maintain flood resilient non-structural intervention measures, including agricultural practices such as agro-forestry, to improve livelihoods of 13 communities in the VRB, and community-based flood early warning systems;

Activity 3.4: Early warning system in VRB modified to include the new hydrometric monitoring network as part of a fully-integrated flood forecasting system (comprised of centrally-based and community-based early warning systems). Municipal-level flood response and preparedness plans prepared and implemented.

Key Project Achievements

Component 1

1) The Project has reviewed existing legislation, policies strategies and plans and identified all sectors of relevance to flood risk.
2) Entry points in the main legislations (law on waters, water management strategies, law on agricultural land, law on spatial planning) for introducing Climate Change considerations have been identified.
3) Climate change model for Vrbas River Basin has been developed.
4) Amendments to the Law on Waters, transposing EU flood directive and introducing climate changes have been adopted by the Government.
5) By-laws identifying clear institutional roles in hydro-meteorological data flow, flood forecasting and early warning system have been adopted by the Government
6) Development of a draft flood zoning policy has been completed
7) Flood risk modelling and mapping methodology has been developed and adopted by both entity institutions.
8) Methodology for identification of torrential basins and torrential flood susceptibility model has been adopted and scaled up for the whole country.
9) Methodology for development of a centralized flood forecasting and early warning system has been adopted and scaled up for the rest of the country.
10) Operational and maintenance plan for hydrometric stations has been completed. Guidance to use PGIS and geoportal has been developed.

Component 2

1) Hydro-meteorological equipment consisting of 7 hydrological, 2 meteorological and 20 rain gauges have been installed and is operational.
2) Automated hydrometric monitoring network has been established in Vrbas River Basin, which makes it the first river basin in Bosnia and Herzegovina with a sufficient hydro-meteorological network coverage.
3) Data collection and processing has been centralized and is taking place in hydro-meteorological institutes. Real-time data transfer is enabled
4) Water information system has been upgraded and includes a platform for exchange of data among water agencies.
5) Hydrological and hydrodynamics models (including 2D model for the whole basin) have been completed. Hydrological modelling included climate change scenarios.
6) Vulnerability assessment, including gender segregated data, has been completed. Flood depth-damages curve has been developed.
7) Socio-economic model has been developed and analysis completed

8) Professionals in hydro-meteorological institutes and water agencies have received trainings on hydrometric monitoring. Hydro-meteorological institutes and water agencies professional have been included in and have received on-work training in hydrological and hydraulic modelling.
9) Geodetic experts have been involved and trained in interpretation of LiDAR survey. Professionals from water agencies and relevant ministries have been receiving continuous training in water information system (data entry, analysis etc.). Members of civil protection units have been trained on how to use early warning system equipment.
10) Project Spatial Data infrastructure, in line with the EU INSPIRE directive has been developed.
11) Socio-economic survey in the Vrbas River Basin has been completed and it includes vulnerability assessment for women in flood risk areas in VRB.
12) Development of GIS-based flood damages, losses and vulnerability model has been completed.

Completed flood hazard and risk maps have been entered in project geoportal have been handed over to water agencies and municipalities.

Component 3

1) Hydrological and hydraulic models for flood forecasting have been completed.
2) Flood forecasting and early warning system platform is being implemented.
3) Participatory GIS, as a means of integrating local community information into the assessments of flood risk, has been developed as part the GIS-based socio-economic tool. Introduction of PGIS in municipalities is in progress.
4) Community engagement, mobilization and sensitization strategy has been developed. It sets out the general community engagement steps for each of the stages of community involvement throughout the project.
5) Till the end of 2018, 20 non-structural measures have been designed and implemented in the Vrbas River Basin. Identification and selection of measures has been based on flood hazard and risk maps.
6) Flood/natural disasters insurance product for individual households developed
7) Early warning system equipment has been purchased for 14 municipalities in Vrbas river basin and handed over to civil protection units.
8) Municipal flood intervention plans have been developed.
9) Continuous education for agricultural workers reference climate changes and flood protection is on-going.

The following sections present some of the key project deliverables, achievements and lessons learned.

7.3 Development of EUFD Flood Hazard and Risk Maps

7.3.1 Flood hazard modelling – hydrological and hydraulic modelling

A foundational activity of the project, on which all other activities depended, was the development of the flood hazard and risk maps for Vrbas basin, using the agreed national EUFD methodology developed by the project in consultation with all relevant stakeholders.

Based on detailed topographic, soil, land use, geology and 53 years of hydrometric data (rainfall, water level, flow and temperature data for 3 stations digitised by the project) a detailed rainfall-runoff model was developed using NAM (within MikeFlood software, purchased by the project), calibrated at 14 gauging stations, and simulates hydrographs for 45 sub-catchments of the Vrbas basin. The 45 NAM hydrological models form inputs to a 1D-2D hydraulic model of the Vrbas main river and major tributaries which was developed in Mike FLOOD software using channel survey (more than 559 cross-sections) and floodplain topographic data (LiDAR flown by the project). The resulting linked hydrological-hydraulic model formed the basis of all flood hazard mapping for the basin and was used to generate flood depth and hazard maps for a number of flood events of different return periods (20-year, 50-year, 100 year, 100 year +CC and 500-year flood) and for modelling the effects of climate change.

7.3.2 GIS-based socio-economic risk model developed

Using GIS to integrate flood hazard maps with physical and socio-economic data on all receptors of flooding, a flood risk model was developed. Based on the flood risk being a function of probability of flooding (return period) and impact (depth, velocity, receptor characteristics) the model calculates a flood risk score for people, infrastructure, roads, agriculture and the built and natural environment. It then calculates damage as a function of property value, depth, and velocity of flooding for properties of different types (small Houses; Large Houses; Apartments; Commercial buildings) based on this risk score. Agricultural Flood Risk is converted to weighted crop loss per hectare according to seasonality of flooding and yield loss through growing period (January to December). Damages and Loss within each of 4 Flood Risk Zones are weighted by modelled flood levels to give an Annual Average Damage/Loss for each which can be calculated down to the level of each property and agricultural plot of land, and results can be aggregated up to the community and/or municipal or regional level. The GIS model calculates all flood risk scores and damages/losses to property and agriculture, and therefore has enabled the estimation of potential flood losses.

7.3.3 Torrents Hazard Mapping

The project undertook a study of the sub-catchments within the Vrbas basin with two main objectives:

1) To develop the missing definitive methodology for mapping of flood-induced debris flow for B&H
2) To develop torrent hazard maps for Vrbas basin for sub-catchments that are prone to flashy torrential flooding.

The project reviewed the existing situation and spatial distribution of erosion categories (strength of erosion processes) in the areas of watersheds of Sava River and Adriatic Sea in Federation B&H and Brčko District B&H, and created the basis for quality-quantity presentation of the proportion of erosion, or the production and transport of sediment per basin. In addition, the development of Erosion Map the basis for harmonization of planning and project documentation for all relevant existing and planned economic and infrastructural objects, as well as the basis for making of the Cadastre of torrent flows (basins) and Sensitivity Model of the occurrence and development of flash floods. Hence, the broader goal of development of Erosion Maps is to provide climate risk information to water management, agriculture, forestry, spatial planning, ecology, environment protection and other activities that are subject to these risks.

Republika Srpska during the period from 2007-2015 produced the Erosion Map for Sava and Adriatic river basin districts (in RS only) using methodological approaches which were adopted and verified for RS in 1985. The Vrbas project enabled the further development of the RS methodology to include climate change and harmonisation with Erosion Map development for river basin of Vrbas River in Federation B&H. The Vrbas project therefore enabled significant technical progress compared to the previous work, by developing the Cadastre of torrent flows and by realization of the Sensitivity Model to the occurrence and development of flash floods for whole river basin of Vrbas River.

Section 3.6 provides further details about the methodology for torrents hazard mapping.

Figure 7-1: Flood depth and hazard map for Vrbas basin

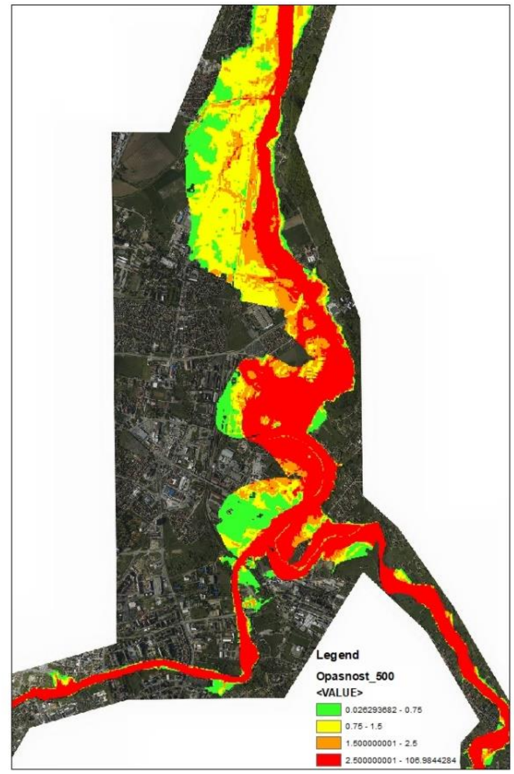


Figure 7-2: Flood risk map for Vrbas basin

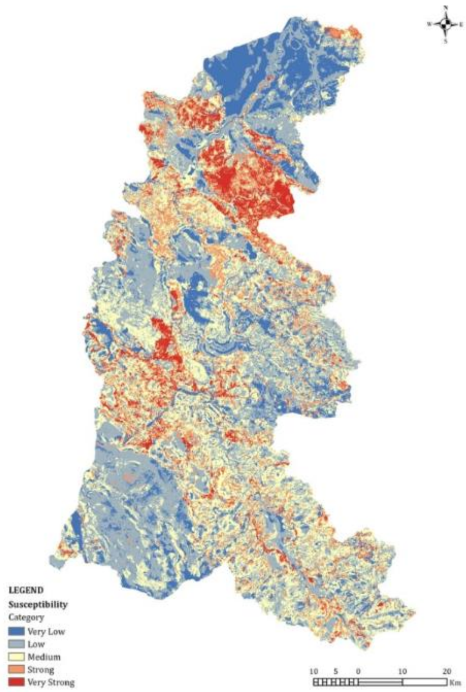


Figure 7-3: Torrent Flood Susceptibility Map for Vrbas basin

7.4 Legislative Amendments

The project undertook a detailed review of the existing FRM legislative and policy gaps and needs (see next chapter which discusses gaps). To address some of the key gaps, the project implemented the following legislative changes:

1) During 2017, the Law on Water of Republika Srpska was aligned with the EU Floods Directive, which defines the method of flood risk assessment and management. It forms the legal basis for better flood risk management.
2) RS Law on Water was amended to define the segments of preliminary risk assessment, development of flood hazard and risk maps, establishing forecasting and early warning systems, as well as regulating the development of Flood Risk Management Plan. It was adopted in July 2017.
3) The Decree on Content and Key Elements of Flood Risk Assessment and Management was adopted in December 21017. This decree regulates content and procedure for Preliminary Flood Risk Assessment (PRFA), process of flood hazard and risk mapping, content and appearance of the maps, goals of flood risk mapping and measures for their achievement, programme of activities for preparation of Flood Risk Management Plan (FRMP), content of the Plan and necessary elements for its update and other issues related to flood risk assessment and management.
4) In Federation of Bosnia and Herzegovina (FB&H) the Draft Amendment of the Water Law FB&H was officially submitted to the FB&H Parliament at the end of 2017. The proposed amendment will provide ‘’additional improvement of protection from harmful effects of waters based on experiences of 2014 floods and requirements of the EU Flood Directive’’. Proposed legislative changes include the financial aspects of water sector management, issuing of water licenses and harmonization with EU Water Framework and Flood Directive. However, legislative development in FB&H requires additional efforts and support in order to achieve full alignment with EU Flood Directive.

7.5 New Flood Zoning Policy and Changes to Spatial Planning

The flood zoning policy was developed as a means of natural flood management, in order to retain the natural functions of the floodplain, minimise loss of life and property damage due to flooding, and maximise the goods and services that can be derived from harmonious existence on the floodplains. The flood hazard and vulnerability maps developed for the Vrbas basin have been used to develop flood zones for utilization in floodplain management activities such as floodplain zoning through development planning, and emergency planning. The Floodplain Zoning Policy Framework provides the framework for managing flood risk. The aim of the Floodplain Zoning Policy Framework is to integrate flood risk management into the land use planning process in B&H. To this end the policy framework has been developed to:

1) Embed climate resilient flood risk management into existing planning policies and plans by focusing on managing floodplain development and, by extension impacting the management of development away from the floodplain.
2) Outline the policy based on detailed risk knowledge based on floodplain hazard and risk mapping.
3) Provide policy guidance for flood risk management in the form of guidance documents (e.g. risk assessment, minimum design standards for buildings in different zones, retrofitting buildings, ensuring flood resilient critical infrastructure, insurance zoning, integration of flood zones with Flood Forecasting and Early Warning System (FFEWS)).
4) Ensure the designated flood zones are considered an integral aspect of determining and specifying appropriate land uses (through restricting and permitting).
5) Provide sound practice examples for managing existing risks (i.e. managing risks to buildings already in high hazard areas) and managing residual risks.

With development of flood hazard and risk maps for VRB basin, the basis for climate/flood risk informed spatial planning and long-term strategic FRM through exposure reduction has been established. Recent analysis of the area of VRB as a pilot area, showed that 158 settlements, 67,000 households with almost 200,000 inhabitants are living within the floodplain, including 120 public buildings (health, education, social service etc..), and infrastructure, communication etc. This gives very high significance to flood zoning as a tool for future flood risk reduction. The document ''Flood Zoning Policy'' defines measures and recommendations for existing buildings/activities and future development within the flood plains, has been developed and presented to the relevant ministries of both B&H entities (spatial planning, agriculture/water management, environment). The Policy clearly outlines 4 flood zones, and 7-8 vulnerability classes or sectors and defines the zones within which each vulnerability class can be placed to minimise risks to users for both existing and new development.

The tables below show the permitted development and restrictions for each sector/vulnerability land use category within each of the four flood zones [1 in 20 year (5%), 1 in 50 year (2%), 1 in 100 year (1%) and 100+CC flood return periods).

Table 7-1: Recommended measures towards existing activities/buildings in the floodplain zones in the Vrbas River Basin

Sector/Vulnerability category	Zone 1 (5% Prob)	Zone 2 (2% Prob)	Zone 3 (1% Prob)	Zone 4 (1%Prob + CC)
Agriculture	Relocation	Preservation, with flood insurance	Preservation, with flood insurance	Preservation
Essential/critical infrastructure	Relocation	Preservation, with taking protective measures (construction of protective structures) and securing access	Preservation, with taking protective measures (construction of protective structures) and securing access	Preservation
Water compatible infrastructure/ activities	Preservation, with taking protective measures (construction of protective structures) and securing access	Preservation, with taking protective measures (construction of protective structures) and securing access	Preservation, with taking protective measures (construction of protective structures) and securing access	Preservation
Emergency response services	Relocation	Relocation	Relocation	Preservation under the condition that there is no possibility of locating in areas without flood risk
Permanent shelters	Relocation	Relocation	Relocation	Preservation under the condition that there is no possibility of locating in areas without flood risk
Business and public buildings	Relocation	Preservation under the condition of taking protective measures after a cost - benefit analysis; Additional measures*	Preservation under the condition of taking protective measures after a cost - benefit analysis; Additional measures*	Preservation, with the introduction of early warning system on floods and programs for raising public awareness of floods
Residential buildings	Relocation	Preservation under the condition of taking protective measures after a cost - benefit analysis; Avoiding the use of basement and ground floor; Additional measures*	Preservation under the condition of taking protective measures after a cost - benefit analysis; Avoiding the use of basement and ground floor; Additional measures*	Preservation, with the introduction of early warning system on floods and programs for raising public awareness of floods

Table 7-2: Recommendations for new activities/buildings in floodplain zones in the Vrbas River Basin (permissibility of new activities/buildings)

Activities/buildings	Zone 1 (5% Prob)	Zone 2 (2% Prob)	Zone 3 (1% Prob)	Zone 4 (1%Prob + CC)
Agriculture	No	Yes	Yes	Yes
Mining	Conditional	Yes	Yes	Yes
Essential/critical infrastructure	No	Conditional	Conditional	Yes
Water compatible infrastructure/ activities	Conditional	Yes	Yes	Yes
Emergency response services	No	No	No	Conditional
Permanent shelters	No	No	No	Conditional
Business and public buildings	No	Conditional, without basement construction	Conditional, without basement construction	Yes
Residential buildings	No	Conditional, without basement construction	Conditional, without basement construction	Yes

Consultation on the draft floodplain zoning policy resulted in the following conclusions:

Federation of B&H

1) The best way for implementation of measures defined by Flood Zoning Policy is integration in relevant laws;
2) In order to incorporate Flood Zoning Policy into the legislative framework (laws, by laws, methodologies and management plans) multisectoral approach is necessary (water management, spatial planning and environment);
3) In order to incorporate FRM measures into the spatial planning and land use sectors it is necessary to develop flood risk and flood hazard maps for all main basins in FB&H, as well as FRMP and implementation of Decree on types and content of Flood Protection Plans;
4) It is necessary to officially inform legal bodies/institutions currently preparing legislative changes in sector of spatial planning, on possibility/intention to incorporate issues of spatial planning and zoning in accordance to flood risk into Law on Spatial Planning which is currently in amending phase in both entities (RS and FB&H);
5) One of the possibilities for implementation of measures proposed by Flood Zoning Policy into the legal framework is its integration in ‘’Decree on Methodology for Development of Spatial Planning Documents FB&H’’ (sub law)

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1) Spatial planning draft and Zoning policy is a great base for incorporation of flood risk into the processes of development planning, spatial planning and land use planning in RS in general;
2) Possible ways for incorporation are: a) incorporation into legislative framework, b) introduction of guidelines for local communities (in cooperation with Union of Cities and Towns of RS and Ministry of Public Administration and Local Self-Government RS, according to successful UNDP practice);
3) The most certain way for implementation of measures recommended in Flood Zoning Policy is its incorporation and implementation trough FRMP (the FRMP for Vrbas basin is under

development and Flood Zoning Policy will be incorporated as one of the main non-structural measures).

4) Some recommendations related to flood risks, flood hazard and risk maps, prepared by UNDP experts, will be incorporated into the Law on Spatial Planning and Construction RS which is in process of being amended (this is an entry point into the legislative framework for flood risk and related issues).

7.6 VRBAS GEOPORTAL- DIGITAL TOOLS IN FRM

Flood hazard and risk mapping within the Vrbas project resulted in development of a number of digital tools and maps which significantly improved access to the definitive maps, climate risk information and other material and tools necessary for proper FRM within the basin. The Geoportal was developed as a spatial data repository that serves to store, manage and upgrade datasets in order to improve risk knowledge and data exchange, especially for local decision makers and population living in the flood plains. The data repository has provided a structured environment to enforce data integrity and support data auditing, versioning and data quality, and to facilitate sharing of important hydrometeorological datasets. In general, the repository system made data collation, manipulation and analysis accessible and more manageable.

River basin management is inevitably a multidisciplinary and an inter-departmental undertaking, and a structured and scalable GIS data repository platform such as the ''Vrbas GeoPortal'' (http://vrb.pmfbl.org/) provides the framework within which to approach flood risk management in a multi-disciplinary manner and to enable data sharing among relevant stakeholders. The design and implementation of the Vrbas GeoPortal has also addressed the issue of low level of risk knowledge and information exchange in order to improve preparedness and response, especially at local level.

The GeoPortal as a GIS-based tool has integrated various spatial socio-economic data with the flood hazard and flood risk maps, vulnerability maps including loss/damage models, real time hydro meteorological data, torrents sensitivity model, cadastre of torrents etc.

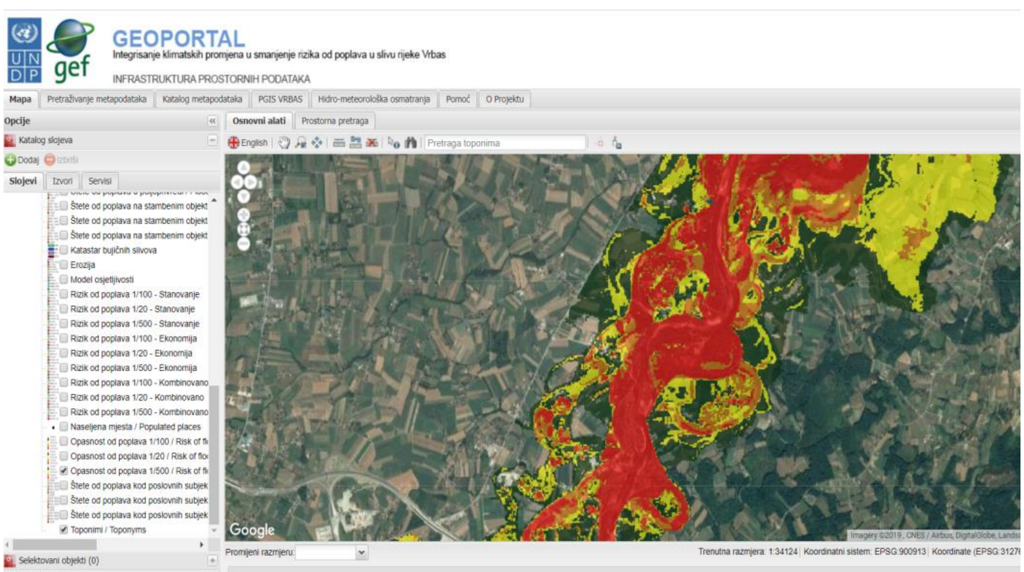


Figure 7-4: Vrbas GeoPortal, flood hazard map 1 in 500-year flood

Within the GeoPortal, tools, methods, guidelines and procedures for recording flood events have been developed in order to enable undertaking post-event surveys and assessing vulnerability to flooding as well as assessing the effectiveness of flood mitigation measures in reducing vulnerability and damages for long-term future management of flood risk within the catchment. It is important to stress that the GeoPortal is available online for public use by different institutions dealing with FRM to common citizens.

The main tools developed within the GeoPortal are: ‘’Mapa” (eng.maps), “PGIS Vrbas” and “Hidro meteoroloska osmatranja’’ (eng. hydrometric monitoring).

- **‘’Mapa’’ tool** consists of dozens of GIS layers based on flood hazard and flood risk maps of different flood return period (1:20, 1:100, 1:500) of which main are:
  - Flood hazard maps with velocity and depth (1:20, 1:100, 1:500),
  - Flood risk maps with risks for population, housing, business sector and maps combining all three risk factors (1:20, 1:100, 1:500),
  - Map of torrent basins,
  - Sensitivity model to flash floods,
  - Erosion map,
  - Loss/damage model for housing sector, business and sector of agriculture,
  - Other layers including: borders of basin, municipalities and settlements within VRB etc.

(note: all Vrbas GeoPortal maps can be used on several background layers as: google street, google satellite, google physical etc.…)

- The Geoportal is publicly available and citizens can check level of flood risk in the area of their household or business very easily. It is also very important that local authorities and decision makers can create long term development plans, action plans, organize system of civil protection (including preparedness and response/reaction to floods), by using this very simple but accurate tool.

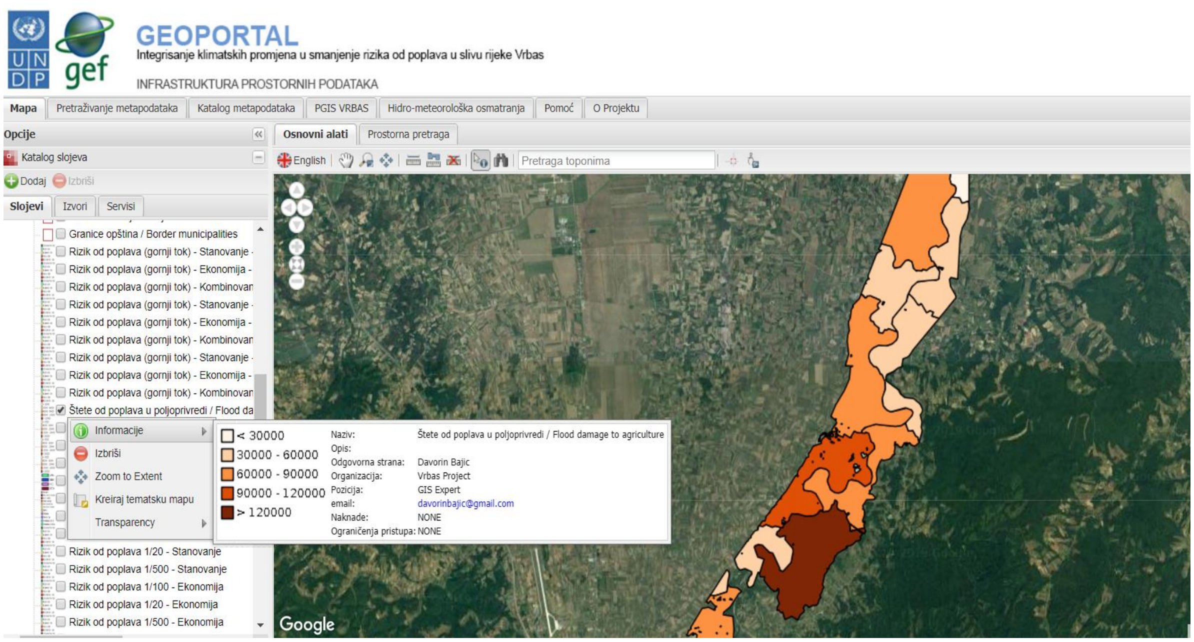


Figure 7-5: Map of loss/damage in agriculture at GeoPortal

- **“PGIS Vrbas” tool** has been created as an upgrade of the basic data repository (GeoPortal) with newly developed maps, administration panels for Participatory GIS (PGIS) as well as PGIS web application and digital data sets relevant for each of 13 municipalities within the Vrbas river basin. PGIS is created as a means of integrating local community information into the assessments of the problem and the formulation of the solution and to strengthen participation of communities in local FRM. After the tool was created, practitioners in each municipality of the 13 VRB municipalities where trained on PGIS data benefits, use and management, stressing flood risk management. Selected municipal officers of VRB local communities learned how to use digital data in order to improve their local abilities in flood risk management. The main goal of the tool is to collect and use local knowledge in FRM.

The PGIS enables two-way communication: from citizens who can report field observation related to flood events, but also other environmental issues (landslides, environmental issues, but also natural beauty spots, etc.). Reports can be generated providing information on date, place/location, observed problem/issue, photo and map. The administrator (nominated by local administration) receives reports and reacts according to internal procedures within the local community (e.g. send information to local service/department that reacts accordingly). After the issue is resolved, the administrator provides information back on PGIS site. That means that each PGIS recorded event/accident has initial information (recorded problem) and information on reaction/response of the local community administration.

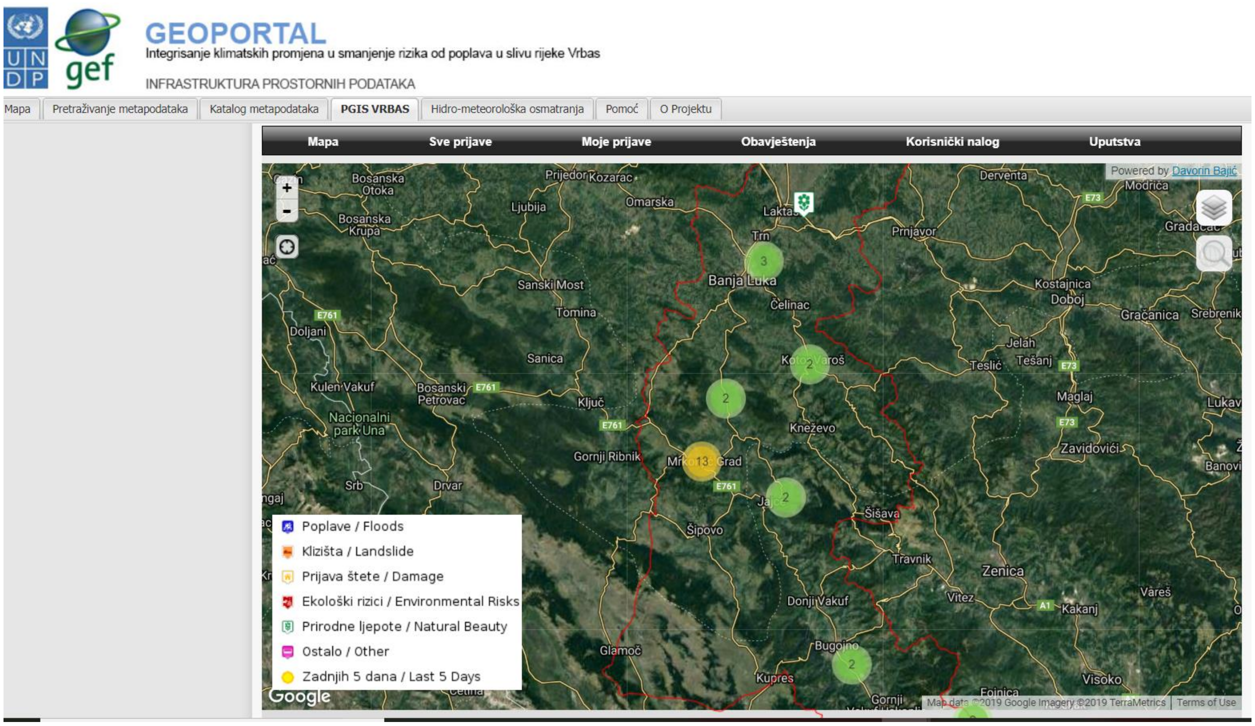


Figure 7-6: Recent records on PGIS tool

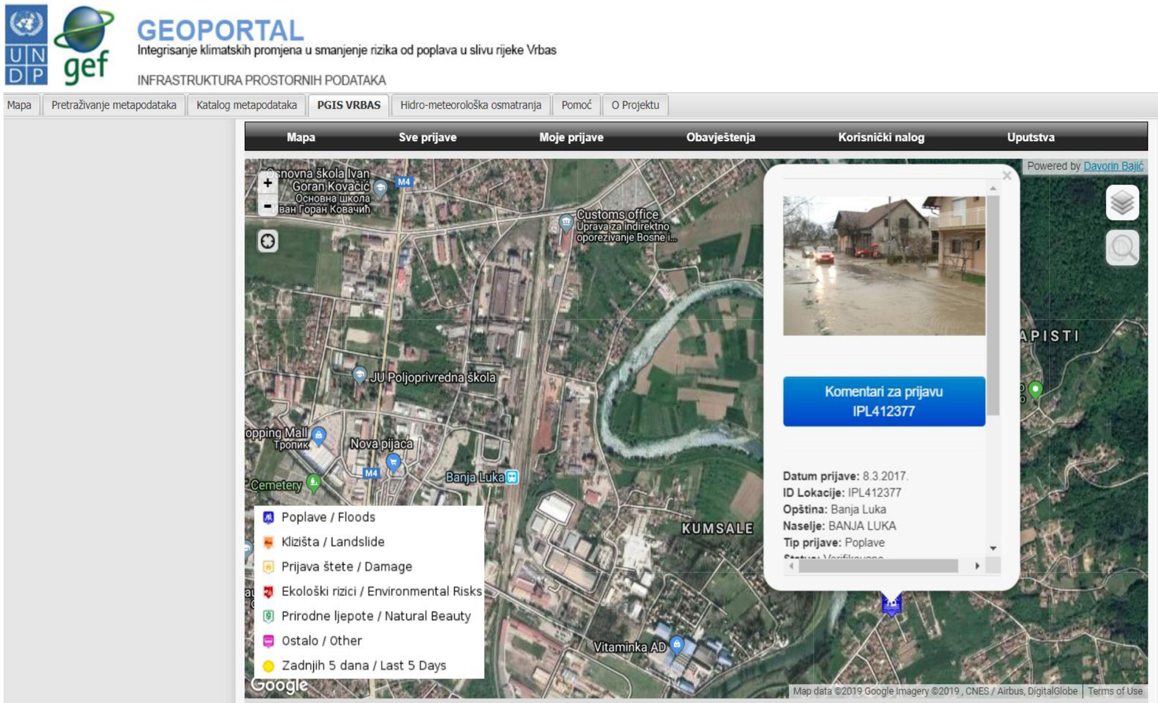
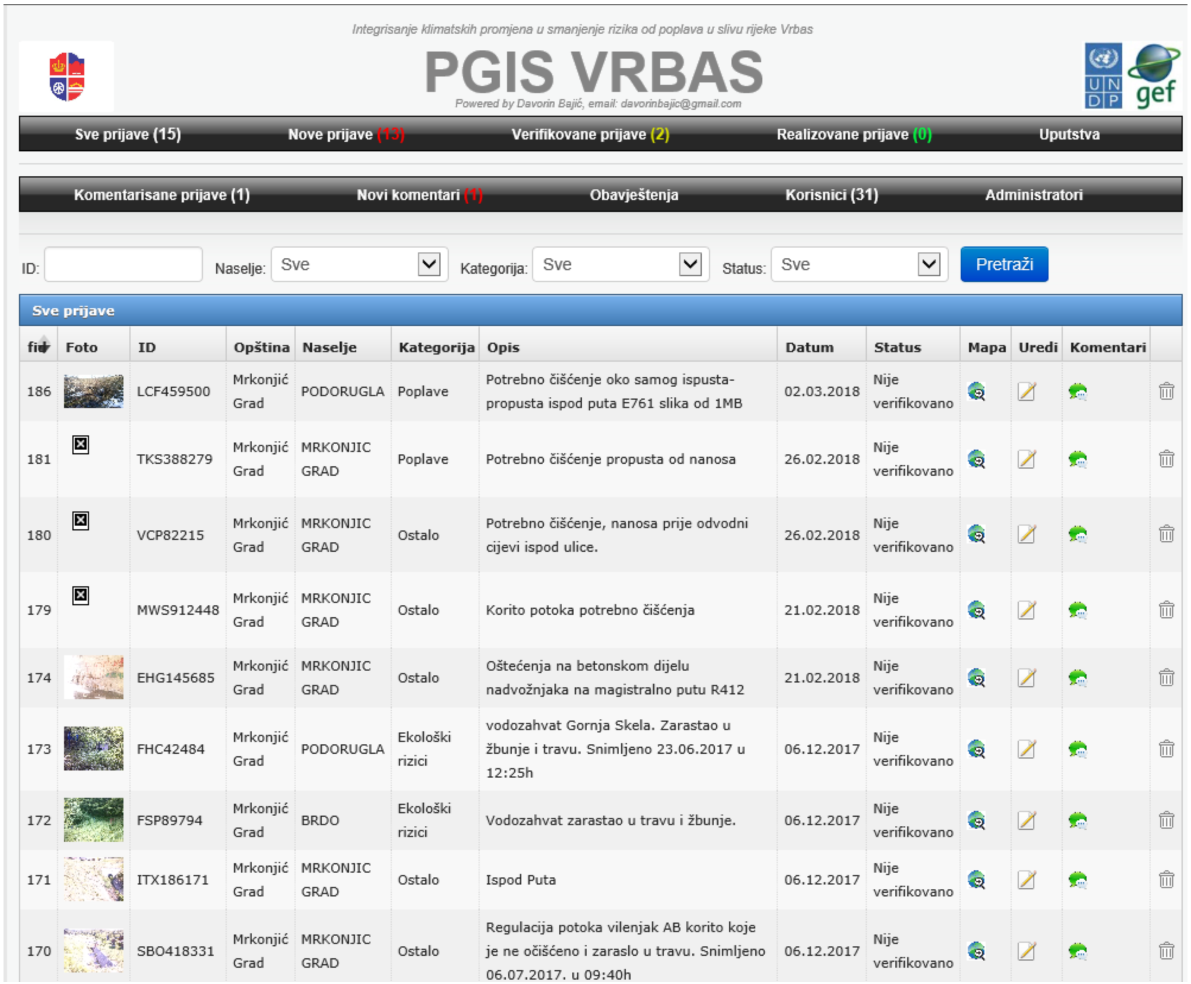


Figure 7-7: Flood recorded in PGIS



fid	Foto	ID	Opština	Naselje	Kategorija	Opis	Datum	Status	Mapa	Uredi	Komentari	
186		LCF459500	Mrkonjić Grad	PODORUGLA	Poplave	Potrebno čišćenje oko samog ispusta-propusta ispod puta E761 slika od 1MB	02.03.2018	Nije verifikovano				
181		TKS388279	Mrkonjić Grad	MRKONJIC GRAD	Poplave	Potrebno čišćenje propusta od nanosa	26.02.2018	Nije verifikovano				
180		VCP82215	Mrkonjić Grad	MRKONJIC GRAD	Ostalo	Potrebno čišćenje, nanosa prije odvodni cijevi ispod ulice.	26.02.2018	Nije verifikovano				
179		MWS912448	Mrkonjić Grad	MRKONJIC GRAD	Ostalo	Korito potoka potrebno čišćenja	21.02.2018	Nije verifikovano				
174		EHG145685	Mrkonjić Grad	MRKONJIC GRAD	Ostalo	Oštećenja na betonskom dijelu nadvožnjaka na magistralno putu R412	21.02.2018	Nije verifikovano				
173		FHC42484	Mrkonjić Grad	PODORUGLA	Ekološki rizici	vodozahvat Gornja Skela. Zarastao u žbunje i travu. Snimljeno 23.06.2017 u 12:25h	06.12.2017	Nije verifikovano				
172		FSP89794	Mrkonjić Grad	BRDO	Ekološki rizici	Vodozahvat zarastao u travu i žbunje.	06.12.2017	Nije verifikovano				
171		ITX186171	Mrkonjić Grad	MRKONJIC GRAD	Ostalo	Ispod Puta	06.12.2017	Nije verifikovano				
170		SBO418331	Mrkonjić Grad	MRKONJIC GRAD	Ostalo	Regulacija potoka vilenjak AB korito koje je ne očišćeno i zaraslo u travu. Snimljeno 06.07.2017. u 09:40h	06.12.2017	Nije verifikovano				

Figure 7-8: PGIS Administration panel panel with recordings

For the majority of the local administrators it was the first time to use a GIS program. However, after initial joint training the Project continued "on job" education of the administrators directly in their municipalities that resulted in a number of new recorded events/issues in the system.

PGIS is also a publicly available tool, and each citizen can use it with prior registration (for the purpose of verification of recorded events). The only obstacle for its mass use are limited capacities of local communities to react promptly on received recordings over PGIS. However, additional work and support to local communities is necessary in this context in order to fully embed the new technology into the daily practice of local communities.

- **<u>Tool: "Hidro meteoroloska osmatranja'' (eng. hydrometric monitoring)</u>** is directly connected with hydrometric stations installed within the VRB (28 automatic stations). Each station provides real time readings of HM parameters in the basin over the GeoPortal.

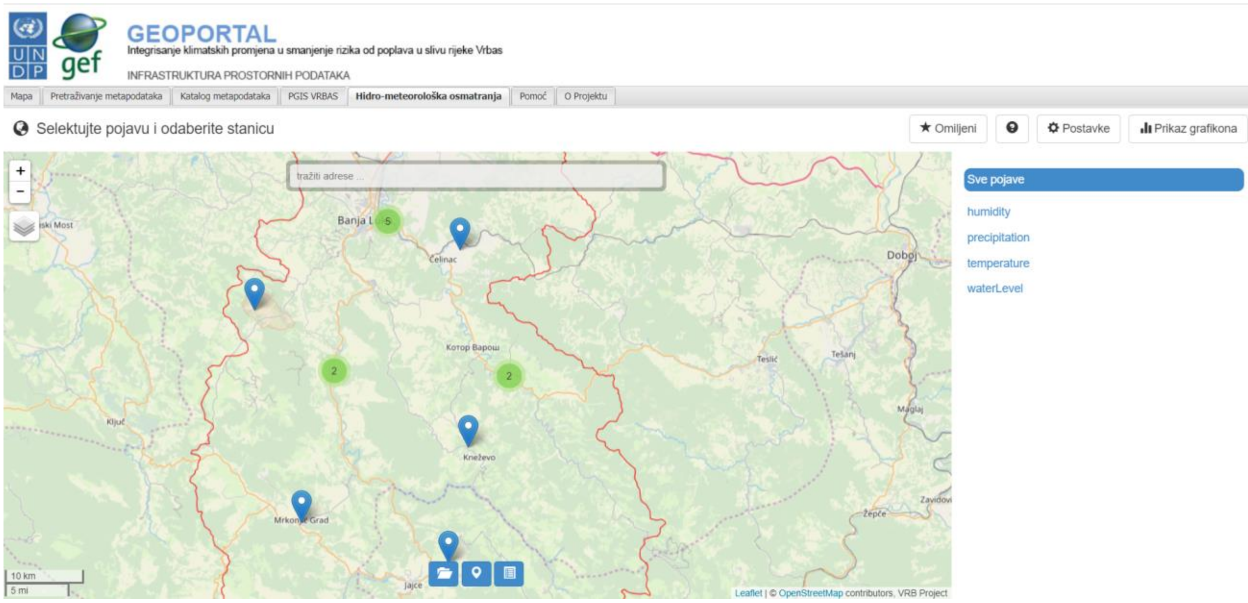


Figure 7-9: Distribution of automated hydro meteorological stations, presentation at Vrbas GeoPortal

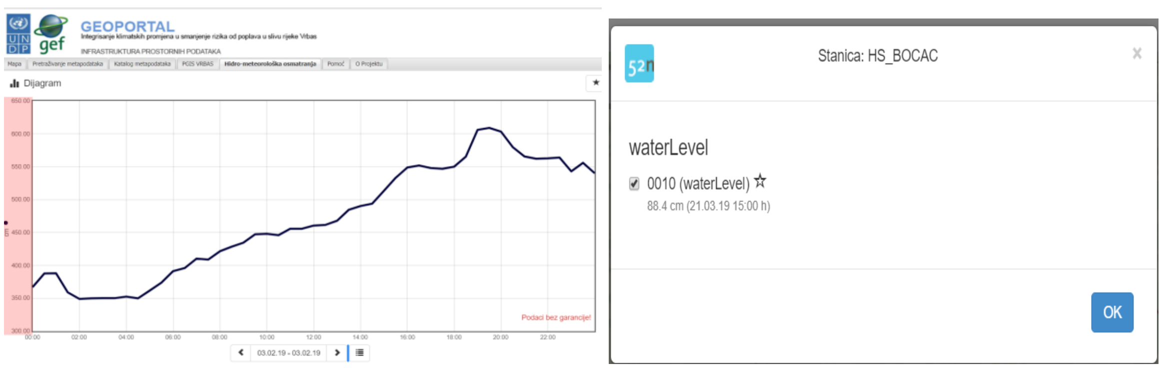


Figure 7-10: Recordings of water level: two ways of data presentation, including historical readings

This tool enables all institutions within the FRM chain to have real time information on water level, precipitation, humidity, temperature etc. This is especially important for local civil protection units that can read and monitor the situation of hydrometeorological parameters from hour to hour and make decisions accordingly, which is a significant improvement to their previous accessibility to such information.

Potential for GeoPortal replication

There are three main preconditions necessary for scaling up Vrbas GeoPortal to the national level:

1) Flood hazard and risk mapping,
2) Increased density of hydro meteorological network,
3) Commitment of local communities and key institutions (civil protection all levels) to improve their abilities in local FRM.

Since the proposed GCF project proposal and other initiatives will develop flood hazard and risk mapping and increase the density of hydro meteorological network the two important technical preconditions will be fulfilled. Also, it is important to say from the technical aspect that HM automated network stations where linked with the GeoPortal over the Hidro Meteorological Institute (HMI) that receives data directly from the stations. Direct connection is already established by the Vrbas project spatial data base. That means that links, for real time data transfer from HMI to the GeoPortal, are already enabled and functioning. From the technical aspect, there are no obstacles to replicate/scale up the system on other B&H areas under flood risk.

Besides the technical issues, for the full functioning of the GeoPortal the cooperation and commitment of local communities is of great importance. Work with local VRB communities has consisted of many different aspects: improvement of communication (radio equipment), improvement of plans and protocols of local rescue and protection (civil protection), trainings for first responders, risk mapping, GIS trainings in order to improve risk knowledge and response and overall local FRM using digital tools…etc. The response and willingness of the local communities has exceeded expectation. In addition to participating in trainings and development (and improvement) of planning documents related to protection and rescue, they also implemented digital tools into their practice, e.g.: incorporated digital tools into reaction plans (risk knowledge), based on the maps, defined evacuation routes, they monitor HM parameters over GeoPortal and record related accidents in their municipalities, enhanced visibility of issues related to floods etc.

The Vrbas Project serves as a great example (pilot project) that has shown great possibilities of working with municipalities, especially local civil protection, in improvement of local preparedness and reaction to floods, including new approach and new digital tools accessible to all, institutions, local civil protection but also to the citizens which is of utmost importance.

7.7 Development of a Fully Integrated Flood Forecasting and Early Warning System

7.7.1 Design and development of the Vrbas FFEWS

A flood forecasting and early warning system (FFEWS) was designed and developed for the Vrbas basin. This system is a fully integrated system which includes a central EWS (entity-based, as well as inter-entity and entity-state coordinated) and community-based EWS for the communities of the VRB set of community-based, municipal and entity level approaches with well-defined procedures for exchanging information and clearly defined roles and responsibilities.

In Figure 7-11 and Figure 7-12 below the architecture of a whole FFEWS is shown. As it can be observed, the meteorological models, satellite data and the automatic station data provides information to the hydrological model, which subsequently provides information to the hydraulic model. Results from both the hydrological and hydraulic model are compared to the climatological database and to pre-defined thresholds in order to define the issuance of a warning.

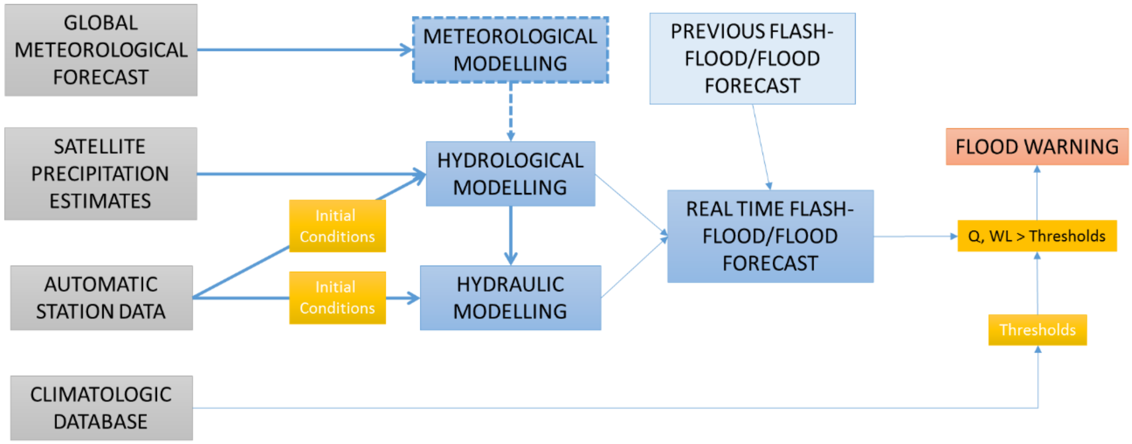


Figure 7-11: Generalised system architecture of the FFEWS (**grey** represents input data, **blue** represents modelling and **orange** represents outputs).

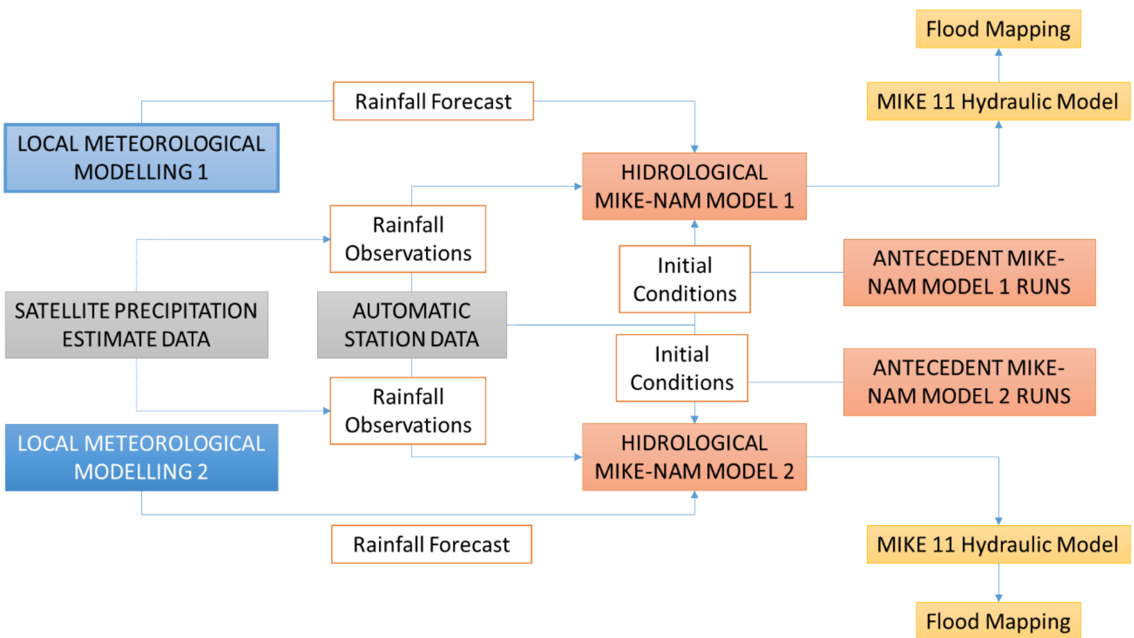


Figure 7-12: Specific system architecture of the Vrbas FFEWS system (**grey** represents input data, **blue** represents modelling and **orange** represents outputs).

7.8 Community Based Flood Early Warning System, Community Flood Emergency Plans and Communication Plan

In order to identify specifics of each local community to design locally adopted CBEWS all municipalities were assessed against basic requirements for the system implementation, in order to:

- To identify the requirements of the communities. Different communities will have different requirements, and therefore it was important to get local insight regarding their actual needs, given that the design of the final CBFEWS would be dictated by the local particularities of each community.

- To ascertain the level of commitment to the implementation of CBFEWS likely involvement of the local community.

Based on the information collected, some key conclusions are:

- The VRB municipalities are very heterogeneous so it was difficult to define and implement common procedures for all the municipalities and develop common communication procedures between entity level organisations and municipalities.
- It was crucial to ensure that municipalities and communities understood where they will be receiving information from, when they will be receiving the information, and what the information received means. Therefore, it was necessary that:
- A common communication provider is established for all the different municipalities and local communities.
- A common communication procedure is understood between all the relevant actors, understating that warnings will be disseminated in a timely manner.
- A common warning message content is agreed among all the different relevant actors.
- Several communication means are established, in close cooperation with the relevant municipalities and communities, analysing existing capabilities and ensuring that all community members are able to receive a warning when needed.

Also, the different levels of warning should have associated different actions from communities and community members.

7.8.1 Community Flood Emergency Plan-CEFP

In order to ensure that the Community-based Flood Forecasting Early Warning System is fully embedded into the community practices during disaster events, the implementation of a Community Flood Emergency Plan (CEFP) is necessary.

A Community Flood Emergency Plan outlines the roles and responsibilities of all parties to be involved, actions to be taken, coordination arrangements and communication channels to be used prior to, during and after a flood event. The purpose of planning for flood emergencies is to reduce the risk to health and life and the damage caused by flooding.

Building community resilience is something that many people and communities already do without realising it, however having a flood emergency plan may form an important part of how a particular community might best respond to a flood situation. By building on existing local relationships and networks, using local knowledge and preparing for risks, a community is in a better position to cope before, during and after a flood event. A flood resilient community will not only be better prepared to respond at the time of a flood but will be able to better cope in the long-term.

Formalising the flood response in the form of a CEFP will help to inform all who need to be involved as to the overall response effort, and illustrate what tasks are being carried out by other parties. This has the advantage of ensuring that duplication of tasks will not occur and gaps in response are avoided.

The knowledge and experience of flood response procedures gained by local authorities and emergency services (civil protection) staff can be lost when they are absent, move to other posts or retire. Having a flood emergency plan ensures that the experience and lessons learned by current responsible people in the community can be preserved and drawn upon by being incorporated and recorded in a written format for use by all relevant people in the future.

It should be noted that no two communities are the same as each one may have different needs. Thus, there is a need to gather local flood information, which can then be used to create the community flood plan. The flood emergency plan should be maintained and practiced regularly.

There are some key steps required during the implementation of the CEFP:

1) Establishment of Community Group: a community group in each community should be established, with relevant householders, business and community leaders. Working together as a community or group to complete a plan will help in responding quickly when flooding happens and what practical actions to take before and during a flood, helping reduce the damage flooding can cause.

2) Raise awareness of the flood risks in the community: Prior to a flood, the flood community group should promote awareness to householders within the community of the actions and responsibilities they have in regard to preparing, responding to and recovering from a flood.

3) Identify the flood risks in the community: local knowledge on how every community has been flooded in the past or how it is likely to flood in the future should be gathered. All the properties within the community at risk of flooding should be listed, including property other than homes damaged by flooding (e.g. where gardens or cars were damaged by floodwater). These lists will help to form a flood plan and enable the group to target resources to specific areas. It should be added that this exercise should be completed using the information from the Flood hazard and Risk Assessment. The Flood hazard and Risk Assessment, as described above, was undertaken using international best practice hydrological and hydraulic modelling, and the resulting flood hazard maps, were calibrated and validated using historical flood records, and information from the communities with local knowledge of previous flood events.

4) Identify vulnerable people that are at risk of flooding: Some members of the community may be at greater risk from a flood than others due to their age, disability, or illness (both short term and long term). Vulnerable people should be identified prior to a flood so that providing assistance to them is included in the flood plan. People in the community should be encouraged to contact the flood plan group if they feel they might need assistance, even if it is only during a short period of time.

5) Identify community resources: the community should be aware of the flood protection products available and especially communication equipment.

6) Also, evacuation routes and centres should be identified and properly disseminated throughout the community. This identification should be carried out considering both historical flooding and information from the flood hazard maps (i.e. including future flooding with climate change considerations).

7) Decide on a Communication Plan: the communication plan should cover all different possibilities. The deployment and use of communication devices within the community should be undertaken considering that all the different households are covered and that household members understand the meaning of the warnings and the associated actions. Also, a detailed list with all the different contact numbers should be compiled. Floods can occur when people are working or are away and may need to be contacted, and also when they are sleeping, and this should be taken into account. Designated people should keep the list updated and keep the list with the flood emergency plan. It should be decided in advance how a flood alert is to be communicated.

8) Decide on an Action Plan: once the flood risk, the vulnerable people and the community resources are identified, safe actions to be taken by residents to protect against those risks should be decided and disseminated throughout the community. The proposed actions should be realistic and safe. Also, actions regarding the vulnerable people in every community should be agreed. Actions could be: moving valuable possessions, furniture and paperwork upstairs; switching off water, electricity and gas supplies if needed and switching them back on when it is safe to do so; gathering together prescribed medication and repeat prescriptions if it is likely that they may need to be evacuated from their home.

9) Test the flood plan: a dry-run of the community emergency flood plan should be undertaken with as many as possible community members participating.

Development procedure, methodology and content of CEFP in B&H is defined by Law of Protection and Rescue in RS and FB&H including cantons. In accordance to the Law, the CEFP consists of the following documents:

1) Vulnerability and risk assessment
2) Prevention plan
3) Preparedness plan
4) Mobilisation plan
5) Emergency plan
6) Evacuation plan

7.8.2 Communication Plan

The warning dissemination system must secure an efficient communication of warnings and other relevant information, including remote households with limited access to information and consider warning at any time during the day/week. The structural set up must be clear to all stakeholders. They have to know who is supposed to inform them and they have to know whom they have to inform in turn.

Because of the high importance of this component and the fact that the monitoring component does not reside in the community, several redundant systems were proposed. It is recommended that at least two local residents in every community are appointed as contact. The recommended system will be discretised depending on the warning level.

1. Level 1 Alert (***Be aware***) – 48 hours in advance

If the forecasting system predicts that a local event may occur, local appointed residents will be contacted through mobile phone. Television and local radio will also be used to inform community members. Information will be displayed in local boards and in a dedicated webpage.

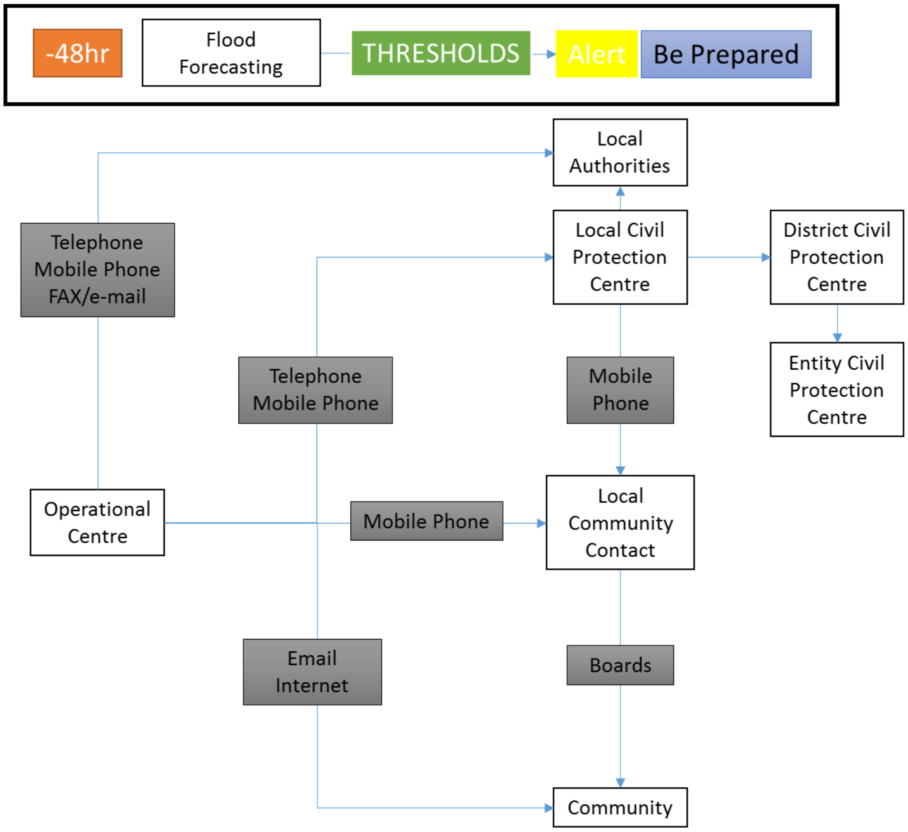


Figure 7-13: Tentative communication for alert (be aware) situations

2. Level 2 Alert (***Be prepared***) – 24 hours in advance

If the forecasting system predicts 24 hours in advance that a local event may occur, local representatives will be contacted again via mobile phones. It should be noted that the probability of an event occurring at this level is higher than in the alert level above. Television and local radio will also be used to inform community members. Information will again be displayed in local boards and in a dedicated webpage.

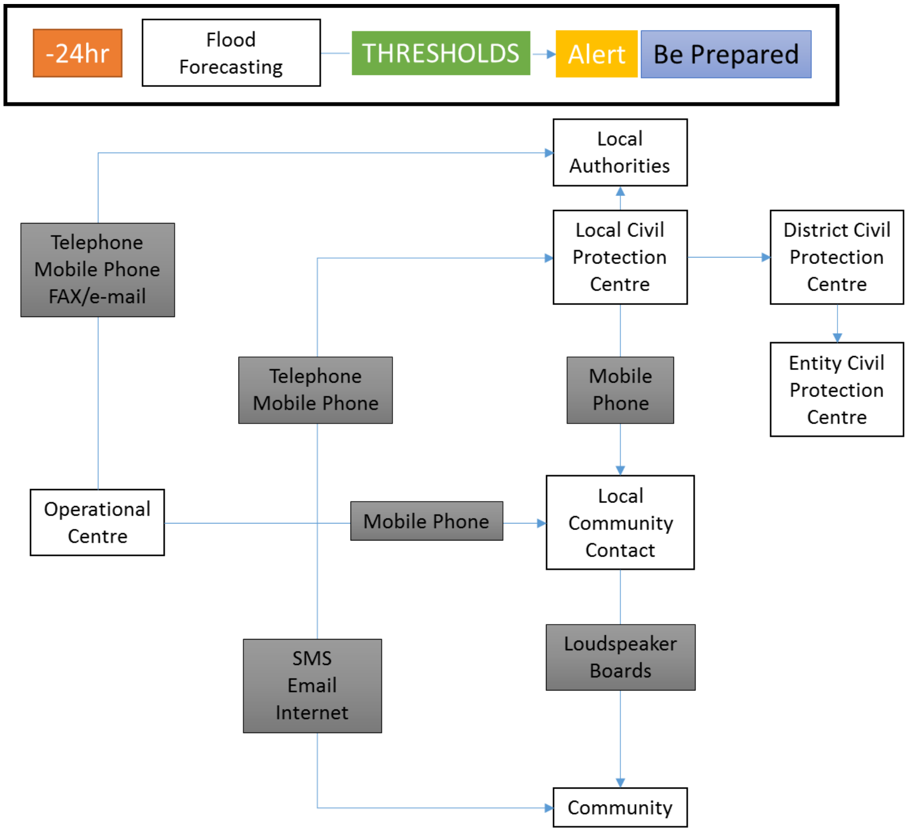


Figure 7-14: Tentative communication for alert (be prepared) situations

It should be noted that, even if no event was forecasted 48 hours in advance, it can be predicted 24 hours in advance due to the higher accuracy of forecast during the first hours.

3. Level 3 Warning (***Take action***) - Event

This level of warning will be based on recorded rainfall and water levels further upstream, and therefore the certainty of the event is much higher. Local representatives will be contacted by mobile phone and radio HF. Sirens will be operated remotely from the operation centre. Local representatives will be in charge of further alerting other members of the community through bells, walkie-talkies and/or (WIFI) sirens. Local Authorities will also be contacted by the main operational centre and all the rescue/disaster management organisations will be contacted by the local civil protection centre.

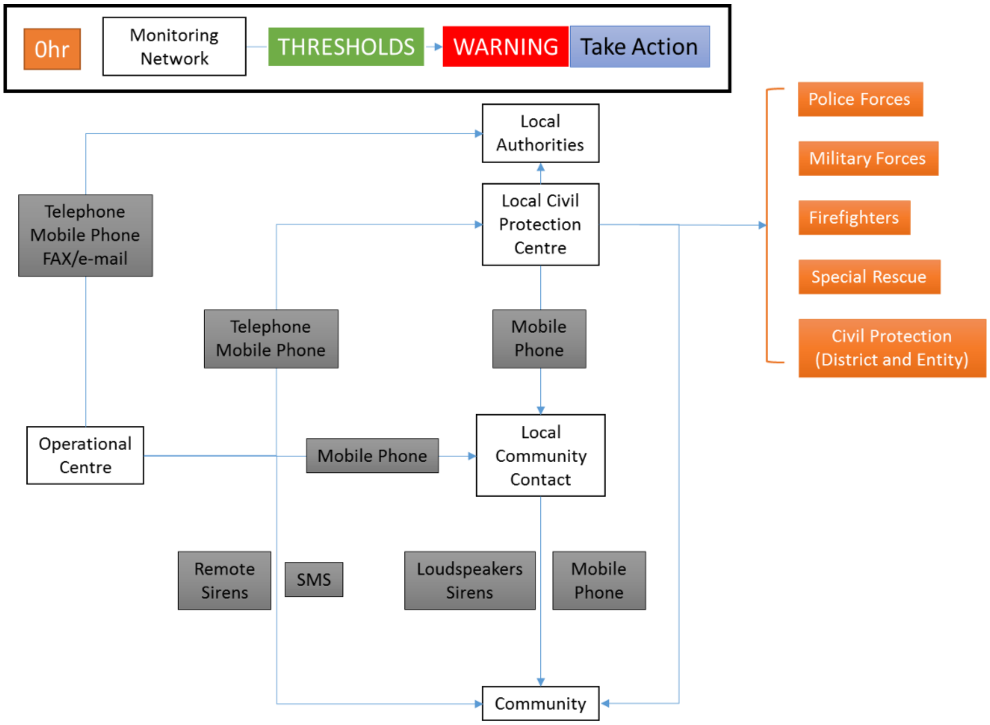


Figure 7-15: Tentative communication for warning situations

It should be noted that a flood event, as registered by the monitoring system, may occur even if no alert has been previously issued by the forecasting system (full FFEWS), and therefore communities should be aware that the highest level of warning can be activated directly.

In emergency situations there is no time for lengthy conversations. The message has to be short and easily understood. This means the sender and the receiver of the message use agreed standard messages. The main agreed standards are the three warning levels (be alert, be prepared and take action). This requires that the sender of the message and the receiver need to have the same understanding of what the three warning levels mean.

The warning levels have certain preconditions and distinct expected actions. In order to avoid confusion, the content of the messages should be clear to all concerned. Therefore, posters describing the three warning levels and the associated actions should be posted in communal areas.

Finally, it is recommended that the system is tested periodically (probably as part of a more complete drill programme) and that maintenance activities are organised.

7.8.3 Required Equipment

In order to identify the necessary equipment for the implementation of the community-based early warning systems and the community flood emergency plans, a more thorough analysis of the existing resources and the requirements at a more local level is needed. An assessment has been carried out using the information from the questionnaires in the different municipalities.

The requirements can be summarised as follow:

- Equipment for Civil Protection: this requirement is the most noted one by the different municipalities. It is obvious that there is a lack of adequate equipment for the Civil

Protection Brigades. Tentative list of required equipment for Civil Protection brigades during flood emergency situations would be: boats, generators, extension cables, power saws, various type of ropes, metal cutting scissors, gloves, water pumps, shooter hoses, suction hoses, lamps, shovels, boots, buckets, crowbars, hand saws, axes and raincoats.

- Training for Civil Protection: this is considered very critical. This should include training to the different volunteers. Training for Civil Protection Brigades on how to efficiently respond to floods is considered paramount.
- Monitoring equipment: staff gauges and/or hydrometric stations, precipitation stations.
- Communication devices: as described in the Communication Plan section above, there will be a requirement for communication devices in order to successfully implement this plan at community level. The type of communication means to be required in each of the communities would depend on the existing resources and the existing practices within each of the villages and towns. It is recommended that several communication devices need to be used in order to improve the possibility of the warnings reaching all the community members. There are several communication devices to consider such as:
- Mobile phone-SMS
- Loudspeakers
- Walkie-talkies
- TV
- Radio:
- Radio HF
- Email - Internet
- Sirens (possible remote control for siren systems)

In the communication plan above, the preferable communication devices were listed, but as previously noted this should be explored further with the different communities, considering their resources and existing practices.

- Better coordination: this is a very critical aspect. The present institutional arrangement within the existing warning system does not ensure the sustainability of the system and it is not adequate for early warning purposes. As part of the project, institutional arrangements were reviewed and recommendations were made for changes to the arrangements in order to support functionality of full FFEWS, including the institutional arrangements required for a successful CBEWS. At a more local scale, however, it is necessary that responsibilities are clear to all the relevant organisations involved in the EWS communication flow. Based on the information obtained from local communities, it was evident that there was no common pattern for the communication flow during early warnings and disaster situations. This should be improved, and it has been suggested that municipalities receive the early warning information through the local civil protection representative.
- Raise awareness: awareness about the system and about how to act during flood warning and emergency situations should be raised. In order to do that it would be necessary to organise local workshops in the communities participating in this scheme and to prepare leaflets and posters to be distributed among the community residents. Also, awareness should be raised among the main scheme actors, such as community representatives.

To address the issue of effective emergency response at municipal level and last-mile communication of flood warnings, the Vrbas project has strengthened response capacities (flood reaction plans, trainings and drills for local civil protection and first responders, communication and warning equipment etc.) but also, early warning capacities.

The process has been implemented in two phases:

In the first phase the project provided technical assistance to all of the 13 municipalities within the Vrbas river basin to improve local flood intervention planning and practice. That included intensive work with various local actors including local authorities, civil protection, local fire brigades and police, local red cross, media representatives and public, in general. The following activities were implemented in 13 municipalities:

1) Improved Local Protection and Rescue Plans, improved/developed Flood Reaction Plans
2) Developed Public Communication and Raise Awareness Plans
3) Implemented various trainings for local authorities and first responders (roles and responsibilities during flood emergency procedures, preparedness, flood forecasting, warning and communication, evacuation, mobilisation…)
4) Drill exercise:" Upcoming flood event" for local civil protection and first responders
5) Improved public visibility and knowledge on floods (by participation on radio and tv shows, developed flood hazard maps and info leaflets for citizens, upgraded local web pages with flood important information…).

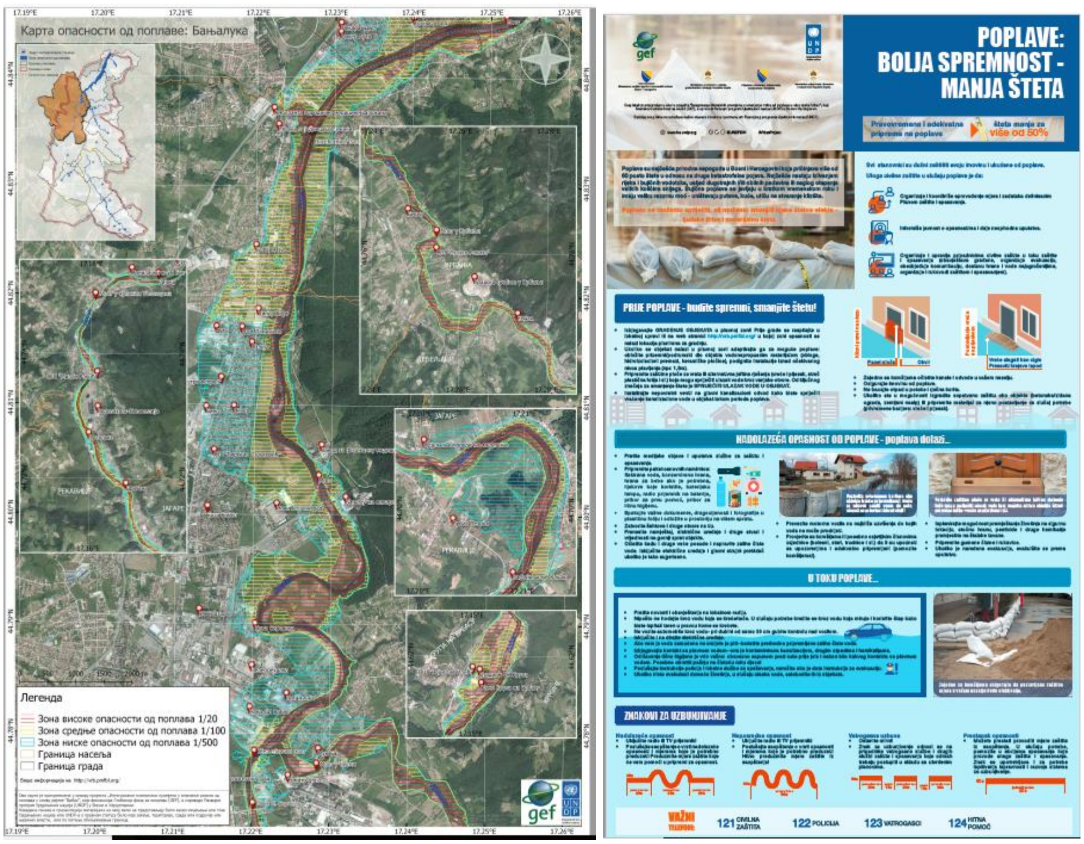


Figure 7-16: Informative material prepared for local communities in order to raise awareness and knowledge on floods in their region (left: hazard map, right: informative leaflet ''better preparedness for damage reduction'')

Prior to implementation of above-mentioned activities, the Project assessed communication abilities of local communication from the technical aspect. The state of the equipment was extremely poor, with just one municipality properly equipped with warning sirens and radios. Most of the municipalities did not have sirens or radios. In order to improve warning and communication the Vrbas project has purchased 168 radios, 8 sirens and 3 radio relays and provided training on operation and maintenance. This technical improvement enabled communication within local response structures, between all municipalities within the basin and civil protection headquarters. In that initial phase, all municipalities were provided with flood hazard and flood risk maps and trained on benefits and use of Vrbas GeoPortal GIS digital tools in flood risk management (http://vrb.pmfbl.org/).

It is necessary to note that a full flood forecasting and early warning system (FFEWS), within the framework of the Vrbas project, has been finalized.

In its very last phase the SOP, including communication procedure, will be defined. That means that municipalities will be provided with warning message provider (entity level institution), communication channel and common communication procedure, that will be agreed between message provider and all 13 municipalities. With this final phase of full FFEWS development, the crucial link with the local VRB communities will be established. All 13 municipalities have already passed a yearlong preparatory phase and improved their preparedness through development/upgrade of their protection and rescue plans including flood reaction/emergency plans, communication plans, evacuation plans etc. and improved their internal procedures to receive and react on warning messages.

The second phase:

Most municipalities involved in the first phase participated in their full capacity and achieved significant improvement. For example, some municipalities, prior to this intervention, did not have developed planning documentation regarding protection and rescue. With the project's support they developed completely new planning documentation (municipalities of Jezero, Kneževo, Donji Vakuf, Mrkonjić Grad, Srbac). However, the level of participation and involvement in activities, is highly depended on available human capacities, organisational structure, size of the local administration etc.

Since implementation of CBEWS in the second phase is highly dependent on community's interest and participation, selection of three municipalities for pilot implementation was made on basis of:

- Strong interest and commitment of the local community
- Good internal organisation of local administration, especially civil protection
- Local situation: streams and torrents with local flooding effect, but not covered by FFEWS (full FFEWS is covering Vrbas main river and two main tributaries: Pliva and Vrbanja)

Based on these criteria three VRB municipalities where selected for implementation of more specific CBEWS: Kotor Varos, Celinac and Bugojno. Moreover, all these municipalities have organized ''informal'' water level monitoring and local flood warning system based on experiences from previous floods. In general, they have well organised local civil protection structures that perform monitoring of water level and send warnings based on experience, historical knowledge and current weather forecast. They use specific local knowledge and experience including landmarks (stairs or walls placed into the river) for determination of critical water levels, based on historical water levels that caused flood in the local community.

Based on these criteria the project has purchased 10 staff gauges which are installed at location of local land markers to aide in the monitoring of water level to be organized by local community. Also, the flood communication plans in these municipalities will be upgraded in order to define communication lines and local warning procedure. By implementing these specific CBEWS the historical knowledge and experience-based procedures will be formalised and incorporated in official local protection and rescue plans and/or its relevant parts.

7.9 Development and Implementation of Flood Insurance Scheme

The risk model described above was used to develop a flood insurance model from which a climate risk informed flood insurance scheme was developed. The flood insurance financial risk transfer instrument was developed to mitigate losses and replace the need for Government or Donor intervention after flood events. It works by equating premiums to risk exposure and comparing annual average anticipated losses (calculated by socioeconomic model) with annual premiums. The scheme was developed to be easily implemented and to relies on the use of improved and accurate river gauging (implemented by the project) to confirm flood levels and flood damages used in the calculation of flood premiums. The main advantages of the scheme are that it will work in tandem with non-structural measures such as flood zoning and FFEWS and structural measures for flood alleviation. In addition, as standards of flood protection improve with time, then residual flood risk will reduce, and this will be reflected in lower flood premiums. The following key activities were undertaken:

- Reviewed the current insurance sector in B&H, its profile and sectors that it covers (e.g. property, contents, agriculture, perils/hazards etc.) and assessed the affordability and current coverage of insurance across relevant sectors;
- Reviewed and analysed current practices related to risk management techniques and risk financing modalities (e.g. micro-financing) in B&H in general, and cities/municipalities in Vrbas river basin, in particular;
- Analysed of the institutional and legal environment for insurance market in B&H;
- Reviewed the insurance and risk financing mechanisms of countries at a similar stage of development as B&H and compared with those of developed countries. This analysis and comparison included the following key considerations: basis of flood insurance zoning (i.e. hazard mapping of other methods of zoning), mechanisms for setting premiums, mechanisms for financing/capitalising the scheme, the role of Re Insurance, the role of Catastrophe insurance, methods of collecting premiums, willingness/ability to pay and who pays (government/citizens/at risk population, all population), the Role of Government, capacity of the country to administer the scheme etc,. It also included a detailed review of the regional schemes being developed/implemented by the World Bank (SEEC CRIF/Europa Re);
- A feasibility study for a flood insurance scheme for Vrbas basin and explored the potential of developing property or infrastructure investment insurance products that can provide strong flood exposure signals and steer the new infrastructure, settlement development and expansion away from high risk zones. The feasibility study identified the type of scheme that would be most appropriate for B&H and considered *ex-ante*, *ex-post*, index-based, and indemnity- based schemes, with various configurations of government role. The feasibility study included a review of data availability for the development of the identified preferred scheme.
- Initial consultation with key stakeholders (community, municipality, private sector companies, insurance companies) on the proposed flood insurance scheme and the insurance zone designations. Consultations compromised of bi-lateral meetings, and workshops;
- Based on the feasibility study and the identified type of schemes, development of a GIS-based index-based flood insurance model and insurance scheme for B&H was developed with support of the GIS and other project experts (in particular the socio-economics and modelling experts). The developed scheme included, a basis for setting premiums and pay-outs at household and community level, in each of the identified flood insurance zones (zones developed from flood hazard and risk maps), the value of premiums in each insurance zone was based on risk indices developed by the modelling team, while the value of the pay-out out was based on appropriate considerations of proportion of damages and losses to be covered. Of the scheme options considered – *ex-ante*, *ex-post*, index-based, and indemnity - it was found that the index-based insurance model would not be appropriate for B&H due to legal barriers, i.e. Law on Obligations which would be breached under such a scheme.
- Identified the key barriers, both institutional and data related, that need to be addressed in order to implement flood/natural disasters insurance and the potential ways of addressing them;
- Analysed possibilities for insurance premium subsidies;
- Tariffs for the insurance of crops and fruits grown in the municipalities of Vrbas river basin as well as for residential households and homeowners insurance, the most significant project result, were calculated on the basis of risk maps, the available real historical data on losses, the distribution function corresponding to the data, the loss functions that were made based on the anticipated losses depending on the water level in the facilities, as well as on the basis of the existing experience.

- Tariffs are calculated for insurance of individual crops and fruits by hazard zones and may be applied in voluntary insurance. On the basis of the individual tariff rates, an aggregate, average weighted tariff rate was calculated that could be used in index insurance when the conditions for that type of insurance are met, but also in compulsory indemnity insurance.
- Insurance tariffs for residential households with appreciation of the type of construction are also calculated by hazard zones. The average weighted tariff rate that could be applied in compulsory dwelling insurance is also calculated. Tariff rates by hazard zones and types of construction can be applied in voluntary dwelling insurance. Homeowners insurance tariff rates are also calculated by hazard zones.
- Flood/natural disasters insurance product for individual households was developed.
- Finally, each municipality is, on the basis of the created risk maps and hazard zones, situated in a certain hazard zone corresponding to the specified calculated tariff rate, and in this way the insurance maps are also developed.
- Willingness to pay survey for insurance including development of questionnaire, defining the sample, size of the sample, sample coverage, sampling methodology, completed.
- Data received in the Questionnaire was analysed with conclusions and recommendations for further steps in the field of flood/natural disasters insurance.

7.10 REHABILITATION OF THE VRBAS HYDROMETRIC NETWORK

Prior to the implementation of the Vrbas project the hydrometric network comprised of 11 hydrological stations with varying degrees of automation, equipment, physical condition and frequency in data collection.

Under the project the existing hydrometric network for the study basin was reviewed, and, based on technical assessments of meteorological and hydrological variability of the basin, and the need to provide forecasts and early warning for floods, and to undertake long-term monitoring of the basin, an appropriate hydrometric network, was identified and implemented.

In the Republika Srpska 10 precipitation, 1 meteorological and 6 hydrological stations were installed and in the Federation of B&H 10 Precipitation and 1 Meteorological station were installed. Automatic stations which were placed in whole Vrbas river basin in Bosnia and Herzegovina are generally placed on the sites where they were measuring up to 1991. This was very important in terms ensuring continuity of monitoring and comparing the new data with the data that were measured before 1991 and provides the ability to analyse trends observed data, including climate change trends.

The data from the new stations are crucial input to the hydrological and hydraulic model of the Vrbas river as well as for the flood forecasting system. The optimised and rehabilitated hydrometric network provides the spatial and temporal density of monitoring that enables detailed rainfall runoff modelling and flow and flood forecasting at hydrological stations within the basin.

In addition, a manual was developed which provides detailed instructions for the installation, operation, and maintenance of the precipitation, hydrological and meteorological automatic stations installed in the basin. Equipment for monitoring and follow-up data was obtained from ALEMSISTEM Ltd. Sarajevo who are providing maintenance of the active stations during the period 2015-2019. After this period, both HMI's will continue to maintain stations by themselves.

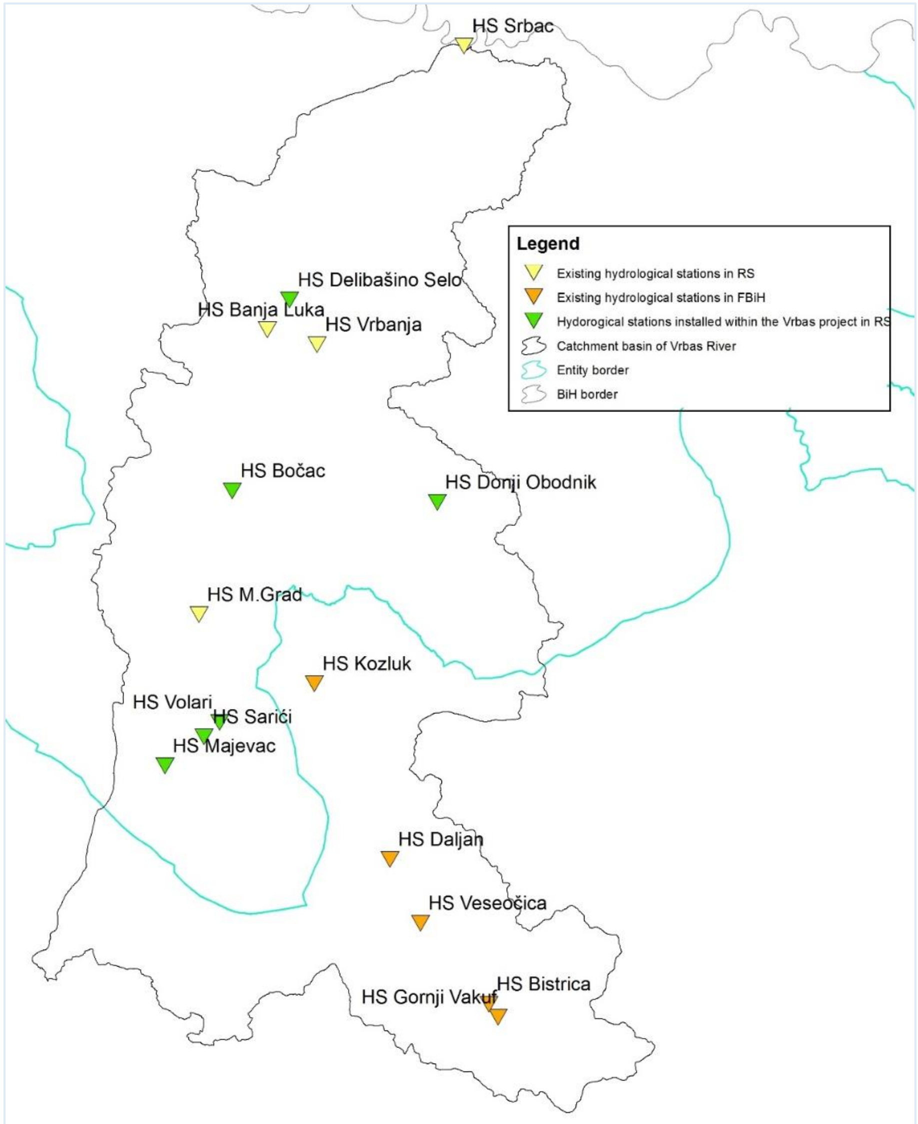


Figure 7-17: Map of existing and installed stations in Vrbas basin

Figure 7-18: Meteorological station installed under the Vrbas project

7.11 Implementation of Non-structural Measures

Under the Vrbas project a number of non-structural measures were implemented to address flooding, river bank erosion as shown in the following table:

Type of measure	Before:	After:
Cleaning and profiling of Vrbas river bed and strengthening of eroded banks with gabion wall and stone embankment in Gornji Vakuf-Uskoplje municipality		
Cleaning and profiling of Vrbas river bed and strengthening of eroded banks with stone embankment and reconstruction of existing degraded meander in Bugojno municipality		
Cleaning and profiling of Vrbas river bed and strengthening of eroded banks with gabion wall in Kotor Varoš municipality		

Regulation of two torrential watercourse with natural stone and profiling the existing riverbed in city of Banja Luka		
Cleaning and profiling of secondary channel network in Laktaši municipality		
Cleaning and profiling of secondary channel network in Srbac municipality		
Rehabilitation of right river bank in Jajce municipality with stone embankment.		

Regulation of torrential watercourse with natural stone in Kneževo municipality		
Strengthening of right river bank with natural stone in Čelinac municipality		
Regulation of Bukovica river with natural stone and profiling the riverbed in Laktaši municipality		
Cleaning and profiling of secondary channel network in Srbac municipality		

Regulation of Vrbas river with natural stone and profiling the riverbed in city of Banja Luka		

8 GAPS, BARRIERS AND NEEDS FOR SCALING UP CLIMATE RESILIENT FRM

8.1 Barrier 1: Limited Institutional Capacities (Technical, legislative and institutional) Barriers for Nation-wide Climate Resilient FFEWS

Gaps in the hydrometric observation network of B&H: Limited financial and human resources coupled with a severely reduced monitoring network since the end of the Yugoslav era limits B&H's ability to monitor important hydrometeorological variables at the appropriate spatial and temporal scales to provide adequate input to effective long-term management of hazards, or to support an effective national FEWS. There is, as yet, no comprehensive flood hazard, risk or vulnerability mapping for B&H and the insufficient institutional technical and financial capacity of water management authorities and their extended services, hydro-meteorological institutes and river basin agencies capacity to undertake such mapping. Ongoing projects undertaking EUFD mapping are severely delayed and will only be done for selected high-risk areas within river basins. There are limited modern approaches and technologies in hazard and risk assessment for strategic flood risk management to cope with climate induced risks. Technical capacities related to risk identification and assessment, risk prevention/mitigation, risk reduction, risk transfer, preparedness, climate risk management and climate change adaptation are weak across institutions and governance levels.

The regulatory framework for FFEWS is incomplete as it lacks protocols/SOPs on climate data generation, data management and communication and there is no protocol on early warning system. There is no national protocol for the FFEWS. Adequate protocols and SOPs for disaster prevention, preparedness and response are missing or not enforced. While the methodology for flood risk modelling has been finalised and agreed for B&H (already implemented under the Vrbas project), flood risk assessment and vulnerability assessment mandates and methodology are not finalized and not enforced. Data sharing protocols to enable inter-departmental working and single point of all climate hazard and risk information is missing.

The lack of horizontal (between entities and among sectors within the same entity) and vertical (among state, entity, cantonal and municipal levels) communication within the water management sector further limits effective cross-sectoral climate risk management. Hence, clear communication lines between different agencies, Standard Operational Procedures (SOPs), communication protocols and Codes of Conduct are lacking within the agencies responsible for the various elements of the FEWS and response.

8.2 Barrier 2: Lack of a strategic integrated FRM approach, insufficient Technical Knowledge and Capacities on Ecosystem-based and Non-structural Approaches to Climate Resilient Flood Risk Reduction

There is a lack of strategic integrated flood risk management approaches in B&H that identifies the best combination of structural and non-structural measures to address climate induced risks. Flood defences currently rely on limited structural measures that are becoming increasingly ineffective in terms of the Standards of Protection they provide, in the face of climate change, have high cost, can sometimes result in the problem being moved elsewhere if the impact is not fully assessed during design, may result in complacency of 'protected' populations, potentially increase the impact and consequences if structures fail or are overtopped and have residual risks that will remain as cost and other factors will limit the structure to a given standard of protection (i.e. cannot protect against all events).

Due to this preference for structural measures there is little knowledge about non-structural measures and limited capacity to design and implement them. Hence there is currently no strategic integrated flood risk management approach in B&H that identifies the best combination of structural and non-structural measures to address climate induced flood risk. There is therefore a lack of knowledge and application of non-structural measures and ecosystem-based approaches (EbA) to flood risk management such as the use of agro-forestry, community-based early warning systems, floodplain zoning, reforestation and financial instruments such as flood insurance and other risk transfer mechanisms as a means of minimising the impact flooding on communities.

Sector specific flood risk management which embeds climate resilience measures is lacking due to insufficient knowledge and experience across sectors for flood risk assessment and planning according to international requirements and standards. Climate risk information is not being systematically used to inform national, sectoral and local planning, mainly due to the lack of comprehensive and definitive national hazard and risk mapping. Hence activities within key sectors such as water management, energy, transport, agriculture, forestry, spatial planning, are not risk-informed and do not take account of climate change. In addition, sectors lack the sector resilience and preparedness plans which would enable them to manage hazards and minimise the impacts to people, critical infrastructure, and normal economic activity within the sectors.

8.3 Barrier 3 a) Outdated non climate-risk informed approach to flood defenses design; b) Lack of capacity, knowledge and information for enhanced climate-proof public and private investments into flood risk reduction and community response

Insufficient, outdated and poorly managed flood defences increases exposure to increasing flood risk. In B&H, flood defence implementation is done in a reactive manner and as budgets allow. The limited annual budgets are used to address urgent repair to defences and does not currently take a strategic approach (e.g. river basin approach) nor does it take account of climate change. Existing defences have exceeded their design life and are therefore now largely ineffective. In addition, many were damaged in war and have not been repaired since. There is a lack of up-to-date expertise in the field of flood defence design in B&H including the lack of modern tools and approaches, to design defences that provide an appropriate standard of protection taking account of climate change and other changes in the basin. There is also a lack of technical and financial capacity to operate and maintain climate resilient flood protection infrastructure. The Post-Disaster Rapid Needs Assessment (PDRNA) following the 2014 floods revealed that 49.2 Million USD in damages to flood protection and control infrastructure was incurred.

There is currently a lack of engagement with private and productive sectors in climate-responsive flood risk management. There is limited to no involvement of the private sector in climate risk financing, despite the large damages incurred by the private sector from flooding. Flood risk financing and investment is not supported by robust assessment of benefit and costs, no investment plans and no comprehensive financial risk transfer mechanisms exist for dealing with the losses and damages from flooding. Risk financing is mainly from central, Entity and local government budgets, which do not meet the needs of climate risk management and flood risk management in particular compared to the damages and losses that will be incurred from such events under climate change. Lack of adequate risk financing undermines the ability to carry out statutory functions and the ability to enforce regulations against harmful practices and activities, such as development in the floodplain, the uses of flood resilient building codes for houses and other structures, thus increasing exposure and vulnerability of people, property and economic activity in built areas. Risk transfer mechanisms are not well developed and currently post-event compensation and reliance on external donor recovery funds, are the main approaches to dealing with the economic shocks of flooding disasters.

In order to ensure the sustainability of the measures being implemented, particularly related to the cost of operating and maintaining equipment, information provision services (such as forecasting and early warning), regular maintenance and operation of flood defences, and payment for all other flood risk management and reduction activities that the project will implement, there needs to be engagement and willingness to pay for such, from a wide range of beneficiaries including private sector, public sector, and the public at large (individuals). Information on the interest in, and willingness to pay for, flood risk management and flood risk reduction, and strategies for long-term involvement of the private and productive sectors in FRM, which is critical for planners and policy makers at the national and sub-national government level, is currently lacking.

The population, in particular in rural areas, is lacking general understanding of climate induced risks and community response capacities. There is limited knowledge and capacities among local communities on climate resilient livelihoods for coping with climate-induced hazards due to a lack of community level resilience technologies and adaptive strategies to minimise flood impact, including lack of a comprehensive and unified flood forecasting, early warning and response system to increase community resilience. Lack of community resilience is also due to lack of climate risk information at the community level to enable people to respond effectively to flood warnings. This so called, last mile connectivity is key to an effective FFEWS and requires impact-specific information on imminent hazardous flood events.

For high-impact imminent events, warnings are not tailored to user needs and, as forecasts do not always indicate the area at potential risk, the messages are not geographically specific. Moreover, warnings do not contain specific information on the potential impacts. Forecasting and advisory products targeted to key sectors such as agriculture, energy, transport, flood preparedness and response plans do not exist at municipal and community levels, do not use detailed and definitive food hazard and risk maps, nor do the relevant methodological and knowledge base for carrying out such planning exercises. In addition, recording damages and losses from disasters at the local level is not systematically done due to the lack of tools, methods and guidelines for collecting such data, and lack of a centralised D&L database.

PART II – PROJECT STRATEGY

9 THEORY OF CHANGE AND PARADIGM SHIFT

1. The GCF project has been developed to address the barriers to integrated climate-informed flood risk management and is aimed at supporting the commitment of the B&H governments to avoid losses of lives and to reduce economic and infrastructure losses caused by climate-induced flood disasters.

2. In the **baseline scenario**, without the GCF project the lack of technical, institutional and financial capacities to implement and maintain a fully integrated flood risk management framework will continue to result in limited (in terms of accuracy, skill and spatial extent) flood warnings not reaching the communities who are most affected by flood hazards, in a timely manner. The absence of comprehensive and definitive flood risk information and legislative and policy framework will continue to exacerbate weak land use, spatial planning and climate risk management, leading to increased exposure of communities to damages, losses and loss of lives. In addition, a lack of institutional and financial capacities and modern technologies will prevent the design of climate risk informed mitigation measures. The large proportion (26%) of the population at risk from flood hazards (902,906) will continue without coping capacities and adaptation strategies to adapt to climate change and the capacity to manage and minimize their exposure and resilience to intensifying flood hazards. Hence, in the baseline scenario without GCF investment, the B&H population and economy will face increasing pressures from more frequent and severe climate change induced flooding, including losses of lives and economic losses due to climate change-induced flood disasters and associated impacts on GDP. In addition, a continued lack of financial resilience will further limit recovery from more frequent flooding, thus keeping the affected population in a cycle of loss and diminishing recovery capacity, eroding and limiting further sustainable development gains. Scaling-up of tested integrated FRM approaches will not be possible due to the existing financial gap between DRR needs and required investments, as well as an underdeveloped national capacity for flood hazard and risk knowledge.

3. In the **adaptation alternative**, this GCF project will support the commitment of the B&H government to avoid losses of lives and to reduce economic and infrastructure losses caused by climate-induced flood disasters by implementing a Theory of Change described below. The project will scale-up technological, institutional and financial innovation in flood risk management through nation-wide implementation of fully integrated FFEWS based on state-of-the-art modeling technologies, mainstreaming of flood risk into key sectoral policies, mainstreaming nature-based solutions to flood risk management into FRM policy and practice, engaging private sector, promoting new risk financing tools, embedding risk-informed municipal investment planning approaches and implementation of priority flood risk reduction measures in the highest risk communities.

Theory of Change

4. GCF project goal statement: **IF** flood risk management in B&H is transformed towards a more proactive, integrated and climate-informed system supported by climate risk informed FRM policies, strategies, technologies and practice **THEN** B&H vulnerable communities will be less exposed to increasing frequency and intensity of climate-induced floods and will face reduced losses of assets, infrastructure and livelihoods **BECAUSE** of the accurate and timely impact-based flood warnings, and effective climate-proof flood protection measures integrating structural and nature-based solutions supported with long-term investment frameworks.

5. As outlined in the goal statement, the project will catalyze **paradigm shift** in flood risk management in B&H by transforming the existing FRM practices and shifting from an ex-post facto i.e. reactionary post-disaster recovery approach to ex-ante i.e. risk informed preparedness approach based on adequate climate information and risk knowledge, as well as on climate-informed FRM policies, strategies,

technologies and investment. These elements of the paradigm shifts are further described in Section D.2 below.

6. To achieve the GCF paradigm shift and deliver the project goal, the following two high-level Outcomes are planned: **Outcome 1:** Climate informed impact-based FFEWS and increased generation and use of climate data reduce vulnerability to flood related disasters; and **Outcome 2:** Vulnerable communities in B&H are better protected from and less exposed to climate induced flood risks through a combination of structural and non-structural flood risk reduction solutions. Through these outputs, the project's paradigm shift will be pursued by embedding innovation and technology transfer through scaling up of state-of-the-art technologies in floods monitoring, modelling, impact-based forecasting and early warning, including "last mile" communication (Outcome 1), as well as by identification, selection and implementation of cost-effective EbA measures to complement traditional structural solutions, mainstreaming FRM into sectoral policies and introducing innovative risk financing and transfer mechanism as well as investment planning (Outcome 2).

7. While pursuing these Outcomes, the project will also leverage several important **social co-benefits.** Co-benefits for health and well-being will include improved health and reduced health risks due to the reduction in the number of floods-related injuries and exposure to water borne diseases. The health co-benefits will occur primarily for the vulnerable B&H communities currently lacking access to sanitation and drinking water: 59% of the population in B&H are currently not connected to sewerage systems and 25% are without access to drinking water, and therefore at higher risk of suffering from illness due to water borne diseases that arise due to flooding. In addition, the project will deliver substantive **gender co-benefits** as it will train and empower female practitioners in all aspects of FRM and establish gender-responsive risk assessments and FRM framework. The gender-responsive system of data collection and modelling of vulnerability to floods will underpin the socio-economic risk model which will guide identification and prioritization of the risk management, planning, preparedness and response measures in order to ensure that the most vulnerable groups are prioritized.

8. The outcome-level change will be pursued through three interconnected Outputs to be delivered by the GCF project.
Output 1: Fully integrated impact-based Flood Forecasting and EWS facilitates timely preparation and response;
Output 2: Non-structural flood risk reduction measures and nature-based solutions mainstreamed in sectoral policies and plans and effectively contribute to protection of people and livelihoods from climate-induced flood risk;
Output 3: Climate-proof flood protection measures scaled-up through new and improved national and local investment frameworks increasing resilience of the most vulnerable groups to climate induced flooding.

9. The project's **Output** 1 will contribute to the delivery of Outcome 1 by enhancing the capacity for flood forecasting and early warning through the development and implementation of a nationwide sustainable impact-based FFEWS which will provide improved warning times and reduced losses. This path has been chosen by the project among the other outputs based on the analysis of successful comparable efforts (EWS, climate information, and community-based DRM) which have shown effective impact related to saving of lives, assets, and livelihoods .This output will be achieved through a set of four interconnected and sequenced **activities** required to deliver a functional integrated impact-based FFEWS. First, the GCF project will significantly **improve the hydrometeorological network** which was damaged during the 1992-1995 war and currently cannot not provide adequate spatial and temporal coverage for an effective impact-based FFEWS. Across all river basins the project will expand the hydrometeorological monitoring network to cover a greater range of hydrometric variables that climate change is bringing to enable effective monitoring, management, forecasting and early warning of all flooding process including pluvial and fluvial flooding, groundwater flooding, floods from dam operations, and torrential floods **(Activity 1.1)**. Further, the project will address the lack of **comprehensive hazard and risk mapping of flood risk and vulnerability** by enhancing technical capacities related to hazard and risk identification, assessment, modelling and mapping. The project will develop hydrological modelling and extend hydraulic modelling for all main basins, undertake

hazard modelling for torrents, include HPPs and groundwater modelling in flood hazard, risk and vulnerability modelling and mapping for all relevant basins, and develop a GIS-based socio-economic risk modelling **(Activity 1.2)**. To address the lack of a country-wide flood forecasting and early warning system and lack of comprehensive, timely, specific and actionable flood warnings to communities and high risk sectors, the project will implement a **countrywide FFEWS based on an impact-based forecasting** approach and following the WMO standards, the FFEWS will include provisions for effective "last-mile" communication and the community-based EWSs for the highest risk communities **(Activity 1.3)**. Finally, the project will strengthen climate risk information sharing and institutional coordination and communication between different agencies, through **SOPs, Communication Protocols and Codes of Conduct** to be developed for each of the institutions responsible for impact based FFEWS **(Activity 1.4)**. Implementation of the Output 1 will address barriers preventing the effective integrated FRM in B&H related to the limited institutional capacity (technical, legislative and financial) for nation-wide FFEWS.

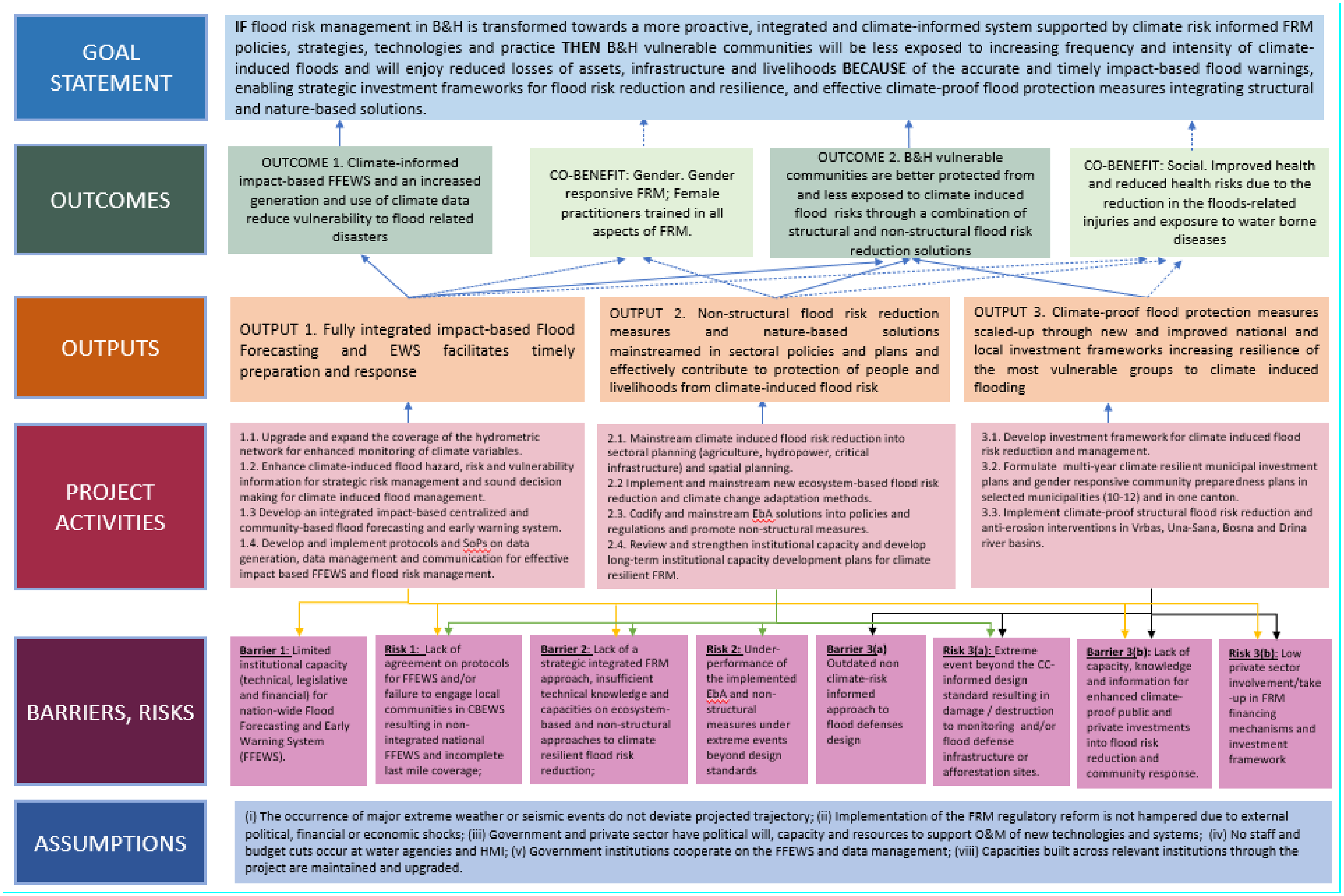
10. The project's **Outcome 2** will be achieved through the Outputs 2 and 3 which together will enhance the capacity to identify, plan and implement long-term flood risk management strategies at the basin and sub-basin scale by introducing combined structural and non-structural methods including EbA measures.
11.
12. More specifically, the **Output 2** will mainstream climate-informed integrated flood risk management into key sectoral policies and plans, enhance institutional technical capacities in all aspects of FRM, and facilitate scaled-up implementation of nature-based and non-structural flood protection solutions. Through the application of nature-based flood risk management solutions, the output will above all result in improvements in watershed ecosystems and restoration of ecological flood protection functions. This output will be delivered through four complementary activities. First, in order to address the institutional, legal and policy framework barriers to the effective integrated FRM, the project will **enhance the existing legislative and regulatory FRM framework** by mainstreaming climate-induced flood risk management into sectoral policy and planning for agriculture, forestry, environment, hydropower, critical infrastructure and spatial planning **(Activity 2.1)**. Then, the project will promote and scale up nature-based approaches to flood management which can provide added benefits such as enhanced ecosystem services, to be implemented in the highest risk basins in B&H. In particular, the project will **implement 21 non-structural and EbA measures that will enhance the ecosystem services** through afforestation, regrassing and soil protection/sediment management measures **(Activity 2.2)**. These solutions will complement structural measures to ensure that the combination of both structural and ecosystem-based measures provides the best solution to climate-resilient flood management and protection. To fully embed these new EbA methods into FRM in BiH, the project will establish a knowledge framework for the application of climate resilient EbA methods, including **guidelines, technical specifications, standards and protocols (Activity 2.3)**. Finally, to **enhance institutional capacity and embed continued capacity development** in all aspects of flood risk management the project will implement country-wide training programmes in the technical and practical areas of flood risk management for practitioners, decision-makers, communities, emergency responders based on the assessment of technical and functional capacities and the development of the long-term capacity development plan **(Activity 2.4)**. Implementation of the Output 2 will address the lack of a strategic integrated FRM approach, insufficient technical knowledge and capacities on ecosystem-based and non-structural solutions for climate resilient flood risk reduction.

13. Finally, **Output 3** will support the enhanced long-term flood risk investment planning at the national and local levels, engage private sector in risk management, and implement priority climate-proof structural flood protection measures in high-risk areas, thus contributing to the enhanced flood protection and reduced losses from flooding. This output will be achieved through the implementation of three activities. First, the project will **enhance the climate risk financing and risk transfer framework** in BiH shifting from largely public sector and donor financing towards blended finance and public-private partnerships; the project will support development of FRM investment frameworks, risk transfer schemes and enabling regulatory framework **(Activity 3.1)**. Further, the project will develop and implement the national methodologies, guidelines and tools for municipal climate-resilient investment planning based socio-economic risk and vulnerability modelling. **Investment planning will include Early Action**

plans identifying humanitarian funding (Forecast based Financing FbF) for early action based based on impact-based FFEWS **(Activity 3.2)**. Finally, the project will embed climate-change responsive design of flood defenses which will be supported by new standardized methodologies, tools, guidelines and capacity for **climate resilient flood defense design and implementation (Activity 3.3)**. Hence the project Output 3 will address barriers to the effective integrated FRM in B&H related to the outdated not climate-risk informed approach to flood defenses design, and the lack of capacity, knowledge and information for enhanced climate-proof public and private investments into flood risk reduction and community response.

14. This flow of outcomes, outputs and activities has been designed with the view of the following **assumptions** about the external environmental, political, economic and institutional circumstances. Success of the project in reducing the losses of lives, assets, livelihoods and infrastructure relies on the assumption that the occurrence of major extreme weather or seismic events do not deviate from projected trajectory. Implementation of the FRM regulatory reform and investment frameworks promoted by the project is based on the assumption that there will be no external political, financial or economic shocks that may hamper implementation capacities and priorities of the government and private sector partners. Consequently, sustainability of the technological solutions and infrastructure, including FFEWS and flood protection structures, depends on the capacities and resources of key stakeholders to support O&M of new technologies and systems, and to maintain adequate level of staff and budgets at water agencies and HMI. Finally, the effectiveness of the FFEWS in improving the timeliness and accuracy of flood warning is based on the assumption that government institutions cooperate on the FFEWS and data management.

15. Please refer to the Theory of Change (TOC) diagram below, which illustrates how the proposed sets of funded activities will deliver the planned Outputs, which address the barriers and risks to the desired adaptation alternative and contribute to the achievement of Outcomes and co-benefits.



GOAL STATEMENT
IF flood risk management in B&H is transformed towards a more proactive, integrated and climate-informed system supported by climate risk informed FRM policies, strategies, technologies and practice **THEN** B&H vulnerable communities will be less exposed to increasing frequency and intensity of climate-induced floods and will enjoy reduced losses of assets, infrastructure and livelihoods **BECAUSE** of the accurate and timely impact-based flood warnings, enabling strategic investment frameworks for flood risk reduction and resilience, and effective climate-proof flood protection measures integrating structural and nature-based solutions.
OUTCOMES
OUTCOME 1. Climate-informed impact-based FFEWS and an increased generation and use of climate data reduce vulnerability to flood related disasters
CO-BENEFIT: Gender. Gender responsive FRM; Female practitioners trained in all aspects of FRM.
OUTCOME 2. B&H vulnerable communities are better protected from and less exposed to climate induced flood risks through a combination of structural and non-structural flood risk reduction solutions
CO-BENEFIT: Social. Improved health and reduced health risks due to the reduction in the floods-related injuries and exposure to water borne diseases
OUTPUTS
OUTPUT 1. Fully integrated impact-based Flood Forecasting and EWS facilitates timely preparation and response
OUTPUT 2. Non-structural flood risk reduction measures and nature-based solutions mainstreamed in sectoral policies and plans and effectively contribute to protection of people and livelihoods from climate-induced flood risk
OUTPUT 3. Climate-proof flood protection measures scaled-up through new and improved national and local investment frameworks increasing resilience of the most vulnerable groups to climate induced flooding
PROJECT ACTIVITIES
1.1. Upgrade and expand the coverage of the hydrometric network for enhanced monitoring of climate variables.
1.2. Enhance climate-induced flood hazard, risk and vulnerability information for strategic risk management and sound decision making for climate induced flood management.
1.3 Develop an integrated impact-based centralized and community-based flood forecasting and early warning system.
1.4. Develop and implement protocols and SoPs on data generation, data management and communication for effective impact based FFEWS and flood risk management.
2.1. Mainstream climate induced flood risk reduction into sectoral planning (agriculture, hydropower, critical infrastructure) and spatial planning.
2.2 Implement and mainstream new ecosystem-based flood risk reduction and climate change adaptation methods.
2.3. Codify and mainstream EbA solutions into policies and regulations and promote non-structural measures.
2.4. Review and strengthen institutional capacity and develop long-term institutional capacity development plans for climate resilient FRM.
3.1. Develop investment framework for climate induced flood risk reduction and management.
3.2. Formulate multi-year climate resilient municipal investment plans and gender responsive community preparedness plans in selected municipalities (10-12) and in one canton.
3.3. Implement climate-proof structural flood risk reduction and anti-erosion interventions in Vrbas, Una-Sana, Bosna and Drina river basins.
BARRIERS, RISKS
Barrier 1: Limited institutional capacity (technical, legislative and financial) for nation-wide Flood Forecasting and Early Warning System (FFEWS).
Risk 1: Lack of agreement on protocols for FFEWS and/or failure to engage local communities in CBEWS resulting in non-integrated national FFEWS and incomplete last mile coverage;
Barrier 2: Lack of a strategic integrated FRM approach, insufficient technical knowledge and capacities on ecosystem-based and non-structural approaches to climate resilient flood risk reduction;
Risk 2: Under-performance of the implemented EbA and non-structural measures under extreme events beyond design standards
Barrier 3(a) Outdated non climate-risk informed approach to flood defenses design
Risk 3(a): Extreme event beyond the CC-informed design standard resulting in damage / destruction to monitoring and/or flood defense infrastructure or afforestation sites.
Barrier 3(b): Lack of capacity, knowledge and information for enhanced climate-proof public and private investments into flood risk reduction and community response.
Risk 3(b): Low private sector involvement/take -up in FRM financing mechanisms and investment framework
ASSUMPTIONS
(i) The occurrence of major extreme weather or seismic events do not deviate projected trajectory; (ii) Implementation of the FRM regulatory reform is not hampered due to external political, financial or economic shocks; (iii) Government and private sector have political will, capacity and resources to support O&M of new technologies and systems; (iv) No staff and budget cuts occur at water agencies and HMI; (v) Government institutions cooperate on the FFEWS and data management; (viii) Capacities built across relevant institutions through the project are maintained and upgraded.

The project objective is to address the increasing vulnerability of B&H communities and livelihoods to intensified climate-induced hydro-meteorological flood-related disasters (pluvial, fluvial and torrential). This will be accomplished by adopting a comprehensive and integrated approach to flood risk management, resulting in strengthened institutional, technical, and financial capacity to develop and implement long-term flood risk management strategies, including a combination of structural and non-structural measures which protect communities, employ eco-system-based approaches, and re-balance natural eco-system functions. In addition, strengthened early warning and emergency response systems will provide forecasts and early warning to at-risk populations.

The project will reduce vulnerability to floods across B&H (pluvial, fluvial and torrential flooding) through improved climate information and establishment of flood forecasting and early warning systems. Improved generation and use of climate information will enable sound decision making and investment into climate resilient flood risk reduction measures. The proposed project aims to address the above barriers and shift the baseline scenario towards climate resilience through two Outcomes and three outputs:

Outcome 1: Climate informed impact-based FFEWS and increased generation and use of climate data reduce vulnerability to flood related disasters

Output 1: Fully integrated impact-based Flood Forecasting and EWS facilitates timely preparation and response

Outcome 2: Vulnerable communities in B&H are better protected from and less exposed to climate induced flood risks through a combination of structural and non-structural flood risk reduction solutions

Output 2: Non-structural flood risk reduction measures and nature-based solutions mainstreamed in sectoral policies and plans and effectively contribute to protection of people and livelihoods from climate-induced flood risk

Output 3**:** Climate-proof flood protection measures scaled-up through new and improved national and local investment frameworks increasing resilience of the most vulnerable groups to climate induced flooding.

PART III – DETAILED DESCRIPTION, DESIGN AND COSTING OF INTERVENTIONS

10 DETAILED DESCRIPTION, DESIGN AND COSTING OF INTERVENTIONS BY OUTPUTS AND ACTIVITIES

10.1 OUTPUT 1: FULLY INTEGRATED IMPACT-BASED FLOOD FORECASTING AND EWS FACILITATES TIMELY PREPARATION AND RESPONSE

Activity 1.1: Upgrade and expand the coverage of the hydrometric network for enhanced monitoring of climate variables in Category I catchments and torrential streams. GCF Financing =$1,535,980; Co-financing = $2,869,966

The previous upgrades to the hydrometeorological observation network - for more effective flood monitoring, management, forecasting and early warning - have not yet been realized at the appropriate spatial and temporal scale. The GCF project will increase the density of the hydro-meteorological observation network and expand monitoring with a greater range of hydrometric variables that climate change is bringing. In particular, climate change is increasing the risks from torrential streams which are currently not monitored or studied (except for Vrbas basin). Small torrential tributaries require finer spatial scales of monitoring. The project will provide increased density of meteorological network where needed for torrents, as well as hydrological monitoring of torrential discharges. In addition, the project will provide technical assistance to review and integrate the HPPs hydrometric network and identify opportunities to establish or formalize data access and sharing between HPPs, hydro-meteorological institutes and water agencies to maximise the network. The project will also assist in setting-up sustainable operation and maintenance (O&M) of the network and identify long-term financing mechanisms for the maintenance of the hydrometric network.

Key technical considerations for expansion of the Hydrometric network

WMO recommends that hydrometric networks should be reviewed periodically to consider the "reduction in hydrological uncertainty brought about by the data since the last network analysis" and any changes related to budget, data needs, and users, etc. The adequacy of the density of basic hydrological observation stations based on physiography found that globally, the WMO recommendations for minimum density were not reached in 74% of mountainous basins for nonrecording precipitation; 52% percent for recording precipitation; 65% for water temperature, evaporation, and discharge; 58% for sediment; and 44% for groundwater. Hence, for the majority of mountainous areas, the WMO recommendations on minimum network density are not met. Network density has a significant influence on the accuracy with which key hydrometeorological variables such as streamflow, can be estimated or modelled. Studies have shown that there is a minimum rain gauge density required to adequately represent mean areal precipitation over a catchment. There is also an optimal geographical configuration of rain gauges which give the optimum hydrological modelling performance, which shows that there is a strong dependence on the local geographical and climatic patterns. Simulations generally improve when the precipitation inputs are estimated using a denser station network for most drainage basins, and peak flows are generally better simulated when a denser network is used to calculate the mean daily precipitation used as input. Network density also has a significant impact on forecasted variables. Some rain gauge combinations lead to better streamflow forecasts than when all available rain gauges are used to estimate the mean areal rainfall with the best performance improvement achieved when the mean areal rainfall is computed from a specific rain gauge combination, revealing the complexity of the identification of an optimal sub-network. From an optimization point of view, these results show that it may sometimes be beneficial to reduce the size of the total rain gauge network in order to optimize forecasts.

Apart from spatial density, which is an integral part of network design, one must take into consideration many other parameters for monitoring network design. In particular, the problem of selecting optimal sampling designs is complicated when other parameters are considered, for example, current need of users, variability of streamflow patterns, maintenance costs, accessibility, security of sampling sites, and politics, to name a few. Some of the main criteria for selecting the representative stations include: (1) stations which provide information for multiple business areas should be considered as primary stations and are important to the network. (2) the combination of stations, keeping the primary stations as part of the network, which reduces overall errors based on variance. (3) the rank of different scenarios of different combination of stations based on their capacity to reduce overall errors. (4) Comparative cost associated with maintaining and continuing different combinations of stations. (5) the combination that can improve network performance without requiring much additional resources. (6) Finally, the combination of stations providing more information as well as minimum error and minimum cost can be chosen as representative stations. On the basis of the above criteria, the selection of optimal rainfall networks considers the number and location of rainfall gauges, which gives greater accuracy of areal rainfall estimation with minimum cost.

Of particular importance when considering the hydrometric network optimisation for B&H is **torrential flash flood** monitoring. Flash floods are generally associated with intense rainfall exceeding 100mm in a few hours and affecting limited areas (Douvinet and Delahaye, 2010). The generating rainfall can also be long-lasting rainfall (about 24h with moderate intensities but leading to accumulative rainfall of several hundreds of millimetres). In terms of magnitude, Gaume et al. (2009) show that European flash floods are characterised by specific peak discharges ranging from about 0.5 to $40m^3\ s^{-1}\ km^{-2}$. The rise of the hydrographs is very short (a few hours or less for catchments of $1–100km^2$ and less than 24h for catchments of about $1000km^2$). Many hydrological factors have relevance to the occurrence of a flash flood: terrain gradients, soil type, vegetative cover, human habitation, antecedent rainfall, etc. In steep, rocky terrain or within heavily urbanized regions, even a relatively small amount of rainfall can trigger flash flooding. These hydrological factors determine the response of the catchment to the precipitation event. Thus, a flash flood is clearly the result of the concatenation of both meteorological and hydrological circumstances. Most flash floods associated with rainfall are produced by thunderstorms. However, while a single thunderstorm cell is unlikely to produce enough rainfall to cause a flash flood, the typical flash flood is the result of several thunderstorms moving successively over the same area. Occasionally, flash floods are created in conditions that are not favourable for thunderstorms but which still produce heavy rainfalls. This can occur when moist air is forced upward over mountains by the wind flow, called orographic precipitation. Sometimes, the location where flash flood damage occurs may actually receive little or no rainfall. That is, the rainfall that causes the problem falls upstream of areas susceptible to damage from the flash flood. Optimisation of the hydrometric network to ensure adequate monitoring of torrential catchments is challenging because flash flood events are characterized by time- and space scales that conventional measurement networks are not always able to sample (Creutin and Borga, 2003; Kirchner, 2006). An approach based on the monitoring of nested spatial scales: (1) the hillslope scale, where processes influencing the runoff generation and its concentration can be tackled; (2) the small to medium catchment scale ($1–100km^2$), where the impact of the network structure and of the spatial variability of rainfall, landscape and initial soil moisture can be quantified; (3) the larger scale ($100–1000km^2$), where the river routing and flooding processes become important will be designed.

Groundwater flooding mainly occurs when aquifer water levels (water table) rise to above ground level, due to high rainfall quantities over extended periods, and is likely to contribute to, or is linked to other sources of flooding, such as fluvial or surface water, on a local scale during heavy rainfall events as opposed to separate distinctive events. Because of the delayed response in vertical and horizontal flow in aquifers, flooding often takes place sometime after the causative rainfall events, and may persist for some time (days, weeks), as outflow is also controlled by the aquifer characteristics. The specific conditions leading to groundwater flooding need to be identified from analysis of localised rainfall linked to past events and correlation with reference groundwater levels. The design and optimisation of a **groundwater monitoring network** should consider the following: establishment of well inventory and control of monitoring functionality; control of suitability of well design and maintenance/rehabilitation requirements, control of hydrogeological assumptions (aquifer unit, aquifer geometry, hydraulic parameters, suitability of monitoring location and monitored depth interval, etc.); determination of reference monitoring wells; determination of optimal locations; determination of redundant and unusable monitoring wells; determination of new monitoring sites. Groundwater observation wells are dedicated monitoring stations, sited and designed to detect potential changes in groundwater flow and quality— design parameters include selection of depth for the intake screen, frequency of measurement (if not continuous) and selection of quality parameters. To overcome the widespread presence of depth variation in hydraulic head and/or groundwater quality, nested piezometers or well clusters can be used. Piezometer nests are more cost effective than observation well clusters but should only be used if proper sealing can be achieved to prevent vertical flow between their screens. A suite of observation wells coupled with a selection of abstraction wells normally comprise a monitoring network. Hence the design of the observation wells should consider existing locations of any abstraction wells. The main components of expenditure of groundwater monitoring are the capital cost (of network installation), sampling costs (for instrumentation, personnel and logistics) and analytical costs (for laboratory, data processing and storage). The return on investment can be substantial where monitoring represents an integral part of an integrated management process and avoids losses of assets (such as agricultural and property) that can be caused by groundwater flooding.

The above discussion clearly highlights the necessity and importance of optimal hydrometric network design that meets the needs of the various types of flood risk that can occur in different basins, as well as the needs of all uses of the data. The first task under this activity, therefore, will be to review, identify and confirm the optimized hydrometric network for B&H for all flood types (fluvial, torrential, groundwater) to be monitored, based on which the equipment to be procured will be confirmed. The activity will review all existing hydrometric networks for each target river basin and, based on technical assessments of meteorological and hydrological variability of the basins, and the need to provide flood forecasts and early warning, as well as to undertake long-term monitoring of the basin, an optimised hydrometric network will be identified and recommended for implementation. This will include more detailed specification of the type and location of equipment, as well as the necessary telecommunications systems that will be required to support the automatic transmission of data. Detailed design will then be done for prioritised gauging stations within the basins.

The project will also develop a basin operations and maintenance plan for the optimized hydrometric network as well as an Institutional capacity development plan for hydrometric network O&M, based on which training of hydrometric specialists with responsibility for operation and maintenance of the hydrometric network will be undertaken. The project will further develop the water information and hydrological information systems hydrometric databases and strengthen data sharing protocols.

To ensure sustainability of the rehabilitated and optimised hydrometric network, the project will develop financing mechanisms, establishing and safeguarding public sector long-term commitment of network maintenance, capacity building for design, installation and maintenance of monitoring networks, community-managed gauging stations. The project will also develop innovative financing mechanisms that would seek to engage the private sector (hydropower, tourism, agriculture) for which willingness-to-pay surveys will be conducted during project implementation. Risk financing mechanisms will also engage local government and beneficiary communities (e.g. through engaging local people to assist in maintenance of stations), where possible, to complement entity-level budgeted government financing of O&M. Initial consultations during project formulation have identified and engaged with key private sector players and further market assessment will be conducted to determine their interest in sector-specific climate risk information products that would enhance their operations and their resilience to floods, determine their interest in paying for tailored products and services that will be used in their operations, their willingness to support or partially support the O&M of hydrometric monitoring and early warning systems, equipment and information products and services for themselves and the communities within which they operate.

Sub-Activity 1.1.1 –Develop optimised hydrometric network specification, develop ICT strategy and plan for hydrometric network

1) Undertake a detailed review and assessment of the existing hydrometric monitoring network for all flood mechanisms in the target basins (fluvial, torrential, groundwater). Identify and design the requirements for an effective and optimised monitoring network for strategic flood risk management, flood forecasting and early warning in the future and optimised station coverage. **Deliverable: Assessment of existing hydrometric network and conceptual design of the optimised hydrometric network.**

2) The detailed hydrometric network design document will be prepared covering network design, prioritised station list, conditions of existing stations, equipment options, rehabilitation/new installation plan for all meteorological and hydrological network improvements required for monitoring of torrents, integration of the HPPs hydrometric network into the overall network, and groundwater monitoring network for Adriatic Sea basin. **Deliverable: Detailed design document of the optimised hydrometric network;**

3) Undertake an assessment of the existing ICT infrastructure and capacity to support the telemetered and automated stations. Develop ICT strategy and plan to support rehabilitated hydrometric network for effective data transmission, storage, sharing and management., **Deliverable: Assessment of telecommunications for support to hydrometric network. ICTs strategy and plan to support rehabilitated hydrometric network. Upgraded ICT for hydrometric network.**

4) Strengthen the existing protocols for the collection, transmission, sharing, storage, management and use of the observed data. **Deliverable: Finalised protocols for the collection, transmission, sharing, storage, management and use of the observed data.**

5) Digitize all paper format data and systematize and store within the relevant hydrometric databases. **Deliverable: Complete digitized data for all basins.**

Sub-Activity 1.1.2 - Procure and install equipment to increase density of the hydro-meteorological observation network and expand monitoring to include greater range of hydrometric variables that climate change is bringing

A gap analysis of the existing hydrometric network has been carried out during the project development phase and equipment has been specified by the relevant Water Agencies and HMIs based the available strategy documents and the existing technical capacities fully specify, design and operate a modern hydrometric network including its equipment and technologies. The following is the proposed indicative list of equipment to be acquired by the GCF project, which can be considered as the upper limit of the required expenditure for budgeting purposes:

Table 10-1: Indicative list of required hydrometric stations to be procured under GCF

	Quantity	Unit price (USD)	Construction works (USD)	Total Capital Cost (USD)
Groundwater Monitoring network				
Groundwater monitoring stations for measuring profiles of the most significant karst springs	9.00	11,000.00	7,200.00	163,800.00
Installation of the appropriate measuring equipment into existing piezometers which are out of function or never were installed with measuring equipment	24.00		7,200.00	172,800.00
Performing piezometer 100 and 200 m deep, with installation of equipment on following locations, average depth of 180 m	18.00	11,000.00	7,200.00	327,600.00
boreholes with average depth up to 50 m, with casing and installation of equipment	10.00	3,400.00		34,000.00
boreholes with average depth up to 30 m, with casing and installation of equipment	30.00	2,100.00		63,000.00
Hydrometric network requirements				
Meteorological Stations: GMS program Measurement: Temperature (t, tmin, tmax, tmin5), Humidity, Wind, pressure, precipitation, insulation, snow depth, soil temperature per depth:(2 cm, 5 cm, 10 cm, 20 cm, 30 cm, 50 cm, 100 cm) AMS sensors: precipitation, temperature, wind, humidity, pressure, global radiation, snow depth, percentage of water in snow. AAS sensors: Soil temperature up to 1m of (5 cm, 10 cm, 50 cm i 100 cm) Humidity of soil up to 1 m (5 cm, 10 cm, 50 cm i 100 cm) humidity of leaves	26.00	12,900.00	2,600.00	403,000.00
Automatic Hydrological stations: The level and depth of the water, pressure, temperature.	23.00	4,500.00	800.00	121,900.00
Total cost				**1,286,100.00**

. From the end of the project to year 20, maintenance costs will be $5,445,000.

Table 10-2 is the annual cost of O&M for the existing and planned hydrometric network equipment. Total maintenance costs during the project 6-year implementation period will be $1,633,500. Relevant entity governments and WA's will provide O&M during the implementation period of the project and for at least 20 years thereafter. From the end of the project to year 20, maintenance costs will be $5,445,000.

Table 10-2: Estimated Annual maintenance costs for existing and new hydrometric stations

Station type	Annual maintenance (USD)
Existing hydrological, meteorological and precipitation stations	320,000.00
New Hydrological, meteorological and precipitation stations	50,000.00
New and existing groundwater monitoring stations	73,000.00
TOTAL	**443,000.00**

1) Based on the optimised hydrometric meteorological and hydrological network for improved monitoring of torrents, integration of the HPPs hydrometric network into the overall network and Groundwater monitoring network for Adriatic Sea basin, develop and provide detailed specification and design including costs of all equipment and each component of the networks specified, including the detailed design and bid document for the stations for rehabilitation / new installation. .**Deliverable: Technical specification, bill of quantity (BoQ), procurement plan for the optimised hydrometric network.**

2) **Procurement and installation of new hydrological, meteorological and groundwater stations**

3) Based on optimised telecommunications and ICT system design, develop and provide detailed specification and design including costs of all equipment and each component of the ICT and telecommunications systems, including the detailed design and bid documents. Telecommunications installation and configuration of equipment from monitoring stations across the network, based in the national telecommunications infrastructure and long-term strategy. **Deliverable: Detailed design of new prioritised ICT and telecommunications system including specification of all necessary hardware and software, Bid documents, BoQs. Fully functioning ICT for flood hazard monitoring in place. Deliverable: Technical specification, BoQ, procurement plan for the optimised ICT and telecommunications network and systems.**

4) Procurement and implementation of equipment for ICT and telecommunications systems upgrades for hydrometric network support.

Sub-Activity 1.1.3 - Set-up sustainable operation and maintenance O&M for the network

1) Assess the institutional arrangements, existing roles and responsibilities and the capacity of staff responsible for operating and maintaining the optimised hydrometric network and for the operation and maintenance of the optimised hydrometric network and identify manpower and financial requirements, and training needs, for the efficient O&M of the optimized network. **Deliverable: Report on the existing institutional arrangement for optimised hydrometric monitoring**

network management with recommendations for improved institutional arrangements for O&M; **Report on institutional capacity for optimised hydrometric network including required manpower, capacity, material and financial resources for long-term management.**

2) Develop strategic plan, methodologies, technical guidelines and manuals for the operation and maintenance of the optimised hydrometric network. Deliverable: **Strategic plan, methodologies, guidelines and manuals for the operation and maintenance of the optimised hydrometric network; The strategic operations and maintenance plan will cover strategies and plans for ensuring human, technical and financial capacity, including retention and succession planning, material and finance resource planning.**

3) Provide training for hydrometric staff in the O&M of up-graded hydrometric stations**. Deliverable: 50 practitioners of HMIs and WAs trained in O&M of up-graded hydrometric stations**

Sub-Activity 1.1.4 - Develop long-term financing mechanisms for the maintenance of the hydrometric network

1) Review of existing public and private sector financing mechanisms for climate and flood risk management. **Deliverable: report on public and private sector climate and flood risk management financing.**

2) Identify key private sector players at risk from flooding, including or with an interest in flood risk reduction critical Infrastructure providers/managers such as utility companies communications, telecommunications, Transportation Sector (Airlines/Air Traffic, road and rail operators), energy (hydropower and other than Hydropower); Private enterprises such as hotel groups, chamber of commerce or business community, insurance and micro-finance companies and undertake awareness raising on flood risk, flood risk management approaches. **Deliverable: Awareness raising/sensitization workshops for private sector players.**

3) Conduct a willingness to pay analysis for key private sector players for increased data provision of key hydrometeorological data. Conduct detailed feasibility assessment of key private sector players to; a) determine their interest in paying for tailored products that will be used in their operations; b) to determine their willingness to support or partially support the O&M of hydrometric monitoring and early warning systems, equipment and information products. **Deliverable: Feasibility report on private sector financing of hydrometric network O&M and shortlist of tailored products and services to be provided to private sector.**

4) Develop prototype mechanisms for cost recovery from a variety of private sector sources. **Deliverable: Prototype mechanism for private sector cost recovery**

5) Develop public sector financing mechanisms, establishing and safeguarding public sector long-term commitment of network maintenance, capacity building for design, installation and maintenance of monitoring networks, community-managed gauging stations. Development of innovative risk financing mechanisms that would seek to engage entity level and local government and beneficiary communities in O&M of hydrometric network. **Deliverable: Public Sector O&M financing strategy, action plan, budgetary allocation mechanisms and tools**.

Activity 1.2: Enhance climate-induced flood hazard, risk and vulnerability information for strategic management and sound decision making for climate induced flood risk management. (GCF Financing = $1,067,833; Co-Financing = $4,528,756)

WBIF project is developing EUFD flood hazard and risk maps for all basins in B&H (except Vrbas which is already done) and is expected to be completed by end of 2020. These flood hazard and risk maps will only cover high risk (AFAS[32]) areas of category I rivers, will not have holistic river basin approach and will not include detailed hydrological modelling, which will be required for future flood forecasting and development of river basin flood risk management plans. Category II rivers pose a significant risk to populations, particularly where torrential flash flooding is significant. There is currently no hazard or risk mapping of torrents, expect for Vrbas basin, and WBIF project will not develop the torrents flood maps. In addition, the IPA2016 has allocated funds for development of flood risk management plans for all basins in B&H, and this work is expected to be completed by the end of 2021.

The WBIF hazard mapping will meet the minimum requires for the EUFD with regard to flood hazard and risk mapping for B&H. However, the strategic assessment of risk to population, to economic activity and to future development under conditions of climate change is a government priority to support and guide local municipalities to wisely and rationally manage risk exposure to acceptable levels.

The GCF project will assess current level of implementation of the EUFD hazard modelling and mapping in each basin and review data availability for implementation of more detailed strategic basin-wide flood hazard and risk modelling and mapping. GCF resources will be used to enhance the developed WBIF hazard models and maps under current and climate change conditions and will take a whole basin approach for the entire project area. To achieve this the GCF project will undertake modelling of the rest of the basins and will incorporate the WBIF models into the basin wide models. The project will commission/purchase essential datasets and surveys to enable flood risk mapping of the non-AFAS areas. The unified basin approach to flood hazard modelling based on EUFD that has been established for B&H and implemented under the Vrbas project will be used for the additional and enhanced modelling. Using the agreed unified flood hazard modelling techniques, the GCF project will establish and/or amend existing numerical hydrological and hydraulic models of the basins based on detailed surveys of the physical characteristics of the river basins and produce high resolution flood hazard inundation maps in line with the EUFD, suitable for use in land use planning, development zoning, strategic flood risk management planning, flood risk mitigation design, establishment of flood insurance criteria, raising public awareness, and emergency planning. These definitive basin hazard maps will be produced for a number of different return periods and for a range of climate change scenarios and will be the basis of climate risk information for use on climate risk management of the B&H.

In addition, the enhanced hazard models and maps will be used as the basis of the Flood forecasting and early warning system to be developed within the framework of this project. The maps will benefit decision makers, and all involved in flood risk management at all levels. It will also enable government and donor agencies to better focus their efforts in dealing with flood hazards in the basin in the future. Importantly the enhanced flood hazard maps will provide the basis for the management of climate-induced flood hazards in B&H now and in the future.

The GCF project will enhance the WBIF EUFD hazard and risk modelling by a) developing hydrological modelling for all main basins (category I rivers), b) undertaking torrents hazard modelling, c) including HPPs and groundwater modelling in flood hazard, risk and vulnerability modelling and mapping for all relevant basins. An essential task of flood management in HPP modified catchments is determination of an effective reservoir operation strategy that minimizes downstream flood risk and damage, while maintaining dam safety within reasonable limits and optimising water availability for power generation. Operation of HPP reservoirs exposed to floods presents many challenges, since important decisions have to be made under time pressures in an uncertain context with regard to information availability and the predictability of the

[32] Areas for further assessment

unfolding hydro-meteorological situation. To minimise disastrous impact to downstream property, human life or even to the dam itself there needs to be an integrated approach to basin flood risk management which includes adequate representation of HPP operations in the basin flood hazard modelling and mapping, as well as in flood forecasting models. To this end, the project will incorporate HPP operations into flood hazard and risk modelling (to strengthen the role of HPPs in flood alleviation and maximize their capacity to utilize flood forecasts in their operations) in all relevant basins. The project will additionally develop sector-specific climate risk information products for hydropower sectors with a particular focus on the Neretva and Trebišnjica sub-basins of the Adriatic Sea basin. This will be done by reviewing the existing Neretva and Trebišnjica basin models and either upgrading the existing models or developing new models to include HPP operations and groundwater modelling (not currently included in the existing model), and inclusion of representation of the downstream floodplain to enable routing of the flood wave through the floodplain for assessment of flood risk downstream of the reservoirs. This detailed model will build upon the current NAP project "*Development of study on economic impact of climate change on the hydropower sector in Republika Srpska – multipurpose hydrosystem Trebišnjica*", which is assessing hydrological and energy efficiency of the basin and will also identify additional monitoring needs to support improved HPP system operations and will provide essential input observation data for the more detailed model of the basin. The NAP project aims are as follows: contribution to the protection from flooding of agricultural zones during growing seasons (karst fields) and the protection from flood of settlements and urban zones; water for irrigation of agricultural land is ensured; water for water supply to population and technical purposes is ensured; conditions for low water 'replenishment' in the low water period are ensured; conditions are created for optimum energy use of water resources, which are considered as ecologically acceptable/renewable energy sources (reduction of CO2 and greenhouse gases emission); conditions are ensured for use of water for other purposes (tourism, water sports, recreation, etc.); conditions are ensured for social, socioeconomic and any other progress of the population, the region, etc.

The GCF project will also develop the institutional capacity of HPPs operators to use climate risk and forecasted information in their operations by providing the necessary supporting protocols and tools and training. In addition, the ability to assess flood risks posed by dams and reservoirs in the case of overtopping or breaching will be strengthened by reviewing and updating essential dam breach modelling and mapping approaches in B&H and development of updated unified technical guidance and specification for dam breach modelling.

This activity will also build on the bespoke GIS-based socio-economic flood risk and vulnerability model (which is based on EU flood Directive methodology for flood socio-economics assessment) developed for Vrbas basin. The developed socio-economic flood risk model will be enhanced with improved receptor and socio-economic datasets to be acquired/established by the GCF project, but the underlying methodology will be the same. The enhanced hazard maps and underlying information will be used in combination with receptor data including infrastructure (bridges, roads and buildings, hospitals, schools, power plants, critical infrastructure), land use (settlements, agriculture, grazing lands, and conservation areas), property and socioeconomics data, to assess the socio-economic impacts of each hazard and produce vulnerability maps for the river basins. The tool will integrate various spatial socio-economic data with the hazard maps, and produce risk maps, which will include economic losses and damages and loss of life estimates. In addition, the project will develop the technical methodology and tools for the systematic collection of socio-economic datasets that are important to flood risk and vulnerability modelling and assessment.

To support the development and implementation of the socio-economic flood risk and vulnerability modelling tool, the project will develop methods and tools for systematic collection of socio-economic data to enable the assessment the vulnerability of communities to flood risk under current and climate change conditions, as well as the collection of datasets on assets and infrastructure at risk at the community level. While data about physical assets will be largely based on secondary data held by relevant government institutions, data required for exposure, vulnerability and coping capacity will be based on both primary and secondary data sources. Hence the approach to socio-economic risk and vulnerability assessment will combine survey results with secondary and observed data available from all levels of governments. Survey methodologies and tools will be based on extensive community surveys to help characterise the socio-economic status of the communities and to consult with communities. Participatory GIS (PGIS) methods and tools that were developed under the Vrbas project will be used as a means of systematic collection and integration of local community information into the assessments.

Sub-Activity 1.2.1: Develop hydrological modelling for all main basins (category I rivers) to complement WBIF project's EUFD hazard and risk models

1) Hydrological model conceptualisation for each basin and review and analysis of available data for developing detailed hydrological models for fluvial, torrent, and groundwater and HPP hydrological modelling in each river basin
2) Acquire/procure datasets necessary for the development of enhanced hydrological models for detailed fluvial, torrent, and groundwater hydrological modelling in each river basin
3) Using the most appropriate modelling techniques, establish basin numerical hydrological models as inputs to the hydraulic models. **Deliverable: Detailed hydrological models for each target basin.**

Sub-Activity 1.2.2: Develop full basin hydraulic models

1) Undertake detailed topographic surveys of the river channel where necessary, including all major infrastructure across the river (e.g. bridges, dams etc.) and along riverbanks (e.g. flood walls, levees etc.) for the parts of the basins to be modelled. **Deliverable: Topographic surveys in target basins**
2) Acquire/purchase/commission high resolution topographic data for the floodplain areas through high risk areas. Aerial photographs or LiDAR sources would be recommended in order to obtain a high-resolution DEM covering entire basins. Coarser DEM and topographic data will be used for the rest of the basin for basin wide modelling d) Using the most appropriate modelling techniques, establish numerical high-level basin wider hydraulic models. For each basin undertake detailed linked hydrological-hydraulic modelling in line with the unified EUFD methodology and produce high resolution flood hazard inundation maps suitable for use in land use planning, development zoning, flood risk mitigation design, flood risk, vulnerability, damage and loss modelling, establishment of flood insurance zones, raising public awareness, and emergency planning. Maps will be produced for a number of different return periods and for a range of climate change scenarios. Flood modelling and mapping will cover all relevant flooding mechanisms within the basin. **Deliverable: Relevant topographic data sets procured.**
3) Integrate detailed hydrological and hydraulic modelling for Areas for further assessment (AFAs) being modelled by WBIF project into the high-level river basin models. **Deliverable: Integrate detailed hydrological and hydraulic modelling of each target basin.**
4) Develop the technical methodology for the systematic collection of gender-sensitive socio-economic data to support natural disaster risk and vulnerability assessment, based on community surveys and PGIS methodology developed under Vrbas. **Deliverable: Technical methodology for the systematic collection of gender-sensitive socio-economic data to support natural disaster risk and vulnerability assessment**
5) Undertake socio-economic surveys for target river basins. Deliverable: socio-economic surveys for target river basins
6) Undertake socio-economic risk and vulnerability modelling and assessment based on enhanced flood hazard maps using the Vrbas risk modelling methodology. Develop socio-economic flood risk and vulnerability modelling and mapping of target basins. **Deliverable: Updated flood risk maps for target basins**
7) Undertake capacity assessment of relevant institutions for flood risk assessment and modelling and develop a long-term capacity development plan and training needs. Deliverable: number of trained experts/modelers

Sub-Activity 1.2.3: Produce country-wide maps of torrents hazard, risk and vulnerability

1) Develop maps of erosion for FB&H territory (this is being done with IPA funds and will be completed in 2021), and update the existing erosion map for RS in relevant high erosion risk areas
2) Develop Cadastre of torrential basins
3) Develop flash flood cadastre and flash flood susceptibility models, in line with the methodology for flash flood susceptibility modelling implemented on the Vrbas River Basin, for all other target basins.
4) Identify anti-erosion measures including structural and non-structural measures on individual river basin areas.
5) Develop finalised torrential hazard and risk maps for all target basins

Sub-Activity 1.2.4: HPP modelling for development of enhanced operating rules for HPPs. Incorporate HPP operations into flood hazard and risk modelling

1) Review existing guidance, methodologies and specifications for dam breach modelling and mapping. Develop a unified technical guidance and specification for dam safety flood risk assessment, inundation modelling and mapping to include dam breach modelling and mapping which includes climate risk considerations. Develop a strategy and programme of updating dam breach modelling and mapping based on developed unified guidance to cover all high and medium hazard dams in B&H. **Deliverable: Guidance, methodologies and specifications for dam breach modelling and mapping; Strategy and programme of updating dam breach modelling and mapping for all medium and high hazard dams in B&H.**
2) Develop guidance, methodologies and specifications for the inclusion of HPP operations in flood hazard modelling and mapping. Development of reservoir operation models for all target basins and inclusion within basin flood models. **Deliverable: guidance, methodologies and specifications for the inclusion of HPP operations in flood hazard modelling and mapping; Reservoir operation models for all target basins**
3) Review the existing reservoir optimisation models for Adriatic sub-basins – Neretva and Trebišnjica and update/develop a basin model including the detailed operation of the reservoirs and hydraulic routing of the flood wave through the flood plain downstream of the reservoirs. Incorporate groundwater modelling into basin model. Develop optimised operating rules to significantly reduce the height of the flood wave downstream from Mostar. **Deliverable: Updated Neretva and Trebišnjica basin model and optimised operating rules**

Activity 1.3 Develop an integrated impact-based centralized and community-based flood forecasting and early warning system (FFEWS). **GCF Financing = $2,156,040; Co-financing = $1,955,438**

UNDP-run Vrbas project is establishing one of the first FFEWS platform in B&H which will be run by local water agencies and will cover Vrbas river only, without tributaries. Una-Sana flood forecasting model is already developed, and operational and flood forecasting models are being developed by other projects (Bosna basin and Drina basin) but needs to be updated. The GCF project will build on the FFEWS which was developed for the Vrbas Basin and Una-Sana and will enhance the telecommunications system to support an integrated FFEWS platform, for near real time forecasting and warning dissemination.

Under the GCF project the Vrbas prototype will be scaled up to cover the two hydro-energy intensive basins of Neretva and Trebišnjica, and the Una-Sana basin forecasting model will be updated. Bosna river is implementing the Vrbas protype via an EU funded *Technical assistance for development of the hydrological flood forecasting system for Sava River Basin (Phase 1. Bosna River)* project, while Drina forecasting model is being developed under the World bank Drina project.

The GCF project will develop the meteorological and hydrological forecasting capabilities of WAs and HMIs with responsibility for FFEWS, to enable the production of high-quality, high-resolution (grid-size ~2-3km) weather forecasts in B&H. It would include the implementation of the "Last-Mile" warning dissemination and communication system and the implementation of training and capacity building programme on FFEWS.

The forecasting system to be implemented will update and integrate all existing and new FFEWS models covering the whole territory of B&H. The data from the different automatic stations (meteorological stations /posts and hydrological stations described above) will be managed, transmitted and processed following the same procedures as outlined in the description of the system designed under Vrbas project. In order to scale and integrate the existing forecasting systems, several actions will need to be undertaken for each of the components of the system. Below each of the components of the FFEWS is described in detail.

Sub-Activity 1.3.1: Develop and implement impact-based FFEWS system (centralised and Community-based)

Development of the FFEWS platform

The general architecture of the FFEWS system is described in Chapter 5 and repeated in the Figure below. As a brief summary, the flood forecasting platform is based on meteorological forecasting, satellite precipitation estimates, observational data, hydrological model, hydraulic models and a platform to manage, maintain and operate all these different data sources.

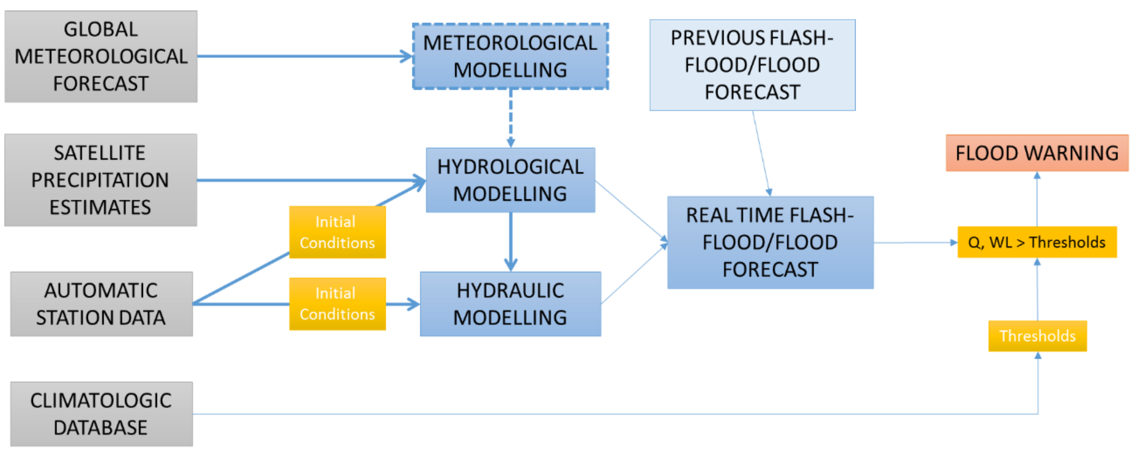


Figure 10-1: General architecture of the FFEWS system

Global Meteorological Forecasting (WRF and COSMO).

The Hydro-Meteorological Institute in the Federation is using a WRF model with a 4km horizontal grid resolution. This model is nested into a 14km NMM model. The latter model is getting its boundary conditions for the GFS[33] global meteorological forecasting model. In the Republic of Srpska, the Hydro-Meteorological Institute is running three different models, an ETA model with a 36km horizontal resolution (implemented by the German Meteorological Department DWD), a local HMM model at 12km horizontal resolution nested into the ETA model, and a HMM model with a 5km resolution nested into the HMM 12km one.

Improvements to the existing meteorological forecasting models is needed to ensure meteorological inputs of better spatial resolution.

The meteorological forecasting information in the upgraded forecasting platform that has been developed for Vrbas is based on two different Numerical Weather Predictions (NWP) models, namely WRF and COSMO. Boundary conditions: It is recommended that additional sources of information are used regarding

[33] The Global Forecast System (GFS) is a weather forecast model produced by the National Centers for Environmental Prediction (NCEP)

the boundary conditions for the local meteorological implementations, due to quality and reliability. Thus, it is recommended that ECMWF sources are evaluated in the local forecasting models.

ECMWF data

A key recommendation of the Vrbas Project, was the use of additional global or regional meteorological forecasting products. Global meteorological forecasting data is needed within the forecasting platform for boundary conditions for the local meteorological models. The Global Forecasting Models (from NOAA) are used to force respectively the WRF and the COSMO local implementations. There are questions about the suitability of the GFS data in the region, because it is not a dedicated provision of data (it is freely available on the Internet).

Therefore, a more dedicated provision of the data (ECMWF) is recommended. The quality of the ECMWF model, however, needs to be further assessed in order to ascertain the quality of the resulting forecasts. The ECMWF data is not free of charge for non-members of the ECMWF consortium, and membership (full or associate) costs. The associate member cost can be reduced for developing countries and the fee (approximately $50,000 USD) entitles several other benefits to HMIs in addition to the provision of data, such as training courses and dedicated data. The membership fee has been budgeted for under this project.

Satellite Precipitation Estimates

It is recommended that satellite precipitation estimates are used to complement the existing observational precipitation data. During the implementation of the upscale of the system the following activities should be undertaken:

- Multi-sensor Precipitation Estimate[34] (MPE) data: the use of MPE data is highly recommended. Data from this source will need to be fully evaluated within the implementation of the FFEWS for the all basins before implementation. Nonetheless, this data is considered to be of high value due to its latency (just 15 minutes) and its resolution (4km). The quality of these data will be fully evaluated within the framework of this project.
- TRMM/GPM[35] data: The quality of these data is generally higher than the WRF forecasting data, However, a thorough evaluation would be required, during long periods, for more extreme events and in a wide area. Also, procedures for the inclusion of these data into the hydrological forecasting will be implemented.

The impact of the use of satellite precipitation estimates in the final predictions of the flood forecasting platform will also be fully evaluated.

Hydrological Modelling

The hydrological model for the FFEWS will be using information and data from both the meteorological forecasting and from the monitoring stations. Meteorological forecast data, especially rainfall and temperature, from the two different local models (WRF and HMM) will be used in the hydrological model. Data from the monitoring automatic stations will be used for both real-time rainfall and for the adjustment of initial conditions. These initial conditions will be transferred from previous runs of the hydrological model (run in a continuous mode) but they will be adjusted based on data from the monitoring stations. In this case, because the Hydro-Meteorological Institutes in each of the entities have different local meteorological

[34] An instantaneous rain rate product, which is derived from a combination of passive microwave imager measurements from low orbiting satellites and infrared data from geostationary satellites. Data from low orbiting satellites shows low spatial and temporal resolution with acceptable accuracy, whereas IR data from geostationary satellites yields high spatial and temporal resolution but lower accuracy data retrieval. Processing is done in near-real time mode with a time delay of less than 10 minutes between image acquisition and data dissemination. Data are provided via EUMETCAST in GRIB-2 data format. Data is available every 15 minutes in a 4 kilometres grid

[35] The 'Tropical Rainfall Measuring Mission (TRMM)' a joint space mission between NASA and the Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rainfall. This mission has been providing rainfall estimates from 1997, and it should be noted that these rainfall estimates have actually been used to calibrate most of the satellite rainfall estimates algorithms used today. The TRMM mission will be terminated around February 2017. However, a similar mission (Global Precipitation Measurement (GPM)) by both NASA and JAXA too, and with a very similar configuration was launched in February 2014.

models, two different hydrological models will be run. The two institutes will run the same hydrological model but with different meteorological inputs.

This is a common approach for most flood forecasting platforms, and therefore the forecast would to benefit from two different outputs.

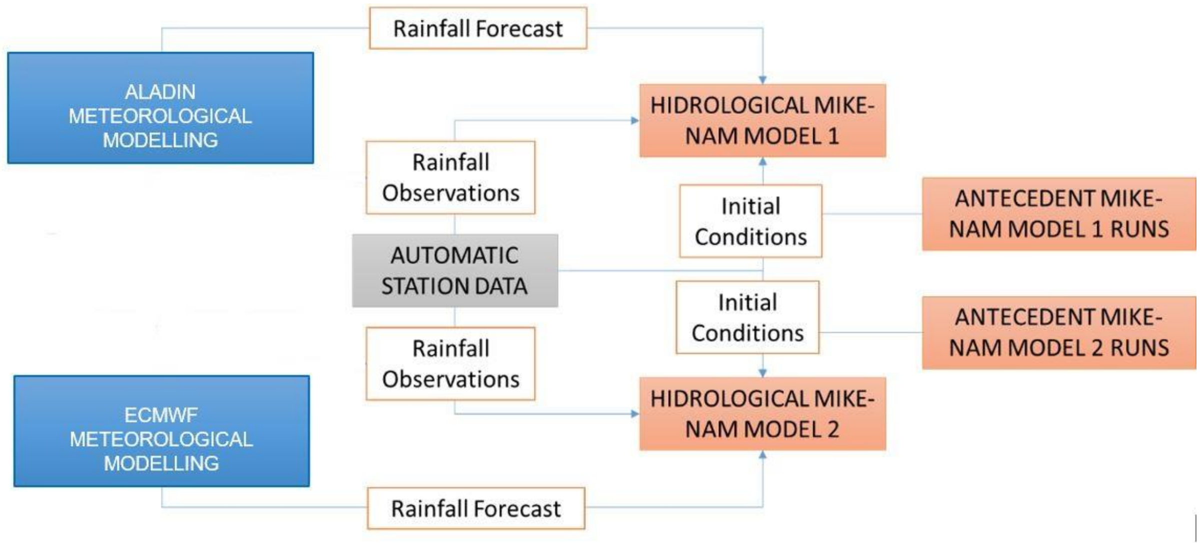


Figure 10-2: Hydrological Model coupling

The hydrological model within the flood forecasting platform will also be expanded to cover the whole territory of B&H. Within the hazard and risk modelling, to be carried out under activity 1.2, detailed hydrological models will be developed for all sub-catchments within the target basins, and these will be used to update the hydrological models within the flood forecasting platform. Hence hydrological models will be implemented to cover all the areas of interest. The resulting hydrological models will be adjusted for flood forecasting purposes. NAM modelling has been used for both Vrbas and Una basins and it is expected that it will be used for all other basins. Within the framework of this project some other hydrological models will be also be explored. This is because due to the new data sources, the use of precipitation gridded data is recommended. There are several options for this, and a full analysis will be undertaken in order to identify the best hydrological model for the flood forecasting platform.

Hydraulic Modelling

The hydraulic models will be coupled to both the automatic stations and the hydrological models.

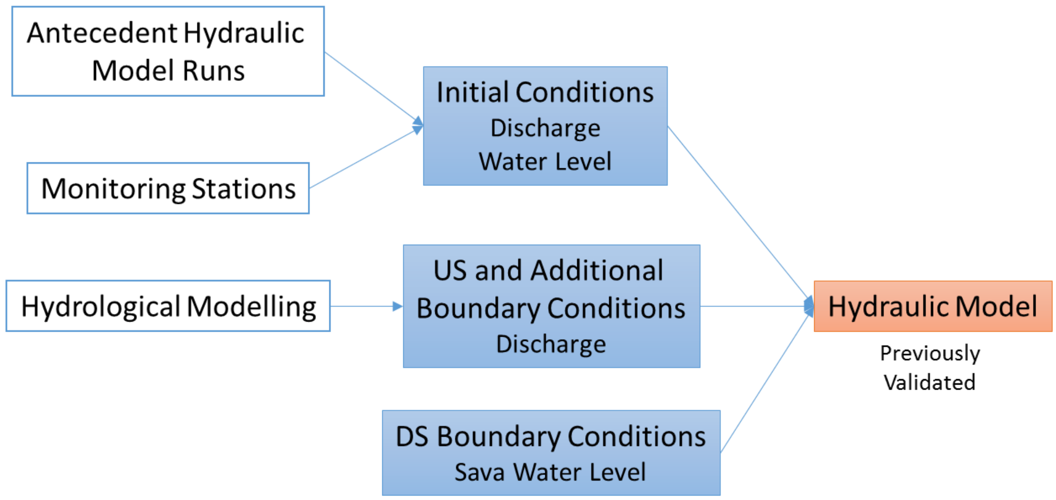


Figure 10-3: Hydraulic Model coupling

As per the hydrological model, the hydraulic model within the flood forecasting platform will be expanded to cover all the areas of interest in B&H, based on the hydraulic models that will be developed for flood hazard and risk modelling under the WBIF project and enhanced by the GCF project. Furthermore, the geometry information underlying the hydraulic model will be based on improved data (LIDAR for floodplain areas and surveyed cross-sections, structures, calibrated resistance coefficients etc.). These basin hydraulic models will be adjusted as necessary for flood forecasting purposes and will be used in the flood forecasting platform. As detailed below, the software to use in this project can be the same as the existing one (MIKE 11). The flexibility of the forecasting platform allows for the use of different modelling software for the predictions.

As previously noted, hydrological models will be run one per each entity with different meteorological inputs. This would result in different outputs from the hydrological models. Therefore, the resulting hydrological outputs from the Federation Hydro-Meteorological Institute (Hydrological MIKE-NAM MODEL 1) will be used to run the hydraulic model by the Federation Water Agency (MIKE 11 Hydraulic Model 1). The resulting hydrological outputs from the Republic of Srpska Hydro-Meteorological Institute (Hydrological MIKE-NAM MODEL 2) will be used to run the hydraulic model by the Water Agency in the Republic of Srpska (MIKE 11 Hydraulic Model 2). The whole arrangement is shown below.

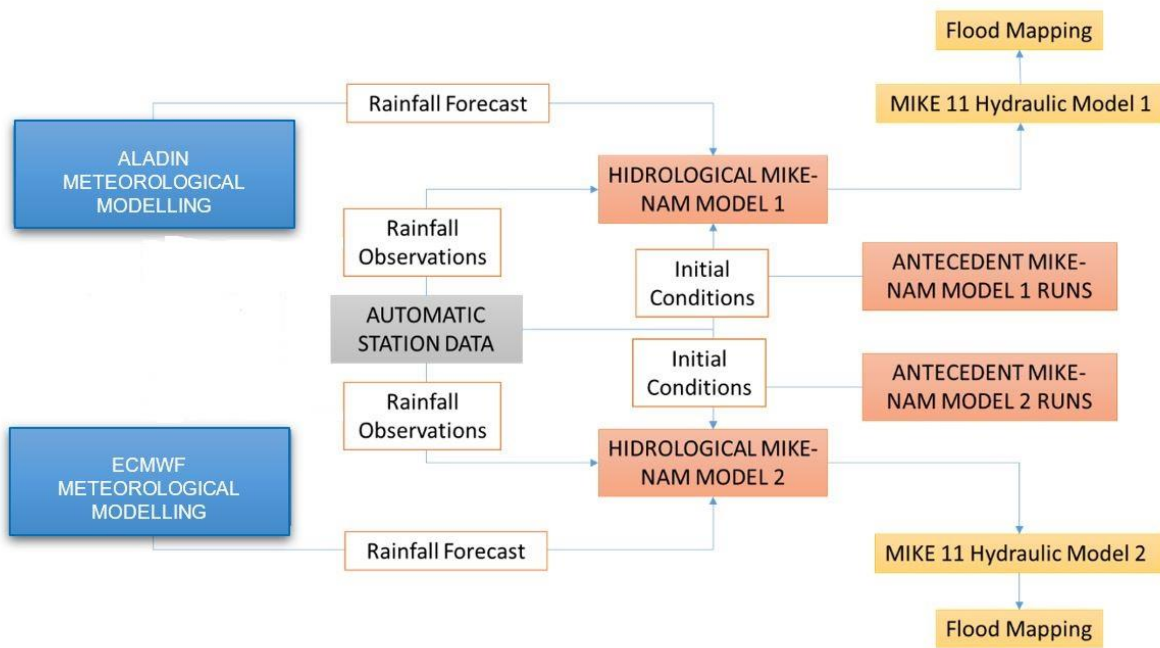


Figure 10-4: Hydraulic Modelling suite

Hydraulic Modelling Software

The current hydraulic modelling software within the implemented FFEWS is MIKE Flood. Technical capacities regarding hydraulic modelling in B&H are related to the use of this specific software. For the implementation of the FFEWS base on Mike 11 modelling is would be necessary to acquire all necessary licenses for MIKE 11 and ensure their renewal and updates.

ICT for FFEWS

The integrated FFEWS will need to be supported by a robust ICT system that meets all of its needs. This will range from high performance computers to run forecast models, additional servers and storage capacity for additional hydrological and meteorological stations and the data exchange from them, as well as improved internet connectivity, for the significant amount of information coming into the system from various sources such as the global meteorological forecasting data to force local models, or the satellite data. In the implementation of a FFEWS, it is usually recommended that a redundant system exists elsewhere, in a different location to the main system. This geographic redundancy to avoid the lack of interruption to forecasts in the event of a failure of the main system. The existing ICT systems and capacities will be fully assessed as part of the project implementation. However, an estimated budget has been allocated for any improvements that will be needed.

Forecasting Platform

The forecasting platform to be used for the FFEWS will be the same as the existing one (Mike Operations). The forecasting platform will be adjusted with the new data sources and the new models, but the core of the system does exist at the moment. There will be, however, a work related to the adjustment to the new data and system testing. Also, the system will need to accommodate more advanced forecasting procedures, such as forecasting ensemble and assimilation to be incorporated into the forecasting routines in order to improve the accuracy of the system. The main objective of the already implemented forecasting platform is to issue warnings. The lead time associated to the warnings depends on different processes, on the area in particular and on precedent conditions. From a flood forecasting point of view, it is envisaged that data from more intensive use of satellite precipitation estimates (especially MPE) would improve the associated lead time in most areas. This is due to the occurrence of localised convective events that have led in the past to significant (flash) flooding. As an example, the June 2014 flood event in in the Sava was a very dramatic event with a significant impact and resulting in a number of casualties. The automatic weather station network coverage in the area was limited, none of the local weather forecasting models available predicted this event. Therefore, the use of additional sources, such as the weather radar data or the MPE data, could both improve the identification of events and also increase the lead time available for the dissemination of the warning.

Thresholds and flood warning

Using the information from the climatologic database and the selected thresholds, flood warning will be issued. Precipitation thresholds, in combination with antecedent catchment conditions will be developed. Water level thresholds will also be developed, although short lead times in some areas reduce the applicability of this. Rainfall thresholds from the numerical weather forecast should also be derived. The procedure for the identification of these thresholds should be:

- Analysis of previous events: a synoptical and detailed assessment of past events should be undertaken in order to identify both the triggers and the thresholds for those events. Historical information from monitoring stations for previous events is from the monitoring stations is probably the most accurate and reliable for this analysis. Data gaps and quality of historical data will need to be addressed to ensure that derived thresholds are accurate. But they can and should be adjusted and more and better data becomes available in the future.
- Modelling of previous events: detailed modelling of previous events undertaken as part of hazard modelling will enable full understanding of the different processes and the contribution of all the different factors. This will be used during the thresholds definition.
- Analysis of near-missed events: the information from near-missed events should be considered in order to diminish as much as possible the number of false-alarms.
- Development of a climatological database: using all the information from the analysis of previous events and from the modelling exercises, a climatological database of selected variables should be designed and implemented

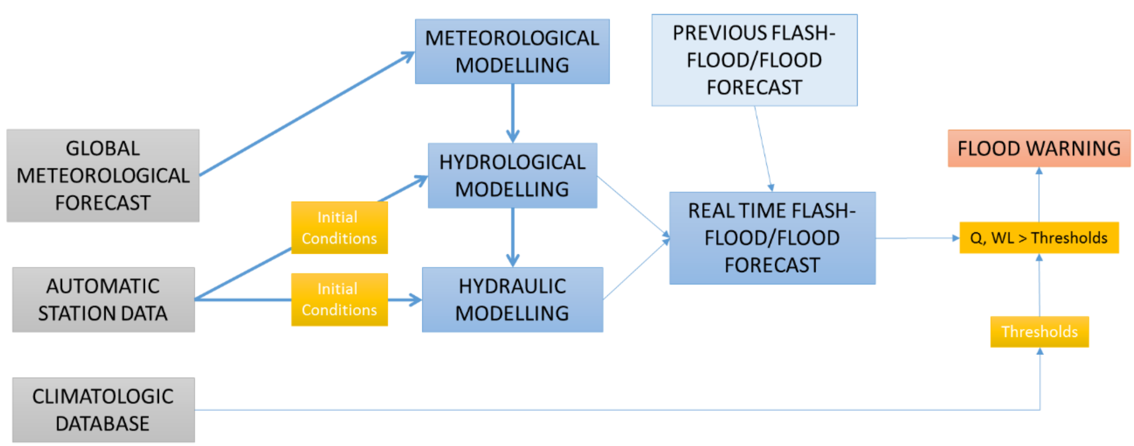


Figure 10-5: Forecasting modelling process leading to warning

Operational Procedures of the Flood Forecasting System

Operational framework

The development of the operational framework is one of the most critical steps of the implementation and operation of the flood forecasting system. In order to accomplish this successfully several things have to be considered, especially the forecasting range, forecasting accuracy and reliability, forecasting time-steps and lead times.

Before the event

Numerical weather predictions from the local models is provided twice per day, and the numerical forecast range is 3 days. Information from these models will be acquired and analysed every 12 hours. Hydrological and hydraulic models will be run with this forecast information and if the resulting discharges and/or water levels are greater than thresholds flood-watch alerts will be issued. The severity of these alerts will depend on the prediction horizon, with higher severity the closer the event is predicted.

During the event

Rainfall information from monitoring stations will be used on a daily basis. Hydrological and hydraulic models will also be run on a daily basis. If defined thresholds are surpassed, warnings will be issued. In most cases, these warnings will have been preceded by flood-watch alerts based on the numerical weather forecasting information.

Structure and organisation of flood warnings

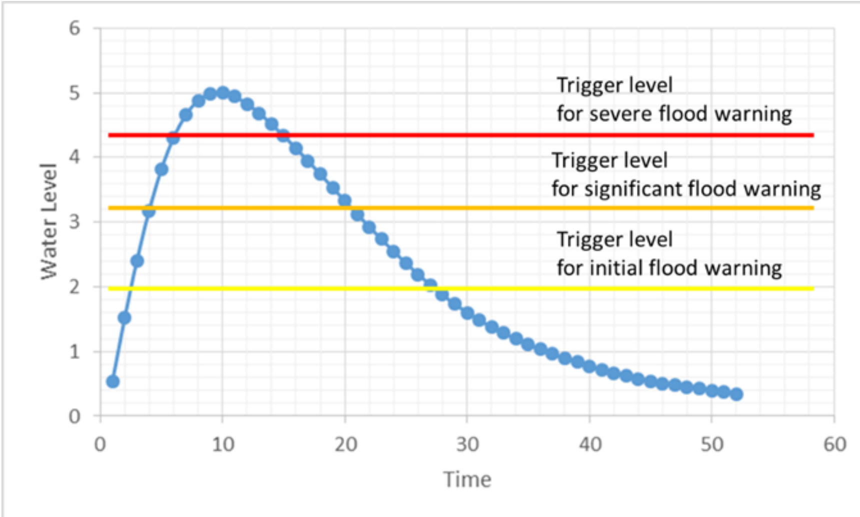
The main flooding mechanisms for which warnings will be issued are flash-flood and riverine flood depending on the lead time. The issue and organisation of warnings would depend on the flooding nature.

Flash-Floods

Due to the short lead-time available for flash floods, warnings in these locations will be primarily based on forecasting and monitoring station rainfall data. As noted above, meteorological forecasts will be used to issue flood-watch alerts. However, accuracy of these forecasts can be limited, and therefore formal flood warnings will be issued based on rainfall data from the monitoring stations. Triggers and thresholds levels for observational rainfall will be derived and three different levels of severity will be defined depending on the recorded rainfall.

Riverine Floods

Lead-time for riverine floods is greater than for flash floods. Time to concentration in the downstream sub-catchments should be carefully assessed to ensure that the issue of warning is carefully planned. In this case, inputs from the rainfall forecasting data, from the monitoring stations, from the hydrological model and especially from the hydraulic model will be used.



The hydraulic model will predict water levels and discharges at previously specified locations where trigger levels are already known or defined. The results from the hydraulic model will be refined using information from the different hydrological stations located along the rivers of the river basins (locations to be determined by WA's). Due to the greater confidence in the observational data from the monitoring stations, alarms can be triggered based solely on the information from these stations if triggers are surpassed.

Impact-Based Flood Forecast and Early Warning System

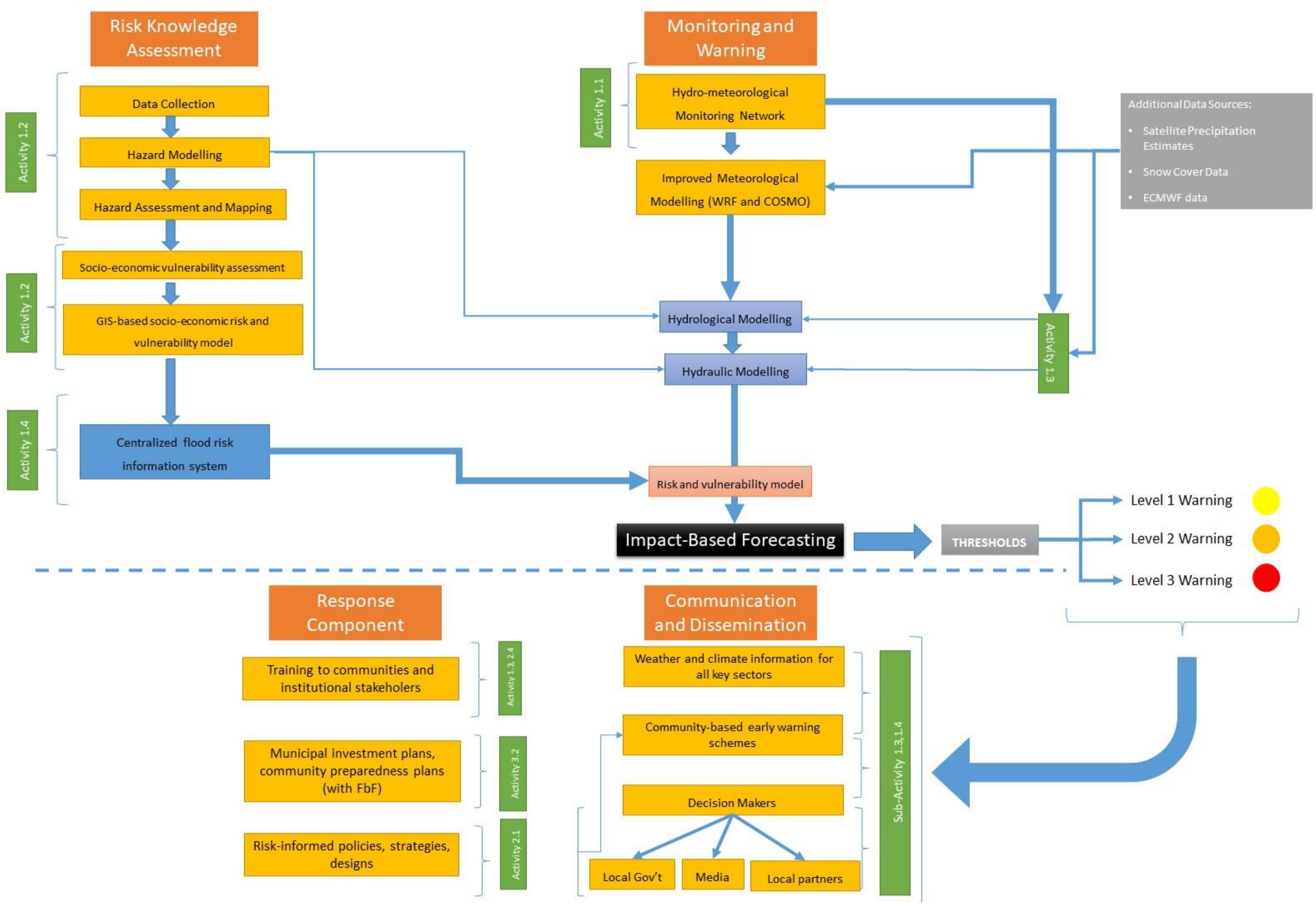
The FFEWS will be based on an impact-based approach which will integrate the forecasting model outputs, with the socio-economic risk model to be developed under Activity 1.2. The operational approach to the impact-based forecasting is depicted in the diagram below.

The risk knowledge component will be the first stage in the implementation, and in addition to the hazard assessment and subsequent risk assessment, a risk modelling framework will be implemented. This risk modelling framework, as previously described, will quantify the damage, loss and other impacts of flood hazards by integrating flood hazard mapping (intensity, depth, velocity, duration etc.) with information about the receptors at risk (infrastructure, people, property, agriculture etc.), exposure and the vulnerability of receptors, based on which, the socio-economic risk modelling will be developed under Activity 1.2.

The monitoring, forecasting and warning componentos the FFEWS will implement, in an operational mode, the models developed for the assessments of flood hazards and, in conjunction with other operational model and monitoring data will provide detailed hydro-meteorological information and flood warnings. These warnings will be produced depending on pre-defined thresholds. For instance, flood forecasting early warning system will yield water level information in pre-defined locations along the rivers at risk, and if those water levels are greater than certain thresholds, then a warning will be issued. Those warnings will be at three different levels in order to discriminate the severity of the predicted warning. Therefore, one of the results of the flood forecasting early warning system would be that the water level in a certain location is going to be 1m above the level 3 threshold, and therefore, a level 3 warning will be issued.

In order to enhance the value of these predictions, and in order to facilitate the understanding of the warning to the general population and to the decision-makers, an impact-based forecasting approach will be adopted. The previously described risk modelling framework will be coupled to the forecasting framework for flood hazards in operational mode. Therefore, following with the flood forecasting early warning system example outlined above, in addition to providing a level 3 warning, the impact-based approach will also provide information about the actual impact that the level 3 event is going to cause in that particular location, and for particular sectors. This will include likely loss of life, likely damages to individuals and communities, likely damage and loss of critical infrastructure and likely failure of protective hazard defences.

The project is developing the methodologies, guidelines and tools for municipal and cantonal climate-resilient investment planning (Under Activity 3.2 pgs. 250-252), utilizing the impact-based forecasting system being developed under this output, to identify the thresholds, and impacts of flood events. These thresholds will include thresholds for forecast based financing (FbF) of early action to reduced flood impacts and respond to flood disasters. The forecast thresholds that will trigger the release of resources for early action will be developed as part of the development of the thresholds for warning and will be embedded in the early warning protocols and SoPs also being developed (under Activity 1.4.1 below).



Detailed specification of the flood forecasting models and platforms to be developed by the GCF project for Neretva River Basin

The Adriatic Sea River Basin District Agency currently uses the forecasting model ALADIN with a T+1 to T+72 hour forecast, with 6-hour precipitation and 8-km spatial resolution.

The part of the system built so far can only partially respond to the stated requirements and objectives, and as such it is regarded as 'semi-controlled' hydropower and water management system. Taking into account the character of the climate, especially in the karst area, as well as evident climate change which is manifested through even more significant variations and precipitation and drought intensity (e.g. occurrence of consecutive dry years), constructing reservoir spaces imposes itself as perhaps the only solution aimed at reducing the aforementioned impacts on people and the environment.

The current configuration of the system includes: reservoirs of Bilećko Lake and Trebinje, as well as hydropower plants which use settled water: HPP Trebinje 1, HPP Trebinje 2, HPP Dubrovnik 1 and HPP Čapljina. Since they became both physical and management reality, two already constructed tunnels ('Dabarsko polje – Fatničko polje' and 'Fatničko polje – Bileća reservoir') are being included in that configuration, through which the streams from Fatničko polje and Dabarsko polje are routed towards Bilećko Lake. At the entrance, the tunnels are equipped with shutters that enable the use or closure of the tunnels, depending on the hydrological conditions and the tasks of protection from high water to be performed at the downstream of Trebišnjica, especially on the move through the city of Trebinje.

The planned configuration of the Trebišnjica hydropower system is expanded with the new reservoirs and hydropower plants in the zone of Gornji horizonti (HPP Dabar, HPP Nevesinje and HPP Bileća), which are defined by Preliminary and Main designs, as well as HPP Dubrovnik II in the area of Donji Horizonti.

The GCF project will support the implementation of measures of the Action Plan for flood protection and river management, through consistent and coordinated development and implementation of cutting edge tools and technologies for flood forecasting and strengthening capacities of Hydro-Meteorological Services (HMSs) and Water Agencies in B&H.

Development of the Neretva FFEWS will integrate information and communication infrastructure, and observation system in B&H to enable automatic, accurate, reliable, timely and consistent hydro-meteorological data acquisition services, data-collections store and improve access to databases and information on weather and hydrological conditions. It will establish consistent Flood forecasting and early warning system for Neretva and Trebišnjica on a common IT platform to provide synoptic meteorological and hydrological services, hourly forecasts and informing on potential hazardous flood events to the responsible governmental bodies at the state and entity levels, institution in charge for flood and civil protection, and thus increase social, economic and environmental safety.

Key deliverables and expected results of the activity are:

1) Assessment Report on legal, institutional, organisational, financial and technical environment, issues and gaps, as well as data availability and systems at HMSs.
2) A logical and physical database model for new and historic meteorological and hydrological data collections is developed.
3) The tools and services for online and offline data and metadata acquisition, quality and quantity control, database feed, post-processing and reporting are fully functional.
4) Developed and calibrated hydrological model for Neretva river Basin
5) Developed and calibrated hydrological model for Trebišnjica river Basin
6) Developed and calibrated hydrodynamic models and real time hydrological flood forecasting system for Neretva River are established and are fully functional.
7) Developed and calibrated hydrodynamic models and real time hydrological flood forecasting system for Trebišnjica River are established and are fully functional.
8) All models fully integrated in existing FFEWS platform, which already have models for Vrbas and Una-Sana models.
9) The staff of the two Hydro-meteorological services (HMSs), Agency for Adriatic sea basin and PI VS, is competent to use and manage the Flood Forecasting Early Warning System (FFEWS) for Neretva and Trebišnjica River.

A detailed description of the Neretva basin and existing basin flood forecasting is provided in Annex 3**.**

Design and implementation of the "Last-Mile" warning dissemination and communication system.

The system will rely on different communication means in order to ensure that the final user receives the information. This is especially the case for local communities, probably the weakest link in the early warning communication chain in B&H at this stage. The work will include design of the “last-mile” communication models, work with the government to update the communication protocols and SOPs, work with the mobile operators on the technical implementation of the system, work with the NGOs and media and provision of training and capacity building in dissemination and warning.

Activity	Cost
Improvements in Meteorological forecasting capabilities	
ECMWF Membership	45,000
ECMWF Data (6 years)	180,000
Global Meteorological Forecasting Data Sources	
GPM	20,000
MPE	20,000
Hydrological and Hydraulic Forecast Model development	
Hydrological Forecast Model development – Neretva and Trebišnjica	100,000
Hydraulic Forecast Model development	180,000
Flood Forecasting Platform	
Integration of new FFEWS models into forecasting platform	20,000
Design and implementation of the “Last-Mile” warning dissemination and communication system.	
Development of last-mile communication models	35,000
ICT for Flood forecasting system	
Upgrade of ICT to support FFEWS platform	100,000
Total	**700,000**

Sub-Activity 1.3.2: Implement CBEWS for high priority communities

The Community Based Early Warning System (CBEWS) will be developed on the basis of the prototype implemented in Vrbas basin and will support the centralised forecasting (operational) and early warning system to effectively minimize or prevent the damages from any disaster by implementing action at the local level. One of the main challenges in early warning systems is sustainability. The idea of incorporating the active involvement of the people in the community with an early warning system aims to increase the effectiveness and sustainability of such systems. Learning by actual participation and taking part in the system enables people to better understand the value of these systems not only for themselves but for the whole community that will be affected and make them become more responsible in performing their tasks in implementing and sustaining the system.

As for Vrbas project, the selection of communities where CBEWS will be implemented will be based on the following considerations: relative risk and vulnerability, lead time of the extreme events (and the need to localised monitoring and warning), willingness of communities to participate, potential technical constraints for the central system to effectively service the community (e.g. due to remote location or connection problems) and Cost-benefit ratio of the implementation

Due to the difference in size and type of communities that will participate in this scheme, not all approaches will necessarily be the same. This will be reflected in a thorough design of the CBEWSs. Therefore, the design outlined in this section will cover the main elements of the CBEWS, which will vary depending on the type of community.

Relative Risk and Vulnerability

A detailed assessment of the risks will be undertaken based on the hazard and risk mapping to be undertaken (Activity 1.2) and through systematic collection and analysis of community-level risk and vulnerability data (households, populations and their specific vulnerabilities, agriculture, assets etc.). This assessment will consider the dynamic nature of hazards and vulnerabilities arising from land-use change, environmental degradation, urbanization and climate change and specific exposure of communities, for example due to the livelihood practices of the communities. Community risk assessment will help to fully characterise the situation, inform and sensitize communities, prioritize needs for developing early warning systems and guide preparations of disaster prevention and response measures.

The vulnerabilities of individual persons, communities, assets and the environment will also be quantified based on community surveys (Activity 1.2) and modelling. In developing the CBEWS special attention will be paid to the most vulnerable groups in the different communities (elderly, disabled, children, seasonal workers, schools, fishing communities etc.). Risk Knowledge Management: Mechanisms will be implemented in order to ensure that the community-based risk assessment exercise is repeated periodically and that the hazard, risk and vulnerability modelling is updated to reflect this as hazards, elements at risk and vulnerability in the catchment and communities may change in the future. Corresponding local institutional responsibility will be established. Also, it is recommended that every community prepare an annual report regarding risks and hazards and communicate periodically with the organization in charge. Incentives will be implemented by the project to secure sustainability of the community engagement.

Monitoring and Warning

An assessment of the lead times of communities will be undertaken as part of the flood hazard and risk modelling and communities will be identified where monitoring does not sufficiently cover the communities due to short lead times, and where dependence on the centralised system alone could result in late provision of warnings. Community-based local monitoring will be established to complement the hydrometric monitoring system. In addition, the proposed scheme will introduce some limited “post-event” monitoring devices in the communities in order to enhance the scheme awareness and cooperation within the community. The monitoring and warning component will be based on several different actions in order to ensure that no events are missed and that lead time is as high as possible.

Three different levels of warning will be defined depending on the time to the event and on the accuracy of the prediction, namely level 1 alert (be aware), level 2 alert (be prepared) and level 3 warning (take action). The forecasting platform will generate forecasts of disaster events. The accuracy of predictions, especially precipitation, decrease as the forecast time increases, and therefore, the higher accuracy is obtained for the first hours of the predictions. Based on international practice, any results further than 72 hours are not usually considered for any detailed prediction. Thus, the proposed system will start to work 72 hours in advance. The hydrological model will be run operationally daily with the information from the meteorological model and with the initial conditions from the previous run. In the case that thresholds are surpassed (48 hours in advance) a level 1 alert (be aware) will be issued. If the predictions 24 hours in advance yield higher flows than the thresholds, then a level 2 alert (be prepared) will be disseminated.

Rain-gauge: In order to increase the accuracy of the forecasting system, a local monitoring system will be deployed for at least 60 high risk communities. The location of the rain gauges will be decided based on the technical analysis. As a first approximation, these sensors will be deployed as high in the catchment as possible, to provide longest lead-time possible. These rain gauges will communicate real-time precipitation information to the municipality CP operational centre. Based on the information from these sensors and the data from WA's, the operational centre will decide if a level 3 (take action) warning should be disseminated.

Radar Sensor Type Water Level Monitoring: It is recommended that non-contact water level monitoring sensors are deployed in watercourses up in the catchments. The idea behind this deployment is to corroborate an incoming event as predicted by the precipitation sensors and to provide the necessary initial conditions for the hydraulic model. These sensors will also provide very useful information regarding run-off times. The water level radar sensor is a device for measuring the surface water level without direct contact to the medium. This is considered necessary due to the high sediment and debris transport capacity of these watercourses during flood events.

Community Water Level Gauges: As previously noted, even if water gauging in the community does not directly yield any benefit to the EWS, it is recommended to monitor maximum water level in watercourses in the vicinity of the communities after significant flood events. This monitoring will fulfil three different objectives: - Enhance the community involvement in the EWS - Enhance the community awareness of the whole scheme - Gather maximum level information for hydrology and hydraulic model improvements. Two different type of gauges are proposed:

Maximum level gauges: these gauges show the highest surface water level by colour marking. They are maximum level indicators for preservation of evidence and offer exact data for a later analysis of a flood event. In a measuring cylinder made of safety glass there is a 1 m long glass fibre reinforced plastic measuring rod. A transparent self-adhesive colour band is fixed on the measuring rod. The rising water in the measuring cylinder rinses the colour out reliably, up to the respective water level. A sharp dividing line displays the highest water level. The exchange of the colour band is easily done via loosening the upper cylindrical head screw. The straining device acts as filter for coarse dirt and acts as a damping device preventing influence by wash of waves in the measuring cylinder. *Staff gauges (painted):* these gauges can be easily painted in strategic locations in the communities (bridges, wall or any other structures). Maximum water level information can be estimated based on the change in colour in the staff gauge. These gauges are not as accurate as the maximum water level gauges described above, but they are cheaper and easy to deploy.

It is advised that every community report the maximum water level recorded after every flood event to the operation centre.

Dissemination and Communication

Forecast and warning dissemination is extremely important. Frequently, the lack of ability to disseminate warnings to the population at risk is the weakest link in an integrated system. Forecasts and warnings must reach users without delay and with sufficient lead-time to permit response actions to take place. Dissemination of forecasts and warnings can be achieved through a variety of communication methods. It should be noted that in this case two different sets of communication methods should be utilised. Mechanisms for the communication between the 'operation centre' and the communities and also mechanisms for the communication within each community will be designed.

Communication of warnings to communities. Different communication means will be explored and implemented to ensure that the final user receives the information. The lack of an effective communication system could lead to ineffectiveness and inefficiency in an EWS, even if the most sophisticated system is implemented. In order to notify the communities of the incoming warning as soon as possible after the warning has been identified a sufficient lead-time is necessary and the notification has to be undertaken through reliable means with robust redundancy in order to avoid potential issues. At least two contact people per community will be identified, but different means to warn communities remotely will also be proposed. In order to reduce potential problems, the communication with the communities will be carried out through different options for this, such as:

Mobile phone-SMS: Mobile phones can be used as communication devices. This communication means can be really useful, but it has some drawbacks, because the mobile phone has to be always available and working. Also, SMS can be sent to all groups of people registered in an established community-based scheme, facilitating the distribution of information to a large number of people. Mobile network reliability can be compromised during some weather conditions, and therefore backup systems should be considered. In Bosnia and Herzegovina, simple SMS warning is technically feasible by B&H mobile operators, and generally, it is considered as the most effective method of reaching recipients with a short message, without requiring special preparation, aside from legal ones, wherein the recipient confirms his/her desire to receive warning messages. The phone numbers of confirmed recipients would then be saved in the data base, sorted by the location of the subscriber, which will serve as data source for future warnings with geo references (by addresses of confirmed subscribers). Current technical limitations of B&H telecommunication operators is that they do not allow CBS, nor location-based SMS to be developed.

According to statistics of B&H Regulatory Agency for Communications (RAK), 97% of citizens in B&H are mobile network subscribers, which is great coverage of population under risk, for the purpose of potential warnings by SMS in the case of a flood disaster. Main mobile network operators in B&H are the three telecommunication companies: Mtel (RS), BH Telecom (FB&H), HT Eronet (FB&H) and they provide standard telecommunication services to their users, with possibility to introduce common/simple type of SMS flood alerts.

The SMS warning will be extended as part of full FFEWS which was developed for 13 municipalities in Vrbas River Basin and could be easily replicated in the other five target river basins (Una, Ukrina, Bosna, Neretva and Trebišnjica), covering 72 municipalities which are also affected by severe flooding. In context of PWS development in B&H, the full FFEWS provides a window of 72h (48h, 24h…) warning in advance, which can be crucial period of time for competent institutions to organize SMS flood alerts to citizens that are previously registered in database and avoid system congestion. This is especially important for river basins with high number of affected citizens (e.g. Bosna, Vrbas, Una), where is a strong possibility for network congestion in extreme situations. ***Radio HF:*** High Frequency radio is considered as a suitable communication means, providing the necessary infrastructure is available. Radio HF can work under harsh weather conditions, and therefore is an excellent redundancy system if the mobile network is not operating.

Email – Internet: It is expected that in B&H a large percentage of individuals have email and web access, and therefore communication via email is extremely effective; especially as smartphones also have 3G/3GS or 4G capability, meaning that users can check their email accounts and surf the web anywhere there is cell phone access. Websites are quickly and easily updated, and emails can be mass disseminated to large numbers of users simultaneously via the appropriate email software program.

Sirens (Remote Control for Siren Systems): There are some siren systems that can either be local or remotely activated. The remote activation can be triggered through radio, GSM or wire. This siren system is suitable for this type of scheme, and it does allow for several types of messages or alerts. The remote activation feature will be highly useful when the warning is produced at night and/or the local contact cannot be reached. In order to fully control a remote siren system with sirens deployed at several locations, a siren management system is recommended.

The final decision on what communication means to use will be based on the community preferences and existing practices, reliability and the international expert advice and provision of the legislative framework.

The legislative framework in B&H allows introduction of SMS warning service. In general, there are two laws in B&H addressing the issue of rules and actions in situation of emergency (e.g. natural disaster). ''Law on protection and rescue in extreme situations'' for RS and ''Law on protection of people and material goods from natural and other hazards'' for FB&H. These laws define that during extreme situation all legal entities (including owners and users of telecommunication and information systems) are obliged to prioritize providing of services to institutions that are in charge of protection and rescue. In both entities, governments declare state of natural or other disaster. Also, in both entities, tasks and duties of Civil protection are similarly defined. Civil protection is obliged to receive, gather, process and transfer data and information from monitoring institutions (e.g. meteorological and hydrological and other data from entities' Hydrometeorological Institutes and Water Agencies). Based on these information and other information from the field, Civil protection warns citizens via sirens, electronic media (television, local radio stations, web site etc.). Also, ''Bylaw on warning and activities of citizens in case of emergency in Republic of Srpska'', defines SMS as legal and available warning channel that can be used „after the conditions are fulfilled with provider“.

Community-based EWS schemes will be implemented in up to 60 communities across B&H based on full community engagement and participation. This project will aim to use participatory methods as much as possible and will ensure the inclusion of women in these participatory approaches.

The choice of the 60 communities will be made based on the risk assessment and mapping completed under the Activity 1.2 which will identify the communities most at risk from each hazard. Communities' willingness to participate and actively engage in the EWS activities will be one of the key criteria for the final selection of beneficiaries under this activity.

As part of the implementation of this activity, the following tasks will be implemented:

- Consultations with local authorities and community leaders on establishing the scheme and hazards experienced, including walkover site visits
- Refinement of estimates for the numbers and locations of households at risk from hazards based on feedback from the consultations
- Identifying vulnerable groups and special assistance required during hazard events/disasters (elderly, disabled, children, seasonal workers, schools, fishing communities etc.), using the risk modelling and vulnerability mapping and community surveys.
- Using a GIS-based approach, develop warning and evacuation maps showing evacuation routes, shelters, the locations of vulnerable people/groups, critical infrastructure, NGO/CBO offices, health facilities, and other operationally useful information, with hazards extents linked to gauge information
- Arranging for the placement of markers and signs on buildings and other structures linked to warning threshold (alert) levels and signage to indicate routes to shelters etc. and showing historical event levels
- Guidance on the numbers and locations for installation of manually-operated rain gauges and river gauges
- Advice on procurement and supervision of installation of telemetered radar level gauges and rain gauges as appropriate
- Developing warning thresholds appropriate to each community (or group of communities)
- Ensuring that central observations and forecasts are available at municipal and community level (e.g. via text message and a website) and that training is provided on how to interpret the information
- Establishing procedures for monitoring and evaluation and regular performance monitoring
- Developing a community-specific engagement programme (e.g. meetings, plays, leaflets, posters, school classwork)
- Development of simple forecasting tools for use at municipal and community level; for example, with a series of maps showing the extent of flooding for different river gauge heights, rainfall depth duration criteria for initial flood watches, and look-up charts showing the travel times of flood waves and correlations between peak levels at river gauges
- Designing a standard set of warning messages, codes, icons, colour coding etc. to be used in future schemes for issuing warnings, based on a review of the in-country warning messages currently used
- Deciding on the text messages (formats, content) to be issued directly from gauges and the associated community education requirements in interpretation of this information
- Preparing a guidance note on the level of technical support to be provided at municipal level for future schemes regarding training, technical assistance with gauge installations etc.
- Developing mechanisms whereby local staff can relay information on rainfall and river levels and flood conditions to state and entity level in addition to voice communications e.g. via text messages for automated display on a website

- Establishing a volunteer observer or 'spotter' training and recruitment programme for rainfall, river conditions and flood extent; initially starting with e.g., NGOs/Community Based Organizations (CBOs) and other interested parties. This will include instructional material, guidance on recruiting volunteers, health and safety aspects, and provision of manually operated rain gauges in some cases.

Item	No. of units required	Cost per unit	Total Cost	Comment
Monitoring Devices				
Water Level sensors	60	5500	330,000	In upstream communities with short lead time of events
Staff gauges	120	220	26,400	
Communication Tools				
GSM/GPRS modem device	2	300	600	
Generators	40	500	30,000	
Sirens	40	4900	196,000	
Portable radio stations	400	220	88,000	
Mobile radio stations	100	390	39,000	
Boards	120	200	24,000	
Miscellaneous		5000	5,000	
Sub-total for equipment			**739,000**	
Technical Assistance – Advice, capacity building, supervision	1	71,000	61,000	
Total			**800,000**	

Sub-Activity 1.3.3: Review, identify and develop sector-specific FFEWS products

Agriculture Sector

The agricultural sector is one area where private sector can be actively engaged in the generation, dissemination and use of climate information which could enhance overall yield and reduce cultivation costs to farmers. The agricultural sector has been identified as one of the most vulnerable to climate change induced flood risk and will incur significant damages more frequently (hence cumulatively significant damages that are difficult to recover from on a regular basis) and during extreme events. This activity will examine opportunities to support the capacities of the Agricultural agencies and extension services through the generation and provision of tailored climate and weather information and advice to the farmers through the following indicative actions:

1) Review existing access to and use of climate and flood risk information in agriculture sector.
2) Development of new climate information products for the agricultural sector (agri-climate maps, calendars, advisories, etc.) and delivery of these products to the farmers. This will be useful in helping the farmers make decisions related to timing, such as choosing the best planting dates and deciding when to apply fertiliser. The activity will include a detailed information needs assessment survey targeting farmers. Workshops and information sessions will be carried out in order to collect information about what data would be particularly useful to them, how would it be best to disseminate this information and their current practices.
3) Capacity building and training for the entity Ministries of Agriculture, as well as municipal level staff, including specific training on the use of climate information and climate change adaptation.

4) Supporting improvement of agrometeorological advisory services to farmers. Agricultural specialists will work with local farmers to teach them how best to use the weather forecasts within their farming methods. For instance, after each forecast is released, there is a window of opportunity before the precipitation arrives (if predicted) to get the forecast to farmers and help increase their understanding of how to apply it to their agricultural practices. Automatic SMS text messaging can be used to disseminate this information to registered farmers. One of the keys to the success in securing the farmers collaboration is good performance of the forecasts, making the farmers more confident that using the forecasts would help them make effective decisions. Therefore, this should be considered when planning the dissemination process with farmers, informing them of the historic accuracy of the system.

The project will bring ICT-based innovations into the communication of forecasts and advisories; improve the use of historical data and derivations; improve medium and shortrange weather forecasts and longer-term predictions for agriculture (seasonal, decadal etc.). This will also include partnerships with the private sector including internet providers or mobile companies that are willing to design tailored information delivery services in collaboration with agribusinesses, farmers' groups and other clients to deliver timely forecasts and advisories to farmers who will benefit from this service.

Climate risk information will catalyse a reduction in agricultural losses coupled with enhanced agricultural livelihoods and will result in overall improvements to the productivity of the agricultural sector.

HydroPower Sector

The energy sector is critical to economic and social development in B&H. As a net exporter of energy HPPs operations generate a sizeable portion of the country's GDP. Energy is essential to practically all aspects of human welfare, including access to water, agricultural productivity, health care, education, job creation and environmental sustainability. HPP development also contributes to the reduction in energy sector global anthropogenic greenhouse gas (GHG) emissions. Emissions reduction targets under the UN Framework Convention on Climate Change (UNFCCC) are expected to significantly increase demand for energy from renewable sources – which are highly sensitive to climate – as well as demand for energy efficiency measures. In 2017. 74% of electrical energy in B&H was produced in thermopower plants that use local coal with a high specific CO2 emission (app 1,3 tCO2/MWh), while 26%, was produced in HPP[36]. These facts stress the importance of clean energy and improved efficiency of HPP via more climate resilient activities and reduction of losses.

An aim of the project will be to engage the hydropower and other relevant private/productive sectors in flood risk management. Key to this will be to include HPP companies in the flood risk management of the basins in which they operate through agreement on operations of their systems during flood events. The project will therefore build upon and strengthen engagement of the HPP's and establish specific areas of cooperation on flood risk management, including private sector financing. In parallel, the project is also aiming to provide support to the HPP sector to enable more climate resilient operations.

Energy planning and operations in the hydropower system are markedly affected by meteorological events and hence climate change, on both the demand and supply side. Thus, by properly taking into account weather and climate information, energy systems can considerably improve their resilience to weather extremes, climate variability and change. The project will assess and identify feasible tailored climate services that can support increased efficiency in HPP operations and will develop enhanced tools and systems that provide decision-makers with the ability to analyse and manage risks, under current hydro-meteorological conditions, as well as in the face of climatic variability and change.

The development and application of targeted climate products and services will help improve efficiency and reduce risk associated with hydro-meteorological hazards affecting energy systems, in particular to support:

[36] Independent System Operator in Bosnia and Herzegovina, Report on Electrical Energy in Transmission Network, Sarajevo Feb 2018

- Greater climate resilience and adaptation across the sector, due to its fundamental importance for development;
- Efficiency of operations (through accurate weather forecasts), enhanced safety under flood conditions and ability to prepare for imminent flood events;

The project will aim to develop products and services which include:

- High resolution weather analysis in real time
- Weather forecasts for substations, power lines and grid regions
- Historical measurements and climate time series
- Long-term energy meteorological re-analysis data
- Live weather data (satellite images, weather station data)
- Real-time weather analysis and model forecasts
- Consistent and proactive warning and alarm system which incorporates HPP monitoring stations
- Customised visualizations of forecasts (e.g. power lines, substations)
- Customized impact-based warnings

Avoided losses to sectors such as hydropower could be significant. The project interventions which will provide sector-specific risk information and risk management strategies will be important for the long-term development of the hydropower sector - such information as water flow forecasts and long-term run-off projections will be critical for sector planning. A tailored risk information will also be used to inform sighting and climate proofing of hydropower installations. Climate risk informed planning of the hydropower sector is important nationally as it impacts the reduction on non-renewable energy (coal) and supports the shift to a clean energy base. Risk information will also enable better planning for and optimising of the operations of hydropower sector, which is affected both on the supply and demand side by climate change.

The activities will include:

1) Review existing access to and use of climate and flood risk information in energy (HPP) sector.
2) Undertake studies to identify and design tailored climate information products and services for the HPP sector. This will include cost-benefit analysis and appraisal of the options as well as detailed sector analysis including willingness to pay surveys.
3) Development of new climate information products and services for the HPP. The activity will include a detailed information needs assessment survey targeting HPP operators. Workshops and information sessions will be carried out in order to collect information about what data would be particularly useful to them, how would it be best to disseminate this information and their current practices.
4) Capacity building and training for HPP practitioners, including specific training on the use of climate information products and services.

Sub-Activity 1.3.4: Develop and implement a capacity development plan for embedding flood hazard and risk modelling approaches and FFEWS into appropriate institutions in B&H

The implementation and maintenance of a flood risk management and flood forecasting and early warning system of this scale will require technical capacities in all areas of flood hazard and disaster risk management to ensure the long-term sustainability of the system. Technical expertise and experience in disaster management and emergency response is present, both at entity and municipal levels to varying extents. While technical expertise exists for specific technical areas, awareness and knowledge of climate change adaptative flood risk management and reduction concepts and practices is an area for improvement. Technical capacities related to risk identification and assessment, prevention, risk reduction, risk transfer, preparedness, climate risk management and climate change adaptation require further strengthening across institutions and governance levels. As part of the Vrbas project, an assessment was made of the existing gaps in institutional capacity for flood and landslide hazard and risk management in B&H. After re-mapping the institutional capacity and reassessing gaps and training needs, a revised institutional capacity building plan will be developed and under the GCF project to address gaps in resourcing (human, technical and financial). The recruitment and training needs to fill capacity gaps will be addressed. The project will develop training plans for each technical area of expertise related to climate-induced flood risk assessment and management and consolidate into an overall capacity development plan. A long-term capacity plan for B&H will be developed and will consider options such as the development of apprenticeships, internships and voluntary schemes for University students, in flood risk management and FFEWS.

To address issues of skills shortage, skills retention and succession planning, the project will develop approaches which will include examining the role of the private sector (consultants, contractors, research institutes) in filling these gaps, the use of Continuous Professional Development (CPD) methods involving cross-fertilising of staff with skills across all organisations (e.g. through training in all technical areas before specialising), development of standardised and country-wide accepted guidance documents, codes and standards which will enable, consistency and uniformity of technical approaches. As a minimum, in order to address capacity needs identified under Vrbas project the project will include the following set of actions, addressing critical capacity gaps:

- Carry out workshops on hydrometry to include modern methods and equipment specification
- Conduct trainings in hydrometric network design and implementation
- Conduct trainings for local O&M staff on equipment maintenance
- Introduce university courses in flood hazard analysis, modelling and mapping
- Undertake refresher training in hydrology, hydraulic modelling and GIS
- Conduct training in forecasting procedures
- Conduct training in warning procedures
- Conduct training in Common Alerting Protocols
- Conduct training of HMIs and WA staff in remote sensing
- Conduct training of HMI, WA staff and other stakeholders in flood hazard risk assessment and mapping
- Conduct FFEWS training on the new system for all institutions involved in FFEWS as identified by institutional mapping and institutional arrangement plan for FFEWS.
- Training on gender sensitive vulnerability and risk assessment and modelling
- Trainings in damages and losses assessment and the use of CBA in FRM options appraisal
- Conduct training on proposed FRM policy and sectoral FRM
- Awareness raising workshop for all government departments.
- Targeted awareness and learning events on climate risk assessment and management for relevant sectoral investors
- A series of targeted training workshops for municipalities
- Workshops and round tables on risk management financing and risk transfer instruments

Capacity development will be undertaken in partnership with WMO regional training centers

Activity 1.4: Develop and implement protocols and SoPs on data generation, data management and communication for effective impact based FFEWS and flood risk management. (GCF Financing = $336,000; Co-financing = $200,000)

The project will revise and implement data access protocols which will be supported by extensive training and capacity building to ensure sustainability. Based on the work undertaken by the Vrbas project, institutional strengthening, coordination, communication will be enhanced by establishing clear communication lines between different agencies, which will avoid any duplication and inefficiencies. Based on the Vrbas recommendations SOPs, Communication Protocols and Codes of Conduct will be developed for each of the institutions responsible for FFEWS. In addition, roles of regional and local authorities will be clarified and detailed. “Last-mile” communication protocols will be implemented as part of the FFEWS. Operational maintenance procedures for hydrometric network will be established.

Sub-Activity 1.4.1: Implement SoPs for “last-mile” warning, dissemination and communication system. Specify and implement the “last-mile” system including dissemination and warning technologies

FFEWS Communication – Dissemination and Warning arrangements

The Protocol for Dissemination and warning must reach those at risk on time. Linking the warning provider to communities at risk requires the involvement of numerous actors from different levels and the time available is limited. EWS protocols follow top-down logic, starting from a warning provider and ending at the communities at risk. Nevertheless, different factors need to be taken into account (gender, cultural, social, etc.). Involving communities and local governments is essential. Protocols shall include two main decision-making processes (UNESCO/IOC, 2015):

1) The first process leads to a decision on issuing warnings and the respective warning levels. This usually takes place at the institutions responsible for hazard monitoring and warning (“provider organizations”).
2) The second process leads to a decision on whether to officially call for an evacuation and helps to translate the warning message into guidance for a community at risk. In most countries, Disaster Management Organizations (DMO) are involved to disseminate warnings to the public and to take decisions on whether or not to call for evacuations.

Under the Vrbas project a review of the existing institutional arrangements for dissemination of early warnings was analysed and a number of recommendations made. These recommendations will be implemented under the GCF project

The suggested arrangement is shown below for the Federation of Bosnia and Herzegovina and the Republic of Srpska respectively. In both cases the proposed arrangement is very similar. It is suggested that in both scenarios any flood warning is issued centrally from the Water Agencies. This implies that meteorological and observational water level warnings identified by the Hydro-Meteorological Institutes in both entities would be sent to the Water Agencies and from there distributed to the different operational centres and Civil Protection Units at different levels. The reason behind this suggested approach is twofold:

- A single organisation issuing external flood warnings will help to avoid any issues and misunderstandings regarding warnings.
- The relationship between the Hydro-Meteorological Institutes and Water Agencies should be very intensive and cooperative. The communication of data should be in a sub-daily basis and in most cases the communication flow should be from the Hydro-Meteorological Institute to the Water Agency, and therefore the communication of warnings would follow the same communication channel.

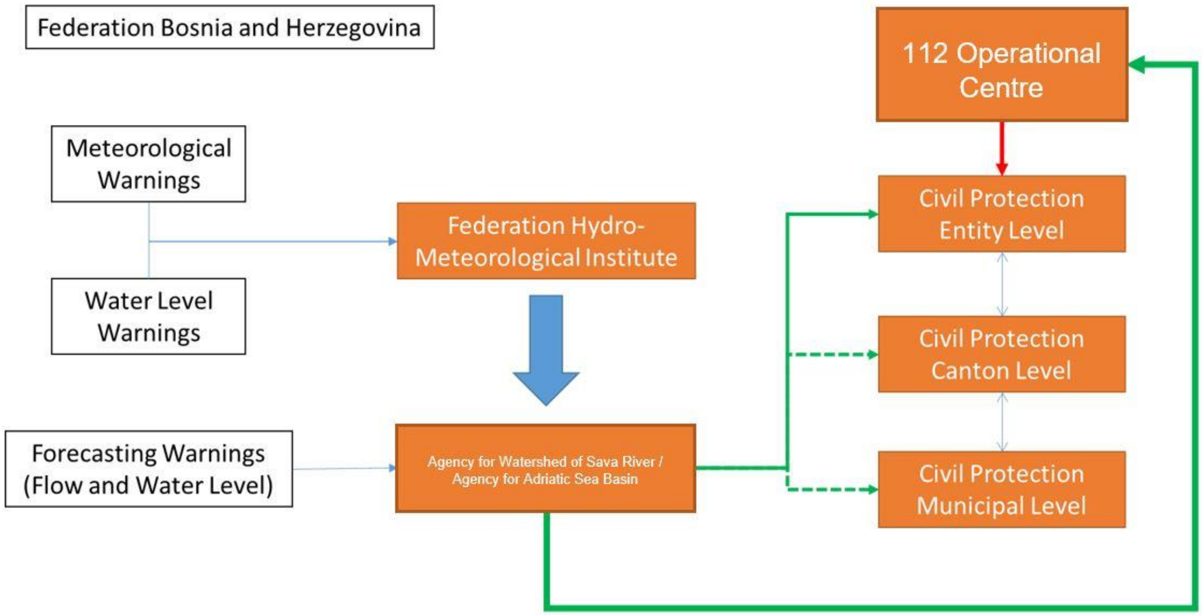


Figure 10-6: Proposed institutional arrangement for the Communication component - FB&H

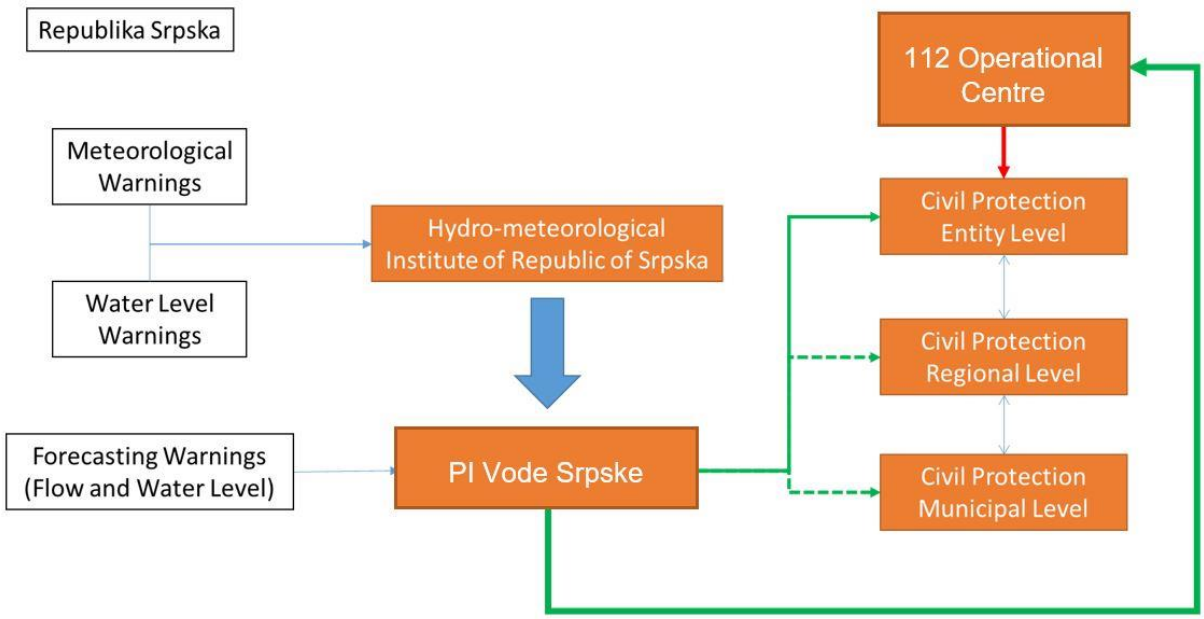


Figure 10-7: Proposed institutional arrangement for the Communication component - RS

It should be noted that both the Hydro-Meteorological Institutes and the Water Agencies could be (and should) considered as an Operational Centre for Flood Forecasting, and the relationship between these two types of organisations should be strong and functional.

The main communication link between the Flood Forecasting Operational Centre and any other organisation would be between Water Agencies and Civil Protection Units. Water Agencies should communicate primarily with the Civil Protection Units at Entity level. The Civil Protection Unit at Entity level should then communicate any warning to the Cantonal or Regional one, and this latter one should communicate with the Civil Protection Unit at municipal level. It is recommended that more communication chains are established in order to ensure redundancy, but the main one should be from the Water Agencies and the Civil Protection Unit at Entity level.

Also, Water Agencies should communicate any warning to the State Operational Centre (112) and they should liaise with the different Civil Protection Units too. This is because most river basin crosses the two entities, and any warning within this basin may affect the two entities. Therefore, the State Operational Centre should be involved and aware of any warning within these river basins. It is recommended that Water Agencies from the two different entities communicate with each other too. The whole arrangement at this level is shown below, where the communication between Water Agencies and the different Operational Centres and Civil Protection Units is displayed.

Based on the recommended arrangements for communication and dissemination of FFEWS warnings, the project will help the government to clearly define the supporting SOPs. This will include the definition of major and minor hazards to which the different levels of response will be needed, and the review and of criteria for their distinction. Thresholds and areas of influence will be determined through hazard and risk mapping based on which definition of the response size and resources to be deployed will be determined for relevant response agencies. The process will be participatory and feedback of any other stakeholder, especially local and regional authorities, will be taken into consideration. Criteria for the definition of the different warning levels will be established and different standard types of messages will be devised depending on the recipient of the message. Clear communication lines between different agencies will be established, any duplication and inefficiencies will be eliminated. Moreover, the role of the operations Center will be clarified, and their capacities strengthened in terms of warnings and operative responses from first responders. Standard Operational Procedures, Communication Protocols and Codes of Conduct will be developed for each of the agencies responsible for the various elements of the FFEWS and response. Roles of entity and sub-entity authorities will be reviewed, clarified and detailed.

Flood Warning Procedures / Concept of Operations / Flood Response Plans

The following procedures regarding flood warning, operations and response plans should be defined:

- Flood warning procedures defining roles and responsibilities
- The criteria for opening the operations room/moving to 24/7 operation
- The criteria for staff reinforcements during flood season
- Establishing a duty roster
- The thresholds for issuing warnings,
- Instructions for disseminating warnings and interagency communications (phone/radio conferences etc.),
- Record keeping requirements (incident and communication logs, situation reports etc.)
- Handover arrangements between shifts
- Temporary secondment of experts between operations centres during flood events and longer term

Sub-Activity 1.4.2: Develop protocols and SOPs on data generation and data management for FRM

Work Instructions / Directives / Standard Operating Procedures

The different work instructions and standard operating procedures for the flood early warning system will be defined. A careful assessment of all the different procedures should be carried out and work instructions, directives or SoPs define as appropriate, and this will include at least the following:

- Definition of rainfall depth-duration thresholds: in combination with other variables, as previously noted, thresholds for rainfall-depth should be defined. Soil moisture and snow water equivalent, in addition to antecedent conditions should be included in this definition of thresholds, providing that this information is available.

- Management, validation and interpretation of rainfall and river gauge data (including rating curves): this procedure should deal with the different aspects regarding data collected from the monitoring stations, both meteorological and hydrological ones. Some of these procedures have already been defined in the work plan for the implementation of the monitoring network.
- The proper management of the collected data is paramount for the success of the network itself and the EWS. Telecommunication protocols should be put in place and transmission reliability on a range of weather conditions should be tested.
- A validation of the proper recording and measuring conditions of the deployed sensors should also be accomplished.
- The analysis of river gauging data should also be undertaken for flood warning purposes. Expected lead times in the study area seem to allow the use of river stage data for warning purposes. Therefore, a thorough analysis of river stage (and flow) data should be carried out in order to define thresholds.
- Development and operation of flood forecasting models and use of outputs in the flood warning process
- Roles and responsibilities of key officers.
- Duties and accreditation of gauge observers and associated training requirements
- Performance monitoring and post-event reviews/reporting
- Organising and running an emergency response exercise
- Use and operation of emergency communications equipment including routine testing outside of the main flood season
- Flood data collection (flood extent, impacts etc.): A flood information record may usefully be held on cards designed to pro-forma for listing heights and effects. In some instances, because a particular consequence of flooding may take place at different gauge heights in different floods, a range of heights may be more appropriate and less misleading than a single value. Good flood records give excellent general pictures and form a much better basis for developing warnings than simple desk studies.
- Analysis of the synoptical situation of past events
- Analysis of past “missed events”.
- Health and Safety in routine and flood conditions
- Interpretation of flood data: To make sense of a flood prediction, and to form a practical basis for communicating it, any prediction cast in terms of gauge height must be translated into terms which describe the coming flood’s likely consequences in the area which will experience inundation. This means adding value to the prediction by giving it horizontal expression and meaning.
- Defining flood warning messages: Precisely what needs to be said in warning people, and how the messages should be couched, constitute key procedures. Some messages that are disseminated can be too bureaucratic and fail to create the necessary bridge between the appraisal of flood characteristics (prediction and interpretation) on the one hand and the making of decisions about protective behaviour on the other. Messages can all too easily be neither user-friendly nor persuasive and can fail to incorporate all the appropriate information. Therefore, warning messages would need to describe the coming flood, say what it will mean to those who may be affected by it and indicate what actions they should take. Simple but evocative language should be used, with an emphasis on the creation of word pictures designed to create arousal and overcome apathy and denial. The ‘community memory’ should be tapped, where possible, by referring to known floods of the past and referencing the likely severity of the coming event to them. Flood warning messages should not be ‘singular’ in the sense that one message is provided for a whole community, because it would fail to recognise that the community is not a single mass of people but is stratified in terms of degree and type of risk, past experience, language and other differentiating characteristics. Different groups will need different information presented differently, so a matching of message and group will be necessary.

Sub-Activity 1.4.3: Develop data sharing protocols and platform for climate data, across all government institutions in both entities. Develop/enhance spatial data infrastructure to ensure climate data flow/exchange

Under the NAP project, “Development of monitoring and evaluation framework for climate change adaptation in B&H”, data sharing protocols are being developed. The NAP study will provide a basis for the development of a protocol for data/information exchange between water and other sectors relevant for integrated water management and climate change (agriculture, forestry, environment, spatial planning and hydro-energy sectors). This study should identify data/information to be exchanged, sectors between which data/information are to be exchanged and timeframes. Special attention is to be paid to data whose exchange will be automatized. The GCF project will assess and further develop the protocols if necessary. The protocols will include the following:

1) Protocol on the horizontal and vertical inter-sectoral cooperation on flood risk management. This protocol will harmonize water management between entities and ensure timely information flow to the state level for the purpose of international reporting obligations. This protocol will establish intensive cooperation between water management and other relevant sectors (agriculture, forestry, environment, spatial planning and hydro-energy sectors) via continuous exchange of identified data/information. In addition to horizontal intersectoral cooperation within one entity and between entities and Brcko District, this protocol will include all administrative levels (municipality, cantons, entity and state) in effective information exchange related to flood risk management.
2) Protocol on cooperation between water management key sectors (agriculture, forestry, energy, spatial planning and environmental protection on active involvement of flood risk management sector in strategic sectoral planning of in the areas of common interest. This Protocol should be made in line with the existing legislative framework. The Protocol will establish standard operational procedures for data/information exchange and implementation of flood risk management activities, as well as a base for M&E framework. Protocol will be integral part of trainings conducted at different administrative levels.
3) Establish an effective M&E system for flood risk management activities: Following the development and acceptance of the protocol, a framework to establish and maintain an effective M&E system for flood risk management processes, flood risk management investments and their effectiveness and relevance is to be developed. It will include a reporting system to track investments and financial flows related to the flood risk management activities. This system will build upon existing monitoring mechanisms and will be strengthened to monitor economic analysis of direct and indirect benefits of investments. This activity is to include, but not limiting to, the following:
    a. Explore potential requirements, including legal and administrative requirements for establishment of M&E in the context of the EU accession status of the country;
    b. Based on defined data flow protocol between sectors relevant for flood risk management, identify data to be monitored, baselines, and standard indicators
    c. Analyse current and envisaged sector-level M&E needs (water management, agriculture, forestry, environment, spatial planning and hydro-energy sectors) with the aim of integration with envisaged M&E system.
    d. Propose the most appropriate Conceptual Framework for M&E, which will include the following, among others:
        i. Collection of all relevant data, sources, and methodologies;
        ii. Data processing and quality control model (s) i.e. roles and responsibilities of institutions in charge of implementing, measuring, reporting and verifying flood risk management actions in respective sectors;
        iii. Performance indicators to measure progress in implementation of flood risk management activities,
        iv. Procedures for reporting and collecting performance indicator data;
        v. Procedures for data communication and dissemination
        vi. Propose governance structure for the suggested M&E framework.
        vii. Propose a pathway describing all steps for implementation of the proposed Framework, including responsible entities, a timeframe, and related costs to the extent possible;
    e. Technical guidelines for M&E activities including baselines, goals and standard indicators to monitor and evaluate flood risk management projects in B&H

f. Capacity building plan and undertake capacity building on M&E (series of workshops on reporting, monitoring and evaluating, including legal framework, defined protocols and development of M&E tools) based on the technical guidelines

It is necessary to conduct a detailed analysis of the water sector information subsystems that exist in B&H, to do the necessary reconstruction and modernization in order to achieve a good level of operational functionality.

The integrated information system of the water agencies will take over standardized and harmonized databases from other functional information systems (will be closely linked with HPP and relevant institutions) from other entities, perform the necessary processing and analysis that will be used to make management decisions. The central part of the water sector information system will be located in water agencies and Hydro-meteorological institutes. Standardisation, harmonisation and unification of existing information systems will enable more effective data sharing.

Scaling up FRM data sharing technologies

To enable access and sharing of climate risk information, a centralised information system and knowledge sharing platform will be required. The Vrbas project developed and established a project SDI comprising GIS database for all spatial data related to the basin flood risk management. The Vrbas GeoPortal is a GIS-based tool which integrated various spatial socio-economic data with the flood hazard and flood risk maps, vulnerability maps including loss/damage models, real time hydro meteorological data, torrents sensitivity model, cadastre of torrents etc. The database was designed to be expandable to include other basins. The flood hazard information system to be developed under the GCF project will consist of an integrated e-Library, databases (including the GIS database previously noted), information systems and knowledge portal (web knowledge portal to increase awareness, provide interactive hazard maps, with integration with social media and possible mobile application to increase community engagement and allow two-way flow of information. The Vrbas Geo-portal is mainly designed to be used by the municipalities for local levels flood risk management to interact with communities through the PGIS tool within the platform. The expanded Geo-portal will continue to function at the local level and will be placed in the ownership of the entity and municipal civil protection units who will have responsibility for maintenance and update of the system in the future. The project will build capacity with civil protection at all levels in the use, and O&M of the portal.

UNDP has developed a Disaster Risk Analysis System which is an online data sharing platform for disaster data. The platform has already been populated with flood hazard maps for Vrbas basin and these will be updated to include all flood hazard maps in the future. The GCF project will contribute to the development of the platform and the embedding of flood hazard and risk information as well as expansion of the platform functionality to provide the specific functionality that will be required or using the flood hazard and risk information.

Establishment of cross-sectoral flood risk management platform

Governments are requested by the Sendai Framework "to establish and strengthen government coordination forums composed of relevant stakeholders at the national and local levels, such as national and local platforms for DRR".

The flood risk management platform will be a country-wide mechanism for cross-entity, multi-sectoral and inter-disciplinary coordination and policy guidance on flood risk management and risk reduction with public, private and civil society participation involving all concerned entities within B&H. The FRM platform will contribute to such coordination forums.

The data sharing platform will coordinate all stakeholder engagement at the entity and local level and will pursue an all-of-society engagement in FRM. It would also have mechanisms for effective dialogue with Local Platforms in place in order to influence, encourage and coordinate local action. In parallel, the country-wide Platform will seek to understand local priorities and issues.

Effective government coordination forums are composed of relevant stakeholders at state, entity and local levels and have a designated focal point. For such a mechanisms to have a strong foundation in institutional frameworks further key element and responsibilities should be established through laws, regulations, standards and procedures, including: clearly assigned responsibilities and authority; build awareness and knowledge of risk through sharing and dissemination of non-sensitive disaster risk information and data; contribute to and coordinate reports on local, entity and state disaster risk; coordinate public awareness campaigns on disaster risk; facilitate and support local multi-sectoral cooperation (e.g. among local governments); contribute to the determination of and reporting on disaster risk management plans and all policies relevant for disaster risk management .

The overarching goal of a country-wide FRM Platform is to contribute to the building of national resilience to flood disasters and thereby support sustainable development. To do this, the FRM Platform should have the following characteristics:

- The structure and experience to interact with the local level and the know-how to help embed FRM into local development processes
- The capability to work closely with the Focal Point to promote effective coordination of activities
- Clear standing and credibility with the government, such that it can influence and shape a cross-cutting range of policies including those pertaining to financing of FRM, spatial planning and urban development, protection and management of ecosystems, institutional and societal resilience, disaster risk management and recovery
- Clearly defined goals that seek to address the underlying causes of disaster risk and promote the resilience of vulnerable communities
- Clearly defined mandates and leadership combined with a secretariat that encourages cooperation, trust and consensus and that shares information, prepares and documents meetings and monitors progress on follow-up activities

The tasks of the Platform for DRR also expect to include:

- The identification of sectoral and multisector flood risk,
- Build awareness and knowledge through dissemination of data,
- Determine and facilitate development of plans and policies pertaining to flood and disaster risk management, and
- To coordinate reports on country-wide flood and disaster risk, public awareness campaigns, and cooperation.
- To facilitate dialogue and partnership within the international community, including the UN system, regional, and local authorities.
- To facilitate information sharing, knowledge exchange and technology transfer among its members and between Platforms for DRR.

Result 1: Fully integrated flood forecasting EWS facilitates timely preparation and response

- Climate data (hydro-meteorological, spatial and damage/loss data) gathered and analysed in line with international standards
- Flood forecasting and EWS in place and operational for the whole country
- Data management and communication protocols and SOPs for effective FFEWS and risk management established at all levels
- Vulnerable communities have access to “last-mile” EWS

10.2 OUTPUT 2: NON-STRUCTURAL FLOOD RISK REDUCTION MEASURES AND NATURE-BASED SOLUTIONS MAINSTREAMED IN SECTORAL POLICIES AND PLANS AND EFFECTIVELY CONTRIBUTE TO PROTECTION OF PEOPLE AND LIVELIHOODS FROM CLIMATE-INDUCED FLOOD RISK.

Activity 2.1: Mainstream climate induced flood risk reduction into sectoral planning (agriculture, hydropower, critical infrastructure) and spatial planning. (GCF Financing - $366,000; Co-Financing = $90,000)

The project will enhance the existing legislative and regulatory FRM framework by mainstreaming the climate-induced flood risk management into sectoral planning for agriculture, forestry, environment, hydropower, critical infrastructure and spatial planning. In the Hydropower sector, there are long term requirements under climate change, to assess the current and long-term ability to operate dams in a flood alleviation role during large flood events, to ensure that sufficient flood storage is provided without compromising dam safety or power generation. This will require the involvement of dam owners and operators in the development and eventual implementation of the flood management plans, and the development of individual operating rules for each dam during floods, which also meets the dam safety requirements for the dam. This will therefore involve optimisation of the dam operations for the dual uses of power generation and flood alleviation.

With respect to the agricultural sector the project will ensure that climate change is considered in the reduction of flood risk to agriculture. Flood risk informed agricultural master planning will be introduced and will include the consideration of risks and opportunities for flood management in the design and development of agricultural infrastructure.

Under the Vrbas project a draft floodplain development policy was developed using detailed climate-risk informed flood hazard, risk and vulnerability maps, which will be scaled up to spatial planning and development control for all other basins. This policy will underpin the floodplain planning and development control to achieve basin-wide climate resilience to increasing flood risks and will result in a paradigm shift from uncontrolled floodplain development to climate-risk informed controlled floodplain usage. Hence the project will develop the country-wide floodplain zoning policy and legislation, based on hazard, risk and vulnerability mapping.

The project will develop strategies for the management of critical infrastructure in the floodplain in order to improve the resilience of critical infrastructure, based on a shared, consistent, proportionate and risk-based approach to reducing vulnerability over time, and embedding flood resilience measures into the planning, design, construction and long-term management of critical infrastructure. The project will identify and assess flood risks to critical infrastructure and will develop a range of options to manage those risks including physical protection, contingency/redundancy within infrastructure, planning for ‘business continuity’ during an event, or improving arrangements for emergency response. Critical infrastructure resilience plans will be developed for key critical infrastructure sectors including energy, water supply, transportation and communications, emergency services, and government infrastructure.

Sub-Activity 2.1.1: Mainstream climate induced flood risk reduction into sectoral strategies, plans and technical guidelines for agriculture, hydropower and critical infrastructure, forestry and environment

At the state level, a cross-entity approach will be taken to integrate flood risk reductions into sectoral planning to ensure that a holistic approach is taken, particularly where entity lines cross basins. This requires the involvement of key stakeholders, the improvement of coordination, and the implementation of related multilateral and regional environmental agreements. Relevant regulations and standards will be reviewed and adjusted to reflect or take into consideration the impacts of climate change induced flood risk. The project will help the entity level governments to develop climate risk informed key strategies, policies and plans by using evidence-based climate induced flood risk impact, vulnerability and adaptation assessments, analyses of the costs and benefits of adaptation options.

Hydropower Sector

For hydropower operators, failure to adequately consider climate risks may lead to shortcomings in their technical and financial performance, safety and environmental functions. In addition, if not designed and managed appropriately, hydropower systems could have adverse impacts on local communities and the environment, particularly under intensifying climate conditions. The lack of assessment and management of climate change-related risks and opportunities could lead to adverse investment decisions that fail to optimise the role of hydropower infrastructure in providing climate-related services. Under activity 1.2, hydropower operations will be fully included in basin flood hazard and risk models and under 1.3, they will be included in flood forecasting models and tailored products will be produced to support the hydropower sector. These interventions are aimed at a comprehensive inclusion of the hydropower sector into flood risk management and providing support to the hydropower to enable climate risk informed operational and strategic decision making.

The recently developed Hydropower Sector Climate Resilience Guide has been coordinated by IHA[37] provides guidance to help hydropower practitioners manage the risks of climate change. The guide responds to the need for clarity on good international industry practice for project owners, financial institutions, governments and private developers to consider climate risks in hydropower development and operations.

The development of the HPP models and incorporation in flood models provides several opportunities for the Hydropower sector including improved understanding of changes in extreme events and the impact of climate change on the calculated design floods for a hydropower system. This will provide the ability to assess system performance under different climate change scenarios. Beyond the technical opportunities, there are significant opportunities for using climate risk information to ensure that HPP systems are an effective part of the flood risk management of all basins in B&H and to embed climate change considerations into the strategic planning and operation of the HPP sector.

The gap in policies and strategies relating to dams and reservoir safety will be examined with the view to strengthen dam flood safety in B&H and include climate change in dams' safety policy. Dams, by their very nature, create risks, which increase substantially without proper maintenance and under climate change. The existing large dams in the Adriatic and other basins (Vrbas) basin, as well as planned dams and their reservoirs are of great importance to the economy of B&H. They contribute to hydropower generation and water supply. They also contribute to seasonal and long-term regulation of river flow and therefore impact on river flooding. Reservoir operations, if integrated into the FRM process could potentially provide flood storage and alleviation functions, while at the same time, increasing the efficiency of hydropower generation and water supply. The establishment of effective strategies, guidelines and plans in the area of dam operations and safety are therefore of great importance for B&H, especially with the view of anticipated climate change impacts on hydrological regimes.

With respect to the Hydropower energy sector, the project will support the development of climate risk informed sector strategies, policies and plans for the flood safety of dams and will examine the potential role of the existing and planned dams in flood alleviation. The policy will examine and strengthen dam safety guidelines for B&H in line with international best practice. This will include development or enhancement of guidelines for the categorisation of dams into different risk categories, the development of improved methodologies (based on improved climate risk data) for assessing spillway discharge capacities that will need to be provided for dams of different risk categories (with CC considerations), the establishment of dam safety inspection intervals, guidelines on the assessment and quantification of risks associated with dams, including risk of overtopping, exposure to landslides and increased sedimentation, and the development of appropriate risk management plans for individual dams. Stemming from the long term requirements under climate change, the project will assess the current and long-term ability to operate

[37] https://www.hydropower.org/sites/default/files/publications-docs/hydropower_sector_climate_resilience_guide_-_vf_interactive.pdf

dams in a flood alleviation role during large flood events, to ensure that sufficient flood storage is provided at the start of large events, to ensure dam safety and to provide some attenuation of the flood wave. This will require the involvement of dam owners and operators in the development and eventual implementation of the overall flood management plans for the basins, and the development of individual operating rules for each dam during floods, which meets the dam safety requirements for the dam, and which also fits into the basin flood management plan, particularly during large flood events. This will therefore involve optimisation of the dam operations for the dual uses of power generation and flood alleviation. At the very least, the policy should ensure that dams are maintained and operated in a manner which avoids exacerbation of the flood risk, and which takes account of the increasing risks they pose due to climate change.

Key activities:

1) Review of existing hydropower sector dam safety strategies, policies and plans and identify entry points for embedding climate risk resilient approaches
2) Develop the climate risk-informed dam flood safety strategy for dams in B&H
3) Integrate climate risk and adaptation priorities into the HPP sector plans, investments and budget frameworks, including the investment appraisal skills, economic valuation of climate change impacts, based on sector model, trade off analysis and cost-benefit assessments for a range of plausible adaptation options in HPP. The skills, tools and methods as well as generated technical material can enhance HPP sector-wide planning and make investment decisions more climate risk responsive.
4) Development of guidance documents, methodologies and technical regulations for the HPP sector on climate risk assessment and management and the use of climate information.

Agricultural Sector

B&H has more than 500,000 farms (estimates of USAID FARMA Project). The average size of approximately 50% of farms is 2 ha, whereas the size of more than 80% of farms is less than 5 ha. Most are privately owned single plot farms growing several types of fruits and vegetables. The agriculture and food industry in B&H are very important for shaping and stabilizing further social and economic development in the country. It provides income generation for the local population and reduces negative social processes (migration, ageing of the rural population, etc.) and enables the preservation and protection of cultural, historical and natural heritage. However, the sector is highly exposed to intensifying climate change induced natural hazard, which exacerbates already weak response to other economic threats. By 2050, flood risk to the agricultural sector under climate change would increase to 7 million USD per event of flood damages compared to the current expected damages of 5.5 Million USD (a 27% increase), and to 12,323ha from current 9,848ha (25% increase). It is therefore very important to shape agricultural policy oriented toward the strengthening of sector performance and particularly the regulatory and institutional framework, to enable the use of use of climate risk information to develop climate risk management strategies including risk reduction and financial risk transfer to safeguard, strengthen and improve competitiveness of the sector.

Regional and country priorities for agriculture and rural development in B&H are centred on five priority areas: policy assistance in institutional capacity building in the process of accession to the European Union; improved quality and safety of food at all stages of the food chain; **sustainable management of forests and trees**, encouraging wood mobilization and sustainable use of non-wood forest products; integration of family farms into value chains for sustainable improvements in smallholder livelihoods and rural development; **enhancement of disaster risk reduction and management for resilient livelihoods**. B&H policy in the sector of agriculture, food and rural development has achieved considerable progress, but reforms are still necessary in order to fulfil the conditions for the EU association and to make progress in alignment with European standards. A State-level strategic plan and operational programme for the harmonisation of agriculture, food and rural development are in place. However, implementation has not started. The Republic of Srpska rural development strategy and action plan and the Federation of B&H operational programme for the harmonisation of agriculture, food and rural development need to be harmonised with the State-level framework. Some legislation implementing the Framework Law on

Agriculture, Food and Rural Development and the Law on Tobacco has been adopted, but there is still an overall lack of implementing legislation that impedes the coordination of harmonised strategies and legislation in this sector throughout the country.

According to the TNC for B&H, adaptive capacity to climate threats in the agricultural sector is low. In terms of available information and knowledge, there is a lack of detailed analysis on regional changes within B&H. Climate data is not fed into early warning systems for farmers, and farmers lack information about adaptive farming techniques, seed varieties, and crops that may be more appropriate with changes in seasonal temperature and precipitation patterns. In terms of skills and management, there is a general need for training farmers in less labour-intensive methods of agriculture, cultivation techniques for better-adapted crops, and hail protection techniques. In the economic sector, there is an overall lack of investment and a lack of crop insurance, which will become increasingly important with future increases in extreme weather. There is a lack of modern technology and there is a low uptake of new technologies due to lack of funding and the small-scale structure of farming. There is also a lack of infrastructure that could address climate threats, such as irrigation systems and reservoirs and rainwater collection. In addition, farmers lack access to broader varieties of climate-suitable seeds and plant varieties. The TNC also states that there is a lack of integration of climate change issues into policies on agriculture and rural development, a lack of coordination and clear jurisdiction for agricultural policies, and a lack of support for agricultural extension programs.

The promotion of more productive and resilient rural livelihoods requires policy support, capacity development, transformations in agriculture, livestock and fisheries/aquaculture, food production and processing and improvements in the management of natural resources such as land, forests, water, soil nutrients, and genetic resources are key areas. Greater investments are needed to prevent and/or mitigate the impact of future disasters. DRR must be mainstreamed across sectors into long-term sustainable development, protecting the built environment such as agricultural or food supply chain (food storage, processing, transport) infrastructure. Better management of crop species and varieties, the adoption of crops and varieties that are more resilient to floods and adapted to new climate patterns, plant breeding to develop new adaptive and productive varieties, and development of efficient seed delivery systems for improving farmers' access to adequate varieties. Other examples include: sustainable water management to increase water use efficiency and productivity, such as rainwater harvesting, water storage and conservation techniques and irrigation efficiency; agro-forestry systems that make use of trees and shrubs as shelterbelts, windbreaks and live fences to diminish the effects of extreme weather events; conservation agriculture which uses minimal soil disturbance, permanent soil cover and crop rotations, thereby contributing to crop diversification, high water infiltration for reduced surface runoff and soil erosion, among other benefits; and natural resource management practices to restore degraded grasslands through grazing management, re-vegetation and supplementing poor quality vegetation, as in agro-silvo-pastoral systems and land tenure to secure land rights.

To adequately protect agricultural livelihoods, it is critical to reduce the underlying drivers of the risks affecting farmers, pastoralists, fishers and foresters. The negative impact of natural hazards and other threats to agriculture and food security can be effectively reduced, mitigated or prevented through investment in sustainable models of food production and the application of appropriate agricultural technologies and practices, which raise yields and increase resilience against production failure. A strategy for the management of risks to the agricultural sector is required to define the approaches that would be appropriate for B&H.

Key project tasks:

1) Development and mainstreaming of a strategy for climate-resilient agriculture which integrates climate risk and adaptation priorities into the agriculture sector plans, investments and budget frameworks, including the investment appraisal skills, economic valuation of climate change impacts, based on sector model, trade off analysis and cost-benefit assessments for a range of plausible adaptation options in agriculture.

a. Technical strategic FRM management approaches to be considered include: ponds and temporary water storage, tillage practices, buffer and grass strips, arable to grassland conversion, re-connecting the river and floodplain (removing watercourse levees and embankments), re-meandering straightened watercourses, drainage management methods, floodplain agro-forestry
b. Development of a range of incentives, such as financial, policy or environmental gains, that will catalyse adoption of proposed FRM agricultural measures. Consideration of a range of different instruments to achieve uptake including, for example, full-cost or partial grants to contribute towards any initial set-up costs; selling an area of land and transferring or leasing of parcels of land to be used for FRM purposes. In terms of O&M of FRM measures, the following will be considered: a one off or annual payment to cover income lost; a one off or annual pay payment to cover future increased flood risk.

2) Support policy development and implementation, by development of methods and tools to collect empirical data on the business impacts of proposed FRM measures, including information on the willingness of farmers to introduce different types of FRM measures within different farming systems.
3) Undertake large-scale surveys of farmers' attitudes to proposed climate-smart FRM methods and to the use of potential policy instruments to promote its uptake and delivery; Undertake an economic analysis of the impact of different FRM measures under different scenarios and across different farming systems.
4) Development of the skills, tools and methods as well as generated technical material to enhance agriculture sector-wide planning and make investment decisions more climate risk responsive.
5) Development of guidance documents, methodologies and technical regulations for the agricultural sector on flood risk assessment and management and the use of climate change induced flood risk information and agricultural risk management.

Forestry

Pursuant to Article III of the Constitution of B&H on Responsibilities of and Relations Between the Institutions of Bosnia and Herzegovina and the Entities, foreign trade activities and international obligations in the field of forestry is the responsibility of, namely the Ministry of Foreign Trade and Economic Relations of B&H. For the management of forests and forest land, according to the B&H Constitution, the competences are at entity level (FB&H and RS) and Brcko District. Institutions in the two Entities and the Brcko District are responsible for the development and implementation of forestry policies and regulations. In FB&H, these competencies are even more decentralized to the cantonal level. The Constitution of the Federation of Bosnia and Herzegovina in Part III states (Division of Responsibilities between the Federation Government and Cantons) that the Federation (in addition to other responsibilities) has exclusive responsibility for economic policy and land use policy on the federal level, but both levels (Federation and Cantonal Governments) have responsibility for the policy of environment protection and use of natural resources. Where necessary, these responsibilities may be exercised jointly or separately, or by the cantons as coordinated by the Federation Government. At all administrative-political levels, forestry is the responsibility of ministries for agriculture, water management and forestry (in some cases the Ministry of economy) while wood-processing industries (sawmilling, pulp and paper) in both entities are under the responsibility of ministries for industry, energy and mining.

Bosnia and Herzegovina has the highest proportion of forests and the largest variety of forest species in the Western Balkans and is among the highest value forests in Europe. Forests and forest land cover 63% of Bosnia and Herzegovina's territory (3,231,500 ha), 51% (1,652,400 ha) of which are high forests, 39% (1,252,200 ha) coppice forests[38], and the remaining 10% comprising shrubs, bare land and other woodland.

[38] A high forest is a type of forest originated from seed or from planted seedlings and can occur naturally or they can be created and/or maintained by human management. Trees in a high forest can be of one, a few or many species. A high forest can be even-aged or uneven-aged. Even-aged forests contain trees of one, or two successional age classes. Uneven-aged forests have three or more age classes represented. High forests have relatively high genetic diversity compared with coppice forests, which develop from vegetative reproduction. A high forest can have one or more canopy layers. The understory of a high forest can be open (parklike, easy to see

Approximately 20% is privately owned and 80% is state-owned. The state owns 72% of high forests, while private forest owners are predominantly coppice forest (around 62% of total coppice forests). High forests are more profitable and under systematic forest management, the state undertakes afforestation and conversion of coppice forests to high forests.

Forest vegetation of Bosnia and Herzegovina is distinguished by the heterogeneity of plant association and the wealth of floristic composition as a result of the historical development of vegetation, specific ecological and geological conditions, and anthropogenic impacts. The forests are characterized by a wide variety of species including fir, spruce, Scots and European pine, beech, various species of oak, and less significant numbers of noble broadleaves, including maples, elms, ash, together with fruit trees (cherry, apple, pear). Primeval forest species are also represented and are separated and protected as I category of protection according to IUCN categorization, among which is the largest and most diverse rain forests reserve in Perucica[39].

The National Communications (INC, SNC, TNC) have suggested a number of mitigation measures including increase in forest productivity and maintaining or increasing the forest area through afforestation/reforestation and rehabilitation of bare lands; increasing carbon sinks through forest conservation and increasing fire protection measures and permanent control of forest health; and reducing forest misuse by raising awareness on the importance of climate change mitigation, to local communities and stakeholders. In addition, a study on "Forests and climate change" was conducted as part of NFP of FB&H. This study recommends further steps directed toward research related to adaptation of forest ecosystems on climate changes, possibilities of using carbon sinks credits, CDM mechanisms and adoption of proper sectoral strategy on climate change mitigation. According to the TNC, adaptive capacities of the forestry sector to climate changes are at a very low level. It states that although there is a possibility that climate change will result in the long-term transformation of almost all forest eco-systems by shifting the schedule and the structure of forest communities, the areas most under threat of climate change have yet to be defined, and there is a lack of a more detailed analysis of climate change effects on individual forest communities; i.e., altitude zones at which they are widespread. Any such changes that will impact the structure and density of the forest cover, will greatly exacerbate flood risk in river basins. In terms of the institutional framework, there is a noticeable lack of integration of problems and issues of climate change into forestry policies and strategies, as well as the lack of coordination between the managers and the users of forest resources. Climate change is not mentioned regularly within policy and strategy documents, nor in legislatively defined forest governance plans. With regards to the new forestry measure of IPARD 2014-2020 programme of the European Commission focus points on afforestation and agroforestry, fire prevention and restoration after fire, and improving the resilience and environmental value of forest ecosystems are highlighted.

Deforested and degraded catchments increase the vulnerability to flooding from extreme events and impact on people and the assets in river basins and sub-catchments. It also increases maintenance costs of built infrastructure in such basins. The catchment is therefore the eco-system unit within which critical processes must be managed in order to minimise the impact of flooding.

This output will develop catchment management strategies for climate resilient catchment management to reduce the exposure of communities and their physical assets, to climate-induced flood hazards. The project will develop catchment afforestation/reforestation strategies for including selection of tree species, methods of afforestation/reforestation and maintenance that are fully informed by the flood and (torrential) erosion hazard maps to be developed under Activity 1.1.2. It will help the entity forestry institutions delineate the priority hazardous areas for a phased afforestation and reforestation strategy. It will assist in the

and walk through), or it can be dense. A high forest's understory can have high or low vegetation species diversity. In contrast to a low forest (also known as a coppice forest), a high forest usually consists of large, tall mature trees with a closed canopy.

[39] Perućica is one of the last remaining primeval forests in Europe. It is located in Bosnia and Herzegovina, near the border with Montenegro, and is part of the Sutjeska National Park.

identification of plant species that will provide the soil, water and nutrient protection properties needed to address degradation of catchment.

Key project tasks:

1) Technical assistance to entity forestry agencies to develop and mainstream basin afforestation/reforestation and agro-forestry strategies and other forestry strategies to enhance flood risk management role of forests, as well as FR adaptation priorities into the forestry sector plans, investments and budget frameworks, including the investment appraisal skills, economic valuation of climate change impacts, based on sector model, trade off analysis and cost-benefit assessments for a range of plausible adaptation options in forestry.
2) Development of a range of incentives, such as financial, policy or environmental gains, that will catalyse adoption of proposed FRM management measures among private forest owners. Develop financial dis-incentives to deter illegal practices such as illegal logging, illegal conversion from forest to agriculture and illegal construction which exacerbate deforestation and increases flood risk.
3) Support policy development and implementation, by development of methods and tools to collect empirical data on the business impacts of proposed FRM measures, including information on the willingness of private forest owners to introduce different types of FRM forestry management measures.
4) Undertake large-scale surveys of private forest owners' attitudes to proposed climate-smart FRM methods and to the use of potential policy instruments to promote its uptake and delivery;
5) Undertake an economic analysis of the impact of different FRM forestry measures on the sector.
6) Development of the skills, tools and methods as well as generated technical material to enhance forestry sector-wide planning and make investment decisions more climate risk responsive.
7) Development of guidance documents, methodologies and technical regulations for the forestry sector on flood risk assessment and management and the use of climate change induced flood risk information in forestry management.

Sub-Activity 2.1.2: Develop country-wide floodplain zoning policy and legislation, based on hazard, risk and vulnerability mapping, flood resilient building codes and embed climate change considerations in the design and construction standards of critical infrastructure

Floodplain management is a process that promotes the wise use of floodplains in order to minimize flood risk by improving natural floodplain function while strategically zoning vulnerable uses away from the highest risk floodplain zones.

Land use planning and development control mechanisms are essential elements in managing flood risk, and one of the most effective ways of ensuring future flood risk is managed appropriately, by taking flood risk under climate change into consideration. Indeed, land use within flood plains may involve trade-offs between flood risk and development. Therefore, such policy decisions should strike a good balance between the floodplain protection for its flood management function and productive uses that do not disturb such function. A strategic approach to flood risk management would therefore be to design flood management policy that maximizes the net benefits from flood plains and minimises conflict with development-oriented land-use, rather than aimed solely at minimizing flood damage. Other policies that might be considered include the use of flood plains for short season crops, pastures, cattle rearing or agro-forestry. This would be useful when considered in the context of sub-activity 2.1.1 which will incorporate climate change into the agricultural sector. Zoning of agricultural land use in this way could be one of the policies that could be developed.

In defining flood zones, categories such as a climate change flood zone, a designated floodway fringe, a floodplain, a designated floodway, and the body of water itself will be considered.

It is anticipated that the flood hazard maps that will be produced under Sub-Activity 1.2, will be used by local authorities and local communities in the development of floodplain zoning policies, emergency preparedness and emergency response plans; for raising public awareness and for improving community preparedness, and for designating insurance zone for the community based flood insurance if this is deemed an appropriate flood management instrument for the study basin. The maps will benefit decision makers and all involved in natural hazard risk management at the all levels and will enable government, NGOs and future donors to better focus their efforts in dealing with flood hazards.

Under the Vrbas project a review was undertaken of land use and spatial planning regulations to ensure that vulnerability to flood hazards and a land use policy developed based on the principles of zoning people, property and economic activity away from high risk areas. In addition, the project reviewed and recommended revisions to strengthen the legislation that govern activities influencing flood hazards, to provide comprehensive floodplain management and spatial planning.

In simple terms policy makers and development planners need to know how often, on the average, the flood plain will be covered by water, for how long, and at what time of year in order to develop effective land use regulations and development control. Natural changes, changes brought on by development activities and climate change affect the floodplain and must be understood, to identify appropriate development and natural resource management practices. Changes in floodplain utilization, such as urbanization and more intensive agricultural production, can increase runoff and flood levels. It is critical for the planner to appreciate these and other effects of land-use change. Consideration of all uses of the floodplain during development planning is prudent, as it enables the planner to foresee and evaluate potential conflicts between present and proposed land use and their relationship to flood events and the hazards they may pose.

Acceptable risk criteria can help in distinguishing between different degrees of risk for different development activities. The chosen acceptable frequency of a particular flood event should be appropriate for the type of development activity. For example, it may well be worth the risk of occasional flooding to plant crops in the floodplain where soils are enriched by cyclical flooding and the deposition of sediments, where resulting sand and gravel deposits may lead to commercial exploitation. On the other hand, it is more appropriate to site a large agro-industrial or housing project in an area with a very small probability of a large flood occurring each year.

As certain types of development and the people who use and live in them are more at risk from flooding than others, development of flood zones and the development activities allowed in each, should be linked to the probability of flooding as well as the vulnerability of types of development and it's likely occupants and users.

Under this activity, the project will embed nation-wide risk zoning policy based on risk and hazard maps (produced under activity 1.2) by developing the relevant regulations and guidance documents. Under the Vrbas project a floodplain zoning policy was developed. The focus of the policy is on the promotion of floodplain zoning as a means of efficient flood risk management, in order to retain the natural functions of the floodplain, minimise loss of life and property damage due to flooding, and maximise the goods and services that can be derived from harmonious existence on the floodplains. It uses the hazard maps to define 4 flood zones (Low Flood Hazard Zone, Climate Change buffer, Floodplain Fringe, Functional Floodplain) and overlain onto land use categorized into 4 land use/development classes (Essential/Critical infrastructure, Water compatible development, Emergency Services Infrastructure, Commercial/Public Buildings and Residential) and three vulnerability categories (Highly vulnerable Infrastructure, Moderately Vulnerable Infrastructure, and Less Vulnerable Infrastructure).

Infrastructure/Development type

- *Essential/Critical infrastructure* - infrastructure that should be designed to remain operational during floods such as transportation routes, utilities, first responder facilities, operational centres,
- *Water compatible development* - development that may need to include elements of other vulnerability classifications in order to operate, the development still needs to be designed to ensure the safety of occupants, with evacuation procedures clearly defined, and it must not increase flood risk to others or affect the functionality of the floodplain normally includes flood control infrastructure such as pumping stations, water transmission infrastructure like canals and

irrigation schemes, navigation facilities like docks, wharves, nature conservation and biodiversity, outdoor sports and recreation areas and essential residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan)

- *Emergency Services Infrastructure* - Emergency services like police, fire and ambulance stations and hospitals need to be located within their catchment even where it may be at high risk of flooding. Overall risk to life may be greater than the risk from floods if response times for emergency services are longer, hence the need to site such infrastructure close to the likely affected area. There needs to be a balance between preventing emergency services' control systems and equipment being disabled in a flood, whilst providing emergency service cover to existing communities already located in flood risk zones. It is therefore important that emergency services have clear strategies to manage their operability during a flooding event. Flood risk should be a key consideration to the location of emergency service provision.
- Commercial/Public Buildings and Residential

Vulnerability Categories

- *Highly vulnerable* - infrastructure which is required to be operational during a flood event (e.g. first responders during an emergency such as some police and fire stations and emergency response command centre, hospitals that might be needed to treat casualties of the emergency situation);
- *Moderately Vulnerable* - infrastructure that is vulnerable due to the low probability of the type of structure physically withstanding a flood (such as mobile or temporary homes and camp sites with transient populations. Other infrastructure can be considered to be 'more' vulnerable due to the vulnerability or reduced capacity of its occupants to escape the flooded area, such as schools, old people's homes etc.;
- *Less Vulnerable* - infrastructure including police, ambulance and fire stations which are not required to be operational during flooding);

The policy outlines the most appropriate mix of land use and vulnerability class that should be permitted in each flood zone, in order to minimize risk to life and economic losses. This policy is applicable for all floodplains of B&H but cannot currently be implemented as the necessary hazard and risk maps for all but the Vrbas floodplains are missing. Under the GCF project the development of the flood hazard maps will enable the implementation of this floodplain zoning policy throughout B&H.

Based on the consultations on the floodplain zoning policy developed for Vrbas basin, the following will be taken forward under the GCF project, to embed floodplain zoning as a flood risk management approach, into spatial planning to mitigate the risks of flooding:

1. **Integration into legislative framework**: Incorporation of flood risk into the laws on spatial planning is the most prominent way for sub laws development, methodologies and development plans that have influence on crucial factors at multiple spatial scales, from the flood risk perspective, from local-level plans to national or even international strategic plans. Spatial planning laws in B&H (RS and FB&H) are currently under amendment and in preliminary discussions, the representatives of the relevant ministries fully agreed that it is necessary to include flood risk (as other risks too) into the spatial laws as an entry point for development of lower level legal documents that will define more detailed enforcement of rules and regulations related to flood risk (land use planning, strategic development planning, construction regulation and building codes etc.). This would be a crucial step for future development processes.

2. **Development of missing and update of existing local/cantonal Spatial Plans** and integration of Flood Zoning Policy (which is already developed for Vrbas basin) and flood hazard and risk information into the local/cantonal Spatial Plans: Spatial plans of local government units (LGU) represent the most active type of strategic documents for spatial planning in B&H since they treat the entire urban and rural space of a particular local government unit at a satisfactory level of detail, in terms of future use of space. The coverage of this type of spatial plan in B&H in general is unsatisfactory.

As the Project foresees formulation of multi-year climate resilient municipal investment plans for 10-12 selected municipalities in Vrbas, Una-Sana and Bosna basins, support of development of missing and update of existing local/cantonal Spatial Plans would be precondition and necessary base for climate/flood risk informed spatial development as well as municipal investment plans in selected municipalities.

3. **Integration of Flood Zoning Policy into FRMPs**. Vrbas FRMP is the first integrative flood risk planning document in B&H. The flood zoning policy is its necessary integrative part as risk informed spatial planning is recognized as one of the main non-structural measures in FRM. Development of FRMPs for other B&H river basins is expected in 2021 (IPA 2016). Based on experiences of Vrbas initiative the project can integrate flood zoning policy into the new FRMPs.

4. **Development of guidance documents for integration of flood risk and spatial plans at local level, and technical support in enforcement**; As already observed, coverage of B&H local communities with spatial plans is unsatisfactory. Out of 13 municipalities in Vrbas basin, as a representative sample, just two municipalities have finalized/adopted spatial plans. A similar situation exists with urban plans - the most important spatial planning document for urban area - which are rarely developed in municipalities of VRB. The regulatory plans represent the most common type of spatial planning documents at the local level.

Zoning plans, as a new type of detailed documents of spatial planning, are not developed in the Vrbas municipalities. As the project aims to mainstream climate induced flood risk reduction into sectoral planning, including spatial planning, it would be necessary to develop guidance documents and provide support in ‘’on ground’’ implementation of zoning plans. This particularly considers development of internal procedures within local administrations necessary in regular practice e.g. strategic planning, issuance of different permits/licenses, implementation of floodplain building regulations as well as public communication and raise awareness of decision makers as well as population in order to learn and apply the new procedures. This is an issue, among others, that could have strong base in already developed Vrbas GeoPortal that will be replicated to other river basins/areas under flood risk.

Key project tasks

The specific tasks for implementing this activity are:

1) Using the detailed flood hazard mapping derived in Output 1.2, update the existing floodplain zoning policy to produce the country-wide flood zone designation policy for all basins in B&H and outline the permitted land uses in each zone. Consult with all stakeholders on the designated flood zones.
2) Establish and publish development control rules and regulations designed to zone activities away from high risk areas and to encourage environmental enhancement of the floodplain.
3) Develop policies that will protect against the impacts of flood risk. This will include development of construction and building codes for properties in the floodplain that incorporate climate change flood resilience. To this end, existing building codes will be reviewed and compared against international best practice, from which the most appropriate flood resilience measures will be adapted and incorporated into existing construction and building codes
4) Integrate the floodplain zoning policy into legislative framework in each entity.
5) Assist the development of missing and update of existing, local/cantonal Spatial Plans by integration of Flood Zoning Policy (which is already developed for Vrbas basin) and flood hazard and risk information into the local/cantonal Spatial Plans for 10-12 municipalities and cantons
6) Development of guidance documents for integration of flood risk and spatial plans at local level, and technical support in enforcement. Develop and implement a capacity building roadmap for state and entity authorities to integrate new policies, plans and strategies into spatial planning, including management tools that will be needed for implementation and enforcement for new policies (such as compulsory flood risk assessments for property developments in the riskier zones within the floodplain, as part of the decision-making process for granting planning permission).

7) Undertake an impact assessment of the proposed new legislation to determine and quantify effects on distribution of population and demographics within the floodplain, projected distribution of economic activity, and benefits to environmental protection. An economic assessment of damages averted will also be carried out.

Sub-Activity 2.1.3: Update climate risk informed methodologies, standards for infrastructure design, construction material, use and maintenance of critical infrastructure in B&H

The Rulebook on the Design of Infrastructure Facilities and the IPPC Plant from the Flood Protection Point in B&H has not been established. Within the Social Federal Republic of Yugoslavia there were JUS standards and specific guidelines for the design of different facilities, and such guidelines became current engineering practice. In B&H BAS standards, based on EUROCODE European Standards and the German DIN standard, are currently in force, but there are no strict regulations on how to design from the point of view of flood protection.

The current Law on Waters of FB&H Article 96 stipulates that it is prohibited to erect buildings and other facilities, that does not have defensive role against floods and which prevent access to the watercourse, at distances not less than 10 meters from the 1/100 water level for all surface waters, the highest levels of coastal waters, unless the owner or user is conditioned to build the facility by taking precautionary measures preventing or reducing the harmful consequences of water. The current Law on Waters of RS has almost identical article. Article 105 stipulates that it is prohibited to erect buildings and other facilities, that does not have defensive role against floods, at distances not less than 5 meters from the 1/100 water level for all waters, unless the owner or user is conditioned to build the facility by taking precautionary measures preventing or reducing the harmful consequences of water.

The maximum flow rates used in the design of different types of **hydro-engineering facilities** have been defined in terms of their safety, economic value, expected life span and possible adverse effects due to their demolition. The choice of the maximum flow rate of a flood wave for the design of a hydro-engineering object depends on the importance of the object, the value of the object, the effects of the demolition of the facility on the downstream users, population density downstream, economic conditions of the downstream parts, etc.

The usual engineering practice is that the **protective dikes** rise above the level of 1 in100 water level return period with a certain over-height (freeboard) of 80-100 cm. Protective dikes for agricultural land (so called summer dikes) to meet the 1 in 20year return period standard of protection. In **dam design, spillways** are calculated on the waters of a much higher return period, depending on the type of dam, from 1 in 5000 to 1 in 10,000-year return period. The river regulations the dimension ranges of the 1 in 100-year return period water level with an extra 80 cm over-height.

For the design of **highways** in B&H, guidelines and rules on bridging and fault design have been developed. For bridges and culverts, the height of the profile is determined in a way that ensures safe highwater flow with an adequate protection height between the high water and the lower edge of the upper structure. For bridges and culverts on motorways and regional roads, the 1 in 100-year return period water level is used. The influence of hydraulic profile reduction must be taken into account. In the case of local roads, 1 in 50 year or 1 in 20-year return period water levels are relevant with 40 to 100 cm freeboard depending on the size and category of the of the river and from the calculated /observed water level from hydrological yearbook. Guidelines for these structures are defined in each water management conditions prescribed by the authorized water management institution. In engineering practice, the bottom edge of the highway bridge is elevated at a distance of 100 cm above the level of one hundred years of water. In places where there are no protective water objects, the engineering practice is to make the roadway on protective dike so that the upper edge of the road is 80 cm above 1 in 100-year return period water level. In this way, it is possible that in the event of a flood the road serves as a defensive dam and at the same time enables unobstructed communication.

When designing **railway bridges**, there are internal rail regulations that prescribe the lower edge of the bridge at a 1 in 1000-year return period water level. The same rule also defines the way of designing culverts through the railroad dike, in order to discharge waters without the damaging impact on the infrastructure.

In B&H, a regulatory policy is enforced on plants/facilities for which **environmental impact assessment** is required, and plants/facilities that can be built and placed into operation only if they acquire an environmental permit and includes: the energy industry (petroleum refineries, kilns, thermal power plants, land power lines of nuclear power plants and nuclear reactors); the chemical industry, Metal industry, mineral induction, waste management, extractive industry, food industry, textile, leather, wood and paper industry. All these facilities must have an environmental permit and an environmental impact assessment that should have an impact on flora, fauna, water, air and land. Pursuant to Article 96 of the Law on Waters of the FB&H and the Law on Waters of the RS Article 105, all existing plants, if they are within the 1 in 100 waters, must take all measures to prevent or reduce the adverse effects on water or water. Unfortunately, there are no guidelines that need to be taken to reduce the harmful impact of water and on water.

The existing standards and guidance do not currently include climate change considerations nor are they based on the most-up-to-date climate risk information or methods for identification, prioritisation, design and implementation of climate proofed infrastructure. Furthermore, it is not clear whether the above standards are systematically applied.

The project will fully review all climate proofing design standards, methodologies, procedures and practice and will introduce climate risk screening methods and embed climate risk reduction criteria across critical infrastructure planning, prioritisation, design, construction and maintenance. It will provide step-by-step guidelines for climate risk reduction measures for all categories of critical infrastructure through the following review and revision of the existing guidance documents. Practitioners will be trained in the new methods of climate resilient infrastructure design, development and operations and maintenance. The intervention will embed the systematic use of climate hazard and risk information (to be developed under Activity 1. 2) in the identification and prioritisation of critical infrastructure projects to provide a more comprehensive, robust and evidence-based means of identifying project needs and will enable an appropriate level of climate risk informed feasibility studies. At the municipal level, the GCF project will also introduce climate risk criteria into the prioritization process and include other methods of measuring benefits of projects based on the introduction of appraisal-led project prioritisation using socio-economic cost-benefit analysis methods and tools to be developed under Activity 1. 2.

Key project tasks:

1) Review of existing design guidelines and specifications and identify requirement for revised and improved approaches to respond to the changing climate and existing conditions on the ground
2) Development and codification of revised guidelines and specifications based on detailed methodologies for incorporating CC considerations into risk assessments, strategies, policies and plans for all critical infrastructure relevant sectors using international best practice, for long term capacity strengthening of practitioners.

Sub-Activity 2.1.4: Deliver training and technical advice on climate resilient infrastructure design, construction and O&M approaches

Based on the revised methodologies developed in 2.1.3 on the identification, prioritisation, design, construction and O&M of climate resilient infrastructure, the GCF project will undertake capacity development of the relevant institutions. Capacity development will be provided to enhance the ability to undertake engineering feasibility studies and will include incorporation of climate-risk considerations into technical feasibility, introduction of investment feasibility considerations, introduction of socio-economic cost-benefit analysis, optioneering and options appraisal methods as well as outline environmental impact assessment, to strengthen the feasibility process, safeguard investments and optimize engineering solutions. At the detailed design level, technical assistance will be provided to introduce climate change considerations into design of infrastructure to ensure that they will accommodate likely changes of environmental variables (frequency and intensity of occurrence) expected with climate change. Importantly, the project will train WA in the new climate-risk informed infrastructure detailed design methods and will include the identification of the best combination of structural, non-structural and eco-system based measures to achieve the desired engineering solution.

Key project activities:

1) Training of WA practitioners and engineers in climate resilient infrastructure design
2) Training and technical assistance WA staff in climate resilient project prioritisation and feasibility studies
3) TA and training of WA and municipal engineering using new CBA methods for project prioritization.
4) TA and training of WA and municipal managers in investment planning, optioneering, project appraisal methods and development of long-term investment planning
5) TA and training of WA and municipal engineers in climate resilient infrastructure design and EIA
6) TA and training of WA and municipal engineers in identification, prioritisation and design of non-structural methods

Activity 2.2: Implement and mainstream new ecosystem-based flood risk reduction and climate change adaptation methods. (GCF Financing = $5,868,747; Co-financing = $20,247,428)

Adaptation to climate-induced flood risk in B&H, if tackled by hard structural measures alone, is likely to require increasingly larger investments in flood protection infrastructure, such as flood embankments, and dams and reservoirs to buffer against increased variability in rainfall and run-off. However, such traditional engineered solutions may not always be the best option. Nature-based FRM solutions, due to their potential value for risk reduction and adaptation has been recognised as viable solutions (European Commission 2015) . Natural flood management (NFM) and natural water retention measures (NWRM) that alter, restore or use landscape features to manage flood risk including (1) interception (retaining water in and on plants), (2) increased plant transpiration, (3) improved soil infiltration, (4) ponds and wetlands for increased floodplain storage, and (5) reconnecting the floodplain, have the potential to reduce extremes in the flow discharge and thus help to reduce flood risk. Nature-based solution (NBS) encompassing EbA and non-structural FRM measures have been proven to be a viable substitute for, and complement to traditional hard infrastructure, and has provided additional eco-system services by enhancing the natural biophysical services of the rivers and river basins. In B&H, torrential flooding which normally originates in steep upland catchments, cannot be addressed by traditional hard engineering measures, but rather needs to be managed by restoration of the vegetation cover and re-establishment of the natural eco-system functions of the catchment. Nature-based solutions are often less capital intensive and more easily reversible than engineered alternatives, thereby providing an additional "option" value. In addition to protection from climate change impacts, they also provide many other benefits to communities, for example through the maintenance and enhancement of ecosystem services crucial for livelihoods and human well-being, such as clean water, water regulation and habitat, recreational opportunities, and often provides employment opportunities. Appropriately designed NBS measures can also contribute to climate change mitigation, for example, by reducing emissions from ecosystem loss and degradation. To reduce flood risks, it is vital to build the resilience of the natural resource base, and to promote sound environmental and natural resource management practices and the sustainable use of ecosystems. Healthy and diverse ecosystems are more resilient to hazards. In particular, healthy catchment ecosystems, reduce soil erosion and runoff that causes flooding. For example, in Switzerland, is it estimated that forests save between USD 2–3.5 billion per year equivalent in disaster damage (including flooding) through restoration of key forest ecosystems . Forests can be used as shelterbelts and windbreaks, and also play an important role in protecting against natural disasters including floods. Trees stabilize riverbanks and mitigate soil erosion. Wetlands serve to store water, provide storm protection, flood mitigation, land stabilization and erosion control. As part of the Vrbas project, several EBA and non-structural measures have been implemented throughout the basin. Over 15 EbA measures were implemented in the mountainous part of basin (See Section 7.11 of FS), as well as in middle and lower plains and they consist of the use of natural materials in the protection of river banks from erosion and degradation, the reconstruction of old meanders and abandoned river beds, restoration of the riverbed to its natural state and agroforestry measures. In the most upstream part of the basin, in the municipalities of Bugojno and Gornji Vakuf, a measure of rehabilitation of the old riverbed was implemented, which enabled water retention in the upstream part, thus ensuring reduced and controlled runoff in the downstream part of the basin. The added value of this measure is that the river island created by the reconstruction of the old riverbed is now significantly used for agricultural purposes as a highly fertile land. During the heavy rains in September 2019, several news portals in Banja Luka pointed out that the projects and interventions made through the Vrbas project gave results and reduced the flood risk compared to the floods from 2014, in the largest city in the basin. Based on the results of the Vrbas project the B&H government has committed to embedding nature-based approaches and are seeking to rebalance the priorities and relative value of “hard” infrastructure versus green solutions to manage flood risk. NBS solutions are embedded in the Flood Risk Management Plan for the Vrbas basin, for the first time in B&H. This move to adopt NBS is in line with many similar tried and proven initiatives in Europe (e.g. “Making Space for Water” in England and similar). During feasibility, 21 EbA and non-structural measures were prioritized for implementation based on CBA analysis of an original 69 such measures identified by WA’s. Government then selected the next 5 for financing. Therefore of the 26 measures, 5 EBA and 13 non-structural measures will be fully financed by government, while 8 non-structural measures will be co-funded by GCF and government. Hence there is a 79% Government to 21% GCF co-funding ratio of EBA and non-structural measures. This shows a very serious commitment of the Government to invest in nature-based solutions. In addition, to address the impact of climate change on forest ecosystems (See para 25 above and Section 10.2 of FS) the project is mainstreaming climate-induced flood risk considerations into forestry policy (See pgs. 227-228), which is expected to establish policies which will protect the forest from the expected impacts of climate change and promote reforestation, afforestation, and sustainable forest use. The long-term impact will be enhanced forest eco-systems which will provide improved services to flood risk management and other biophysical functions.

In the Vrbas River Basin (and all other basins), one of the main "sources" of sediment production is a network of forest roads and paths for hauling logs. Forest roads are mostly truck roads filled with ground material, and depending on the substrate on which they are located, during periods of heavy rainfall they can be soft, muddy and suitable routes for soil erosion during the extraction of timber. Roads are mostly made, without design, by a bulldozer that passed through the forest. During the construction of the road, most of the excavation material that is not needed for embankment is simply pushed from the route down the slope and further under the action of gravity and atmosphere, most of it reaches the hydrographic network of watercourses and is transported all the way to a recipient, usually the Vrbas River. The constructed forest roads do not usually have a quality solution for surface water drainage.

With all this in mind, it is necessary to take measures and works to prevent erosion on forest roads and paths. This is in the interest of water management due to the backfilling of water reservoirs and increasing the risk of torrential floods, but it is also in the interest of forestry. Namely, by eroding soft forest roads and trains and turning them into ravines, they are no longer usable next year, therefore new forest roads and paths must be opened, which means loss of production area and reduction of wood growth.

Forest paths for extraction of timber are usually designed with high angle of slope (over 50%), which causes significant erosion. Density of these forest paths is approx. 150-200m/hA, which sums up length of approx. 21,000 km in basin area*. This area is exposed to extensive erosion and create torrential floods which will produce significant amount of sediment. Sediment in watercourses increases the risk of floods, and rapid drainage of water from slopes reduces concentration time. (*Flood risk management plan in Vrbas river Basin, 2019*).

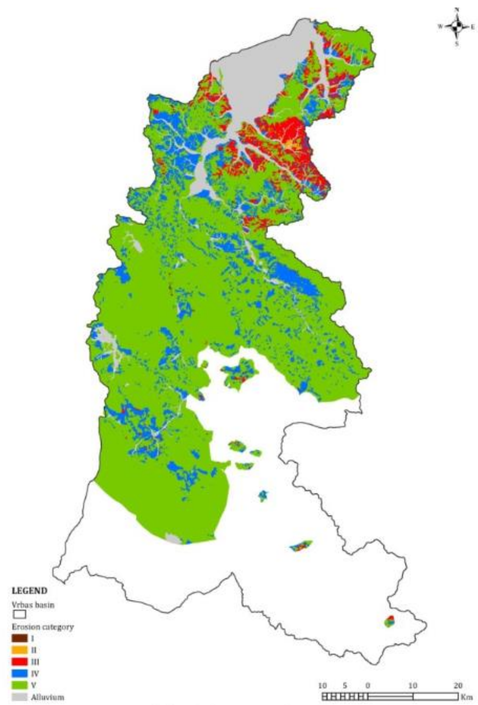


Figure 10-8: Erosion map of Vrbas river basin

This deforestation is noted in all river basins in Bosnia and Hercegovina, mainly due to similar topography.

Effective EbA FRM solutions are being embedded in B&H to address the complex interactions amongst multiple ecosystem degradation processes that are contributing to flood risk and affecting people's vulnerabilities to climatic and other factors. In B&H, terrestrial ecosystems are under increasing pressure from changes in the use of land and natural resources, driven by socio-economic pressures. While climate change is impacting the intensity and frequency of flood risk and well as shifting natural eco-systems, such as distribution of forest cover, anthropogenic activities that increase deforestation, soil erosion and land degradation are combining to increase risk of floods due to the reduced ability of eco-systems to provide services important to protecting people, their property and livelihoods. This, in turn, puts people under increased pressure to resort to unsustainable ecosystem use and management, further degrading ecosystems and their capacity to deliver services. While climate change affects the various terrestrial ecosystems in different ways, and each ecosystem is accompanied by its unique set of socio-economic and political issues, this vicious cycle of degradation is common to most.

Under the Vrbas project a range of non-structural measures utilising eco-system-based approaches, or interventions that encourage natural floodplain functions were successfully designed and implemented. This is the first time in B&H that such measures have been implemented.

In addition to foreseen infrastructural measures that will significantly contribute to reduction of the flood risk, non-structural measures has a significant role to play, as part of systematic approach in river basin organization. Non-structural approaches provide basis for reconsidering required interventions on the basin that will contribute to the flood risk mitigation, through the reduction of erosion process intensity and reduction of quantities of deposit which is transported from the basin.

In the implementation of mentioned measures, it is necessary to reconsider the status of erosion and analyse the torrential flood risk to the basins based on Torrential flood modelling and mapping as described above. This will form the basis for planning of anti-erosion measures on individual river basins.

Proposals for future anti-erosion measures are defined by analysing status of erosion in the basin, number and spatial distribution of torrential basins, maximum discharge values, quantities and structure of deposit on certain river courses profiles, as well as spatial distribution of sensitivity categories to the occurrence and development of torrential floods. Those measures include: technical measures-construction of torrent barriers on critical partition profiles; bio-technical measures-development of (single and double) wattle check dam which create support for vegetation growth on bare hillsides; other anti-erosion measures-economic measures (adjusted land cultivation) and administrative bans. By terrain prospection using indicated maps, necessary scope of anti-erosion interventions in the basis is defined, as well as list of measures and assessment of required funds.

Considering defined status in the basin, proposal of measures for planning and systematic organization of the basin is divided into two groups:

1) anti-erosion measures on the surface where processes of excessive and heavy erosion are present:

- technical works - construction of torrent barriers on critical barrier profiles. The effect of the barriers is reflected primarily in the retention of the sediment, the stabilization of the riverbed and banks, as well as the reduction of the fall of the torrent bed, and thus the reduction of the transport capacity of the flow for sediment transport.
- biotechnical works - production of (single and double) wickers that create support for the development of vegetation on bare slopes. The formation of this type structures on the network of occasional flows and ravines will contribute to a significant reduction of erosion material in the tributary bed and the recipient. In addition, a significant reduction in flood water concentration rates is expected.
- biological works - are based on the use of vegetation in order to protect the land from erosion. This group of works includes afforestation and grazing of bare and degraded arable land and pastures on steep slopes

2) basic measures of systematic organization of the basin, i.e. organization of forest and agricultural areas with light erosion processes.

Under the GCF project approaches that are natural and work with the existing landscape and can provide added benefits such as ecosystem services will be developed and implemented in the highest risk basins in B&H and will be complementary of structural measures to ensure that they, in combination with structural measures provide the best solution to flood management and protection. Non-structural measures will include: floodplain reconnection, selective bed raising/riffle creation, wash lands, wetland creation, two-stage channels, re-meandering straightened rivers, land and soil management activities to retain / delay surface flows, woody debris dams on streams and tributaries, flood plain woodland, re-forestation, agro-forestry, creation or re-instatement of a ditch network to promote infiltration (swales, interception ditches, etc), in-channel vegetation management growth to maximise channel roughness. The project will include community-based EbA as part of the solution, which will be particularly important to reduce the impact of torrential floods. The project will scale up successful EBA approaches piloted by the UNDP/SCCF Vrbas River project.

Sub-Activity 2.2.1: Implement catchment management measures for reduced erosion

The GCF project will implement a limited number of highest priority eco-system-based (EbA) measures to address flooding in torrential catchments in the Vrbas basin. A detailed description of the socio-economic options identification of the priority EbA measures is given in Annex E Section 18.9 below). Vrbas river basin is the only basin in B&H with already developed erosion maps, cadastre of torrential watercourses, torrent flood susceptibility model and adopted Flood Risk Management Plan (FRMP). Based on those activities, which were developed by the Vrbas Project, the GCF project will implement a limited number of highest priority eco-system-based measures to address flooding in agriculture and flooding of torrential catchments. Measures are likely to include the following:

1) Erosion reduction on torrential watercourses e.g. gabion walls, sediment barriers etc.
2) The stabilization of excessively eroding river banks with vegetation cover and its root network
3) Planting of forest stripes in agricultural land
4) Identify agriculture infrastructure that could address climate threats, such as irrigation systems and reservoirs and rainwater collection in each target basin Assess and identify flood risks to agricultural infrastructure in target basins, as well as flood risk management opportunities associated with agricultural infrastructure under climate change and potential new infrastructure such as irrigation retention basins that could also serve as flood storage areas;
5) Design an agro-forestation scheme identified area of floodplain and develop an implementation plan for the scheme;

The Josavka River Basin, in the Vrbas Basin, is a typical torrential basin where all EBA measures can be adequately implemented according to the flood risk management plan. The flood risk management plan envisages 9 partitions, 16 wicker fields, afforestation of the basin in the amount of 200,00 hA and grassing of the areas of approximately 80,00 hA. Detailed design documentation will be developed for all elements but outline design drawings are provided in Annex 1.

General characteristics of the Josavka basin:

Area= 119,52 km^2; Z= 0,22; G =15,702.12 m^3/year ;

1. Rehabilitation of river banks
2. Wicker
3. Barriers
4. Grassing
5. Forestation

Rehabilitation of river banks:

Rehabilitation works ensure the smooth passage of flood waves of torrential flows through settlements and under protected roads. Embankments are made with natural stone, while the agricultural terrain can also be regulated with soil material. These works are sometimes necessary because they solve acute problems of torrential floods, while newly raised forest crops and other biological and biotechnical works are not capable of reducing formation of flood waves in torrential catchments.

Wicker

Wicker is suitable for arranging trenches in which there are conditions for the rooting of willow trees. These are ditches that have constant moisture and a sufficiently deep soil layer. They are made of wood and represent objects for consolidation of erosion processes in steep ditches. The average length of this type of transverse objects is about 10 m, and they are made in systems of several pieces. Reforestation is needed while implementing these works. Single and double wave systems can be used.

Securing parts of the on roads or on steep banks of a river or tributary is also possible to do wicker with or without additional afforestation. This simple, inexpensive but also effective measure has not lost its significance and should be planned in the maximum number of places as effective.

Barriers:

Barriers and thresholds have multiple roles:

- secure transverse profiles of torrents from further flow of deep erosion processes,
- keep the deposit (mostly drawn) behind the barrier until they are fully filled,
- represent an obstacle to further lowering of the bottom of the bed, due to the persistence of a series of stable points, which form a new (artificial) erosion base in the torrent bed,
- due to the reduction of the longitudinal fall of the trough stream, the velocity of water is reduced, as well as the repressing force of water and thus its transport ability to carry sediment.

Choosing place/ cross section for these type of measures within torrential watercourse, must be based on following conditions:

- favourable geomorphological conditions (stable bottom and shores, rocky substrate),
- a narrow and deep river valley that is widening upstream,
- the position of the profile downstream of the main tributaries (in order to stop as much sediment as possible),
- selecting a profile downstream of the mouth of a torrential stream tributary (in this case the barrier acts on both watercourses),
- to protect the longest section of the trough stream with as little barrier height as possible
- accessibility of the site to perform works with usage of heavy machinery for cleaning

Grassing

On agricultural areas threatened by stronger erosion processes, on slope slopes over 20%, it is planned to form grassland through grassing:

- by blending different types of grass seed
- planting monocultural leguminosis.

Forestation

As part of the erosion protection program in the Vrbas Basin, forestation of bare and eroded areas is planned, as follows:

- deciduous
- conifer
- acacia
- by planting shrubs

Forestation with deciduous trees

it is planned in lesser extent than confider, mainly in order to bring together some existing forest complexes. The forestation method is determined by the field conditions.

Forestation with confider trees

In areas threatened by stronger erosion processes, and especially in coastal steep riverbanks, conifer afforestation is planned. The afforestation method is conditioned by field conditions, and the choice of species is reduced primarily to black pine, white pine and spruce. Forestation should be done mainly on terraces.

Forestation with acacia

Areas endangered by stronger and excess erosion processes, as well as interstitials of already formed acacia crops, are planned for afforestation by acacia. Due to the known destructive effects of acacia on soil, afforestation of acacia is minimized. For the planned areas, afforestation should be carried out with annual acacia seedlings of approximately 5,000 pieces per hectare.

Planting shrubs

It is planned unstable terrains, where landslide might occur. Forestation of bare, abandoned farms land, farmland on steep slopes, parts of the basin should be done as the forest naturally reduce surface runoff.

Sub-Activity 2.2.2: Implement 21 selected non-structural flood risk reduction measures

Under this activity a number of non-structural measures will be implemented based on the methods used in the Vrbas project.

The project has identified non-structural measures to be implemented under the GCF project based on identified priorities of the WA’s (see Annex A). A detailed description of the socio-economic options identification of the priority EbA measures is given in Annex E Section 18.9 below). In total 69 structural and non-structural measures were provided by WA's. Cost benefit analysis was carried out on all measures based on the methodology described in the Economic Analysis annex of the proposal. Projects were ranked on the basis of the benefit to cost ratio, and the two highest priority measures from each target basin were selected (except Vrbas where several non-structural measures have already been implemented). A summary table of non-structural measures to be implemented by the project is provided in Annex A of this FS.

Activity 2.3: **Codify and mainstream EbA solutions into policies and regulations and promote non-structural measures among decision makers and communities. (GCF Financing - $208,680; Co-Financing = $90,000)**

Until the implementation of the Vrbas project, flood risk management in B&H involved mainly conventional hard engineering measures which include building embankments, dams, levees, and channels to control flooding. These hard engineering flood risk management approaches are expensive to build, provide limited standard of protection and have a limited service life. Significantly, they have not been designed based on catchment/river basin scale understanding of flood risk, nor have the solutions been developed as part of strategic basin solutions, but instead have been developed along entity lines with no consideration of basin/catchment processes. This has been compounded by a failure to include nature-based catchment/based management measures.

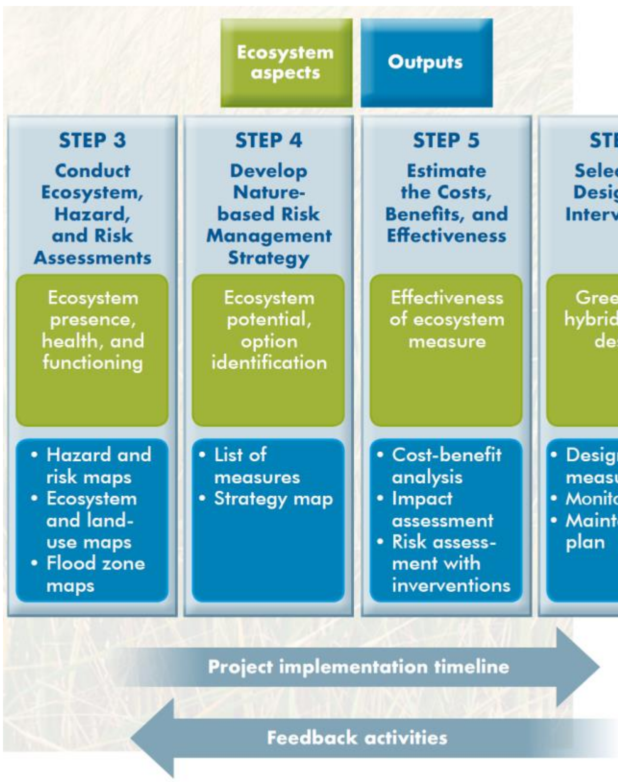
Recently the concept of "nature-based solutions", "ecosystem-based adaptation", "eco-DRR" or "green infrastructure" has emerged as a good alternative or complement to traditional hard engineering approaches. Nature-based solutions make use of natural processes and ecosystem services for functional purposes, such as decreasing flood risk or improving water quality and can include interventions that can be completely "green" (i.e. consisting of only ecosystem elements) or "hybrid" (i.e. a combination of ecosystem elements and hard engineering approaches).

Nature-based solutions can help mitigate flood and other hydrometeorological hazards. In addition, they may help decrease vulnerability to climate change while also creating multiple benefits to the environment and local communities, so called eco-system services. These include sustaining livelihoods, improving food security, and sequestering carbon. Knowledge of such advanced and climate-smart flood management in B&H is limited and traditional hard engineering solutions prevail. The project, through Activities 2.2.1 and 2.2.2 is scaling up and introducing new EbA approaches will develop and, through this activity (2.3.1), will codify detailed methodologies for the design and implementation of EbA solutions.

Ecosystems provide essential services helping people adapt to the impacts of climate change and disaster risks. In recent years, "ecosystem-based adaption" (EbA) and "ecosystem-based disaster risk reduction" (Eco-DRR) have gained increasing attention in risk management. These approaches emphasize the importance of ecosystems in effective climate change adaptation (CCA) and disaster risk reduction (DRR) measures and build on other practices such as conservation and ecosystem restoration that seek to increase the resilience of ecosystems. EbA and Eco-DRR provide multiple benefits for people, ecosystems and biodiversity, enable planning for CCA and DRR on longer time scales, and are cost-effective compared to traditional hard engineered infrastructure. EbA also emphasizes community participation and the use of traditional and local knowledge systems. Due to their participatory nature and cross-sectoral approaches to adaptation and disaster risk reduction, EbA and Eco-DRR can achieve multiple policy objectives, including strategies for climate change, disaster risk reduction, and sustainable development, among others.

The Paris Agreement and the Sustainable Development Goals and other international agreements have called for enhancing the resilience of ecosystems and societies to the impacts of climate change and disaster risk as a key adaptation strategy. Increasingly, countries are integrating eco-system-based approaches into local plans and strategies to reduce the risk of climate impacts and hazards.

EbA approaches applied to flood risk management need to be applied within a defined framework[40][41], for example as outlined below from GFDRR guidance. The introduction of EbA solutions in B&H represents a transfer of a well-established flood management practice from countries that have been using this method for decades. The project will look to these areas for best practice approaches that can be adapted to the B&H context. The project will collect lessons learned from all activities and facilitate dissemination of successful approaches in the country. The successful practices will be codified in a form of guidance documents and upscaling in the rest of the country will be promoted as the guidelines and tools on how to undertake flood risk management for any part of their territories. This activity will document and mainstream non-structural measures into FRM policies and practices. The project will develop country-wide best-practice guidelines, technical specification, standards and protocols for the application of eco-system based non-structural measures and will undertake capacity development in the application of these to the identification, prioritisation, assessment appraisal, design and implementation of such solutions.



Sub-Activity 2.3.1: Develop best-practice guidelines for non-structural measures

Develop the methodology and guidance for undertaking river basin analysis of the local socio-economic, environmental, and institutional conditions that would underpin the selection and design of basin appropriate EbA solutions.

1) Develop the methodology for system evaluation to determine the pre-existing types of ecosystems and abiotic processes and identify opportunities and constraints for effective conservation and restoration of ecosystems
2) Develop methodology and guidance for undertaking risk assessment and appraisal of EbA measures, by adapting traditional risk assessment and appraisal methods for nature-based solutions, to incorporate the full range of benefits generated by nature-based projects. This will

[40] http://documents.worldbank.org/curated/en/739421509427698706/pdf/120735-REVISED-PUBLIC-Brochure-Implementing-nature-based-flood-protection-web.pdf
[41] Guidelines for Ecosystem-based Approaches to Climate Change Adaptation and Disaster Risk Reduction

include guidance on benefit assessment to quantify ecosystem and socio-economic benefits based on the principles of eco-system based services benefits to be derived EbA solutions, and incorporation of projections of future changes in risk as a consequence of climatic, socio-economic, and institutional changes, taking account of the dynamic nature of the risk reduction functions of natural ecosystems including the evolution of ecosystem services over time.

Sub-Activity 2.3.2: Develop technical specification, standards and protocols for design and implementation of non-structural measures

1) Review existing international technical specifications, standards and protocols for the design and implementation of nature-based structures and adapt and develop same for B&H. This should include performance standards as well as mechanisms for monitoring and measuring performance standards to allow for standardized quantification of their effectiveness in reducing hazard or exposure in B&H and reduce uncertainties in design. Such standards and associated performance measures will enable comparison with conventional engineering interventions.
2) Develop a knowledge portal and common resource centre to collect, collate and share knowledge and fill these gaps to advance uptake of nature-based solutions. Developing and applying quantifiable engineering protocols for ecosystems will require close collaboration between ecologists, or specialists with a strong understanding of the natural systems, and engineers. A knowledge portal of this nature allows to co-working and knowledge sharing.

Sub-Activity 2.3.3: Review and implement training required for new non-structural measures

Training will be for 200 FRM practitioners at all levels and all relevant types of stakeholders (entity, municipal, community). Practitioners will include, Water Agencies, Agricultural extensions services experts, municipalities, Forestry departments, Agriculture departments, design companies.

1) Undertake training in the methodology and guidance undertaking risk assessment and appraisal of EbA measures.
2) Undertake training in methodology for system evaluation
3) Undertake training in eco-system valuation methods, and eco-system benefit assessment as part of CBA.

Activity 2.4: Review and strengthen institutional capacity and develop long-term institutional capacity development plans for climate resilient FRM. (GCF Financing = $300,000; Co-financing = $500,000

Technical expertise and experience in flood and disaster management and emergency response is present, in B&H. However, while technical expertise exists for specific technical areas, awareness and knowledge of climate-resilient approaches to flood risk reduction concepts and practices are areas for improvement. Technical capacities related to risk identification and assessment, prevention, risk reduction, risk transfer, preparedness, climate risk management and climate change adaptation are rather limited.

The activity will implement country-wide training programmes in the technical and practical areas of flood risk management for practitioners, decision-makers, communities, emergency responders. Under the Vrbas project an assessment of state, entity and local capacity was undertaken and gaps were identified. The composition of the relevant state, entity and local government departments was also mapped and assessed to determine their functions in flood risk management. Having mapped the institutional capacity and assessed gaps and training needs, an institutional capacity building plan was developed which identifies gaps in staffing levels and gaps in required skills, and outlines the recruitment and training needs to fill those gaps. The GCF project will update the capacity development plan and implement its main recommendations. This will include, adding climate risk management and flood risk management sessions to the trainings for all FRM practitioners, to improve the technical capacity and knowledge base for climate risk management and a long-term adaptation planning for flood risk management, introduction of advanced tools and methods in FRM that are scientifically sound and evidence-based, examination of the feasibility of establishing a University MSc. course in CR-FRM at local Universities, develop training plans for each technical area of expertise related to climate-induced flood risk assessment and management, and consolidation into an overall revised capacity development plan.

Sub-Activity 2.4.1: Embed FRM training in existing government training programmes for long-term FRM training in B&H

The project will embed training in FRM and the use of climate risk information in the relevant entity training institutions to improve the technical capacity and knowledge base for hazard and flood risk management, based on a Training of Trainers (ToT) in the below topics. Capacity development for each of the interventions/components will leverage existing and establish new partnerships with organisations such as the WMO regional training centers, UNESCO/ITU ICT4D and other DRR institutions, as well as national and regional research institutions, universities and training centres. In addition, the project will build partnerships with universities, and other academic research institutions to embed capacity. In particular, the project will work with NGOs to deliver training in preparedness and awareness raising.

Key project Tasks:

1) The project will develop and establish training curricula, and rosters of trainers.
2) Develop mechanisms for delivering long-term capacity development such as development of key partnerships with universities that can be forged to ensure long-term FRM training.

Sub-Activity 2.4.2: Develop a costed and prioritised institutional capacity development plan to address technical, functional and human capacity gaps identified through the completed institutional capacity assessment

As part of the Vrbas project, an assessment was made of the existing gaps in institutional capacity for flood risk management in B&H (Annex G). Based on the institutional capacity and assessed gaps and training needs, an institutional capacity building plan will be developed and implemented to address gaps in resourcing (human, technical and financial) under the GCF project. The recruitment and training needs to fill capacity gaps will be addressed. The project will develop training plans for each technical area of expertise related to climate-induced hazard risk assessment and management and consolidate into an overall capacity development plan. A long-term capacity plan for B&H will be developed and will consider options such as the development of internships and voluntary schemes for University students, in flood risk management.

To address issues of skills shortage, skills retention and succession planning, the project will develop approaches which will include examining the role of the private sector (consultants, contractors, research institutes) in filling these gaps, the use of Continuous Professional Development (CPD) methods involving cross-fertilising of staff with skills across all organisations (e.g. through training in all technical areas before specialising), development of standardised and locally accepted guidance documents, codes and standards which will enable, consistency and uniformity of technical approaches. In order to address capacity needs identified under Vrbas project the project will focus on the following set of actions, addressing critical capacity gaps:

Key project Tasks:

In the area of **flood hazard and risk assessment, hydrometry, forecasting and modelling, EWSs**:

1) Carry out workshops on hydrometry to include modern methods and equipment specification
2) Design and put in place mentoring programme with younger engineers shadowing experienced staff with relevant institutions

3) Embedding methods for periodic review of monitoring needs and hydrometric network optimization and strategic planning for the future
4) Developing budgetary requirements for long-term maintenance of optimized hydrometric network and development of a financing model to be put forward to government for the long-term maintenance of networks (using cost-benefit modelling to support the financing model)
5) Develop curricular and conduct trainings in hydrometric network design and implementation including ToT
6) Develop curricular and conduct trainings for local O&M staff on equipment maintenance including ToT
7) Introduce university courses in flood hazard modelling and mapping (WA's and HMIs to form links to university and help introduce courses)
8) Develop curricular, conduct training of HMI and WS staff in hydrology, hydraulic modelling and GIS, flood risk assessment and mapping including ToT
9) Develop curricular for flood forecasting procedures and undertake ToT
10) Develop curricular for flood warning procedures and undertake ToT
11) Develop curricular for Common Alerting Protocols and undertake ToT
12) Develop curricular and conduct training of WA and HMI staff in remote sensing including ToT
13) Develop curricular on the new FFEWS system for all institutions involved in FFEWS as identified by institutional mapping and institutional arrangement plan for FFEWS and undertake ToT

In the area of **vulnerability and risk assessments**:

1) Introduce university courses on gender sensitive vulnerability and risk assessment and modelling (WA's and HMIs to form links to university and help introduce courses)
2) Develop capacity in the assessment of damages, losses and risk to life will require specialist training of individuals already involved in economics assessments
3) Develop curricular and conduct trainings in damages and losses assessment including ToT

In the area of **river basin flood risk management planning and the use of climate information:**

1) Develop curricular and conduct training in Strategic FRM planning and FRM intervention identification approaches including ToT
2) Develop curricular and conduct training in land use policy and construction permitting system including ToT
3) Develop curricular and conduct training on proposed new floodplain development zoning policy regarding for various sectoral ministries and institutions including ToT
4) Develop curricular for training on the application of EbA for flood risk reduction and management
5) Awareness raising workshop for all government departments. Use of the project developed website to store hazard and vulnerability information including maps.
6) Targeted awareness and learning events on flood risk assessment and management for relevant sectoral investors (Ministry of Energy, Hydropower sector, hydrothermal, agriculture sectors)
7) A series of targeted training workshops for municipalities
8) Workshops and round tables on risk management financing and risk transfer instruments

Sub-Activity 2.4.3: Implement community-based training and awareness raising initiatives at community level

The GCF project will assist the government of B&H in shifting from ad-hoc project-based awareness and education efforts to a planned, consistent and sustainable information and communication system for enhanced flood and disaster risk management. To this end, it will develop an awareness raising campaign which will include the following:

Capacity building at municipal and community levels:

1) Emergency response trainings for first responders in cooperation with Civil Protection
2) Strategic FRM planning and FRM intervention identification approaches for municipality staff
3) Development/adaptation of existing guidelines on community DRR/DRM
4) Development of FRM, DRR and DRM guidelines for specific target groups including teachers, municipal authorities, media, women's groups;
5) Capacity building and awareness raising of municipal authorities, local NGOs, CBOs or non-CBO community members in Community-based Risk Assessment approaches, Community-based Early Warning Systems and gender-responsive Community-based Flood Risk Management;
6) Development of 'training of trainers' programme and a syllabus for topics such as first aid, search and rescue and warning dissemination, and example standard specifications for external training providers
7) Working with the appropriate agencies to develop generic educational material and a 5year training programme on flood and disaster risk and emergency response for use in school outreach programmes, university courses, communities etc. (training material, course notes, plays etc.)
8) Training on how to use the hazard and risk maps provided (paper and electronic) to raise awareness but also on how to plan development and other activities locally.

Networking and advocacy:

1) Organizing annual community forums on FRM and CBEWSs with participation of target communities and representatives of vulnerable groups to exchange information, lessons learned, successes and impediments;
2) Organizing community-government and public-private dialogues around local risks and risk reduction strategies and their financing.

Country-wide media campaign on FRM and FFEWS:

1) Develop and deliver awareness raising messages through a number of methods including using social media, art and creativity to communicate FRM and FFEWS concepts to broader society and to disseminate project lessons and successes;
2) Organizing TV and radio talk shows around FRM and FFEWS;
3) Media coverage of project activities;
4) Production of footages, Public Social Announcements (PSAs) of short documentaries around FRM and GCF project achievement
5) Training for media on FRM and FFEWS and annual essay/media article awards competitions.

Result 2: **People and livelihoods are informed and benefiting from nature-based flood risk measures**

Measurable change:

- EbA approaches to flood risk reduction are mainstreamed through policies, regulations and awareness building among decision-makers and communities
- Community-based EbA flood risk reduction measures implemented
- Country-wide floodplain zoning policy and sectoral climate-resilient flood risk reduction plans
- 200 FRM practitioners are trained in and skilled to lead climate risk management and a long-term adaptation planning for flood risk management.

10.3 OUTPUT 3: CLIMATE-PROOF FLOOD PROTECTION MEASURES SCALED-UP THROUGH NEW AND IMPROVED NATIONAL AND LOCAL INVESTMENT FRAMEWORKS INCREASING RESILIENCE OF THE MOST VULNERABLE GROUPS TO CLIMATE INDUCED FLOODING

Activity 3.1: Develop investment framework for climate induced flood risk reduction and management. (GCF Financing = $480,440; Co-Financing = $603,174)

The project will develop a strategy and tools for private sector engagement in long-term climate change-induced flood risk management. During proposal development some willingness to pay surveys were undertaken, for a number of sectors and different types of beneficiaries, that will contribute to the effective long-term management of flood risk management and risk reduction. The survey identified key private sector players with a willingness to pay for flood insurance as a key mechanism of transferring risk. Private Sector interest in sector-specific climate risk information products, and their willingness to pay for tailored products that will be used in their operations, and their willingness to support or partially support the O&M of hydrometric monitoring and early warning systems, equipment and information products has been assessed and determined through extensive consultation during proposal development.

Based on these assessments the project will develop the most appropriate mechanisms for risk transfer, risk financing and supporting cost recovery mechanisms from a variety of sources. The Activity will also include the development of policy and legislation for private sector engagement in climate risk financing and for risk transfer mechanisms such as flood insurance. Under the Vrbas project, a risk-based flood insurance scheme was developed including specific products. During project preparation, Willingness to Pay surveys concluded that there is significant interest and feasibility for scaling-up the flood insurance scheme to a scheme applicable for the whole country. Development of risk financing and transfer mechanisms will be further elaborated based on detailed socio-economic risk, damages and losses assessment. The development of flood risk financing and risk transfer mechanisms through embedding in policy and engagement of private sector will ensure the long-term sustainability of flood risk management in B&H.

Sub-Activity 3.1.1: Develop investment framework for climate induced floods risk reduction and management including provisions for public and private/productive sector engagement in climate risk financing

Public-Private Sector climate risk financing

Opportunities to scale up public-private collaboration on building climate resilience are largely underexplored to date. This is partially because resilience is often been viewed as the responsibility of the public sector. However, successful businesses can adapt in a continually changing market. Building resilience to direct and indirect risks whilst continuing to operate in the marketplace is becoming more and more necessary, particularly for private sectors that are highly exposed to and impacted by climate-induced risks. To make substantial and long-term changes, businesses need to understand the return on investment of resilience building actions.

The types of risks faced by the private sector may include the following:

1) *Physical damages to assets and infrastructure:* Damage to a company's assets and the infrastructure on which its operations depend (e.g. roads, bridges, electricity, water). This can affect site location and ground conditions – asset design, performance and integrity.

2) *Disruption of value chains:* Availability, quality and yield of natural resources, raw materials and components; the reliability of transport links, manufacturing and processing operations; and distribution to markets.
3) *Changing downstream market conditions:* Climate-induced events and their impacts can affect the demand for a business' products and services, with new competition emerging to meet new market needs and/or through damages to its reputation/brand position. This will, in turn, have impacts on its competitive advantage within the relevant market segments.
4) *Regulatory and policy risks:* To mitigate physical climate risks on the economy and society, governments at all levels may implement new regulations, laws or policies that affect businesses and their operations. Such regulations may also be created to require businesses to undertake actions, or to control the way in which they operate.
5) *Disruption of internal production (including workforce):* As a result of climate impacts on its assets and supply chains, as well as on public infrastructure, a business may not have the capacity to continue its operations/production; impacts may also affect working conditions.

Businesses may choose or combine approaches to avoid, reduce, share or accept each risk, depending upon their risk appetite. Basic risk mitigation actions include: Physical (e.g. infrastructure design improvements or retrofit); Social (e.g. behavioural change and education); Financial (e.g. use of risk transfer products such as insurance). Businesses already act to reduce direct operational risk, identification and targeting of planned responses to significant business risks. Where a clear and quantified return on investment is evident, action is planned and implemented. However, identification of new risks (e.g. climate change or a historically unprecedented disaster) is often lacking. Prospects also exist for some businesses and sectors to develop new and innovative products and services targeted at building resilience. This brings economic benefits in the form of growth and jobs, but also reduces vulnerability and risk within their markets.

Common barriers to identifying and address emerging climate risks for business includes:

1) A lack of relevant risk information - Limited or no access to information or tools to assess risks and opportunities related to climate change;
2) Low levels of capacity and skills required to address climate risks for the sector - Lack of availability of or access to advanced technologies, tools and structures;
3) Lack of institutional capacity or weak governance arrangements - Non prioritisation of resources to implement resilience measures;
4) Lack of financial resources and budget constraints; limited or no access to finance;
5) Weak knowledge management structures to share good practice;
6) Inadequate policy, regulatory and legal environments; regulatory - Lack of policies, laws and regulations encouraging or requiring climate change adaptation, e.g. lack of disclosure requirements on climate risks by the financial sector; adverse effects of policy and regulation on business motivations for investing in adaptation, e.g. water pricing/ abstraction licensing, building codes/planning regime;
7) Other stakeholders' reaction to climate variability and change. This may result from a lack of education, limited skills and limited awareness on the topic. Inequitable gender norms for instance, can hinder women's participation of adaptation activities, e.g. setting-up a business or leading community activities, which in turn may negatively affect the efficiency and effectiveness of adaptation efforts. and
8) Domestic infrastructure constraints.

There are also collaborative challenges to investing in climate resilience, including investment into community-based FRM schemes that relies on multiple financiers, community cooperation and local government approval. Risk data to inform investment can also be difficult to attain without collaboration.

In addition to develop new resilience-related products and services, different private sector actors may have different needs in terms of the support they require, or the gaps or barriers that were preventing them fulfilling a resilience related opportunity. Barriers exist to develop and commercialise new resilience related products and services in emerging and developing markets. Most significantly, strong access barriers exist that are specific to a local economy further supporting more holistic but sector-focused market intervention. Market barriers include inadequate corporate laws, weak incentives, dilapidated or underdeveloped public and financial infrastructure, underlying corruption; and security related constraints. There are also challenges in understanding and stimulating the demand profile of potential markets, for example due to low risk adversity and/or low purchasing power of the local population. Hence range of barriers may need to be addressed at the same time to unlock a solution for a sector.

Key project tasks will include:

- Using the flood hazard and risk modelling results of Activity 1.2, undertake a detailed assessment of the socio-economic risks, damages and losses to priority public and private sector categories, identifying overlaps between the government's priorities and private sector interests. Facilitate dialogue between relevant public and private sector players to map the adaptation priorities of the Government with that of the sector companies/businesses. Develop sector-specific documentation on various approaches for the private sector to be active in the climate resilience. Identify public-private partnerships, and develop strategies, plans, projects and implementation plans for PPPs
- Working with the relevant priority public and private sectors develop the relevant sector resilience strategies and plans for long-term ongoing investment frameworks that would be required to address flood risk to each sector. Under Activity 2.1, strategy and action plan for delivery of flood resilience in Hydropower, agriculture and forestry sectors will be developed along with tools for addressing flood risk.
- Develop sector specific awareness campaign for the private sector on climate-related risks and associated opportunities, including documentation and dissemination of sector-specific business cases for climate change adaptation;
- Access to climate risk information and technical resources for the private sector to have the necessary capacity and expertise to address climate risks and create opportunities by investing in climate change adaptation; Development of Sector-specific information dissemination portals as part of the information platform to be developed under 1.4.3
- Incentivisation – mechanisms for enhancing access to finance to improve the risk–reward profile of private sector investment in climate change adaptation;
- Reforming the regulatory framework to ensure policies, laws, and regulations create an enabling environment for private sector investment in adaptation;
- Strengthening governance by bringing together private, public and civil society actors to mainstream climate change adaptation in their decision-making processes and develop partnerships and collaborations.
- Develop a strategy and tools for private sector engagement in long-term climate-proof risk management; Under Activity 1.4, the project is developing climate risk information tools and products to support decision making, understand and assess risks and opportunities and/or identify potential adaptation measures. This will help them make more informed decisions to manage and minimise existing or emerging risks while taking advantage of investment opportunities emerging from a changing climate.
- Develop a strategy and plan and provide technical assistance to financial institutions to mainstream climate change risks into their business models to manage the effects. Given their key role both as providers of finance and as investment facilitators to enterprises, these institutions must develop a consistent view on climate-related issues that can serve as the basis for strategic and operational decisions across a range of business units. This is particularly true for the most climate-vulnerable sectors, such as agriculture, water resource management and infrastructure, which represent some of their largest areas for investments.
- Development of risk financing and risk transfer mechanisms strategy to include private sector engagement strategy for long-term implementation of risk financing and risk transfer mechanisms for entity-level flood risk financing and resilience strategy;

Sub-Activity 3.1.2: Develop risk financing and transfer mechanisms based on detailed socio-economic risk, damages and losses assessment

Addressing climate risks could bring opportunities for private sector related to managing existing physical climate risks. Climate change already affects private companies throughout their value chains, and the effective management of these risks may create opportunities to improve financial performance. By managing existing risks through, for instance, contingency planning, market diversification or site retrofits, businesses may benefit from improved processes, increased efficiency and savings. As such, avoiding the costs of physical climate risks can then be seen as an opportunity. Opportunities may also arise in responding to new emerging physical climate risks. As the effects of a changing climate become more visible, it is inevitable that new physical impacts will emerge that require responses. Opportunities may arise from planning ahead to manage emerging physical climate risks. This would give companies the 'first mover's advantage'. For instance, access to accurate weather forecasts gives hydropower companies the ability to plan their generation more efficiently and avoid costly safety-related emergencies. For private financiers, the changing risk landscape and the adverse/ beneficial impacts on value chains will create additional demand for finance and advisory services. The fundamental shifts in climate will affect value chains and drive new consumer needs, thus providing opportunities to adapt to market shifts and cater to new market needs. For example, construction businesses may take advantage of a higher demand for water-permeable pavements, or technology to keep buildings cool as a result of a changing climate. In a similar manner, the agribusiness industry may need to respond to higher demand among farmers for technologies to improve water and energy efficiency, as well as climate-resilient crops. Private financiers in turn may benefit from private companies' higher demand for loans to access such technologies and for innovative financial instruments to cope with loss and damage associated with more severe or frequent climatic events. Under this activity, the project will develop the financing mechanisms for forecast-based financing (FbF) to be included in municipal investment plans. A key element of FbF is the allocation of financial resources in advance for the anticipatory response to disasters, based on specific forecast threshold that triggers the release of those resources for the implementation of early actions based on an Early Action Plan (EAP). Under this output the project will develop mechanisms and tools for ensuring financing for early action interventions to be included in the EAP and the municipal investment plans (See Activity 3.2 below)

Key project tasks include:

1) Identification or public-sector risk financing mechanisms for flood risk management; Identify and develop Risk financing and transfer mechanisms products and tools, based on detailed socio-economic risk, damages and losses assessment;
2) Feasibility studies of all identified and shortlisted risk financing mechanisms based on Vrbas project, development of flood insurance models for the assessment of premiums and pay-outs of flood events of different return periods;
3) Technical assistance to financial institutions and financiers, including micro-financing institutions, for the development of lending products to mainstream the use of climate-risk information into their lending processes that maximises performance and minimises risks and to provide loans to climate responsive/resilient enterprises in B&H (i.e., loans that offer better conditions than the current market practices to borrowers - the conditions are interest rate, loan period and easier credit criteria). These loans will service Small and Medium Enterprises and will provide loans for start-up or expanding climate resilient enterprises, or climate proofing the enterprise.

Sub-Activity 3.1.3: Design natural disasters insurance scheme and explore and identify other risk financing products and tools

Under the Vrbas project a feasibility study for a flood insurance scheme for Vrbas basin explored the potential of developing property or infrastructure investment insurance products that can provide strong flood exposure signals and steer the new infrastructure, settlement development and expansion away from high risk zones. The feasibility study identified the type of scheme that would be most appropriate for B&H

and considered ex-ante, ex-post, index-based, and indemnity-based schemes, with various configurations of government role. The feasibility study included a review of data availability for the development of the identified preferred scheme.

Based on the feasibility study and the identified type of schemes and consultations with key stakeholders (community, municipality, private sector companies, insurance companies) on the proposed flood insurance scheme and the insurance zone designations revealed general acceptance of the proposed scheme. The results of willingness to pay surveys for insurance (Annex H), showed that all assessed sectors (households, public institutions, business subjects, agricultural producers) have relatively high needs for insurance from natural disasters considering the situation and level of development of insurance market in B&H. There is a significant potential for development of insurance package from natural disasters for all four assessed segments. A high percentage of respondents are not inclined to risk retention in all assessed sectors, representing a potential for change of their attitude and behaviour towards the insurance from natural disasters. The respondents had positive attitude to obligation to insure from assessed disasters by lower price compared to the commercial one. For households, the fixed anticipated premium and insured amount for construction part of building and assets is determined - for insurance from floods, landslides, earthquakes and storms. For households, the variable premium and insured amount is estimated as well. Fixed expected premium and insured amount will be determined for agricultural producers for insurance from floods, drought, hail and other disasters. The project will scale up the flood insurance scheme for individual housing developed under the Vrbas project, and develop other schemes for public buildings, businesses and agriculture and will implement many of the recommendations of the WTP study.

Key project tasks:

1) Identification of potential sector-specific natural disaster (including floods) insurance product packages for insurance in each of the defined sectors, based on studies to estimate cost-benefit,
2) Provide technical assistance and training of insurance sector practitioners in the development of insurance products packages from natural disasters adjusted to the needs of the assessed sectors and insurers.
    a. Scale up the household insurance product developed under Vrbas project.
    b. Design the insurance products package from natural disasters for business and public sector subjects.
    c. Design and introduce insurance product for agriculture;
3) Develop sector-specific awareness raising and knowledge management tools on importance of insurance from natural disasters
    a. Develop and implement an ***awareness campaign for citizens*** on importance of insurance from natural disasters, taking into consideration the entity, experience with damages, awareness on exposure to risks of natural disasters, willingness to insure residential buildings/houses from natural disasters, inclination to purchasing commercial assets insurance products, inclination to the risk retention, etc.
    b. For the public sector, develop and implement an intensive marketing campaign, including awareness on importance of insurance, as well as confidence building in insurance industry, with emphasis on coverage of the flood damages. Determined parameters in terms of median value of annual insurance premium for construction part of public building(s) or equipment from natural disasters, as well as median value of anticipated compensations for the damages caused by natural disasters, the price and scope of coverage for insurance products.
    c. Develop and implement an awareness campaign for management of **business subjects** on importance of insurance from natural disasters and building the confidence in the insurance system. In that sense, it would be necessary to consider the variables pertaining to the need for insurance from natural disasters, such as experience with damages, awareness on exposure to risks, inclination to insurance of assets, inclination to the risk retention, etc. The campaign should be organised for big enterprises as well but focusing on the early warning system about future floods and/or torrents, as well as other natural disasters threatening the performance of activities by those businesses.

d. Develop and implement an awareness raising campaign for the **agricultural sector** on natural disasters, their hazardous effects, and the agricultural producers should be educated about benefits and opportunities for purchase of insurance (through brochures, training programmes, counselling, etc.). Campaign should include a clear definition of the role of state and/or local self-governance units, public-private partnership, in risk financing options for farmers to be provided insurance policies at subsidized prices.

4) Develop and implement a programme of engagement of relevant state institutions, insurers and reinsurers, financial institutions, capital market institutions, etc.
5) Undertake a feasibility study into the introduction of micro-insurance for agricultural producers, entrepreneurs and small and medium-sized enterprises in different industries.
6) Feasibility study of a connection between micro-insurance and microfinance. In order for the micro-insurance program to be implemented in practice, changes to the current regulations in the field of insurance are necessary. The micro-insurance concept is mostly unknown in B&H, while the microfinance sector, however, is quite well-developed and regulated, which is often prerequisite for the successful launch of microinsurance in a new market.
7) Feasibility study for creating a regional disaster risk insurance micro-insurance program to increase the degree of diversification of risk.
8) Feasibility of issuing catastrophe bonds to transfer disaster risk to the capital market. In addition to insurance and reinsurance companies and other business entities, these bonds may also be broadcast by governments of countries in order to mitigate fiscal pressures after the realization of catastrophic adverse events. Catastrophe bond issuance helps governments and public entities to transfer the natural disaster risks to the international capital market. In this way, multi-year protection is provided for the covered risks at a fixed price and the government can diversify its risk financing strategy.

Sub-Activity 3.1.4: Develop tool for appraisal-led design for structural and non-structural FRM measures, FRM investment planning, climate risk financing mechanisms and for appraisal-led FRM options design and decision-making, based on cost benefit analysis (CBA) approaches

The project will scale up the bespoke GIS-based socio-economic risk model that was developed for the Vrbas project to provide a country-wide tool for flood risk assessment, cost-benefit analysis and the identification and appraisal of climate resilient intervention measures for use in strategic planning, development risk financing, transfer and management strategies and investment planning in the future. The hazard maps to be developed will be used in combination with infrastructure (bridges, roads and buildings), land use (settlements, agriculture, grazing lands, and conservation areas), property and socio-economics data, to model the socio-economic impacts of each hazard and produce vulnerability maps. This vulnerability map based on the accurate hazard mapping of the current situation will form the baseline. The tools will calculate direct and indirect, tangible and intangible damages and losses including to infrastructure, agriculture property, along with concomitant social effects associated with loss of potable water and agricultural productivity. The baseline model will form the basis of future appraisal-led flood risk management and risk-informed infrastructure planning. Quantification of damages and losses will be linked to a CBA module to be developed as an additional module under the GCF project to enable identification of flood risk financing requirements, and strategies from which annual investment plans can be developed. The project will develop a unified methodology for appraisal-led design for structural and non-structural measures using climate risk information and cost-benefit appraisal methods and application of methods to the detailed design of prioritised structural and non-structural measures.

FRM practitioners will be trained in the use of the appraisal methods and models and importantly, capacity will be built to enable the use of updating and maintenance of the models. Municipal planners and managers will also be trained in the use of the models for appraisal-led FRM planning.

1) Development of unified methodology for undertaking cost-benefit analysis and CBA of FRM interventions and investment planning
2) Extension of the socio-economic GIS-based damage and loss modelling tool to include CBA of FRM interventions.

3) Develop and deliver a training programme on the new tool

Activity 3.2: Formulate multi-year climate resilient municipal investment plans and gender responsive community preparedness plans in selected municipalities (10-12) and in one canton in Vrbas, Una-Sana and Bosna, Drina, Neretva and Trebišnjica basins. (GCF Financing = $525,000; Co-Financing = $3,097,884)

Based on the risk financing and risk transfer strategies and tools developed in 3.1, the project will develop municipal investment plans for climate-resilient investment planning for flood risk management in 10-12 municipalities and 1 canton in the Vrbas, Una-Sana and Bosna basins. The most vulnerable municipalities and cantons will be identified from the enhanced WBIF hazard and risk modelling and mapping to be undertaken under Activity 1.2. Municipal investment plans will be based on cost-benefit analysis and appraisal-led identification of climate-risk informed structural and non-structural FRM requirements and will identify both public and private finance mechanisms.

Sub-Activity 3.2.1: Develop municipal investment plan for climate-resilient FRM planning for 10-12 highest risk communities and 1 canton

The project will develop and implement new approaches to investment planning to ensure that investment including annual and periodic maintenance of FRM interventions which can be met in the long-term and will include climate proofing as well as funding anticipatory response to flood events (FbF).Approaches will include:

1) Identification of financing models for investment maintenance costs (e.g. of community-based scheme that involve the use of tariffs or in-kind contributions to establish municipal maintenance programmes or engagement of private sector in infrastructure maintenance financing).
2) Development of municipal FRM investment plans based on risk-informed project designs, including maintenance, and costs-benefit analysis based on CBA methods and models.
3) Event-based forecasting of financing that will be required to respond to disaster events (FbF). For FbF, the investment plans will define the financial resources that will need to be made available in advance of flood events, based on the specific forecast threshold (See Activity 1.3) that would trigger the release of those resources for the implementation of early actions. The Early Action Plan (EAP) will be part of the preparedness response plan, and will outline the roles and responsibilities of those involved in implementing the early actions. The project will work with Red Cross Society of Bosnia and Herzegovina and the International Federation of Red Cross and Red Crescent Societies (IFRC) to develop the FbF components of the municipal investment plans and the EAP (See sub-activity 3.2.2 below).
4) Use of municipality investment plans for technical justification for budget allocation to cover investment and maintenance cost for FRM activities.
5) Project will assist government in identifying and prioritising flood risk financing, based on the principles of portfolio risk assessment (PRA) and associated cost-benefit analysis. Furthermore, the CBA tools to be developed by the project will be embedded in municipality as a standardised requirement for developing annual infrastructure investment plans.
6) As torrents management comes directly under municipal jurisdiction, these infrastructure investment plans will include detail design for torrents management
7) Formulate multi-year climate resilient municipal investment plan and gender sensitive community preparedness plan implemented in the highest risk municipalities (10-12) and 1 canton.

Sub-Activity 3.2.2: Develop preparedness plans for 10-12 highest risk communities and 1 canton

Using the example of Community Emergency Flood preparedness plans the GCF project will support the development of community preparedness plans for the the most vulnerable 10-12 communities in target basins, excluding Vrbas in line with the procedure, methodology and content of CEFP in B&H as defined by Law of Protection and Rescue in RS and FB&H including cantons. In accordance to the Law, the CEFP will consists of the following documents: Vulnerability and risk assessment, Prevention plan, Preparedness plan, Mobilisation plan, Emergency plan, Evacuation plan

For each high-risk community, the following key tasks will be undertaken in development of the plan:

1) Establish of Community Group: a community group in each community comprising relevant householders, business and community leaders, working together as a community or group to complete a plan will help in responding quickly when flooding happens and what practical actions to take before and during a flood, helping reduce the damage flooding can cause.
2) Raise awareness of the flood risks in the community: Develop an awareness raising plan for the community. Prior to a flood, the flood community group should promote awareness to householders within the community of the actions and responsibilities they have in regard to preparing, responding to and recovering from a flood.
3) Identify the flood risks in the community: local knowledge on how every community has been flooded in the past or how it is likely to flood in the future should be gathered. All the properties within the community at risk of flooding should be listed, including property other than homes damaged by flooding (e.g. where gardens or cars were damaged by floodwater). These lists will help to form a flood plan and enable the group to target resources to specific areas. This exercise should be completed using the Flood Risk Assessment (FRA). A detailed community FRA, should be undertaken using the detailed flood hazard and risk results and validated using historical information from the communities and with local knowledge of known flood events.
4) Identify vulnerable people that are at risk of flooding: Some members of the community may be at greater risk from a flood than others due to their age, disability, or illness (both short term and long term). Vulnerable people should be identified prior to a flood so that providing assistance to them is included in the flood plan. People in the community should be encouraged to contact the flood plan group if they feel they might need assistance, even if it is only during a short period of time.
5) Identify community resources: the community should be aware of the flood protection products available and especially communication equipment
6) Evacuation routes and centres should be identified and properly disseminated throughout the community. This identification should be carried out considering both historical flooding and information from the flood hazard maps (i.e. including future flooding with climate change considerations).
7) Develop a Communication Plan: the communication plan should cover all different possibilities. The deployment and use of communication devices within the community should be undertaken considering that all the different households are covered and that household members understand the meaning of the warnings and the associated actions. Also, a detailed list with all the different contact numbers should be compiled. Floods can occur when people are working or are away and may need to be contacted, and also when they are sleeping, and this should be taken into account. Designated people should keep the list updated and keep the list with the flood emergency plan. It should be decided in advance how a flood alert is to be communicated.
8) Develop an Action Plan: once the flood risk, the vulnerable people and the community resources are identified, safe actions to be taken by residents to protect against those risks should be decided and disseminated throughout the community. The proposed actions should be realistic and safe. Also, actions regarding the vulnerable people in every community should be agreed. Actions could include: moving valuable possessions, furniture and paperwork upstairs; switching off water, electricity and gas supplies if needed and switching them back on when it is safe to do so; gathering together prescribed medication and repeat prescriptions if it is likely that they may need to be evacuated from their home.
9) Test the flood plan: a dry-run of the community emergency flood plan should be undertaken with as many as possible community members participating.

Activity 3.3: Implement climate-proof structural flood risk reduction and anti-erosion interventions in Vrbas, Una-Sana, Bosna and Drina river basins. (**GCF Financing = $875,280; Co-financing = $20,939,153)**

This activity will focus on implementation of priority structural flood risk reduction interventions for areas at highest risk.

The structural measures will be financed through loan resources and Water Agencies. The priority will be given to multi-purpose structures combining benefits of flood protection, agriculture and hydropower generation. GCF funds will provide technical assistance to co-finance design of climate resilient flood defences as part of a strategic river basin approach which will include structural and non-structural measures to address climate change. The project will embed climate-change responsive design of flood defences and will develop standard methodologies, tools, guidelines and capacity for climate resilient flood defence design and implementation. It will utilise flood hazard and risk modelling and will embed CBA and appraisal-led prioritisation methods in developing and implementing structural measures that maximise benefit, make allowance for climate change and which consider environmental impacts.

This activity will be implemented in the Vrbas River basin based on the climate risk information generated by the UNDP/SCCF project (risk maps, climate and flood modelling, socio-economic risk information) and in the Una-Sana and Bosna river basins for which some geodetic surveys and hydrological modelling already exists, and for which detailed modelling will be done under WBIF and enhanced under the GCF project. The Vrbas experience will be replicated in the other basins.

Sub-Activity 3.3.1: Finalize detailed design of climate resilient flood protection structural measures

A number of structural measures have been identified by Water Agencies, for implementation under the GCF project using climate proofed designs (Annex B). A detailed description of the socio-economic options identification of the priority EbA measures is given in Annex E Section 18.10 below). Some of these measures will be co-financed by EiB loan. All climate proofing detailed designs of the measures will be financed by the GCF project.

An initial appraisal of the measures has been carried out based on existing flood risk information and local understanding. As part of project formulation, the measures underwent Social and Environmental Screening in line with GCF criteria, and the environmental and social management framework (ESMF) and plan (ESMP) for the project was developed. During project implementation, a deeper appraisal will be undertaken to confirm the performance in terms of flood damages reduction, technical feasibility of implementation, social and environmental safeguards. Changes in flood levels with the implemented measure against the baseline scenario will also be assessed. The reduction in damages resulting from an option (as compared to the baseline) represents the option benefits. As part of the overall project economic analysis, the structural measures to be implemented under the project as co-financing, has been assessed using CBA methods (See Annex III of the proposal, Annex E of the FS). A brief summary of the assessment of technical benefits and CBA of each structural measure is provided below.

Detailed Design Process

The project will apply the methodologies developed in Sub-Activity 2.1.3 for climate resilient flood defence design to undertaken climate resilient detailed design for all structural measures to be implemented by the project. The approach for detailed design will be as follows:

Field Surveys

- *Inspection of works location and stakeholder consultation*. Inspection of existing locations will be undertaken with WA representatives, which will allow the arrangement of existing features to be confirmed, and a high-level assessment of the condition of any existing structures to be made. The inspection will be documented using photographs and standardized record sheets, which will be held for use during the remainder of the project.

- *Survey*. Following the initial site inspections and review of available data the design team will scope, specify, supervise and review the survey. Standardized survey specifications and requirements will be used. Typical topographic surveys are likely to include: (i) establishment of a control network, including permanent ground markers, referenced to the same datum as the DEM data and suitable for use during construction/implementation of the infrastructure units; (ii) recording position and level of all features of significance; (iii) recording ground levels between features at an appropriate grid spacing.\; (iv) recording river/stream channel cross sections above and below water level at specified intervals.
- *Ground Investigation*. The scope, specification, supervision and requirements for geotechnical investigations will be defined to provide engineering properties of native ground and any existing earth structures and the necessary surveys undertaken. Where appropriate to the works required, ground investigations will comprise boreholes or, where appropriate, trial pits. Samples will be collected for laboratory testing and Standard Penetration Tests carried out to allow soil properties to be estimated. Where appropriate to the works required, sediment samples may also be collected from nearby riverbeds, channel bars, and banks, and analysed for particle size distribution in order to assist with the design of any dredging and scour protection works. Where sources of borrow material can be identified samples of possible fill material will be collected for laboratory testing to determine the soils' suitability for use in earthworks. Results of field observations and geotechnical testing will be used to determine the typical geotechnical properties for use in design.

Detailed Design:

Detailed designs will incorporate ancillary features to ensure the sustainable operation of the works. The use of appropriate vegetative surface and scour protection (indigenous grasses etc.) to control erosion of earthworks and minimize future maintenance requirements will be specified. All designs will be prepared to appropriate standards and guidance and based on the use of locally available materials. The designs will take into account the long-term objective of operation and maintenance by the municipality and local community. Durability and robustness together with ease of operation and maintenance using the local community will be emphasized.

- *Development of procurement strategy and plan:* the proposed programme of works identified at proposal phase will be reviewed and recommendations made on an appropriate procurement strategy, including consideration of packaging of works to provide economies of scale in implementation.
- *Preparation of Tender Documents:* where necessary tender packs will be prepared using Standard Bidding Documents approved by the UNDP. The project will also develop and embed a suitable standard technical specification which will become the standard bidding documents. Other elements of the bidding documents, including bills of quantities, will be standardized across packages as far as possible.

Sub-Activity 3.3.2: Implement new flood defences and the rehabilitation and upgrade of existing flood defences with climate proofing

Under this sub-activity, the investment in construction of the structural measures will be implemented (Annex A).

Contract supervision

Typical construction contracts require an organisation to take role of the Engineer, and a Resident Engineer. It is assumed that such roles will be undertaken by personnel from the competent government departments who will provide fulltime engineers for construction supervision to supervise the implementation of the works. The CRE will review all contractor submissions including method statements, programmes, progress reports, applications for payment and claims. The CRE would check and approve as built records provided by the Contractors and prepare Operation and Maintenance manuals for the specific works – generally based on a standardized template. Training in the operation and maintenance of the works will be provided to municipality and local communities who will be involved in the operation and maintenance in the future.

For each measures the site specific environmental and social safeguards plan (SESP) will be developed and implemented using GCF funds.

Result 3: Climate-proof flood protection measures increase resilience of the most vulnerable groups

Measurable change:

- Country-wide investment framework for combating floods established and integrated into key development strategies/action plans
- Private sector investment for climate-proof flood protection leveraged
- 1million people living in flood prone areas are more resilient to climate-induced floods
- 30% reduction in loses in agriculture and hydropower sectors due to hydro-meteorological disasters
- Cost of post-flood recovery operations reduced by 50% compared to the last 10-year average investment per capita of affected population and/or per affected businesses.

Climate proofing Critical Infrastructure in B&H

The Rulebook on the Design of Infrastructure Facilities and the IPPC Plant from the Flood Protection Point in B&H has not been established. Within the Social Federal Republic of Yugoslavia there were JUS standards (Yugoslav standards) and specific guidelines for the design of different facilities, and such guidelines became current engineering practice. In B&H BAS standards, based on EUROCODE European Standards and the German DIN standard, are currently in force, but there are no strict regulations on how to design from the point of view of flood protection.

The current Law on Waters of FB&H Article 96 stipulates that it is prohibited to erect buildings and other facilities, that does not have defensive role against floods and which prevent access to the watercourse, at distances not less than 10 meters from the 1/100 water level for all surface waters, the highest levels of coastal waters, unless the owner or user is conditioned to build the facility by taking precautionary measures preventing or reducing the harmful consequences of water.

The current Law on Waters of RS has almost identical article. Article 105 stipulates that it is prohibited to erect buildings and other facilities, that does not have defensive role against floods, at distances not less than 5 meters from the 1/100 water level for all waters, unless the owner or user is conditioned to build the facility by taking precautionary measures preventing or reducing the harmful consequences of water.

Hydrotechnical objects

The maximum flow rates used in the design of hydro-engineering facilities in terms of their safety, economic value, expected life span and possible adverse effects due to their demolition are referred to as relevant large waters. The choice of the maximum flow rate of a flood wave for the design of a hydro-engineering object depends on the importance of the object, the value of the object, the effects of the demolition of the facility on the downstream users, population density downstream, economic conditions of the downstream parts, etc.

For different hydrotechnical objects, different high waters are relevant for their design. Hydrotechnics objects are:

- Dams of all types and accompanying objects
- Cofferdams as temporary objects
- Buildings of hydroelectric power plants, nuclear power plants and pumping stations
- River regulation
- Sewerage in urban environments
- Channels of different purpose, especially for the drainage of agricultural lands,
- Dikes for the protection of settlements, industry and agricultural areas

- Bottom discharge on the dams,
- Docks and river piers.

The usual engineering practice is that the protective dikes rise above the level of 1/100 water with a certain over-height (freeboard) of 80-100 cm. In this way, the object's resistance to incidents of occurrence of a flood level greater than 1/100 is achieved, which can in some way cause damage to the specified objects and impair their life span and function. Protective dikes for agricultural land (so called summer dikes) are designed in such a way that the crown of the embankment is above the rank of 1 / 20year water. In dam design, spillway is calculated on the waters of a much higher return period, depending on the type of dam, from 1/5000 to 1/10 000. The river regulations dimension the ranges of the 1/100 water with an extra 80 cm over-height.

Highways and roads

For the design of highways in B&H, guidelines and rules on bridging and fault design have been developed.

For bridges and culverts, the height of the profile is determined in a way that ensures a safe high water flow and contains an adequate protection height between the high water and the lower edge of the upper structure. For bridges and culverts on motorways and regional roads, relevant is 1/100 water. The influence of hydraulic profile reduction must be taken into account. In the case of local roads, 50 years of age or 20 years of water are relevant. The protective over-height beneath the lower structure of the road structures varies within the 40 to 100 cm and depends on the size and category of the of the river and from the calculated /observed water level from hydrological yearbook. Guidelines for these structures are defined in each water management conditions prescribed by the authorized water management institution.

In engineering practice, the bottom edge of the highway bridge is elevated at a distance of 100 cm above the level of one hundred years of water. In places where there are no protective water objects, the engineering practice is to make the roadway on protective dike so that the upper edge of the road is 80 cm above 1/100 water. In this way, it is possible that in the event of a flood the road serves as a defensive dam and at the same time enables unobstructed communication.

Railroads

When designing railway bridges, there are internal rail regulations that prescribe the lower edge of the bridge at a 1/1000 water level. The same rule also defines the way of designing culverts tough the railroad dike, in order to discharge waters without the damaging impact on the infrastructure.

Plants and facilities

In B&H, a regulatory policy is enforced on plants/facilities for which environmental impact assessment is required, and plants/facilities that can be built and placed into operation only if they acquire an environmental permit.

- The energy industry (petroleum refineries, kilns, thermal power plants, land power lines of nuclear power plants and nuclear reactors)
- The chemical industry
- Metal industry
- Mineral Induction
- Waste management
- Extractive industry
- Food industry
- Textile, leather, wood and paper industry

All these facilities must have an environmental permit and an environmental impact assessment that should have an impact on flora, fauna, water, air and land. Pursuant to Article 96 of the Law on Waters of the FB&H and the Law on Waters of the RS Article 105, all existing plants, if they are within the 1/100 Waters, must take all measures to prevent or reduce the adverse effects on water or water. Unfortunately, there are no guidelines that need to be taken to reduce the harmful impact of water and on water.

11 KNOWLEDGE MANAGEMENT, LEARNING AND STRATEGIC COMMUNICATION

11.1 Introduction

The knowledge management (KM) of the project will have the following key aims:

1. To ensure access to data and information generated by the project as well as long-term access to data on which stakeholders' essential institutional functions rely and/or data and information that can be used for evidence for policy and practice advice (**connecting people to information and knowledge**)
2. Connect key stakeholder groups, practitioners and experts to ensure that key learning and experience is shared within and across sectors (**connecting people to people**)
3. Ensure staff in the stakeholder institutions know about effective and relevant KM techniques so that knowledge is shared, captured and retained by the institutions and shared within and across the sector (**institutional KM improvement**)
4. By developing and promoting KM as a tool for continuous and sustainable improvement and ensuring that KM tools generated by the project will be systematically used and maintained within the stakeholder institutions (**Developing and embedding KM tools and practices**).

At the community level the project will seek public participation and community support in the design and implementation of all aspects of the project. Co-design and engagement of communities will be undertaken through activities 1.1.2 (socio-economic surveys), which will involve the introduction of methods and tools for systematically collecting socio-economic data at all levels including community level to include 'crowd sourcing and public participatory' approaches to reporting damages and impacts of flooding. In addition, these socio-economic survey methods will be conducted alongside the awareness raising and capacity building of communities which will enable full participation of communities in the design and implementation phases of all project activities.

Under Components 2 and 3 the planning of non-structural measures will engage stakeholders and will rely on and engage communities and will be led by grass root organizations\NGOs with communities involved in planning and design/implementation of non-structural measures.

11.2 Connecting People to Information and Knowledge

New work should always build on the foundation of previous knowledge. New knowledge gained on the project will be captured and stored appropriately for others to access and learn from. The following series of tools and techniques will be employed to enable people to find information and knowledge more effectively throughout the project.

Tools and techniques	Description	Purpose	Actions
Case Study	Narrative Recording of the Project's progress and outcomes.	Share experiences with others, seeking comments/consultation, advocacy	At least 20 case studies will be generated per year of the project

Rapid Evidence review	A systematic review of research and other evidence producing overview of the knowledge base in a particular area	An evidence baseline to enable project activities to build on what has gone before	Project feasibility studies will form the project baseline which will be updated throughout the project as it progresses.
Knowledge Banks (web databases)	Repositories of stored knowledge (research/evidence/best practice), captured through various tools and techniques, and shared via websites and toolkits	Mass collection of accumulated knowledge in a specific area readily available to stakeholder	The project will develop a knowledge and data management website for all project, stakeholder and beneficiary staff

Case Studies

Case studies will be written on all key aspects of the project and could be generated from technical reports but made appropriate for a number of different audiences. Hence technically detailed studies will be summarised and made appropriate for beneficiaries, the media and other types of audiences for the purpose of sharing experience, for soliciting comment/feedback and for advocacy purposes. Cased studies will have a clear structure that brings out key qualitative and quantitative information from the project and will be published with a broad audience in mind. The project will aim to have at least 20 case studies per year of the project.

To facilitate the generation of case studies in a systematic and consistent manner, project and programme teams will be asked to capture and record their learning and best practice in photos, videos and reports, so that others can benefit. A structured case study format will be used to make information accessible to the reader. Case studies will be published on the UNDP website as well as the project portal to be developed (see Knowledge banks below).

Evidence Review

A rapid evidence review (RER) is a way of reviewing research and evidence on a particular issue. It looks at what has been done in a particular area and records the main outcomes. Evidence reviews can be run in several ways. Some are more exhaustive in their execution and ambitious in their scope. A fully-developed review will scan available literature as comprehensively as possible, using electronic databases and comprehensive sourcing. The RER provides a quicker but still useful way of gathering and consolidating knowledge. It is a useful building block from which to start work on a new topic but should not be considered a definitive review, but rather suitable as a starting point for more in-depth review, or cursory information required to start a more in-depth review. Any new piece of work is likely to draw on what has already been done by others in the sector. An RER ensures that you take account of this work before starting a project. This avoids duplication of effort and gives a foundation on which to build.

The project feasibility studies, and all supporting material gathered during project development will form the project baseline which will be updated throughout the project as it progresses thus ensuring that the evidence baseline for all project activities is always up-to-date.

Knowledge banks

Knowledge Banks are online services and resources which hold information, learning and support and also act as a project data manage and repository database. They are typically used to showcase the work of the project and provide signposts to documents, articles and toolkits.

Project Data Management and GIS

Catchment scale hazard and risk management is inevitably a multidisciplinary undertaking which will use and generate large numbers of spatial and non-spatial datasets. Under Output 1 the project will facilitate the dissemination and sharing of common and definitive climate risk information across by all sectors to embed climate risk considerations into their function, through the Climate Change and Biodiversity Centre (CCCB). It will establish an information platform which will consist of a national e-Library, databases, information systems and knowledge portal (web knowledge portal to increase awareness, provide interactive hazard maps, with integration with social media and possible mobile application to increase community engagement and allow two-way flow of information. It will be an integral part of the NSDI currently being developed for Timor Leste and provide the information access and sharing platform for geospatial information on hazards. This will contribute to a more effective and climate risk-informed management of all sectors.

The system will represent a major shift in how government departments currently work and will need to be supported by the introduction of appropriate data sharing protocols and importantly by extensive training and capacity building to ensure sustainability.

The data repository will provide a structured environment to enforce data integrity and support data auditing, versioning and data quality. Audit trails, as well as structured and categorised schemas, will make data collation, manipulation and analysis more manageable.

The establishment of a structured GIS data repository is envisaged to provide the following advantages:

- Provides a ‘single source of truth’ to provide consistency and transparency in the use of datasets used by everyone working on the project.
- Enables a data security model to be implemented to constrain user permissions to appropriate levels.
- Reduced duplication and redundancy of data.
- Provides a mechanism to enforce data quality and consistency in accordance with standards.
- Provides a structured environment to support the effective discovery of data through web-based portal services.
- Enables datasets to be performance tuned for use in GIS desktop and web systems.
- Provides a comprehensive trusted source of data to permit the effective investigation of spatial relationships between different datasets, which will add a further dimension to the analysis.

The spatial data repository will include and enforce metadata. It enhances the value of data, providing business critical information regarding the data’s currency and quality, which can aid in identifying gaps in data, in addition to providing a useful mechanism to support discovery services.

This data repository will perform a crucial role in efficiently managing data and metadata during the project and represents a significant project deliverable. The scale, comprehensiveness and structure of the database will be dictated by the quality and quantity of the data identified in the early stages of the project. It will however also need to be cognizant of future datasets and processes that will be included, and therefore will be scalable with consideration included at the design phase. This knowledge management system will be based on the EU’s INSPIRE directive which provides a clear framework on the establishment of the SDI and its constituting services.

In addition, the data management system developed to provide a single point of 'truth' with respect to datasets to be used and generated by the project, it will also provide a portal for document management and will provide access for project staff and stakeholders to all relevant documents.

11.3 Connecting People to People

The following series of tools and techniques describe how knowledge management will enable people to connect to people more effectively.

Tools and techniques	Description	Purpose	Actions
Community of Practice (CoP/Knowledge network/professional network)	A group people who share a common interest working together over an extended period to explore ways of working in a specific area of knowledge	Learning from Shared experiences, publishing best practice/position papers	The project will set up a number of technical working groups, interagency working groups as well as regional working groups to enable CoP people to interact and share experiences
Peer Assist	Gaining input and insight from outside experts to reuse and reapply existing knowledge and experience	Firsthand knowledge transfer, access the institutional knowledge base	The project will engage a range of local and international experts who will provide technical assistance to the project. For long-term peer assist, the project will help establish relationships between institutions and local as well as international universities and research centres
Knowledge café	A group of people having an open, creative conversation in an informal environment on a topic of mutual interest	Informal learning through dialogue.	This will be achieved through the meetings of the technical working groups and through bi-lateral meetings between individual stakeholder organisations

Knowledge marketplace	Allows matching of a knowledge requirement with someone with expertise	Starts connection of people to people, people to document and documents to people	This will be provided by project experts who will be identifiable by their area of expertise and will provide support the project and stakeholders. In the long-term, a 'directory' of experts can be developed to fill this need.

Community of Practice (CoP)

A CoP provides an environment (virtual and or face-to-face) that connects people and encourages the development and sharing of new ideas and strategies. This environment supports faster problem solving, cuts down on duplication of effort, and provides potentially unlimited access to expertise. Technology now allows people to network, share and develop practice entirely online. Virtual communities overcome the challenges of geographical boundaries. They encourage the flow of knowledge across local government and enable sustainable self-improvement.

The project will set up a number of technical working groups, interagency working groups (through the CCCB) as well as regional working groups to enable CoP people to interact and share experiences. In addition to face-to-face meetings, the project web portal will be configured to enable online cross-organisational working and sharing of ideas.

The project cross-sectoral working group will help to outline and examine the current policy framework relating to hazard management and which could best elaborate current practice and deficiencies with respect to climate risk management and DRR, and the inclusion of climate change considerations climate proofing infrastructure. The strengthening of the cross-sectoral working group, which will be comprised of representatives from all relevant ministries and institutions, is an essential first step to ensure inclusion and consultation from the beginning and throughout the process. This will enable an active participatory approach (experts from relevant line-ministries relevant agencies) and will ensure buy-in. It is envisaged that a number of technical working groups will be required, based on technical area as well as geographical relevance.

Peer Assist

The project will engage a range of local and international experts who will provide technical assistance throughout the project. For long-term peer assist, the project will help establish relationships between institutions and local as well as international universities and research centres.

Technical capacity has been identified as one of the main barriers to implementation of the policy and practice of climate resilient rural infrastructure. The project will ensure that the necessary technical assistance is provided to address this, and that the long-term capacity development is assured through formal learning, and also through increased access to experts e.g. through the establishment of relationships between institutions and local as well as international universities and research centres.

Knowledge café

The knowledge café approach will be used when developing workshops for the technical and cross-sectoral working groups as follows:

Preparation for a knowledge café

- appoint a facilitator – someone who can encourage participation.
- identify the topic for discussion (e.g. to discuss/consult on a project preliminary output).
- provide an informal/relaxed setting.

During a knowledge café

- The facilitator should introduce the knowledge café concept, any codes of conduct, and finally pose the question.
- Participants should arrange themselves into groups to discuss the question.
- Each participant in turn shares their knowledge and experience without interruption, giving everyone an opportunity to talk. Alternatively, a 'talking-stick' can ensure only the person holding the stick can speak, thus avoiding the discussion becoming dominated by one or a few speakers.
- After each participant has shared, the group continues the discussion together.
- The groups should eventually reconvene to exchange ideas and findings – these could be captured electronically or on paper.

Knowledge Marketplace

Knowledge marketplace identifies what people know and what they need to know on a particular subject, then connects them appropriately. The knowledge marketplace can be facilitated online, via email or face-to-face.

It can be used in many situations and is particularly useful when delegating roles and responsibilities within a new project team. Success depends on the willingness of participants to both contribute and benefit in equal measure from exchanging knowledge. It is highly dependent on the degree of trust between individuals. Given the scale of the project and national remit, it will be important to develop and use the knowledge market place approach to ensure that the right expertise and knowledge is not missed by any part of the project team stakeholder or beneficiaries. By placing the knowledge marketplace online (and open to beneficiaries as well) it would also identify local experts that would otherwise go unnoticed.

11.4 Institutional KM Improvement

Summarising lessons learned and experiences and sharing them with others can help build and retain knowledge. The following series of tools and techniques describe how knowledge management can enable improvement through impact assessments, evaluations and people management.

Tools and techniques	Description	Purpose	Actions
Gone well/not gone well	Quick debrief at the end of an event/activity concentrating on good points and items for improvement	Tactic knowledge capture and feedback about effectiveness of the event	All significant project events/activities will be subject to a debrief to capture good/bad points and lessons learned
After Action review (AAR) formative evaluation	Quick discussion at the end of key stages of an activity reflecting on the	Tactic knowledge capture of lessons learnt e.g. noted	All significant project events/activities will include formal minutes which will be made

	current position and future actions	minutes of project meetings	available on project portal
Retrospective review (summarise evaluation)	A formal process to evaluate the completion of the event or activity to capture lessons earned	Capture lessons learned for future activities. Publish on internet or intranet	A formal project lessons learned document will be available for all project staff to complete (managed by PM) online
Knowledge Exchange	Staff leaving should exchange unique knowledge to allow others to capture it.	Build institutional/project memory	All project staff will have as final deliverable a summary report to include knowledge transfer information and other lessons learned

11.5 Developing and Embedding KM Tools and Practices

As far as possible, all KM tools will be provided as project deliverables and, importantly, through the project it is hoped that by using these tools with the stakeholders, the KM practices will be embedded within their organisations in the future.

In addition to the above the project provides many opportunities, for formal learning, awareness raising, and capacity building cut across almost all outputs and activities. These sets of measures will catalyse longer-term learning and short-term professional training/retraining programs targeting all stakeholders, including vulnerable communities, local governments, universities and relevant authorities.

All knowledge products, generated within the project including technical reports, methodological guidelines, regulatory and policy, planning and outreach materials will be available on-line, and all project knowledge products and documents will be collected and archived on e-library on multi-hazard disaster risk management.

11.6 Knowledge Brokering

Knowledge brokerage will be developed to support evidence-informed decision making and to facilitate relationships, interaction and engagement between the project, academia, private sector and policy makers. Under the project, a Technical Advisory Working Group will be established, which will be drawn from government, private sector, academia and civil society to provide guidance and technical advice on the project with a balanced representation of women and men. This TAWG will additionally act as a convener and facilitator linking between government, academia, and private sector to create conducive environments to enable the take up of scientific expertise and evidence to be developed by the project.

Research institutes, academic networks, learned societies, think tanks and charities will be invited when necessary, as secondary members of, or consultees to the working group during the development of evidence-based policies. Thus the TAWG will fulfil multiple complimentary functions, such as fostering networks and synthesising evidence, and working at different levels of influence. It will provide the platforms and channels for promoting the project results and evidence, through targeted workshops, and information sharing (through many of the knowledge management structures discussed above). In addition, the project will seek to engage with other organisations and people who can potentially act as knowledge brokers within the TAG.

12 PROJECT IMPACT EVALUATION

The project-related M&E will provide a platform of data to use in management of the project, and feeds data into evaluations of the project's overall effectiveness and efficiency. The project related system will be designed to provide timely progress reports of project implementation based on key performance indicators.

A detailed impact evaluation of Output 2: Scaled-up ecosystem-based and non-structural climate resilient flood risk reduction and Output 3: Climate-proof flood protection investments strengthen adaptive capacity and reduce exposure to climate-induced floods will be undertaken to measure the project's impact on outcomes such as resilience of the communities and improved well-being at household/individual level and vulnerability to poverty and breaks to poverty cycle. Some of the outcomes that will be measured will include:

1. Access to formal microinsurance products improves clients' financial capabilities and makes their risk management behaviours more cost-effective (e.g., less high-interest borrowing, reduced out-of-pocket expenses).
   Class of household that benefits from insurance – will upper poor and vulnerable non-poor benefit more from insurance than other groups
2. Access to insurance has positive or negative spill-over effects on non-beneficiaries living in the same communities (e.g. improved risk preparedness and information or weakened informal risk sharing networks for uninsured members) in the case where insurance is not compulsory.

   - Impact on changes in asset accumulation - physical and financial assets
   - Impact on Social Capital, Empowerment and change of behaviour
   - Impact on Food Security

To examine the impacts of the project on rural communities, the review will examine whether the interventions implemented by the project have enhanced the value and derived benefits from existing community assets such as land, water, livestock and livelihoods. Impact on income generation and improvement in livelihoods will be key direct benefits to be examined while improved skill or health, education, and socio-economic conditions will be key indirect benefits to be examined. Impact on increased capacity of local communities to exploit potential economic opportunities and to develop stronger link with the markets and external partners, through the risk reduction and adaptation interventions provided by the project, will be examined. Efforts to strengthen local level organizations in the implementation of similar projects in the future will be a key impact as this will reflect whether the project has built local capacity to implement and use these new climate resilient measures in the long-term. The project also envisages measuring behavioural change in the beneficiary communities. Likely contribution of the project to food security will be examined. Key elements of food security are availability (production and trade), access (income, markets and prices) and stability (storage and other marketing arrangement at household and local level. Environmental degradation is very often a manifestation of poverty and the struggle for survival by the rural poor and contributes to non-resilience to climate change and increased risk from climate related disasters. The extent to which the project contributes to rehabilitation of the environment (particularly of the agricultural resource base and watershed management) in areas currently affected by land degradation and at high risk of hazards, is strongly associated with poverty impact. This domain concentrates on the local level environmental impacts of the project, as well as any environmental consequences of the project. It is also concerned especially with those environmental aspects, which are under the control of, or are influenced by, the rural communities. Environmental impacts may be negative as well as positive intended or unintended and all of these will be examined. Existing institutions, policies and regulatory frameworks significantly influence the lives of the rural poor. Supporting the capabilities of existing national, and especially local public institutions in servicing the rural communities and reorienting the existing policies of institutions in favour of the poor is an increasingly expected result of development projects and is an expected outcome of this project. This encompasses the change brought about in sectoral and national policies affecting the rural communities and their exposure to hydro meteorological hazards. In addition, the degree to which the project impacts local-level decision making capacity, is also a relevant consideration and important to this project. Hence the effectiveness of the ‘last mile’ component of the EWS and particularly the CBEWS will be closely assessed. In addition, traditional and social practices may also serve to restrict the equitable access to benefits, for example social restrictions on women’s activities, traditional allocation by gender of rural tasks and income from different crops and livestock, etc. The review will examine the extent to which a contribution has been made to improving the national, and particularly local institutions to implement, and manage CBEWS and CBDRM which affects the lives and livelihoods of rural communities.

Approach

The design of the project-related M&E will be linked to the impact evaluation to provide data on: (a) the vulnerability level of households and communities with access to CBEWS and non-structural benefits of the project; (b) the impact of increased income from risk transfer mechanisms, and (c) the effect of capacity and systems building activities and new technologies and approaches for enhanced flood risk management applied to increase resilience of vulnerable communities in VRB. The impact evaluation includes a baseline survey (year 1) and two follow-up surveys. Monitoring tools will also be developed to aid the monitoring of the project. The tools will continuously be updated based on the lessons learned following regular M&E cycles. In addition to continuous monitoring, a database of households and communities will be maintained by the project team to aid in assessing progress up to project completion and to ascertain progress made toward the attainment of the set indicators.

Specifically, to monitor and measure the changes brought by the project, impact evaluation will be designed to assist the project team to collect baseline information/data, final survey to gain insights into developmental and adaptive impact of the interventions that will be carried out during the project. For this purpose, before any interventions take place, a robust baseline survey needs to be administered. During the project, it is expected that follow-up surveys and final survey will also be carried out at end of project.

The impact of the project will be assessed by undertaking the following:

1) A household survey targeting beneficiary households at least two times (baseline and final) during the project implementation;
2) Analysis of the survey data;
3) Follow-up survey which will be used by project staff; and
4) Training of project staff on the follow-up survey methodology.

The impact indicators will include:

- Extent to which structural measures and non-structural measures have reduced exposure to hazards (e.g. whether frequency of flooding has reduced etc.)
- Changes in income from agriculture and related activities (changes in income should consider the level of own consumption);
- Yield from agricultural production for key produce including home gardens;
- Migration for seasonal work;
- Farm land left fallowed; and

- Freshwater availability for household use.

The project will be implemented nationally but will directly implement measure such as CBEWS in 60 communities, and structural and non-structural intervention measures. Beneficiary communities are selected based on their risk and vulnerability status which has been determined through the socio-economic risk and vulnerability assessment during proposal development. Under output 1.2, the project will be developing and embedding long-term socio-economic and livelihood survey methods for B&H and will develop GIS-based tools and models which will use these surveys. The project will implement a participatory survey and engagement methods and the baseline data will be collected throughout B&H. Since the project impacts from many of the interventions are likely to be realised close to the end and after the project implementation, the impact evaluation methodology and tools will be embedded within responsible agencies to monitor in the long-term, thus ensuring regular surveying of the key impact and development indicators required for long-term assessment of project impact.

Potential Impact evaluation questions:

Depending on the beneficiary selection approach that will be developed at the beginning of the project, a Phase-in design and/or random assignment approach can be applied. The random assignment approach will be important for cases where there is no excess demand for the program, but participation is voluntary and not everyone is likely to enrol in the agricultural practices such as agro-forestry. Difference-in-Difference and/or matching can also be applied to the structural intervention.

Other things to potentially measure include:

1. Nationwide flood Insurance scheme (with co-financing from the insurance sector). This will be one of the first projects (or maybe the first) to implement risk-based flood insurance on a national scale (after successfully developing the scheme and products under the Vrbas project).
2. The project is also working with micro-financing institutions to help them develop climate smart financial products based on climate risk information. Take up of these products and how it impacts outcomes will be useful to test and understand.
3. Another area of innovation is partnership with private sector, in particular the Hydropower sector which is co-financing activities, but importantly, will also be involved in long-term O&M of hydrometric network. The project is designed to ensure that hydropower sector also play an active role in FRM and will be part of flood alleviation (the project will be developing and incorporating HPP models in flood forecasting models and systems which will ensure that reservoirs levels are managed to provide storage to incoming floods). Effectiveness of this approach relative to standard flood management techniques will be useful.

The impact evaluation approach for this project will be implemented in four phases;

1) Impact Evaluation Design. The process of completing the design will include:
    a. Desk review of project documents and FAA by the IE team.
    b. Initial draft of the impact evaluation design including theory of change based on understanding of project document.
    c. Impact evaluation mission including 2-3 days workshop with relevant stakeholders. Very important for common agreement on outcome to be measured.
    d. Finalization of the impact evaluation design including power calculation, treated and control group selection, budget and timeline for implementation (baseline, midline, endline and high frequency data required).

2) Impact Evaluation Implementation: Based on the timeline and impact evaluation design, annual workplan and activities will be developed and implemented.
    a. It will be the responsibility of the project team and primarily the M&E officer to carry out the activities of the impact evaluation design.
    b. Procurement of impact evaluation team:
        i. Household survey firm/individual
        ii. Data and Sampling expert: (Power calculation and Data analyst/data quality expert).
        iii. Local researcher

3) Impact Evaluation Data collection: Different types of data are collected for impact evaluation.
    a. Baseline assessment and indicator tracking
    b. Baseline survey
    c. Midline survey
    d. Endline survey
    e. High frequency data: Crowdsourced data, monitoring data, secondary data.
    f. Geo-coded/referenced data including satellite data

4) Impact Evaluation Data analysis and knowledge products:
    a. Some elements of the data analysis will be carried out at different points by the survey firm and/or research assistants.
    b. Reporting and analysis on indicators and short-term outcomes are as important as analysis of impact at the end.

13 CONCLUSION

The proposed GCF project will enable B&H to safeguard vulnerable communities and their social and economic assets from climate change induced flooding disasters. To enhance climate resilience of communities, the project is providing relevant government institutions at all levels with the necessary technical, and financial capacity to comprehensively address the increasing risks posed by flooding.

The project will implement a number of transformative interventions that would set B&H on the path of the climate risk informed, integrated flood risk management. The proposed strategy is to address the increasing flood risks by improving institutional capacity to assess and manage flood risk in the long-term, invest in direct structural and non-structural intervention measures, including EbA approaches. The project will reduce the risk of catastrophic loss of life, property and economic assets and livelihoods throughout B&H and will direct benefit 902,906 people (25.6% of the population) through introduction of an integrated approach, which will embed new skills, methods and technologies to assess the flood hazard, risk and vulnerability strengthening the knowledge systems and institutional capacity to monitor flood risk evolution processes, better understand the risk, and develop a range of risk reduction and management strategies.

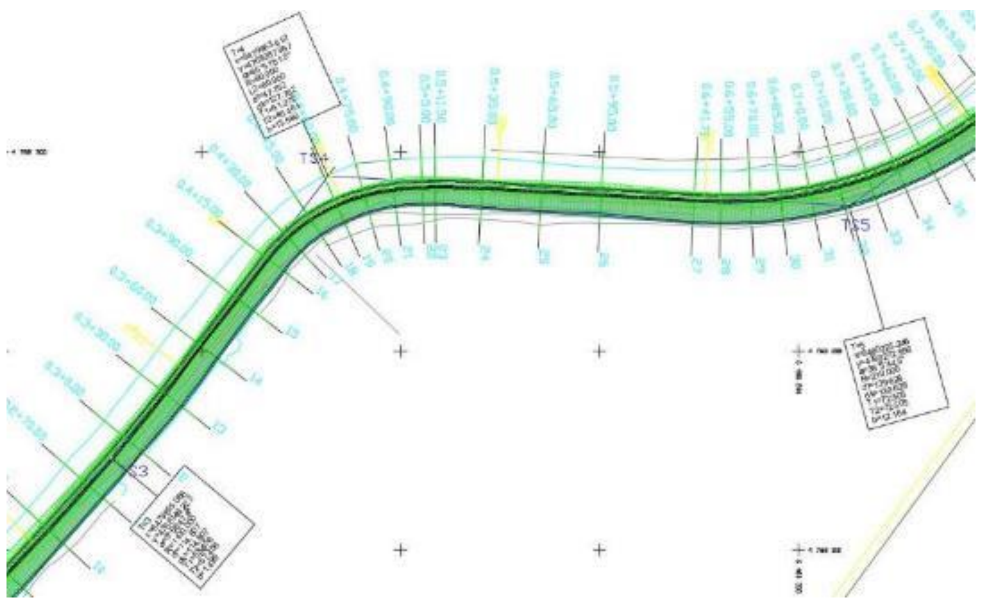
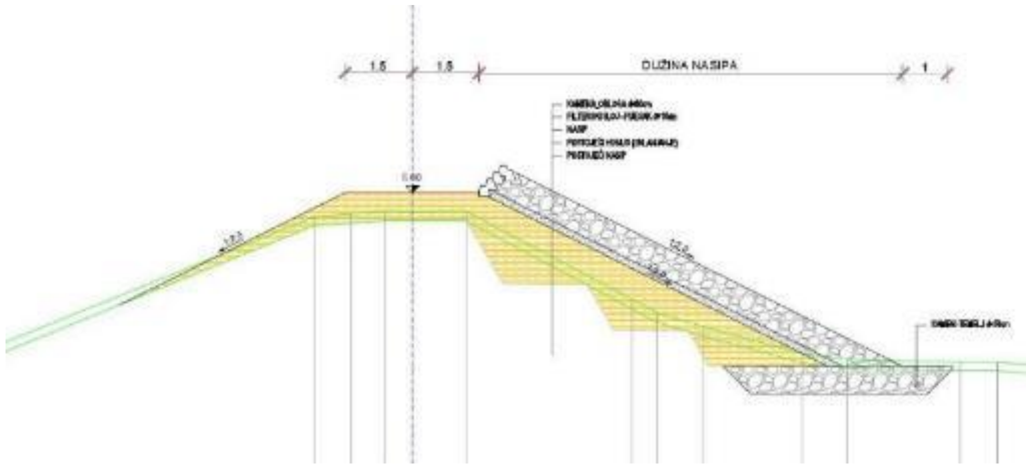
The project will enhance the capacity for flood early warning, implement a national FFEWS and will improve warning times through a long-term sustainable EWS systems as well as capacity flood risk reduction. In addition, the project is introducing innovations by empowering local communities to undertake local disaster risk reduction (DRR) and response measures, that complement the centralized system of EWS. The project will enhance the capacity to identify, plan and implement long-term flood risk management strategies at the basin and sub-basin scale by introducing combined structural and non-structural methods. Long-term flood risk investment planning will also be enhanced, and policy and legislation strengthened to enable long-term sustainability of interventions, by engaging the private sector to shoulder some of the increasing costs of required observation networks and risk information and early warning services. It is developing the capacity and systems whereby the current gap between the demand and supply on vital climate risk information is closed. The project will result in improvements in watershed ecosystems and restoration of ecological function through the use of EbA strategies which will reverse the deleterious effects of catchment degradation and enhance livelihoods of rural communities

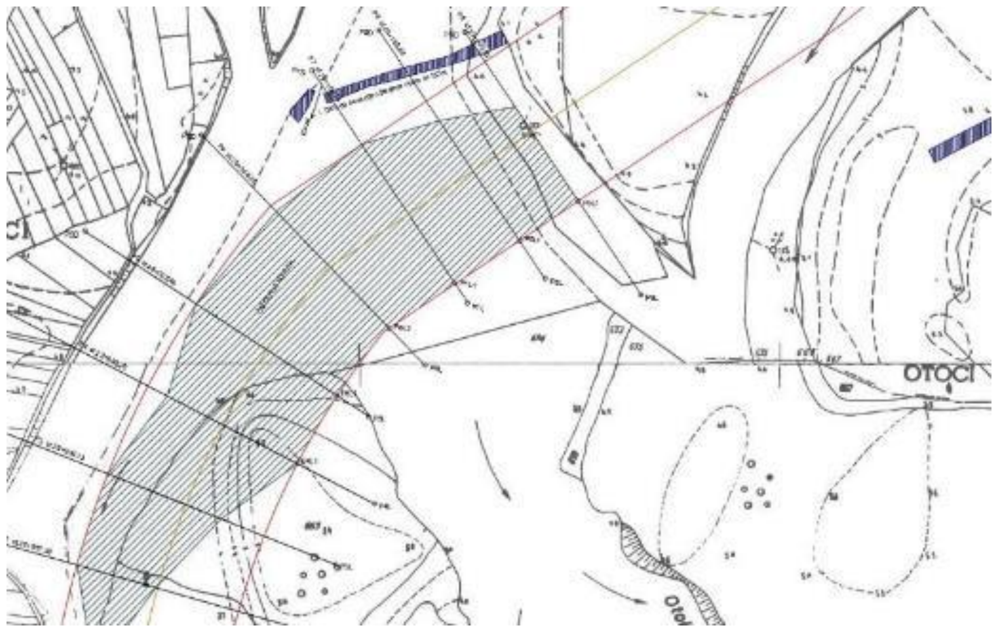
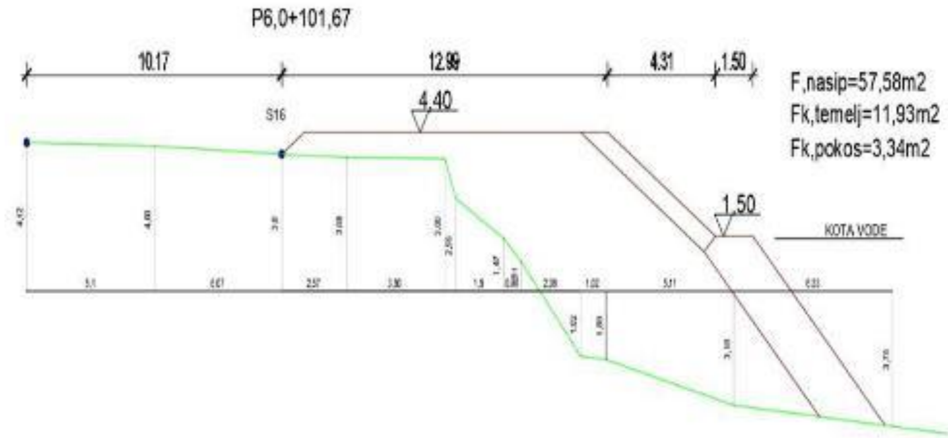
In summary, to adapt to climate change, the GCF project will adopt a proactive integrated flood risk management approach centred on climate change induced flood risk reduction, prevention, and preparedness.

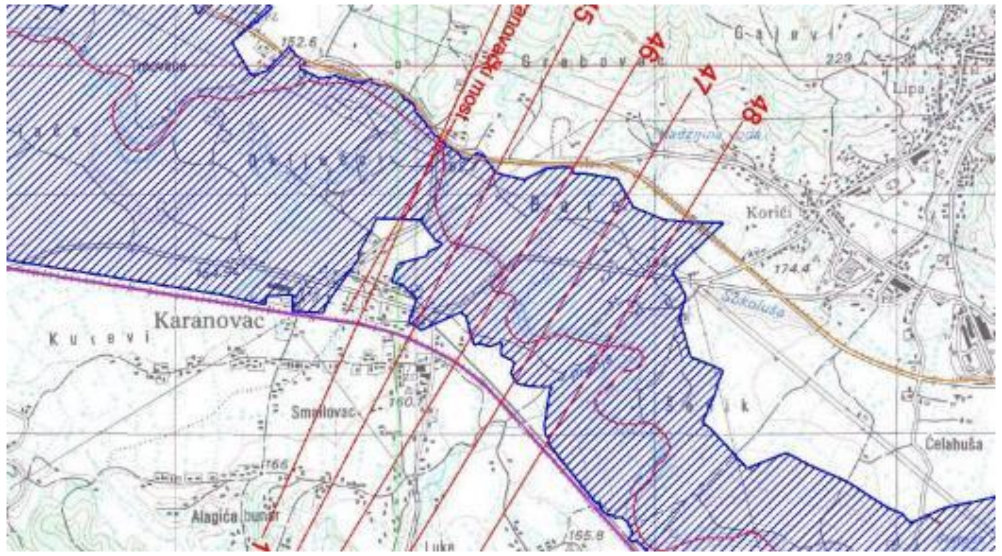
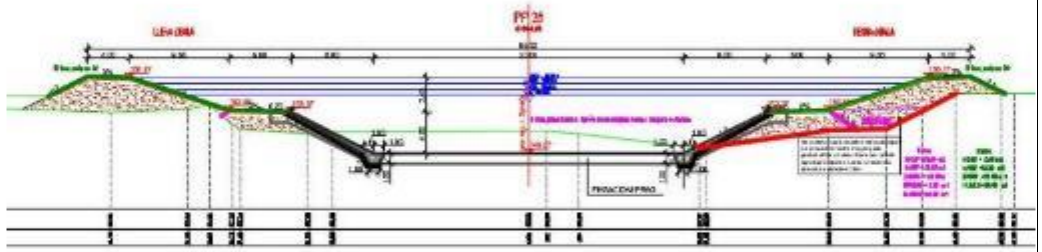
PART IV ANNEXES

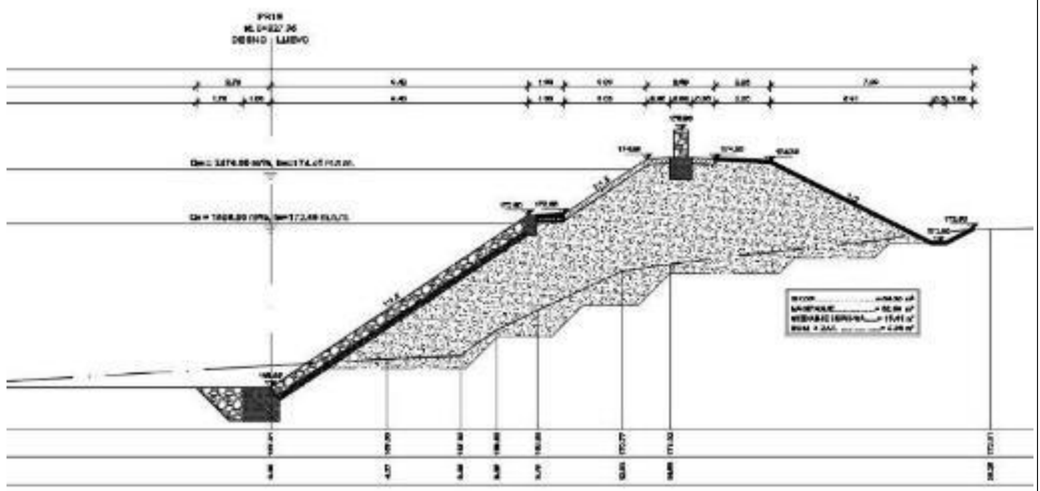
14 ANNEX A: EBA NON-STRUCTURAL AND STRUCTURAL MEASURES

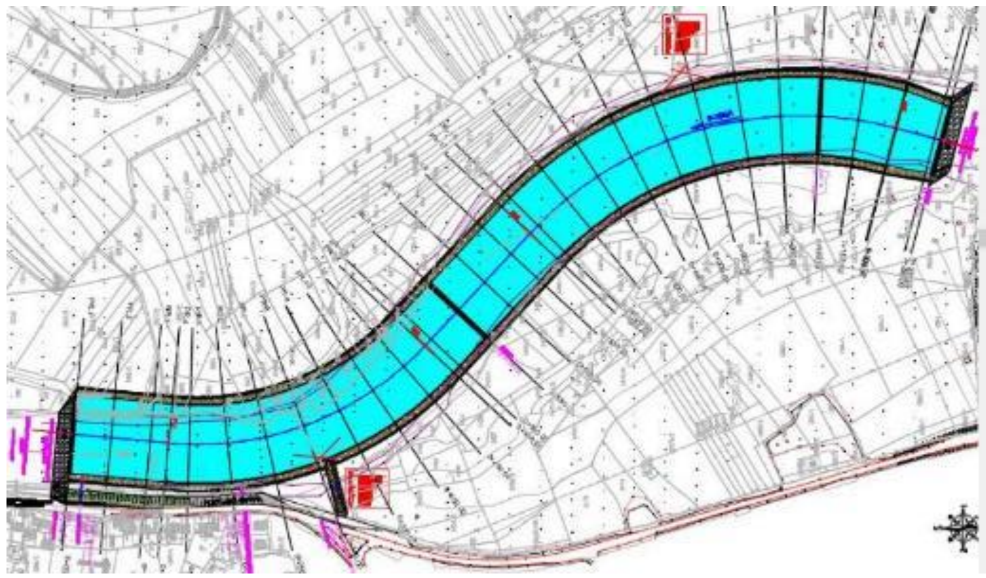
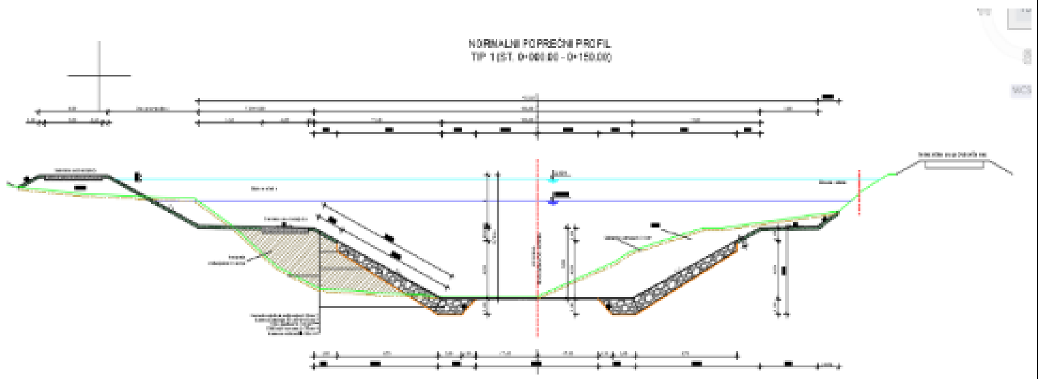
Table 14-1: Non-structural measures to be implemented under sub-activity 2.2.2

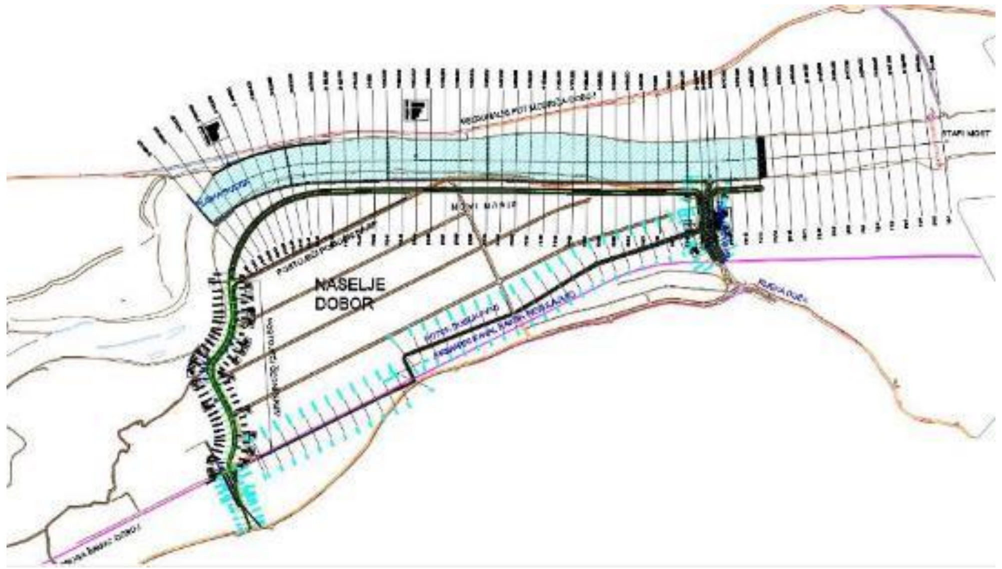
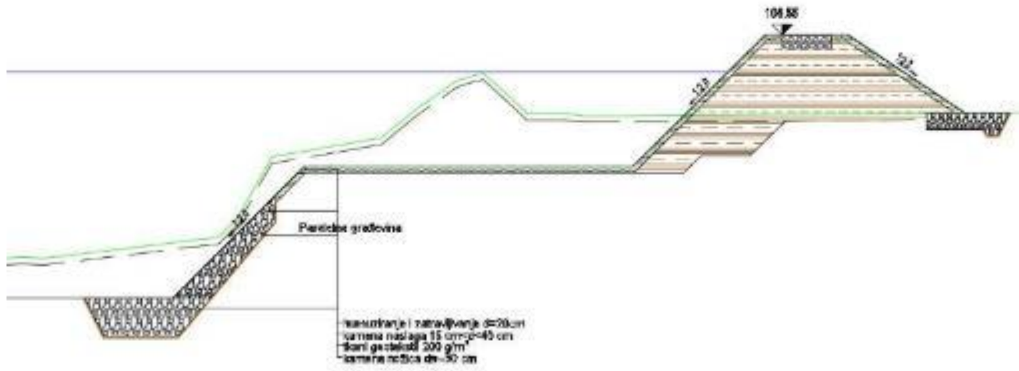
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
1.	Neretva	 	Rehabilitation of the right defensive embankment on the Krupa River in Višići settlement. L=4,000m  	Works consists of upgrading of existing protective dyke on the right bank of Krupa river. Existing dyke cannot withstand cc induced flood levels for 1/100 water. Number of households protected: 624 Population: 2053	253,125	562,430.

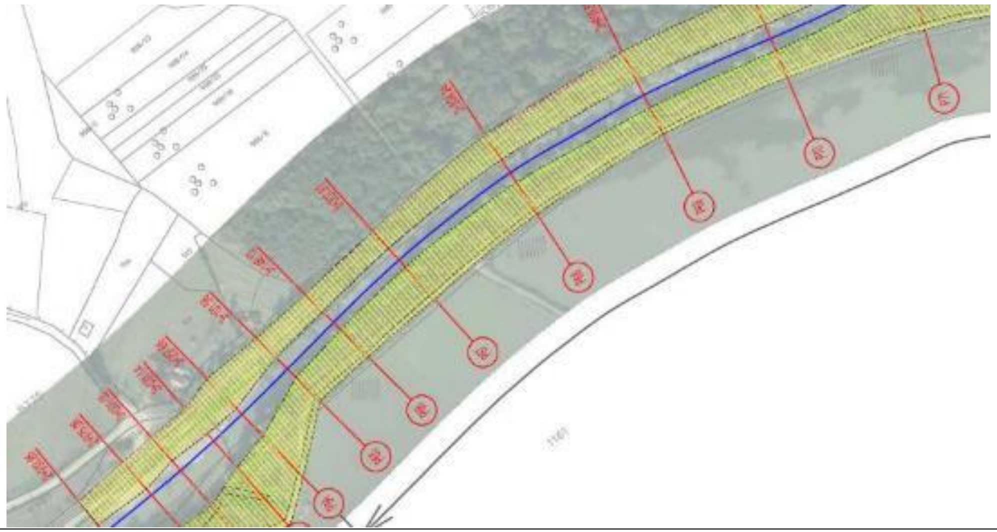
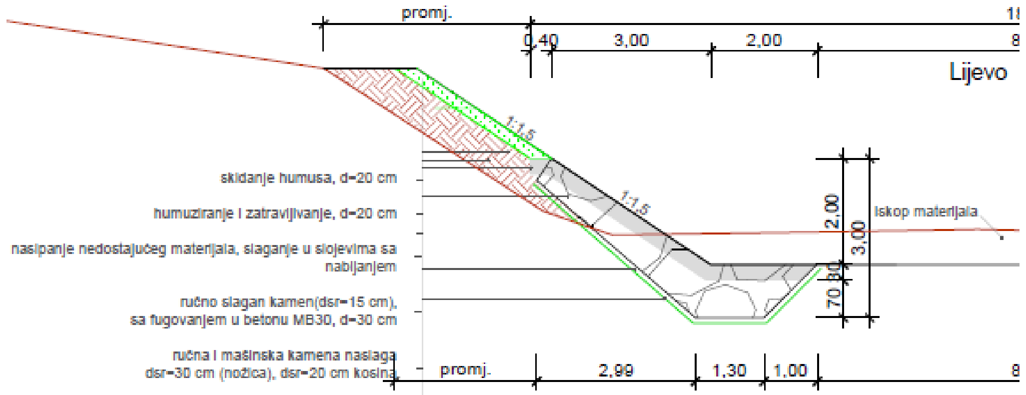
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
2.	Neretva	 	Flood deposit removal and rehabilitation of damaged banks of the Neretva River at the Struge-Čapljina section.  	Removing of excessive flood deposit from the riverbed and protecting river banks -left river bank with natural stone lining, to prevent further erosion. No additional excavation is necessary from the river bed. On critical parts, excavated flood deposit from riverbed will be used for backfilling of eroded bank. No additional excavation of eroded banks is required. Number of households protected: 245 Population: 806	196,875.	562,430

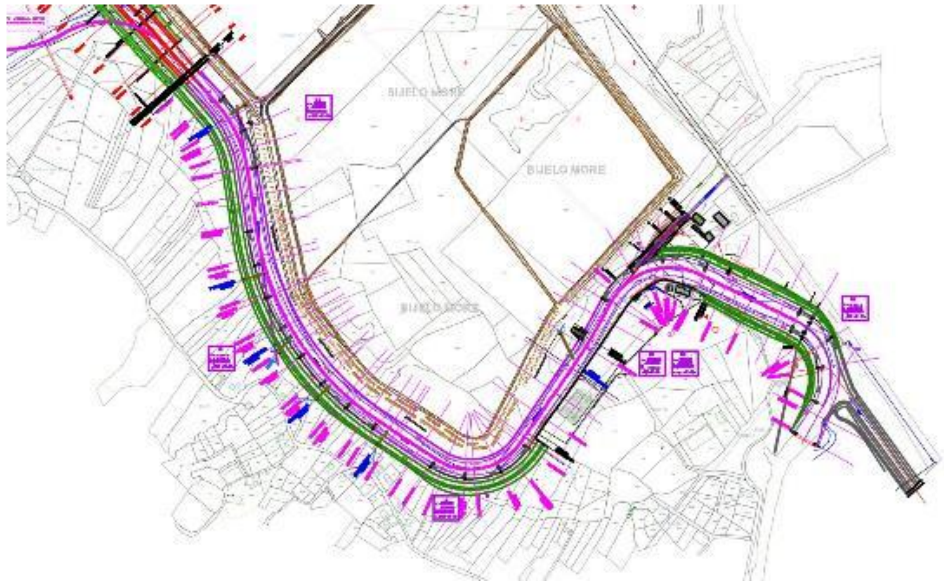
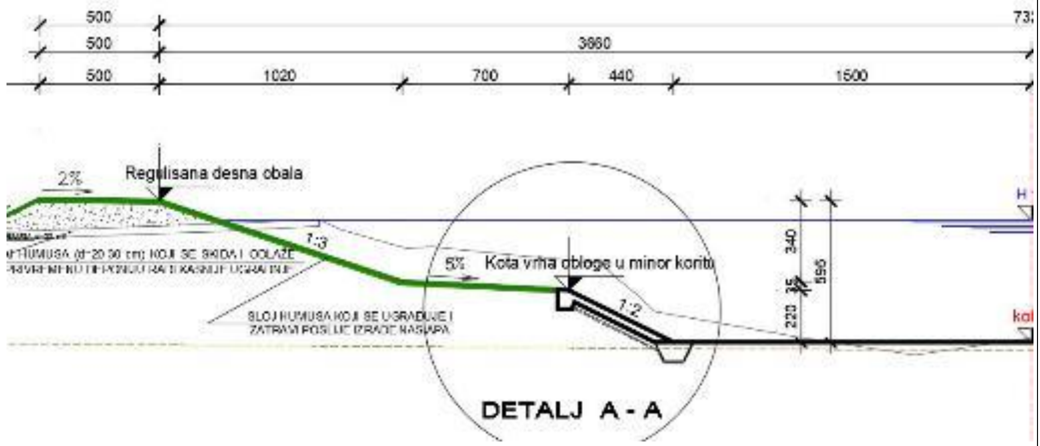
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
3.	Bosna	 	Completion of flood protection line in urban areas (Bosna River Basin) - Gračanica River Spreča - cross entity river.  	Right river bank is in FB&H and left in RS. Total length of rehabilitation: 2,500.00 m. Removing flood deposit, protecting the banks with natural stone and erecting small dykes in order to keep 1/100 water within riverbed. All material is provided from local quarries.	1,875,000	2,952,756

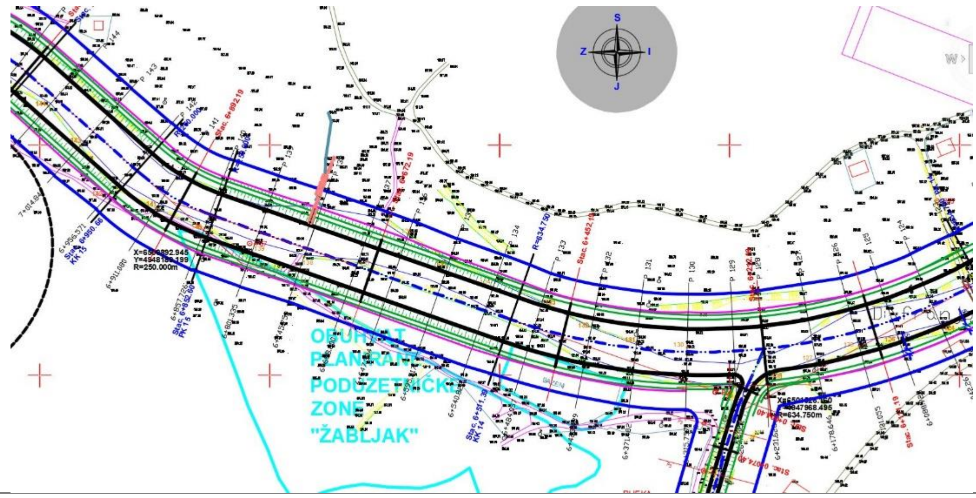
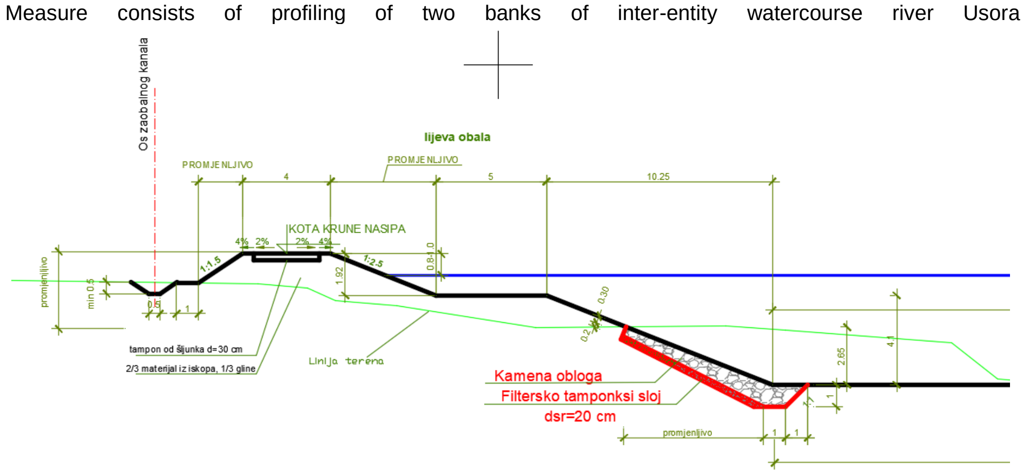
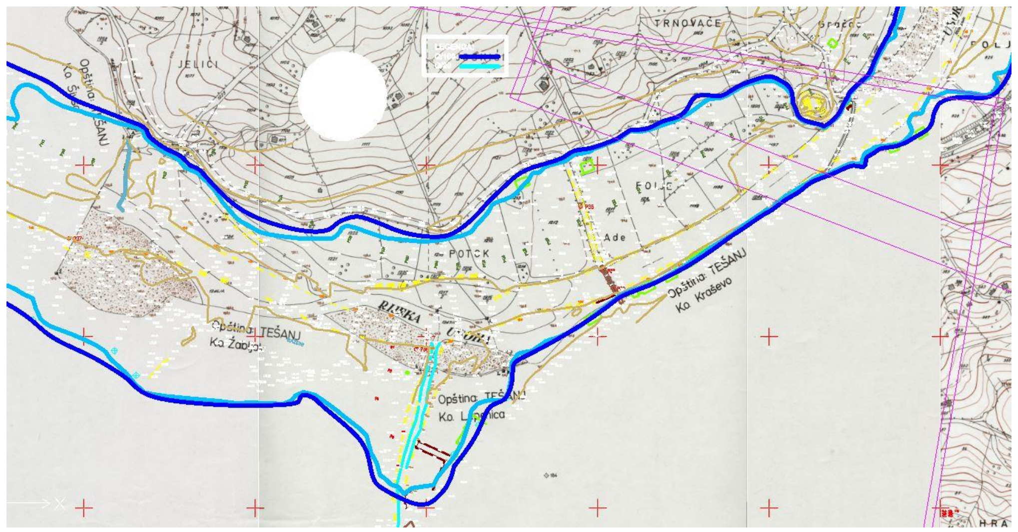
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
4.	Bosna	 	Completion of flood protection line in urban areas (Bosna River Basin) – Maglaj 	Measure consists of profiling of right river bank of Bosna river, removing flood deposit, protecting the banks with natural stone in cement mortar and erecting small dykes in order to keep 1/100 water within riverbed. Stone embankment is ečevated to hight of 1/20 year water level, while rest of the embankment is constructed from soil and clay. In order to maintain "life with river" policy, Water Agency requested construction of staircases from top to bottom of embankment on every 100m of river banks. Also, pedestrian walking trail is designed on top of dyke. Stone material is provided from local quarries. Total length is 1,3 km. Total household: 581 Total population: 1,749	196,875	413,386

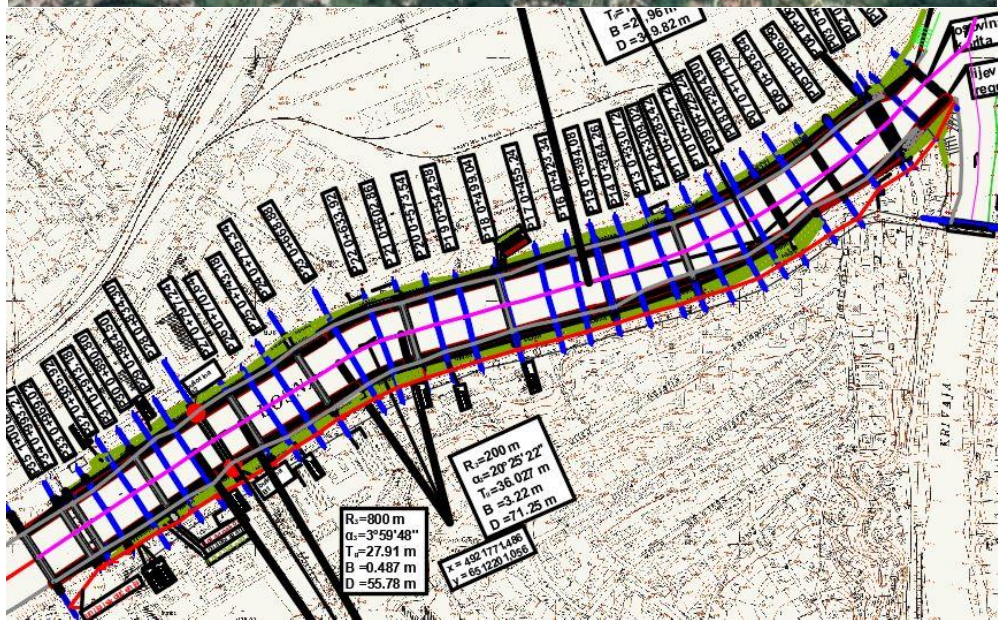
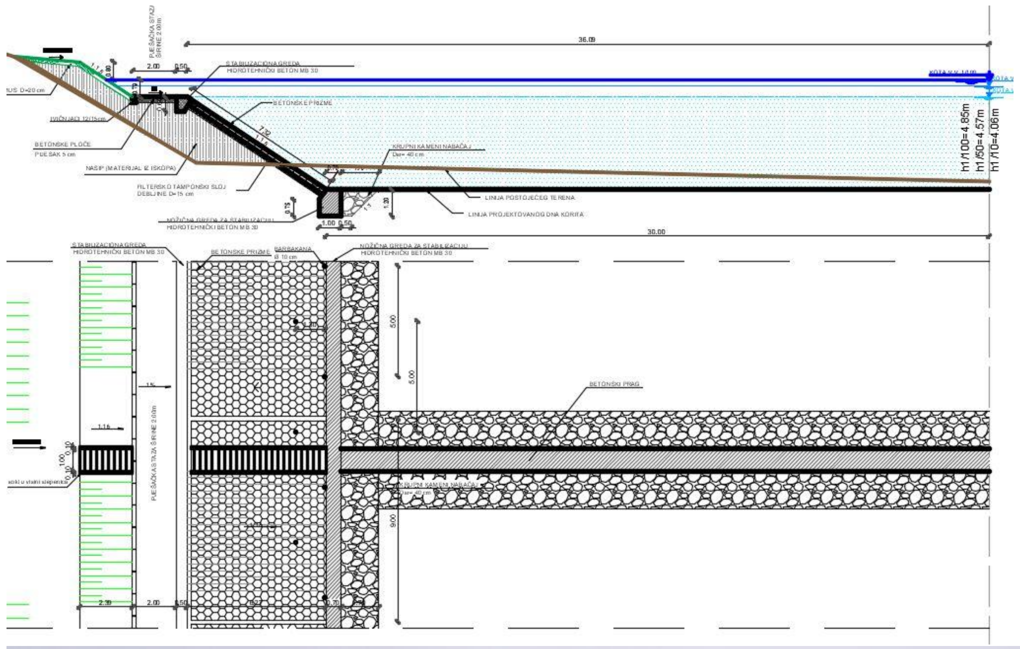
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
5.	Bosna	 	Construction of a bank revetment on the left bank starting from the New-Japanese Bridge in Doboj towards downstream at a length of approximately 1,0 km.  	Removing flood deposit, protecting the banks with natural stone and erecting dykes in order to keep 1/100 water within riverbed. All material is provided from local quarries. Total households: 388 Total population: 1103	427,500	453,409

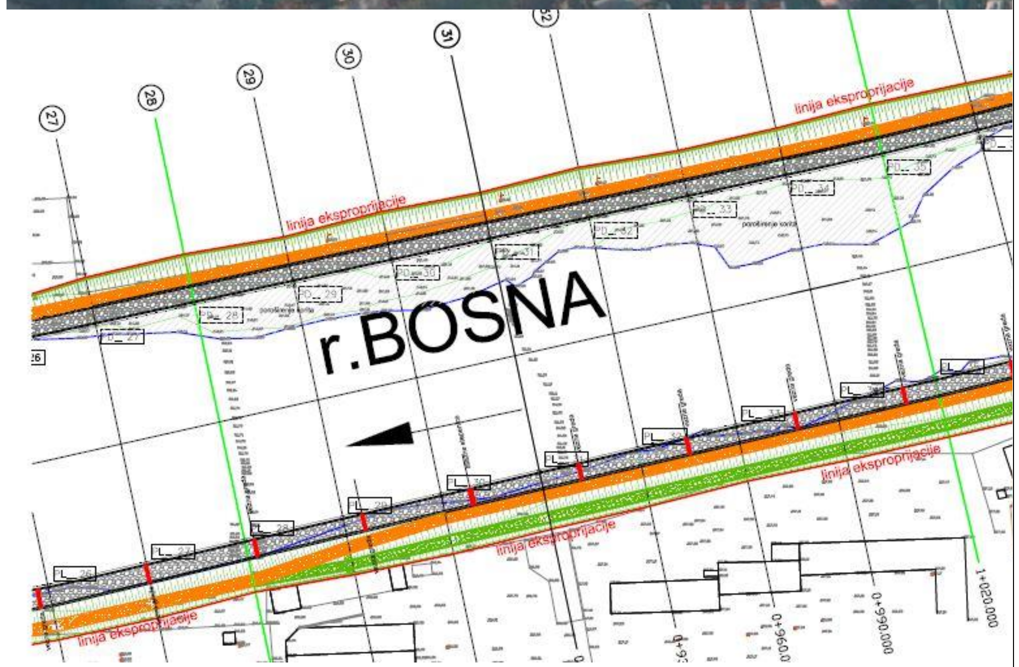
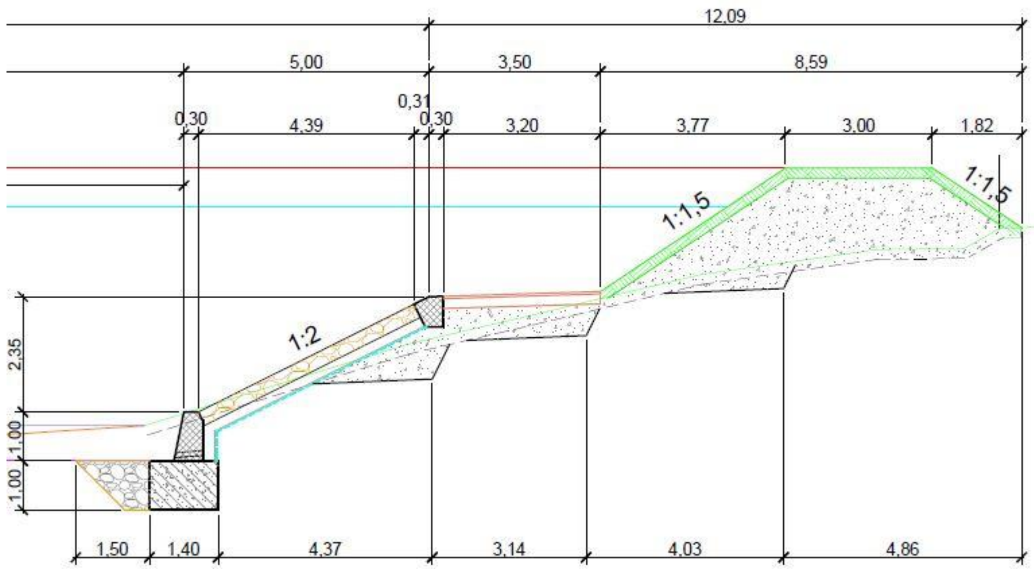
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
6.	Bosna	 	Construction of protective structures in Dobor settlement: • Regulation of the main riverbed of the Bosna River at a length of 2,000 m • Construction of a protective embankment along the Bosna River at a length of 2,000 m • Construction of an embankment along the Dusa River with a length of 250 m and the structure on the mouth of the Dubokovac canal.  	Removing flood deposit, protecting the banks with natural stone and erecting dykes in order to keep 1/100 water within riverbed. All material is provided from local quarries. Total households: 392 Total population: 1109	771,750	818,522.72

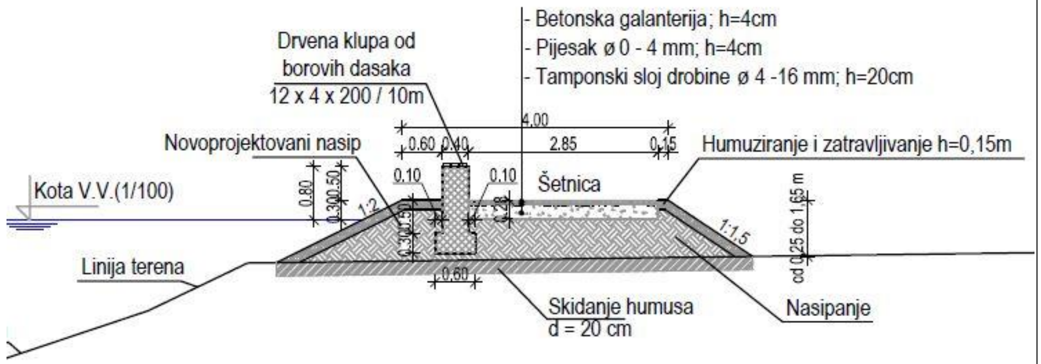
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
7.	Una-Sana	 	Regulation of the canal of the Gomjenica River in the area of the City of Prijedor from the confluence with the Sana River and upstream at a length of approximately 4 km.  	Slashing and trimming of existing vegetation within inundation area, removing flood deposit, protecting the banks with natural stone and erecting dykes in order to keep 1/100 water within riverbed. Total length of proposed works is from mouth of river Gomjenica upstream for 3,0 km. Stone for critical parts of embankment will be provided from local quarry. Total households protected: 1142 Total population protected: 3289	679,500	720,682

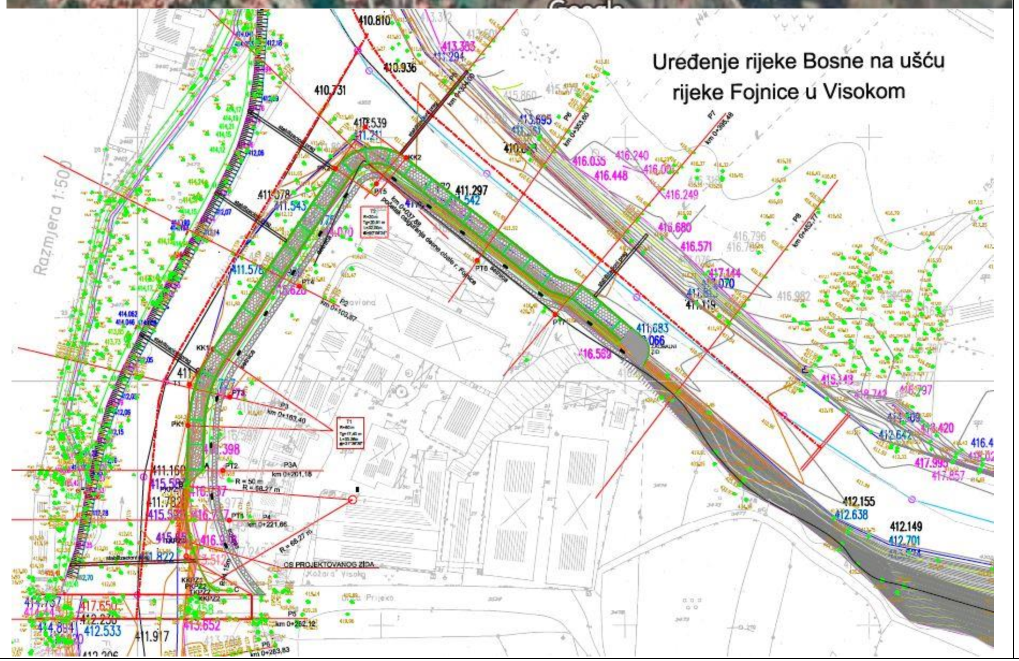
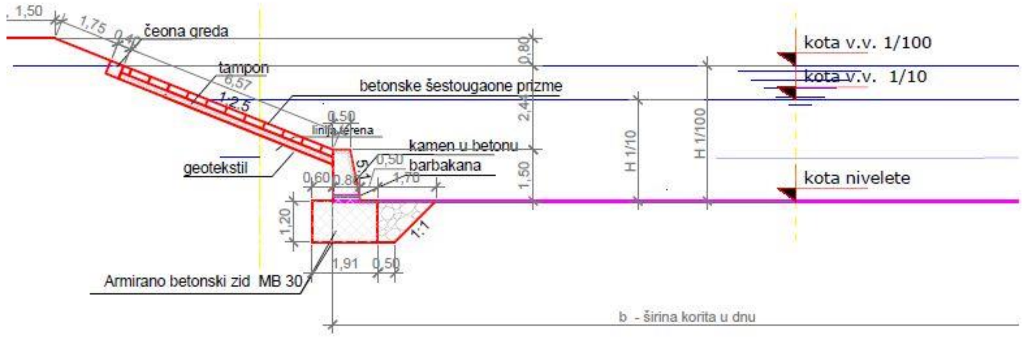
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
8.	Bosna	 	Completion of flood protection line in urban areas (Spreča river) – Lukavac L=1200 m 	Removing flood deposit, protecting the banks with natural stone and erecting I dykes in order to keep 1/100 water within riverbed. All material is provided from local quarries. -Removing/Slashing vegetation from banks and within riverbed, The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total households protected: 150 Total population protected: 500	478,125	1,771,654

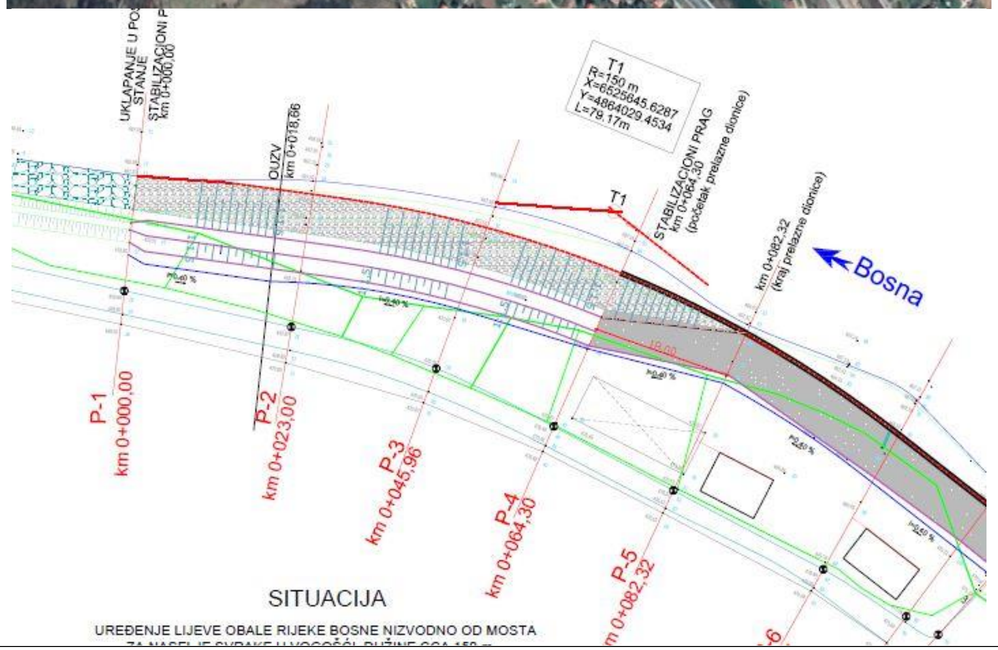
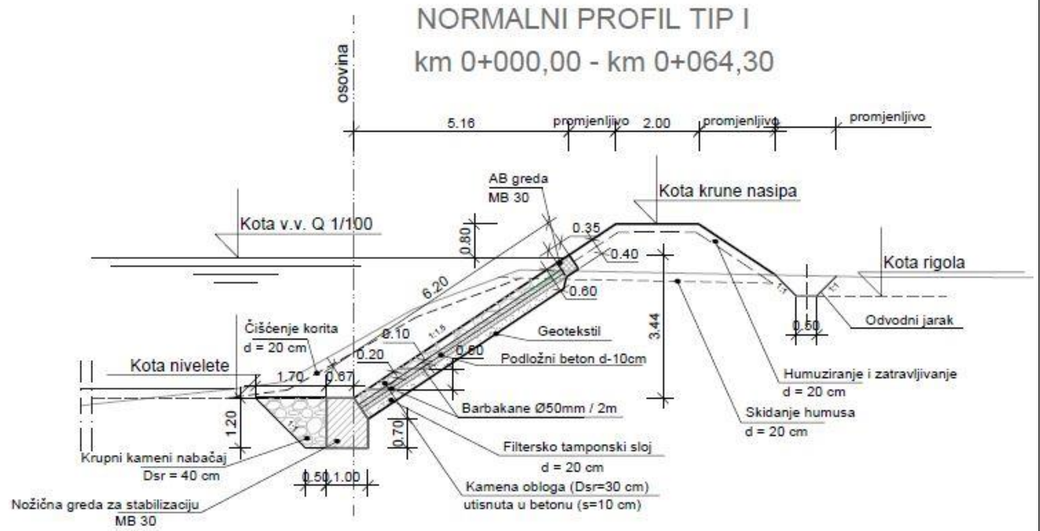
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
9* AVPS co-financing	Bosna	 	Completion of flood protection line in urban areas (Usora river) -Tešanj----Doboj Jug Measure consists of profiling of two banks of inter-entity watercourse river Usora  	Removing sediment, cutting wild vegetation, maintaining existing profile with protecting the banks with natural stone and erecting small dykes in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. All material is provided from local quarries. Total length is 6,2 km. Total households: 146 Total population: 469		2,849,449.54

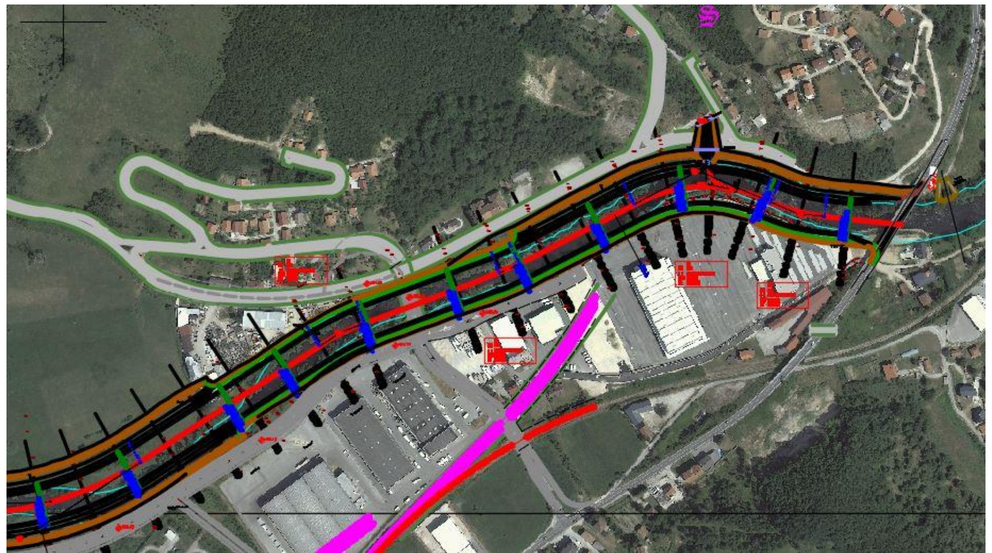
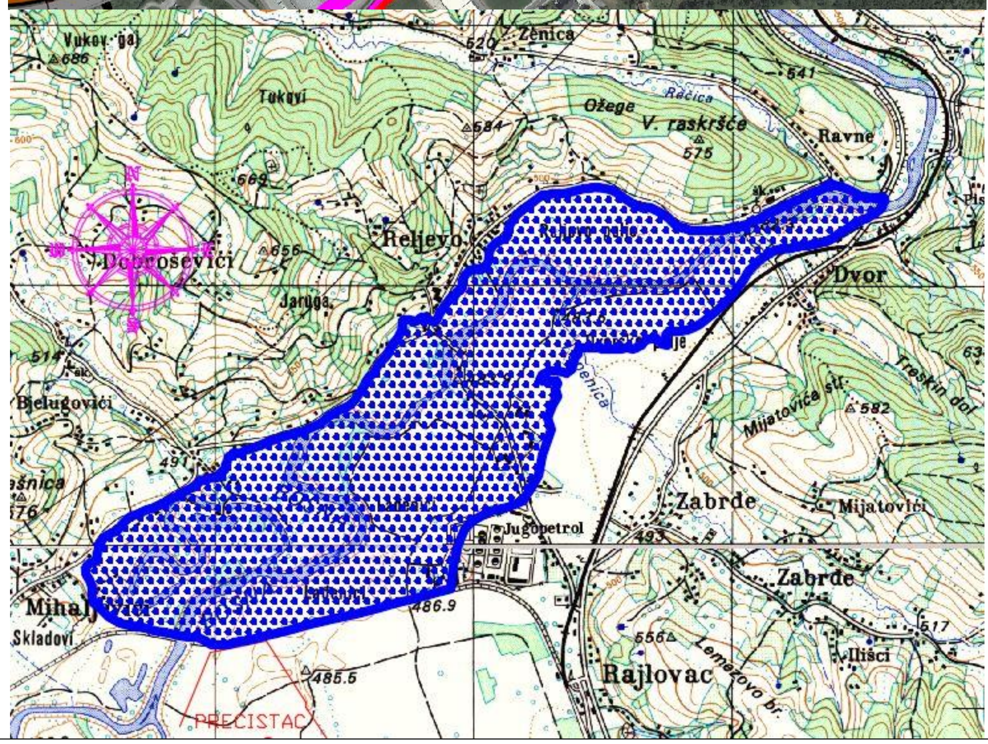
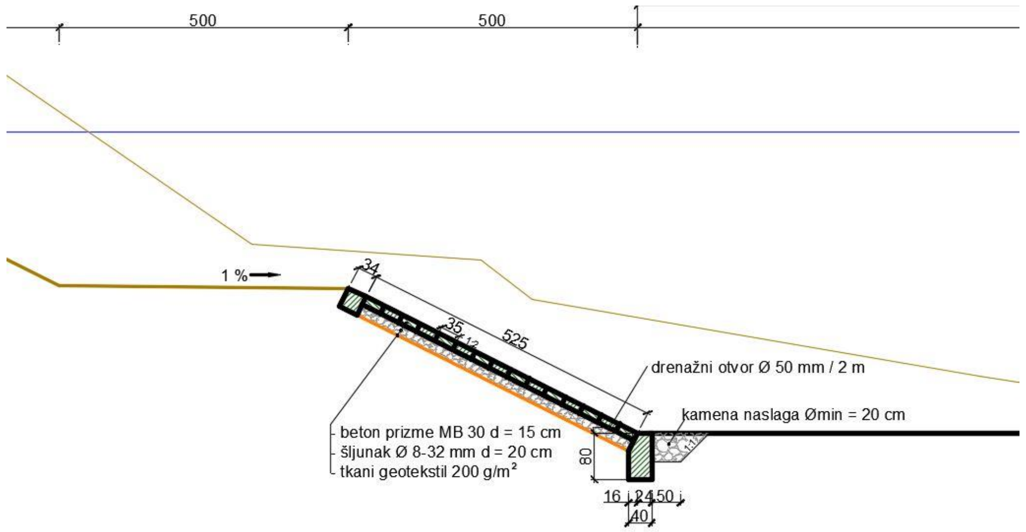
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
10* AVPS co-financing	Bosna	 	Completion of flood protection line in urban areas (Bosna river) -Zavidovići  	Removing sediment, cutting wild vegetation, maintaining existing profile and protecting the banks with concrete prisms, in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total length is 1,18km Total households protected: 54 Total population protected: 161		754,266.06

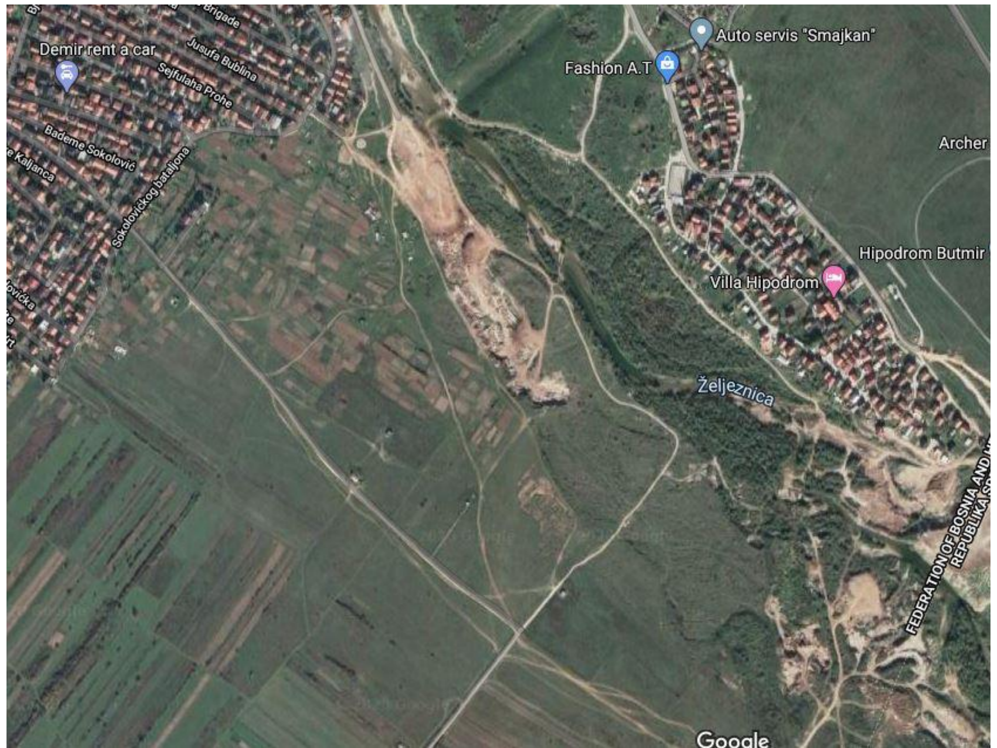
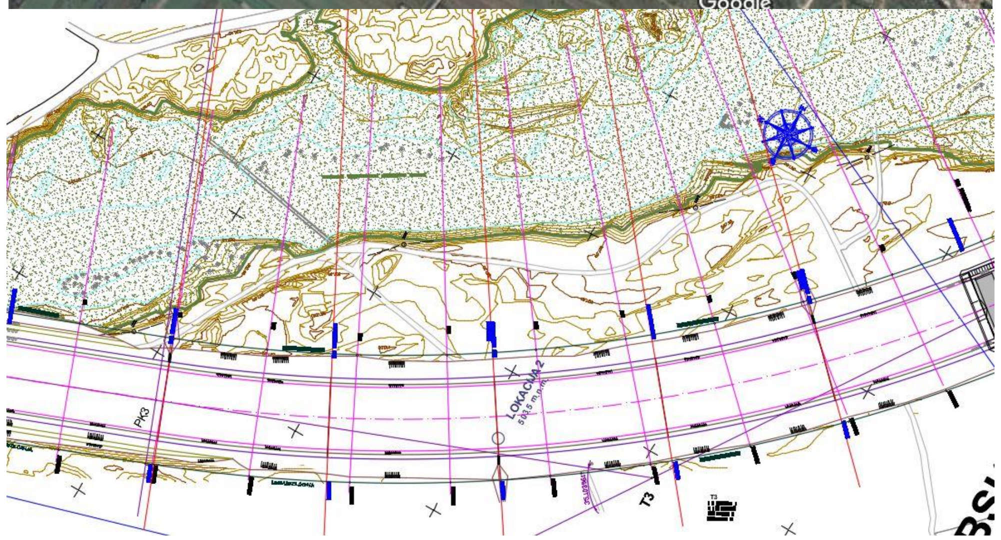
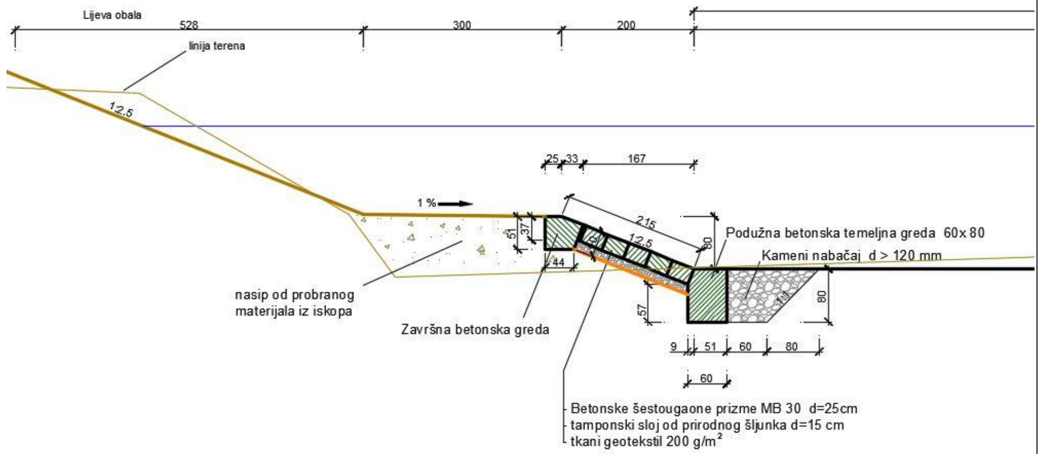
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
11* AVPS co-financing	Bosna	  	Completion of flood protection line in urban areas (Bosna River Basin) - Zenica  	Removing sediment, cutting wild vegetation, maintaining existing profile and protecting the banks with natural stone in cement mortar and erecting small dykes in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total length is 0.9 km L=400+500 Total households: 196 Total population: 557		502,844.04

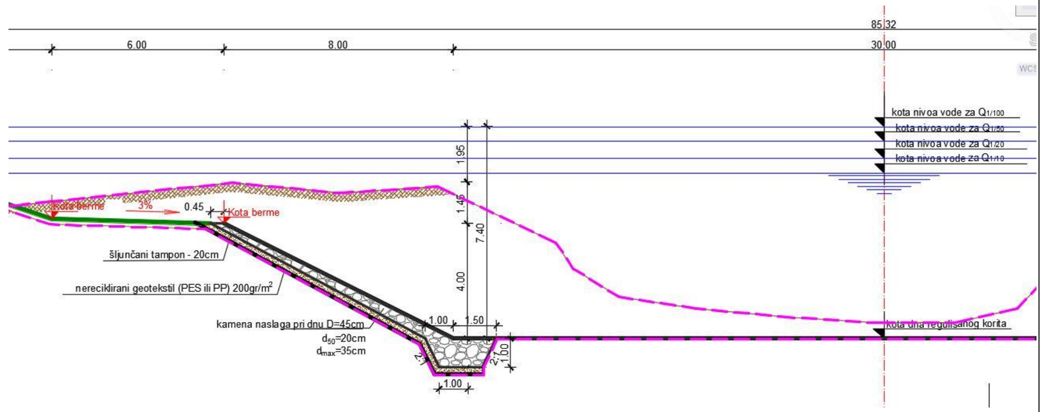
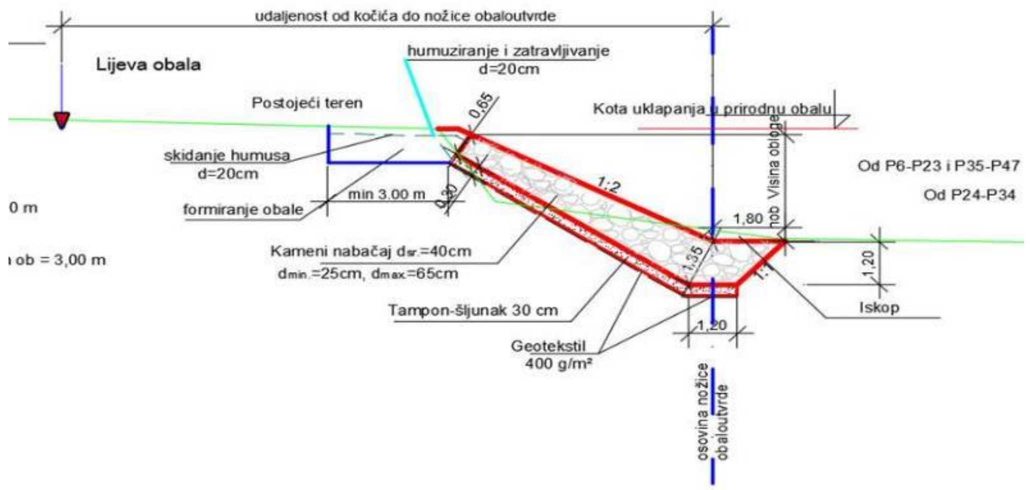
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
12* AVPS co-financing	Bosna	 	Completion of flood protection line in urban areas (Bosna River Basin) - Kakanj 	Removing sediment, cutting wild vegetation, maintaining existing profile and erecting small dykes in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total length is 0.6 km Total households: 64 Total population: 205		446,972.48

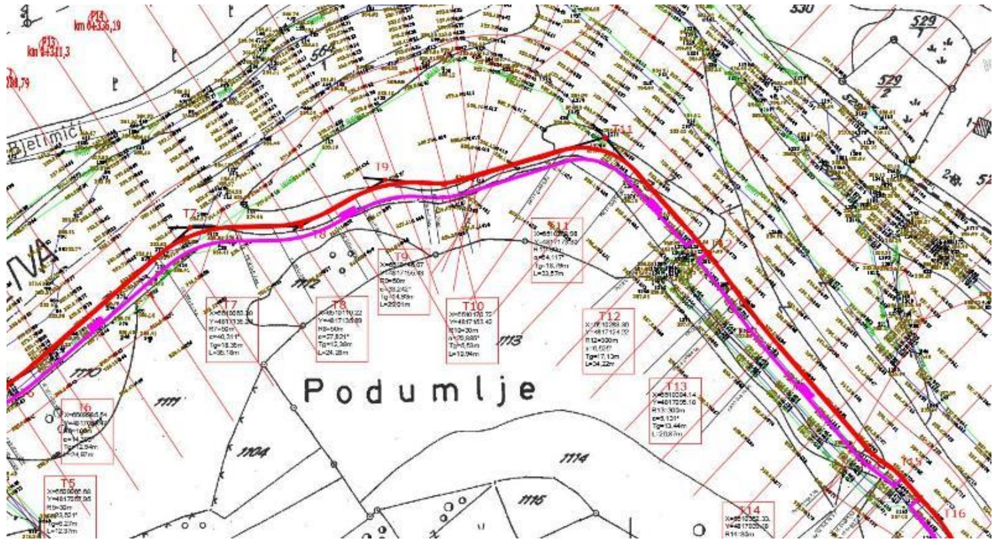
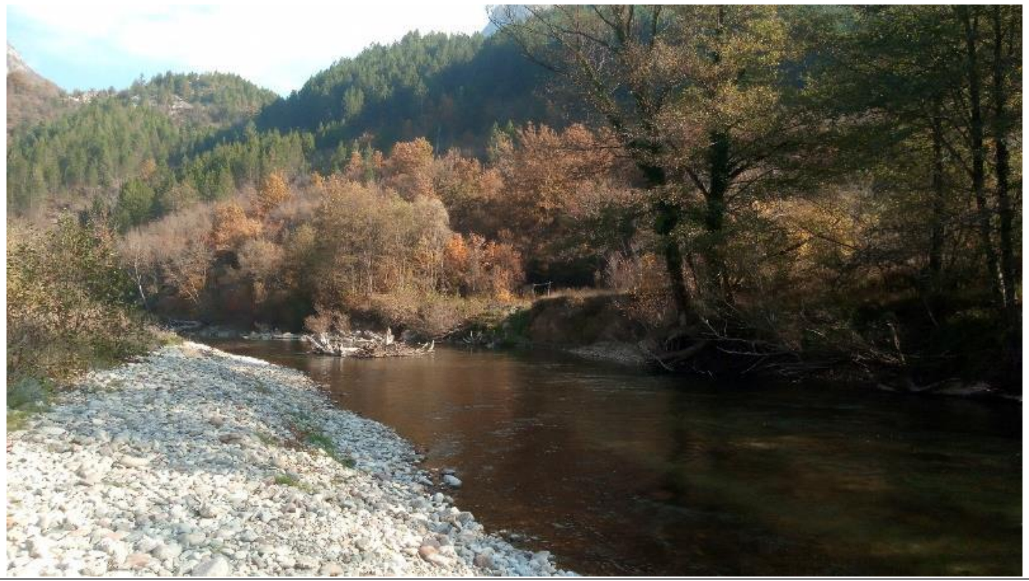
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
13* AVPS co-financing	Bosna	 	Completion of flood protection line in urban areas (Bosna River Basin) - Visoko NORMALNI PROFIL 	Removing sediment, cutting wild vegetation, maintaining existing profile and protecting the banks with concrete prisms, in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total length is 0,5km Total households: 21 Total population: 65		279,357.80

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
14* AVPS co-financing	Bosna	 	Completion of flood protection line in urban areas (Bosna River Basin) - Vogošća 	Removing sediment, cutting wild vegetation, maintaining existing profile and protecting the left bank with natural stone in cement mortar and erecting small dykes in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. L=600 Total households: 23 Total population: 69		335,229.36

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
15* AVPS co-financing	Bosna	 	Completion of flood protection line in urban areas (Bosna River Basin) - Novi Grad  	Protection of business and agricultural zone. Removing sediment, cutting wild vegetation, maintaining existing profile and protecting the banks with concrete prisms, in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total length is 3,5km Total households: 8 Total population: 22		4,469,724.77

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
16* AVPS co-financing	Bosna		Completion of flood protection line in urban areas (Bosna River Basin) – Ilidža	Protection of underground water sources from contamination. Works consists of removing sediment, cutting wild vegetation, maintaining existing profile and protecting the banks of Željeznica river with concrete prisms, in order to keep 1/100 water within riverbed. The top of the dyke is above 1/100 high with additional overhang of 0.80m. Total length is 3,3km		3,911,009.17

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
17* AVPS co-financing	Bosna		Completion of flood protection line in urban areas (Bosna River Basin) - Doboj-Istok 	Slashing and trimming of existing vegetation within inundation area, removing excessive flood deposit, protecting the banks with natural stone in order to keep 1/100 water within riverbed. Total length of proposed works is on river Spreča in total length of 1,5km. Protected agricultural area: hA 448		1,676,146.79
18* AVPJ co-financing	Neretva		Rehabilitation of the pumping station "Svitava" in the Svitava polder	TOR for detailed design is under development		562,430.00
19* AVPJ co-financing	Neretva		Rehabilitation of the left embankment upstream above Koćuša	TORfor detailed design is under development		415,068.00
20* AVPJ co-financing	Neretva		Rehabilitation of damaged banks of the Neretva River in Konjic Municipality, locality Glavatičevo 	Protection of bothriver banks, left and right, with natural stone, to prevent further erosion. All material is from local quarry. Total length of proposed works L=800m Number of protected households: 57 Population number: 183		674,915.00

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Phase I Investment (GCF-Financed) (USD)	Total value of measure after Phase II - continuation of activities from other sources of co-financing (USD)
						

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<td>21*
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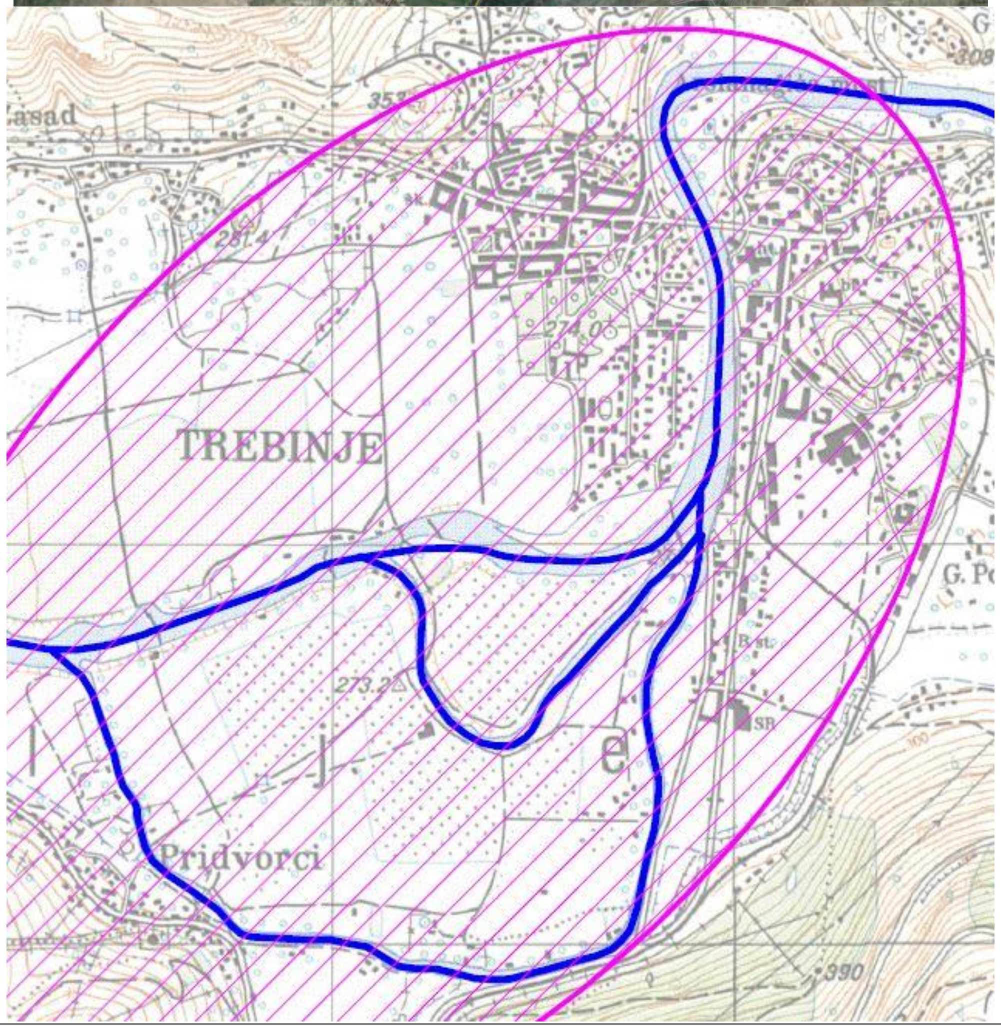
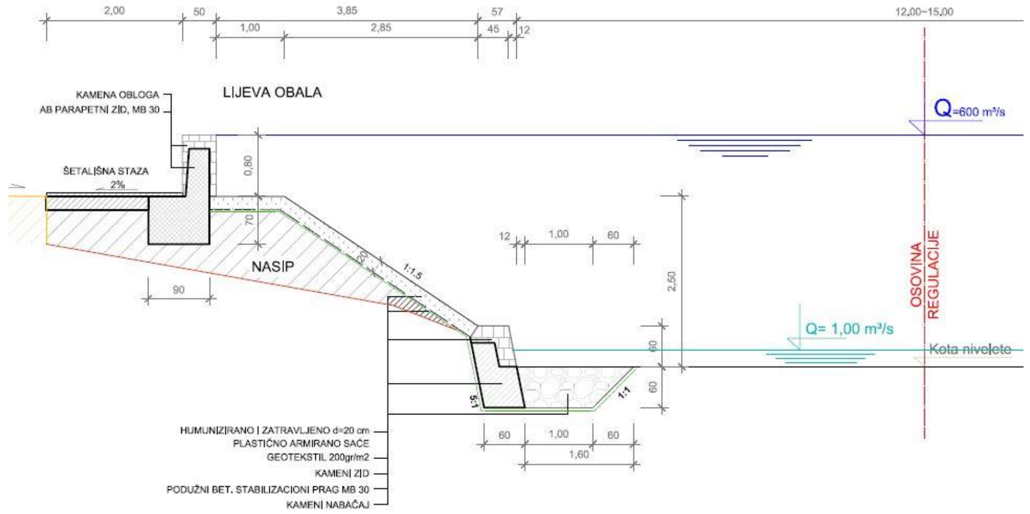
ng</td>
<td>Neretva</td>
<td>


</td>
<td>Regulation of the riverbed of Trebišnjica River in Trebinje.

• Regulation of the main bed of the Trebišnjica River from Perović Bridge to the confluence with Pridvorački krak at a length of 2.30 km

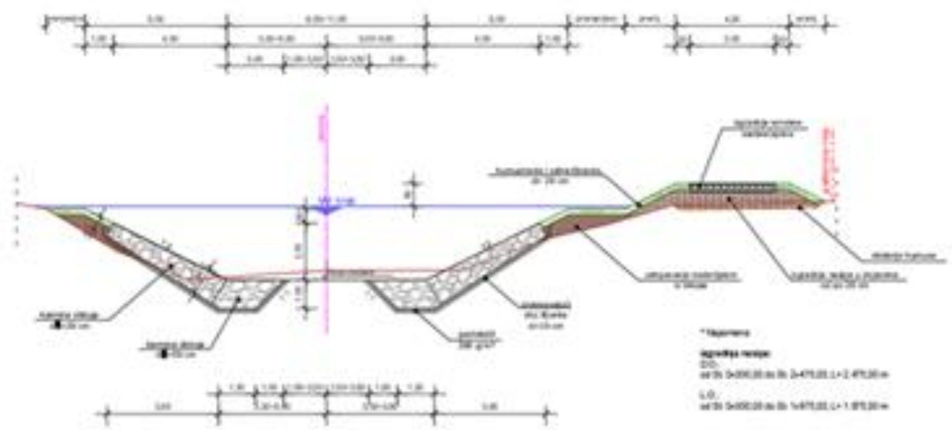
• Regulation of Pridvorački krak in the length of 2.89 km

</td>
<td>Proposed works consists of protecting the banks with concrete prisms and erecting small concrete wall in city center of Trebinje, in order to keep 1/100 water within riverbed.

Total length of rehabilitation is 5,3 km.

Total households: 772

Total population: 2316</td>
<td></td>
<td>1,913,273</td>
</tr>
</table>

Table 14-2: EbA measures to be implemented under sub-activity 2.2.1

Measure No.	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
EBA 1.	 	**Rehabilitation of downstream parts of Jošavka river, on critical locations where erosion is significant.** 	Total length of rehabilitation on critical parts river Jošavka. Total length of eroded banks is apporc 500m. Removing flood deposit, protecting the banks with natural stone and erecting small dykes in order to keep 1/100 water within riverbed. All material is provided from local quarries. Number of households protected: 2120 Population: 7420	200,000.00

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<tr>
<td>EBA 2.</td>
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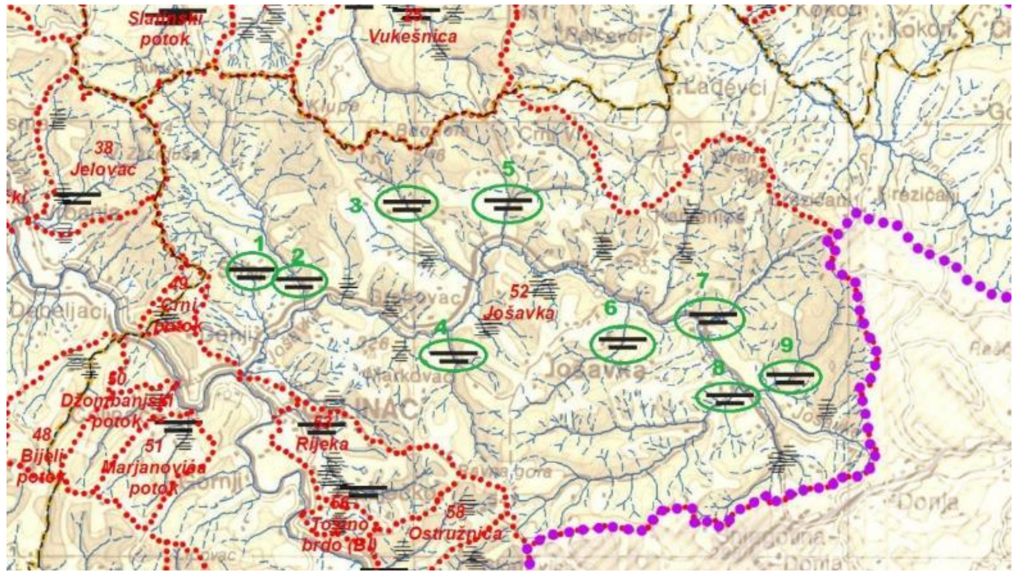
</td>
<td>Flood deposit torrential barriers on Jošavka basin
</td>
<td>Construction of 9 torrent barriers for sediment control. 9 barriers are planned for construction.

Total volume of stone barriers is aprox 17,000.00 m3.

Cost estimate of one barrier is approx. 30,000.00 USD.</td>
<td>300,000.00</td>
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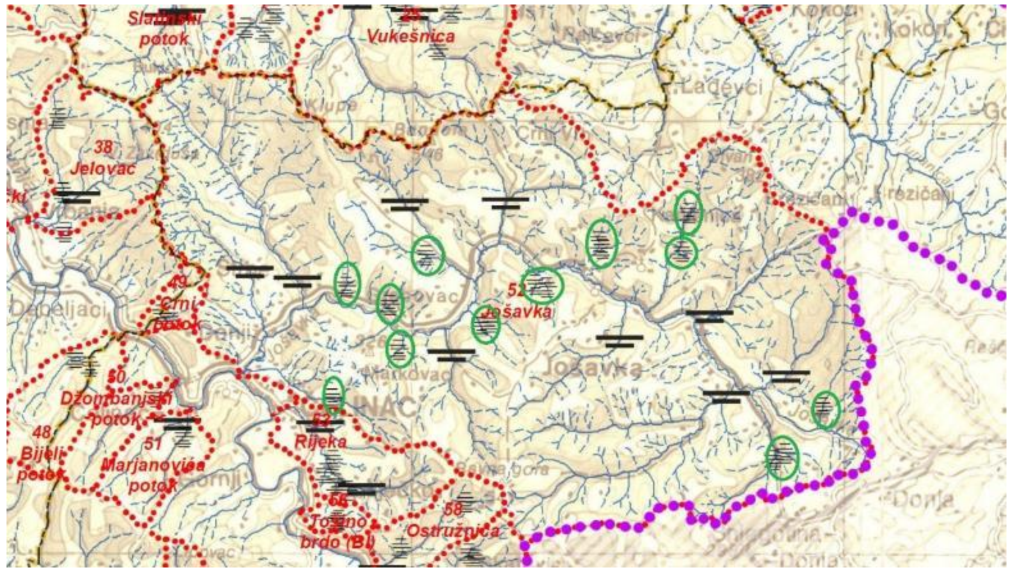
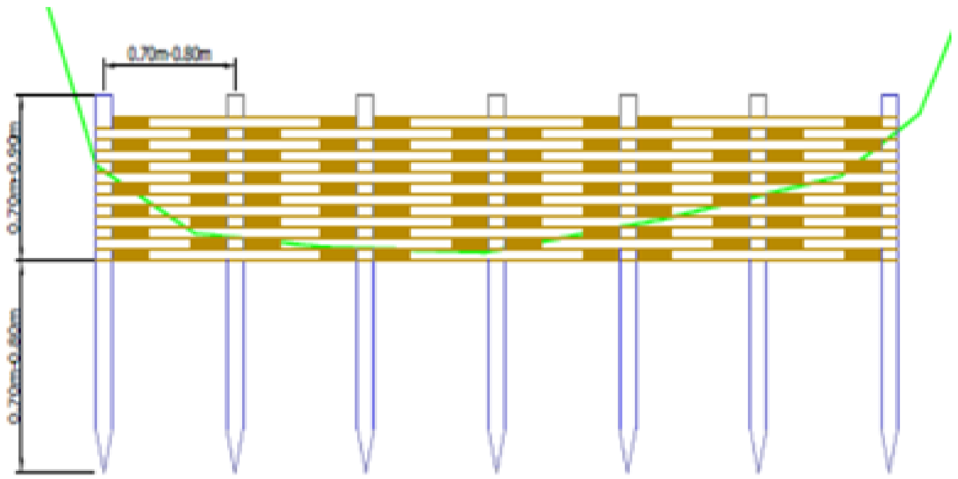
<tr>
<td>EBA 3.</td>
<td></td>
<td>Wickers</td>
<td>Construction of 16 wicker barriers for sediment control. 16 barriers are planned for construction within whole river basin.

Total length of 16 wicker barriers is approx. 1100m.

M'.

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<td>40,000.00</td>
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<td>EBA 4.</td>
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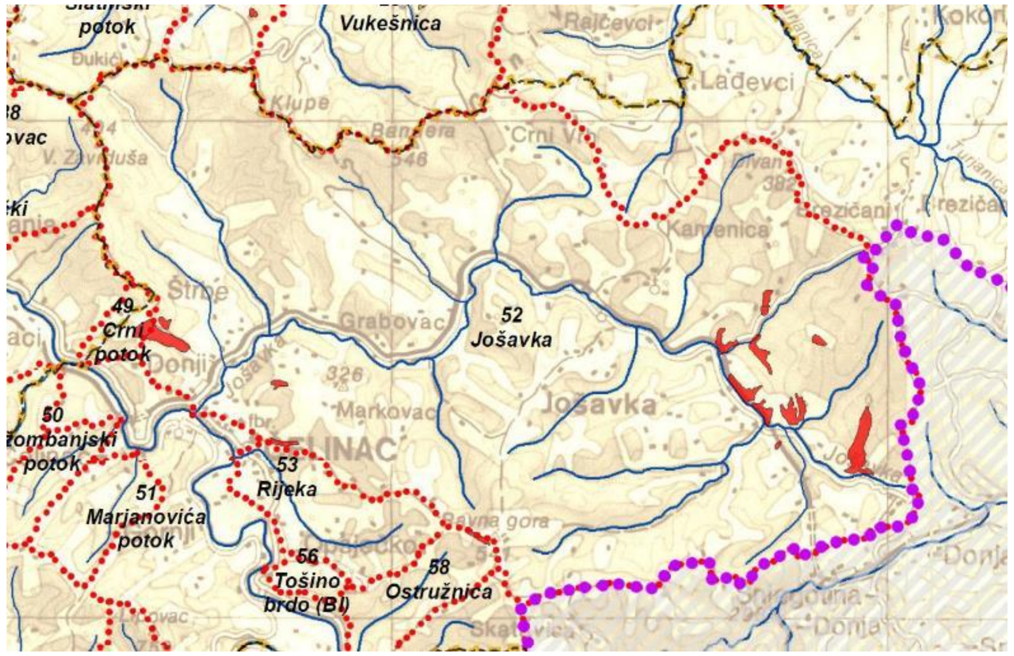
</td>
<td>Forestation

</td>
<td>Recommended forestation in Jošavka river basin is approximately 200hA.</td>
<td>400,000.00</td>
</tr>
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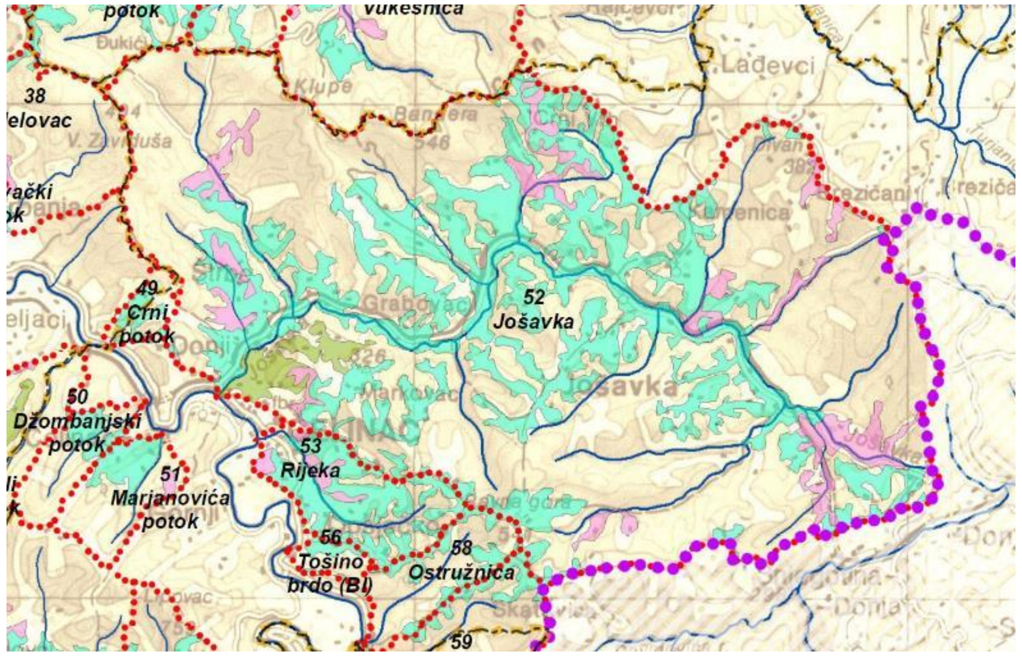
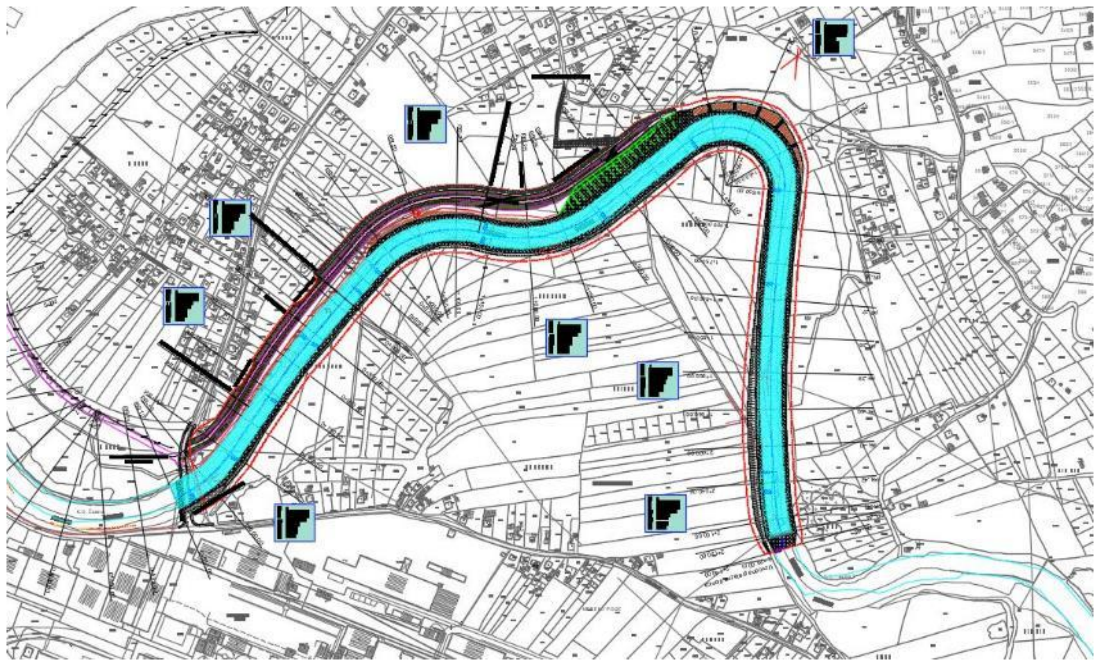
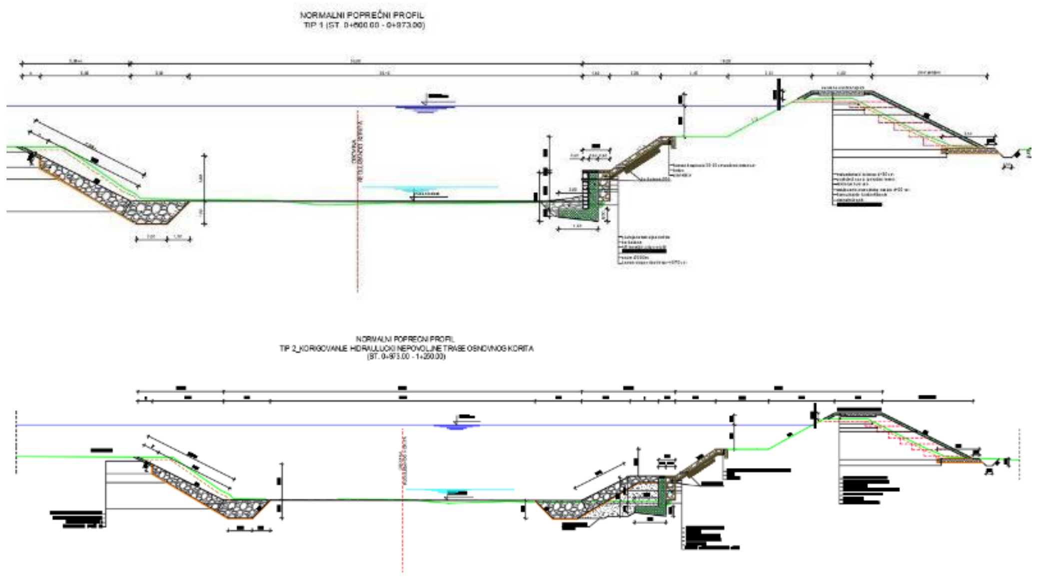
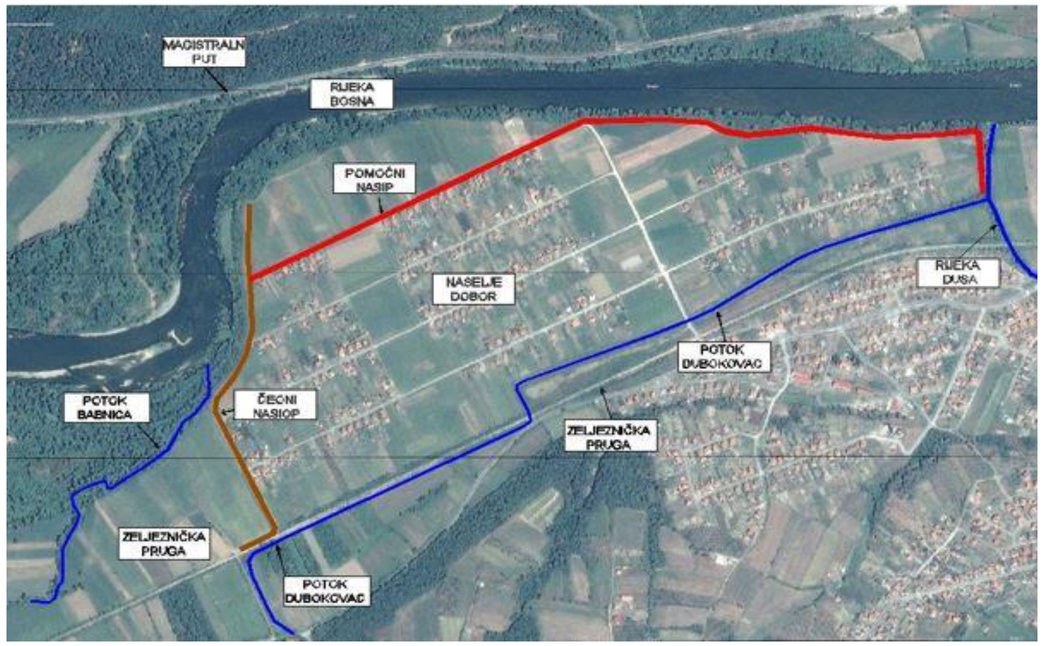
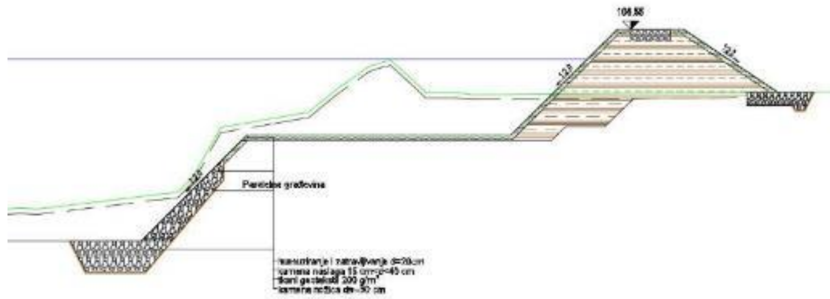
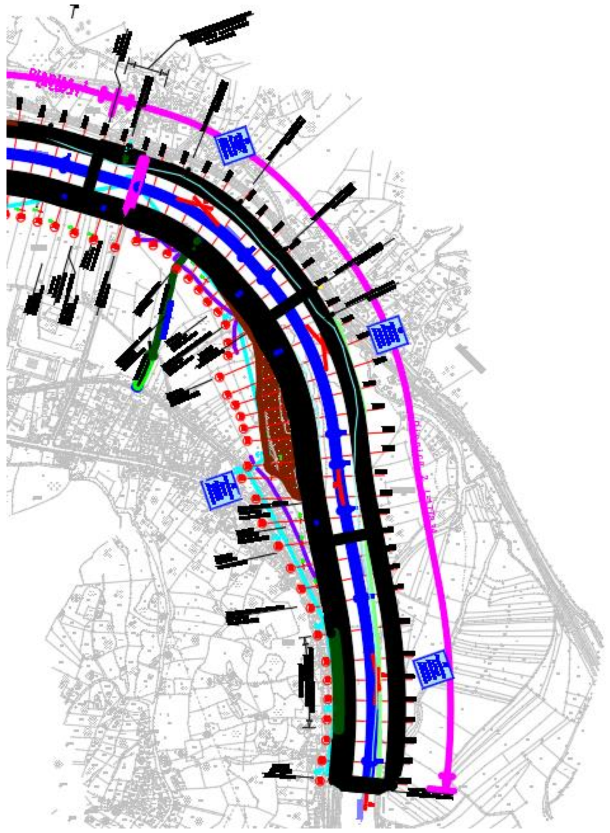
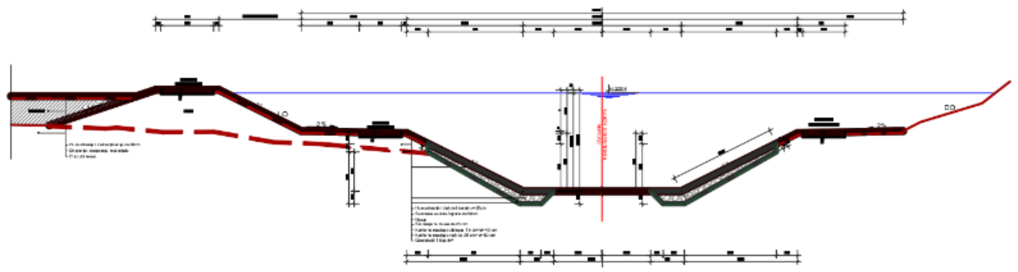
EBA 5.	 	**Grassing**  	Recommended grassing in Jošavka river basin is approximately 80hA.	50,000.00

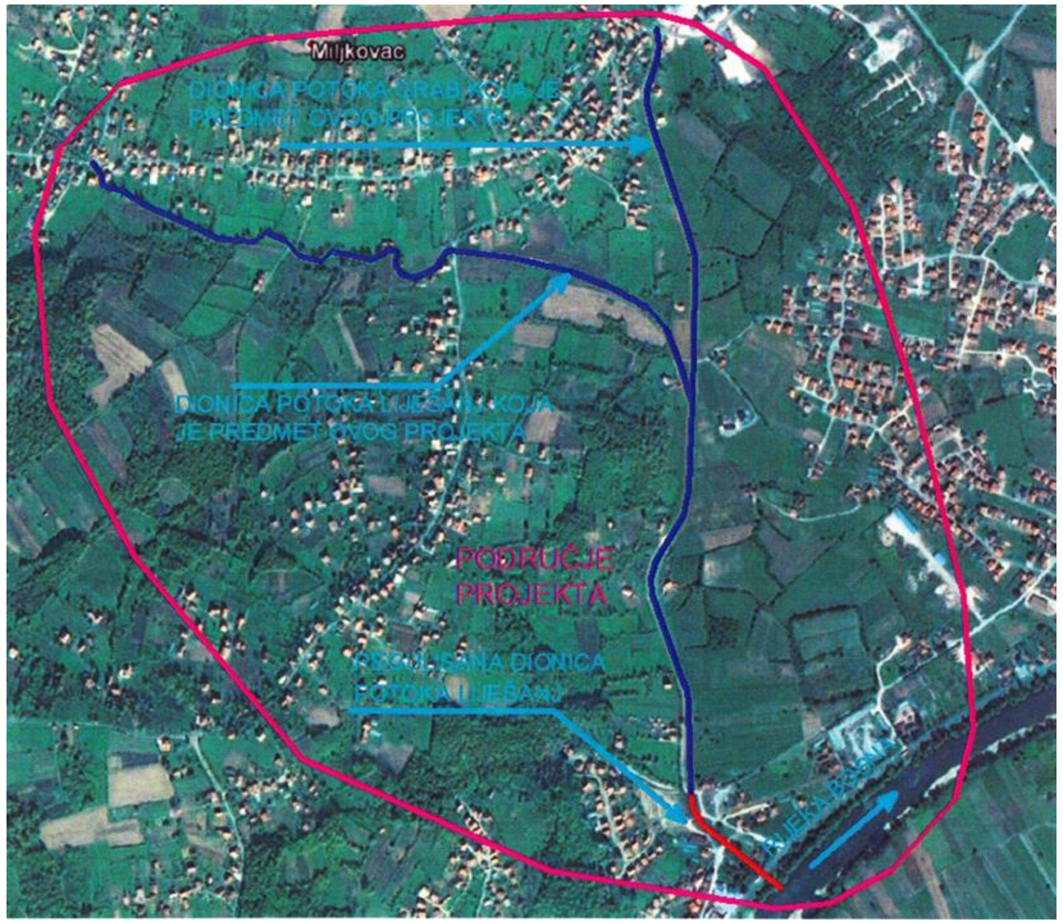
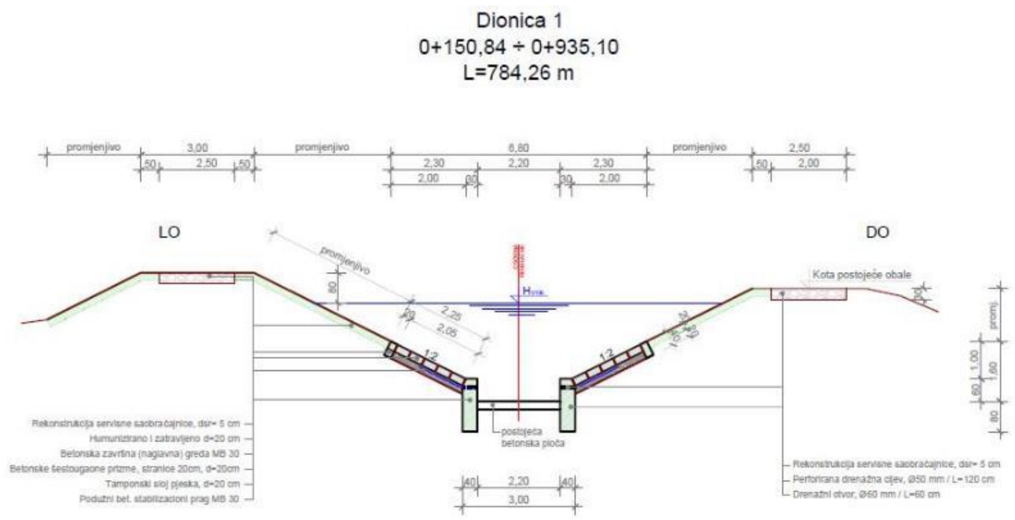
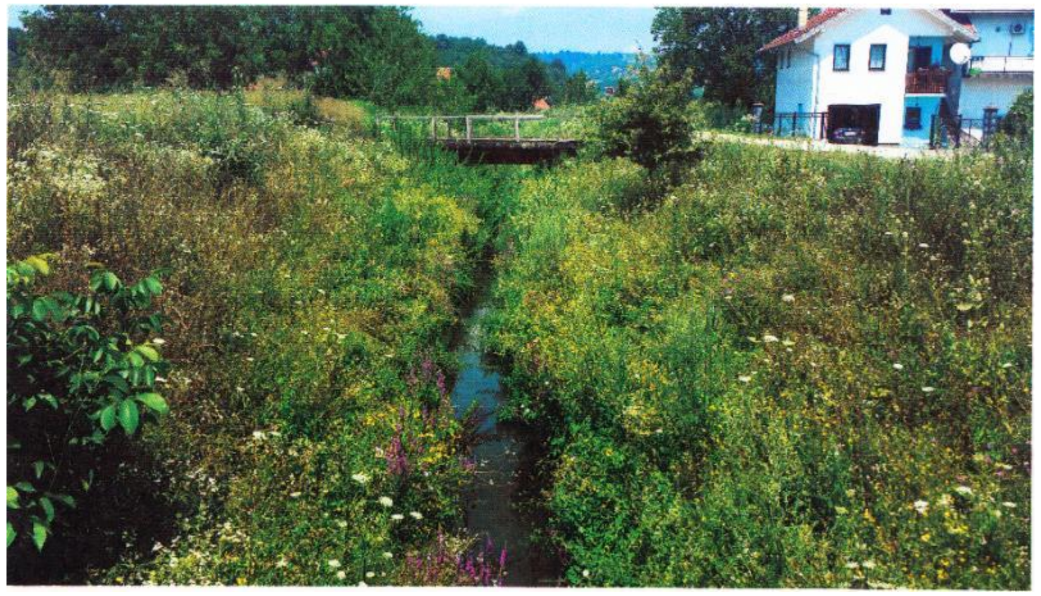
Table 14-3: Structural measures to be implemented under sub-activity 3.3.2

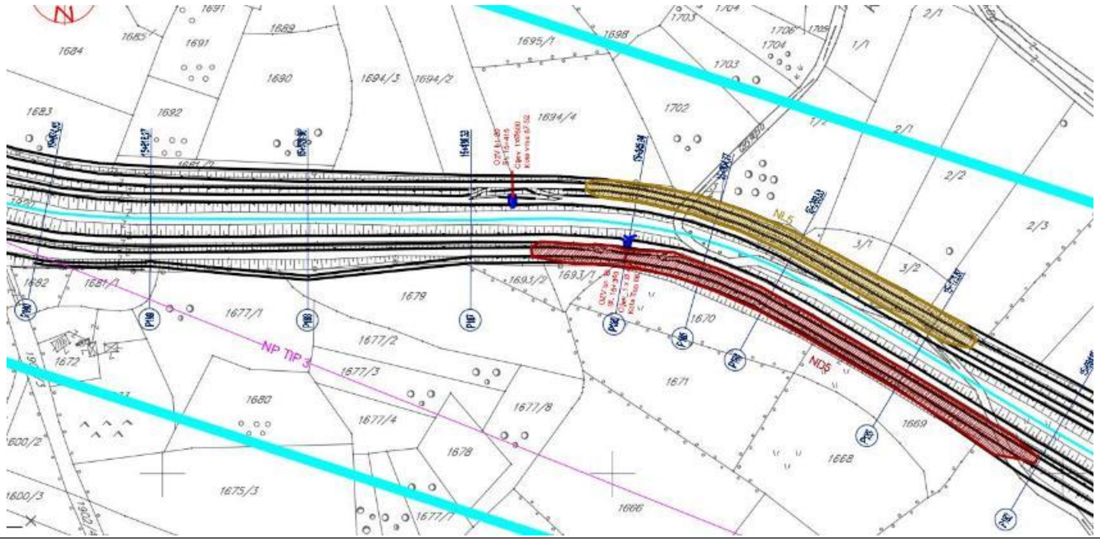
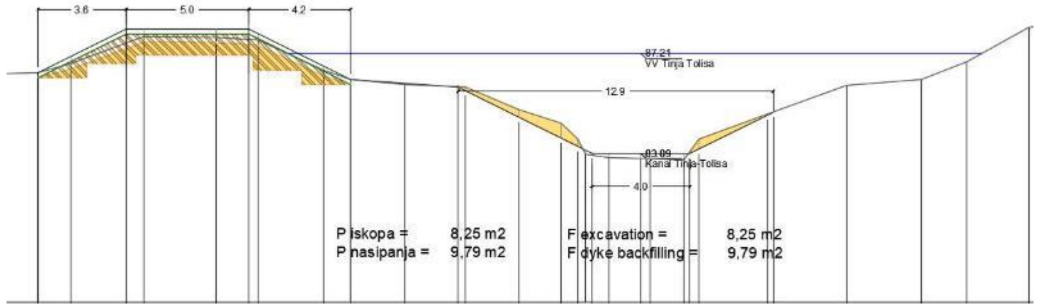
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
1.	Vrbas	 	Rehabilitation of the Vrbanja River bed in Banja Luka  	Works on landscaping of the main riverbed in terms of stabilization and securing of river banks, as well as on the profiling of the riverbeds. The project will additionally improve the concave curve at the site of "Crni Vir" and will include rehabilitation and overhanging of the existing right embankment.	2,337,736

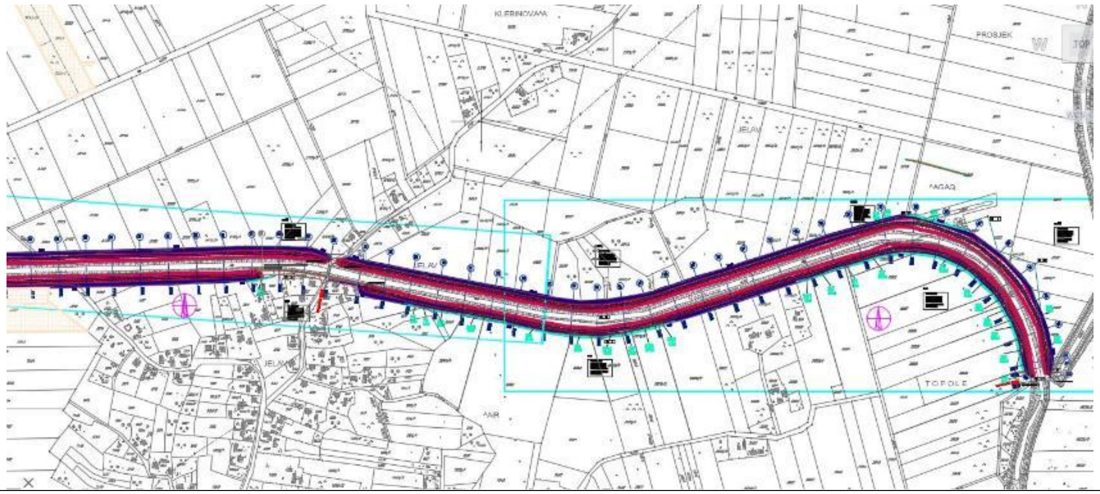
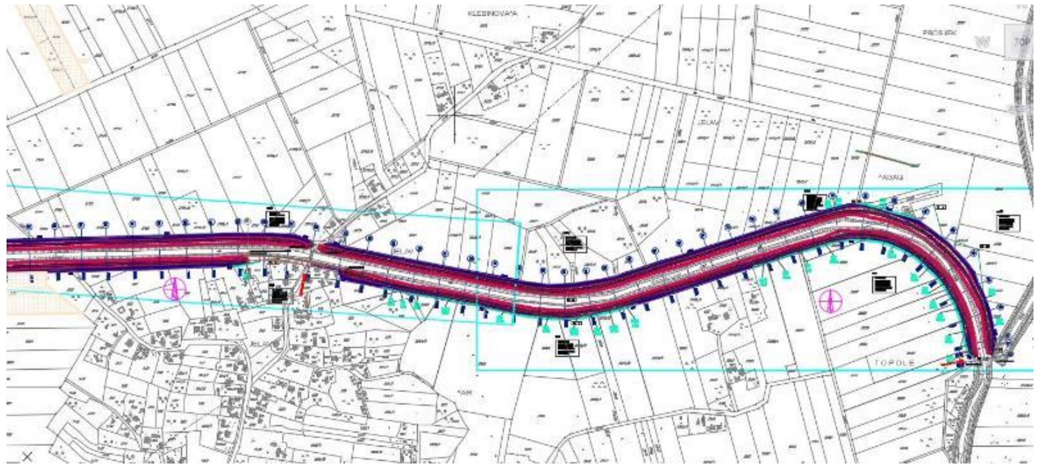
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
2.	Vrbas	 	**Revitalization of Borna channel in Gradiska Municipality**	Rehabilitation on the left bank of the canal with 2,1 km long dyke along the canal. On the left bank, an elevation of about 0.4 m is required on average 300 m in length, as a concrete wall along the existing road. On the right bank, an elevation of 0.6 m in length of about 2 km is required. Bottom of canal in the length of 2,1km is required which also includes restoration of 4 existing cascades.	547,732

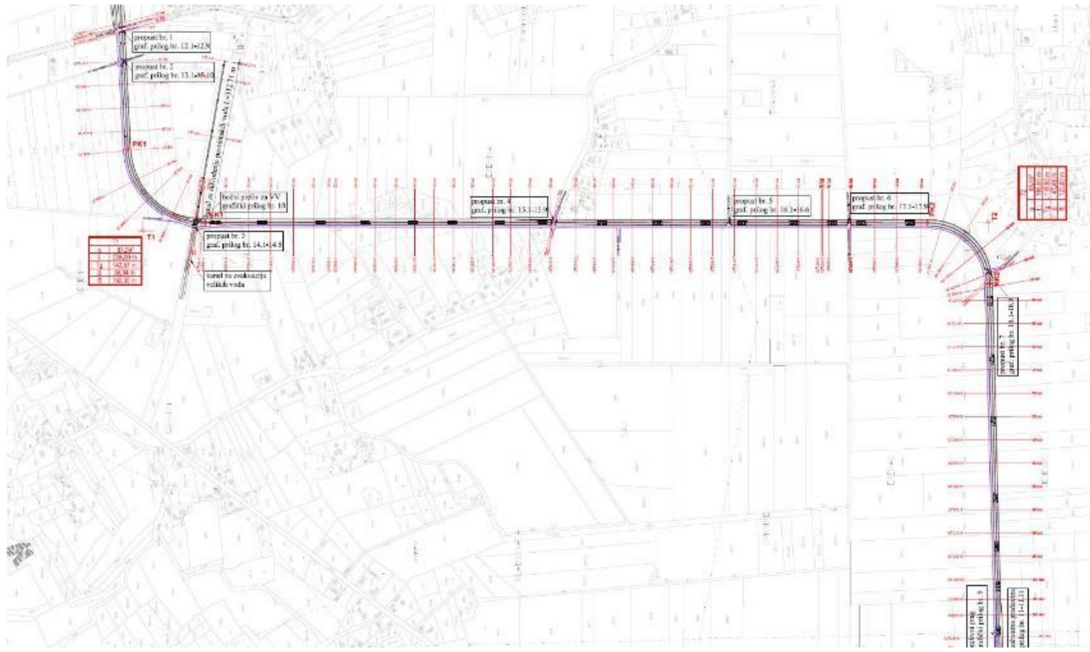
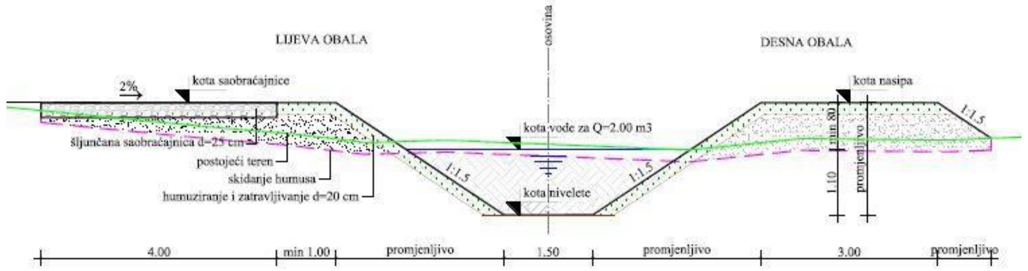
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
3.	Bosna	 	Upgrading of Bosna River dykes in Modrica IV settlement in Modrica Municipality 	The system of protection of the settlement Dobor from the high waters of the river Bosna through the construction and reconstruction of the right defensive embankment. Removing flood deposit, protecting the banks with natural stone and erecting dykes in order to keep 1/100 water within riverbed. All material is provided from local quarries. It also envisages regulation of two watercourses of the tributaries of the river Bosna, Dusa and Dubokovac in the area of the settlement Dobor as well as internal drainage through the construction of primary, secondary and tertiary channel network	7,620,925

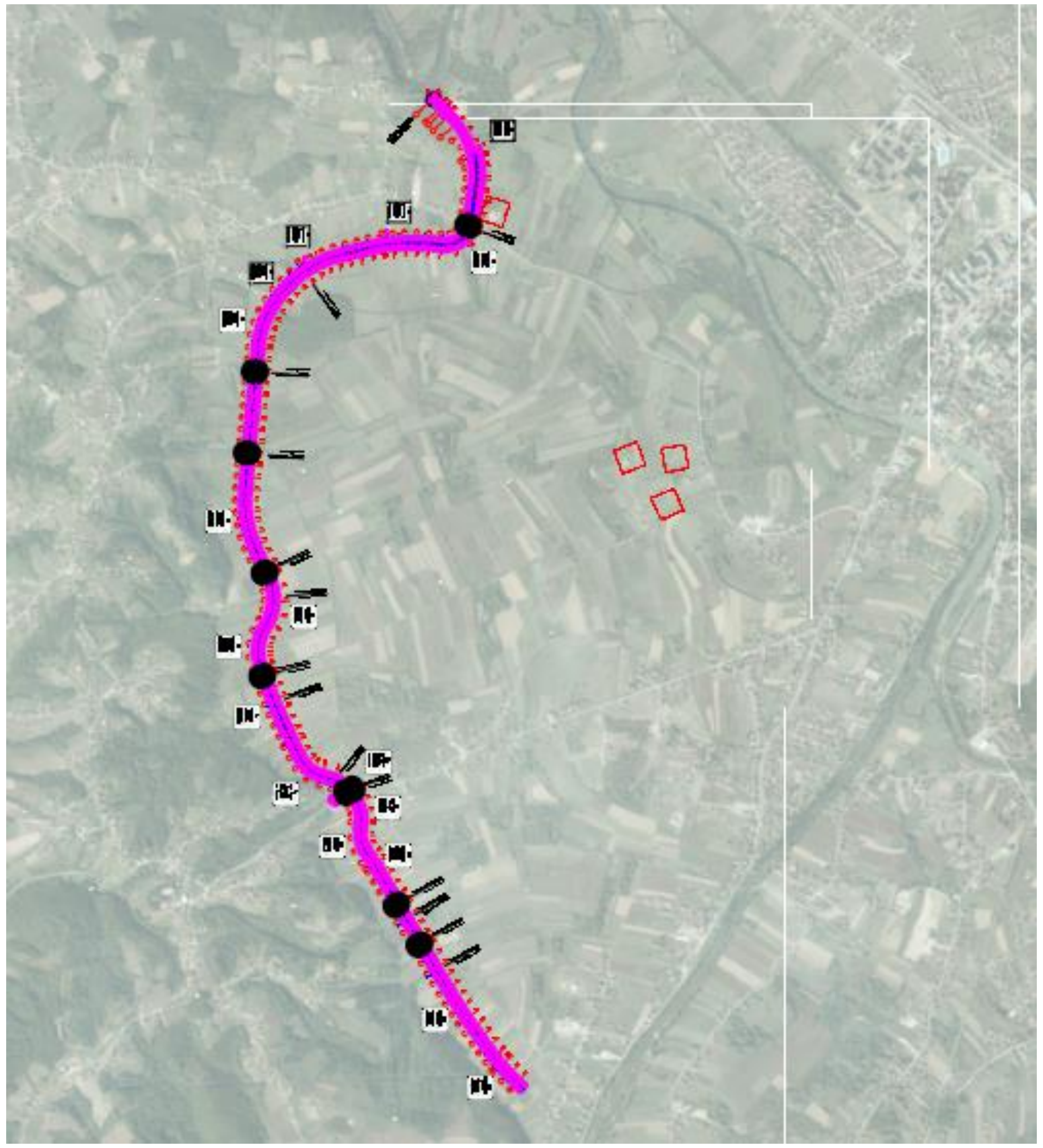
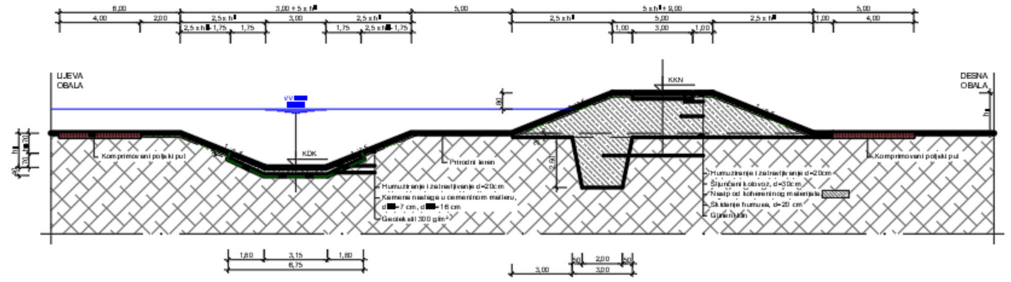
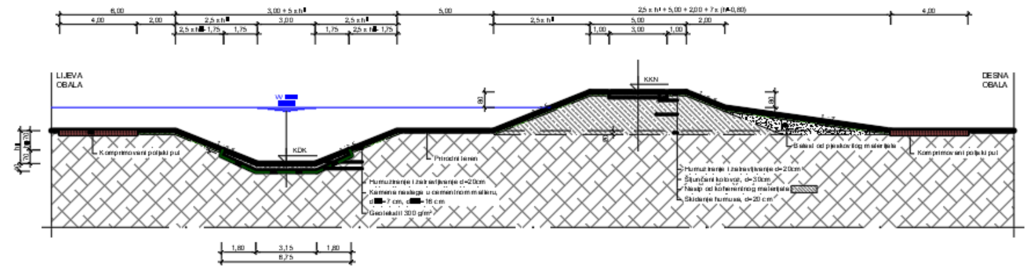
Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
4.	Bosna	 	Flood protection of the settlement Bare, City of Doboj  	Cleaning and stabilization of the basic river bed of the river Bosna from the bridge in Bare settlement and upstream at a length of 1.78 km. The river bed is 100 m wide with a slope of 1: 2 and a stone embankment up to a water level of 1/10 years. The embankments were designed to protect the Bare settlement from the high waters of 2014 with a overhang of 30 cm.	3,992,740

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
5.	Bosna	 	**Rehabilitation of the Ljesanj and Grab Rivers beds, City of Doboj**  	Permanent regulation-regulation of the perimeter canal and the Ljesanj stream at a length of about 2,000 m, regulation of the perimeter canal Grab at a length of about 650 m. The degree of protection against flooding is defined by the coincidence of the water levels of the 20-year-high water of the Bosna River and the 100-year-old large water of the Liješanj Canal. Top of dyke is 80cm higher that 1/100 water level	1,587,087

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
6	Drina	 	Rehabilitation of channels network in area of PS Đurići (Tinja-Tolisa)  	Rehabilitation of canal: cleaning and slashing of in-canal vegetation, cleaning flood deposit and sediment. On critical parts, additional elevation of top on levee is needed. In addition, strengthening of canal banks due to erosive process is needed Total length of the proposed works is 940m. In order to connect back coastal waters, reconstruction of existing inlets as proposed as well as construction of three new.	695,198

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
7.	Drina	 	Rehabilitation and raising of dyke on the GCK channel in the City of Bijeljina  	The works include rehabilitation of eroded banks as well as the overhang of the embankment crown on critical sections. In order to allow ongoing maintenance in the full profile of the embankment, slashing of low vegetation will be conducted. New service road will be constructed on top of the embankment.	2,207,677

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
8.	Drina	 	Construction of channel (Selište - Dašnica)  	Construction of new canal that connects two existing ones. By connecting the Selište canal to the Dašnica-old canal, gravity supply of irrigation water to the subsystems and planned pumping stations is ensured, which will also enable drainage of inland surface waters to the Drina river. The canal is 2.8 km long, 2.5 m wide at the bottom and slope 1: 1.5.	750,649

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
9.	Una-Sana		Construction of the Lateral channel in west part of Prijedor   	Construction of a perimeter canal in Mataruško field, total length 5.29 km, for protection against flooding of agricultural parcels and drinking water intake for the City of Prijedor. The channel is variable width at the bottom with partial stone lining sections. The embankment crown on the right bank of the Lateral Canal is above 1/100 high with additional overhang of 0.80m.	1,955,261

Measure No.	River basin	Google image/Design Layout/Photo from location	Name of the measure	Brief description of measure	Initial value of the proposed measure (USD)
10.	Vrbas, Bosna, Drina, Sava		Cleaning of areas near canals and dykes in north RS	Cleaning of areas near canals and dykes in north RS Total area 110ha.	1,124,719

15 ANNEX B - FLOOD PROTECTION INFRASTRUCTURE

15.1 Review of the Existing and Planned Flood Protection - Republika Srpska

In the upper parts of the basins of the following rivers: Bosna, Ukrina (water reservoir Drenova at Vijača River), Una and Sana, no significant impoundments have been made so there is no active protection of downstream communities from the large flood waves and flash floods.

15.1.1 Sava river basin - Planned infrastructure to be co-financed EIB

The Project components co-financed by the Bank include the following measures:

Municipality	Flood Protection Measures	Cost (x10^6 BAM)
North RS	Rehabilitation of Sava dyke and lateral channels in RS **Channels:** - Rehabilitation of Tinja-Tolisa channel, Loncari - Rehabilitation of Kladik channel, Loncari - Rehabilitation of Lateral channel Srnova-Potocani-Svilaj, - Rehabilitation of channel for PS Ivanjsko Polje, Brod - Rehabilitation of channel K II/1 for PS Glavinac, Kozarska Dubica - Rehabilitation of Lateral channel Hatipovac, Kozarska Dubica - Rehabilitation of Upper Lateral channel, Kozarska Dubica **Dykes**: - Rehabilitation of right Sava dyke in Brod - Rehabilitation of right Una dyke in Dubicka ravan, Kozarska Dubica - Rehabilitation of right Sava dyke in Dubicka ravan, Kozarska Dubica	0.8
Donji Zabar	Rehabilitation of channels network in area of PS Đurići (Tinja-Tolisa)	2.8

15.1.2 Drina River Basin - Planned infrastructure to be co-financed EIB

The Project components co-financed by the Bank include the following measures:

Municipality	Flood Protection Measures	Cost (x10^6 BAM)
North RS	Rehabilitation of Sava dyke and lateral channels in RS ***Channels:*** - Rehabilitation of Lateral channel Seliste, Bijeljina, - Rehabilitation of Lateral channel Drina -Glogovac, Bijeljina, - Rehabilitation of Dasnica channel, Bijeljina - Rehabilitation of Batar-Johovac channel, Bijeljina - Rehabilitation of B2 channel, Bijeljina - Rehabilitation of Johovac channel, Bijeljina ***Dykes:*** - Rehabilitation of right Sava dyke in Semberija, Bijeljina - Rehabilitation of left Drina dyke in Semberija, Bijeljina	0.8

Bijeljina	Rehabilitation and raising of dyke on the GOK channel in the City of Bijeljina	1.4
Bijeljina	Construction of channel (Selište - Dašnica)	

15.1.3 Bosna River Basin

According to the preliminary flood risk assessment (PFRA) for the territory of the Republika Srpska it has been recorded that the areas that were affected by flooding of the river Bosna and its tributaries have covered 17,919 ha. Extreme floods occurred in 1999, 2003., 2005, 27/05/2010, 22/06/2010 and 15/05/2014, and lasted for three to four days. Extreme intensity and extent of the flooding were recorded in the floods from May 2014. According to Annex 1of the PFRA over 10,000 housing units were flooded with nearly 28,000 residents who were in flooded areas. The number of evacuated residents (close to 24,000) illustrates the scope and the destructiveness of this historic flood.

Municipalities located in the immediate area of the Bosna River basin in the Republika Srpska have undergone the most severe damage: Doboj, Modrica, Vukosavlje and Šamac (Šamac mostly belongs to the direct catchment basin of the Sava River, but in 2014 there was a spill-over of high water of the Bosna River across the dikes designed for slow waters of the Sava River).

Planned infrastructure flood protection measures at the territory of the Bosna River basin are as follows:

- It is necessary to reconstruct certain dikes to obtain the desired degree of protection reliability of 1%, with a protective height of 1.2 m up to the dike crest elevation point (along the Bosna River and its tributaries where slow high waters of the Sava River occur), but also in the directions of other water currents flowing through urban settlements with the camber of 0.8 m so that the dikes do not get damaged when the overflow of high waters happens. The reconstructions with cambers are related to:
- The dikes of the right bank along the Bosna River, known as Šamac-Miloševac dike mainly does not comply with the camber regulations with regards to the Bosna River slow waters.
- Camber of the regional road (and dike reinforcement at the same time) in the Town of Doboj - at the left bank
- The construction of new dikes along the main stream of the Bosna river:
  - The right protective dike along the Bosna river in Samac, next to the villages Pisari, Crkvina Donja and Zasovica from the existing dike in Samac, and upstream with the length of about 7 km.
  - The left defence dike along the river Bosna, along the settlement Vukosavlje from the bridge in Modrica downstream up to the existing dike Prud - Neteka, with the length of 13 km.
  - The right defence dike along the newly built settlement Dobor in Modrica, with the length of 2.4 km.
  - The left defence dike along the village Bare in Doboj, with the length of 1.6 km.

- The Bosna River:
  - Protection of the left concave coastline stretching from Modriča to Šamac with a total length of 5.5 km.
  - Regulation of the Bosna River from the bridge in the village of Bare upstream to the mouth of the Spreča river and from the mouth of the river Spreča upstream to the mouth of the Usora River, with the total length of 4.5 km.

- In the area of the Bosna River Basin at the territory of the Republika Srpska, it is necessary to regulate the river flow in the following locations: Tolisa (1.50 km), Grapska (2.10 km), Spreča (0.80 km), Velika Usora (1.70 km), Željeznica (3.50 km), Kasindolska river (0.50 km), Lukavac (5.00 km), Tilava (1.20 km), Lukavička river (3.00 km), Dobrinja (1.40 km), Mokranjska Miljacka (2.50 km) Repašnica (2.50 km) Jahorina stream (2,10 km), Seliški stream (2.00 km), Ljubogošta (1.50 km) and Bistrica (1.20 km).

The estimated financial framework for the investment in infrastructure measures for flood protection in the Bosna River basin in the Republika Srpska, which would reduce the flood to an acceptable level, according to various strategic, planning and project documents is around 120 million (BAM) KM.

Below is a Table showing the Planned Infrastructure flood protection measures for which the Detail Designs have been done:

Table 15-1: Planned Infrastructure flood protection measures for which detailed design exists – Bosna River basin

Ranking priorities	Investment measure	Detail Design	Cost ($x10^6$ BAM)
1	Regulation of the Bosna River from the mouth of the river Spreča upstream to the mouth of the Usora River, with the total length of 4.5 km (Phases I, II and III)	YES	24.3
2	Regulation of the Bosna River from the bridge in the village of Bare upstream to the mouth of the Spreča river with the construction the left defence dike along the village Bare in Doboj, with the length of 1.6 km (Phases I and II)	YES	12.2
3	Regulation of the Bosna River and the construction of the right defence dike along the newly built settlement Dobor in Modrica, with the length of 2.4 km.	YES	15.8
Total:			**52.3**

15.1.4 Ukrina River Basin

According to the preliminary flood risk assessment (PFRA) at the territory of the Republika Srpska, it has been recorded that the area affected by flooding caused by the Ukrina River and its tributaries covers 6363 ha. The extreme floods occurred: 31/05/2010, 21/06/2010, 22/06/2010, and lasted for three to four days, while data on previous flood waters has not been recorded. According to Annex 1 PFRA, nearly 1300 households with about 4500 people who were in flooded areas were affected by flooding.

Planned infrastructure flood protection measures at the territory of the Ukrina River basin are as follows:

- The dikes along the river Ukrina, from the mouth of the Ukrina river into the Sava River, upstream to the new bridge in Derventa, do not have the required degree of protection, and it is necessary to carry out the rehabilitation and reconstruction along the whole length of 7.00 km.
- The dam and impoundment "Drenova" constructed in the Drenova river basin, control only 30% of Vijaka River basin, it has an effect in alleviating the high waves of the Vijaka River only up to the mouth of the Ukrina River and has a limited effect in reducing major flash floods of the Ukrina River. The capacity of all pools at the Carp Pond built on the right bank of the Vijaka River is 17,265,000.00 m^3 of water with reinforcement of dikes of 0.80 m, with an additional volume of approximately 5,524,000.00 m^3. The additional volume in fish ponds of 5,544,000.00 m^3, could be used for accepting large flood waters of the Vijaka river. In order to use the additional volume of the fish ponds as retention ponds to mitigate flood waves of the Vijaka River, the fish ponds need to be prepared for the new role with the construction of inflow and outflow structures for flood waters. So, it can be concluded that "Drenova" impoundment can also significantly influence the Ukrina river high waters in Derventa.
- North perimeter canal Agići-Kuljenovci-Babino brdo, with the length of 5.3 km does not have the adequate throughput and it needs to be reconstructed.
- Due to poor maintenance and deposition of sediment in the bed the regulated riverbed of the Ukrina River in Derventa has a reduced throughput.

- Channel network for discharging internal waters (Vukovija channel with the length of 4.3 km, Channel Novo naselje-Kasarna with the length of 5.0 km, channel in the industrial zone with the length of 2.0 km and the channel along the fish pond in Prnjavor in the length of 10.0 km), need to be reconstructed and put into operation and used in full capacity.

The estimated financial framework for the investment in infrastructure measures for flood protection in the Ukrina River basin in the Republika Srpska, which would reduce the flood to an acceptable level, according to various strategic, planning and project documents is around 20 million (BAM) KM.

Below is a Table showing the Planned Infrastructure flood protection measures for which the Main Designs have been done:

Table 15-2: Planned Infrastructure flood protection measures for which detailed design exists – Ukrina River basin

Ranking priorities	Investment measure	Detail Design	Cost (x10^6 BAM)
1	Regulation of Vijaka river banks, section 5 km long	YES	3.3
2	Regulation of Ukrina river banks, section 5,5 km long	YES	2.4
3	Rehabilitation and cleaning of Drenova reservoir	YES	1.4
Total:			**7.1**

Non-structural measures

In addition to foreseen infrastructural measures that will significantly contribute to reduction of the flood risk, non-structural measures has a significant role to play, as part of systematic approach in river basin organization. Non-structural approaches provide basis for reconsidering required interventions on the basin that will contribute to the flood risk mitigation, through the reduction of erosion process intensity and reduction of quantities of deposit which is transported from the basin.

In the implementation of mentioned measures, it is necessary to reconsider the status of erosion and analyse the torrential flood risk to the basins based on Torrential flood modelling and mapping as described above. This will form the basis for planning of anti-erosion measures on individual river basins.

Proposals for future anti-erosion measures are defined by analysing status of erosion in the basin, number and spatial distribution of torrential basins, maximum discharge values, quantities and structure of deposit on certain river courses profiles, as well as spatial distribution of sensitivity categories to the occurrence and development of torrential floods. Those measures include: technical measures-construction of torrent barriers on critical partition profiles; bio-technical measures-development of (single and double) wattle check dam which create support for vegetation growth on bare hillsides; other anti-erosion measures- economic measures (adjusted land cutivation) and administrative bans. By terrain prospection using indicated maps, necessary scope of anti-erosion interventions in the basis is defined, as well as list of measures and assessment of required funds.

Considering defined status in the basin, proposal of measures for planning and systematic organization of the basin is divided into two groups: 1) anti-erosion measures on the surface where processes of excessive and heavy erosion are present (torrential basins) which are erosion cores in the basin, 2) basic measures of systematic organization of the basin, i.e. organization of forest and agricultural areas with light erosion processes.

15.1.5 Vrbas River Basin

According to the Preliminary Flood Risk Assessment (PFRA) and detailed Flood Hazard and Risk Maps at the territory of the Republika Srpska (developed under the Vrbas project), the area affected by flooding caused by the Vrbas River and its tributaries covers 9839 ha. The extreme floods occurred in 2006, on 26/05/2010, 22/06/2010, 26/10/2010 and 15/05/2015 and lasted for three to four days, while data on previous flood waters has not been recorded. According to Annex 1, PFRA, nearly 5000 households with about 16150 people who were in flooded areas were affected by flooding.

Planned infrastructure flood protection measures at the territory of the Vrbas River basin are as follows:

- The construction of the left dike reinforcement on the Vrbas River in Kukulje,
- The construction of the right dike reinforcement on the Vrbas River downstream from the Poveliče mouth and in the settlement Prijebljezi is currently underway,
- Regular maintenance of the constructed dikes downstream from Klašnice to the mouth of the Vrbas River into the Sava River with the length of about 52 km per axis of the main riverbed
- Reconstruction of dilapidated river banks by constructing new river dikes and reconstructing of the existing ones,
- Reconstruction of the Vrbas River riverbed from the border with the Banja Luka Town downstream with the length of 3.8 km, at the territory of the Laktaši municipality,
- Reconstruction of the Vrbas River riverbed at the territory of the Banja Luka Town with the length of 19.5 km,
- Reconstruction of the Vrbas River riverbed at the territory of the village Karanovac with the length of 2.5 km,
- Reconstruction of the Vrbanja River riverbed at the territory of the Banja Luka Town with the length of 5 km,
- Reconstruction of the Vrbanja River riverbed at the territory of the Čelinac municipality with the length of 3 km,
- Reconstruction of the Vrbanja River riverbed at the territory of the Kotor Varoš municipality at 10 sites with the total length up to 15 km,
- Reconstruction of the Pliva River riverbed at the territory of the Šipovo municipality with the length of about 6 km
- Reconstruction of the Pliva River riverbed at the territory of Jezero Municipality, with the length of about 4.6 km,
- Reconstruction of the other tributaries of the Vrbas River, Pliva River and Vrbanja River: Channel Povelič - about 2 km, Channel Ina and Kosolinac - 3.5 km, Channel Gornja Ina - 4 km, Makava and Lepenica - 4 km, Jošavka in Čelinac - 5.5 km, stream Rijeka - 1.4 km, Turjanica River - 8,5 km, Mahovljanska River - 6.5 km, Crkvina River - 1.8 km, Bukovica - 2.7 km, Jošavka River in the municipality Jezero - 3 km, Perućica River - 1 km, Crna rijeka river - 0.85 km, Janj - 5 km, Ugar - 1.35 km, other smaller tributaries.

The estimated financial framework for the investment in infrastructure measures for flood protection in the Vrbas River basin in the Republika Srpska, which would reduce the flood to an acceptable level, according to various strategic, planning and project documents is around 170 million (BAM) KM. This financial assessment is largely based on the project documentation for flood protection in urban areas along the watercourses in the basin of the Vrbas river such as Banja Luka, Čelinac, etc.

Below is a Table showing the Planned Infrastructure flood protection measures for which the Detailed Designs have been done:

Table 15-3: Planned Infrastructure flood protection measures for which detailed design exists – Vrbas River basin

Ranking priorities	The municipality	River	Investment measure	Cost ($x10^6$ BAM)
1	Grad Banja Luka	Vrbas	Regulation of the Vrbas river water regime on Section 1 from the Stari most in Trapisti and downstream to the border with Laktasi municipality, 5,56 km long section (Stage X and X+)	19.3
2	Jezero	Jošavka	Regulating of the Jošavka river bed from the mouth into Pliva and upstream, 416 m long section	0.5

Ranking priorities	The municipality	River	Investment measure	Cost (x10^6 BAM)
3	Grad Banja Luka	Vrbanja	Regulation of the water regime of Vrbanja river from the bridge at Incel and upstream for 1,5 km and rehabilitation of the right dyke in Cesma settlement, 100 m long section	3.3
4	Grad Banja Luka	Vrbas	Regulation of the Vrbas river water regime Section 2, from the bridge in Trapisti and upstream to the Vrbanja river mouth, precisely to the bridge for Toplana, on section 5,29 km long regulation of Vrbas river and regulation of Vrbanja river bed from mouth into Vrbas and upstream to the bridge nearby Incel, 588,57 m long section.	24.0
5	Čelinac	Vrbanja	Regulation of the stream channel of Vrbanja in the zone of Josavka river mouth, c/a 340 m long section and regulation of Josavka river bed from mouth into Vrbanja and 250 m upstream	1.4
6	Srbac	Vrbas	Construction of the revetment structures on four locations of degraded banks and protection against further destabilization of soil and dykes, total length of 4,3 km via project measure TG 23	7.7
7	Laktaši	Vrbas	Rehabilitation of the Vrbas river right degraded banks (construction of the revetment) at the location upstream of the bridge in Klasnice/section Veliko Blaško-Šušnjari	3.8
8	Čelinac	Potok Rijeka	Regulation of the right Vrbanja river tributary-Rijeka stream on length of 1,4 km in total	1.5
9	Laktaši	Vrbas	Regulation of the Vrbas river stream channel in the area of the future water intake for Vrbas-Osorna connection channel	1.5
10	Laktaši	Vrbas	Rehabilitation of degraded banks on Otoka location	1.0
11	Grad Banja Luka	Vrbas	Regulation of the Vras river water regime on Section 3 from the bridge for Toplana and upstream to Rebrovacki bridge, 1,22 km long section	5.7
Total:				**69.8**

According to the draft version of Flood Risk Management Plan for the Vrbas River Basin in Republika Srpska, all investment measures for reducing the flood risk are grouped into three priority categories as follows:

- I category – Urgent measures,
- II category – Short term measures and
- III category – Long term measures.

Considering the huge investment needs in construction of foreseen objects, for flood risk to be significantly reduced for the area of Vrbas River basin in Republika Srpska, recommendation presented in the Plan is that following is required urgently:

- To develop design documentation- Detail Design that will be base for application, for all previously described additional investment measures at the basin level,
- Immediately start with preparation and presentation of individual and internally connected projects to international institutions and try to provide as much of grant funds as possible through their participation.
- By submitting this document at the Republika Srpska level, **urgently to perform strategic assessment of possible implementation for the of Plan validity period.**

By analysing priorities, the Plan defines that for implementation of urgent investment measures for flood protection of Vrbas River basin on Republika Srpska territory 93.3 mil BAM is required, it represents averagely 58% of totally defined required funds to be invested in reconstruction and upgrading of flood protection systems. This data illustrate present vulnerability of population and economy concerning the flood hazard and flood risk within Vrbas River basin in Republika Srpska.

Short term measures of flood protection, which also should be implemented in short period, require estimated investments of 34 mil. BAM or 21% of total estimated investment measures for mitigating flood risk on Vrbas River basin in Republika Srpska.

Long term measures are investment measure by which flood protection system of Vrbas river and its tributaries would be completed and upgraded to acceptable level of flood protection. Estimated value of financial funds for this category of investment measures is 34.5 mil BAM or 21% of total estimated investment measure for mitigating flood risk in Vrbas river basin in Republika Srpska.

Summary of investments into flood risk mitigating measure for Vrbas River basin in Republika Srpska per municipalities

Table 15-4: Summary of investments into flood risk mitigating measure for Vrbas River basin in Republika Srpska per municipalities

Summary of investments into flood risk mitigating measure for Vrbas River basin in Republika Srpska per municipalities						
Ranking priorities	**Municipality**	**Investment Measures Value (BAM)**	**Estimated value of expropriation (BAM)**	**Supervision of works (BAM)**	**Project Management (BAM)**	**Total (BAM)**
1	Srbac	18,474,000	1,821,400	364,280	910,00	21,310,380
2	Laktaši	32,679,000	3,267,900	653,580	1,633,950	38,234,430
3	Banja Luka	75,101,000	7,510,100	1,502,020	3,755,050	87,868,170
4	Čelinac	14.379.000	1,437,900	287,580	718,950	16,823,430
5	Kotor Varoš	10,268,000	1,026,800	205,360	513,400	12,013,560
6	Kneževo	850,000	85,000	17,000	42,500	994,500
7	Mrkonjić Grad	735,000	73,500	14,700	36,750	859,950
8	Jezero	2,495,000	249,500	49,900	124,750	2,919,150
9	Šipovo	6,716,000	671,600	134,320	335,800	7,857,720
10	Gradiška	425,000	42,500	8,500	21,250	497,250
Total:		**161,862,000**	**16,186,200**	**3,237,240**	**8,093,100**	**189,378,540**

Table 15-4 indicates that very demanding designing, expropriation, performing and administration activities have to be implemented in the next period for reducing flood risk in Vrbas River basin in Republika Srpska to the acceptable level, for all three categories of defined priorities (urgent, short term and long-term measures).

Indicated amounts of investment measures cover also funds required for development of design documentation on the level of the Detail Design with all necessary basis developed such as hydrological, hydro-morphological, geodetic, geological and geo-technical basis.

The biggest scope of works is foreseen for territory of the City of Banja Luka, in amount of 46% of all foreseen and additional investment measures for the area of 10 municipalities in the Vrbas River basin in Republic of Srpska, this is in accordance with historical flood events, economic activities, population density and potential damages to the capital of Republika Srpska.

Lowest scope of investments foreseen by Plan is for Gradiska municipality which is on the borders with Vrbas River basin along the Osorna-Borna-Ljevčanica channel for which rehabilitation and reconstructions measures are foreseen.

15.1.6 Una River Basin

According to the preliminary flood risk assessment (PFRA) at the territory of the Republika Srpska, it has been recorded that the area affected by flooding caused by the Una River and its tributaries cover 7661 ha. Extreme floods have occurred in 2009, on 07/01/2010, 20/06/2010, 25/06/2010, 03/08/2010, 01/04/2012 and 15/05/2014 and lasted seven to eight days, while data on previous flood waters has not been recorded. According to Annex 1 of the PFRA nearly 4,236 households with about 13005 people who were in flooded areas were affected by flooding.

The most sensitive area with regards to damage caused by floods in this basin in the Republika Srpska is in the Town of Prijedor, which is located on the Sana river basin (Una River sub-basin) which does not have a finalised system of protection from external high water. This statement is grounded in the records of enormous damages affecting the area during and after the floods, which will, as it is expected, increase in the future due to the further population of the Prijedor town urban area, the increased value of material goods and the forthcoming climate changes, which are reflected in extreme hydrological events. Due to the large area and the diversity of the basin, a significant increase of high water can occur in different parts of the Sana river basin, who in these lower parts of the basin can form an extreme "peak" of the flood wave.

Planned infrastructure flood protection measures at the territory of the Una River basin are as follows:

- Reconstruction of certain dikes is necessary in order to reach the protection level with 1% desired reliability, with a protective height of 1.2 m up to the dike crest (along the Bosna River and its tributaries where slow high waters of the Sava River occur), but also in the directions of other water currents flowing through urban settlements with the camber of 0.8 m so that the dikes do not get damaged when the overflow of high waters happens.
- Research with regards to testing water permeability and stability and performing reconstruction on the following accompanying dikes:
    - Una dike, Una River - Kozarska Dubica,
    - Left dike along Mataruško polje in Prijedor,
    - Right dike next to the Town of Prijedor,
    - Right dike next to the fish pond "Saničani" and the Gomjenica river,
    - Left dike along the Gomjenica river.
- Management of the Sana River water course in Prijedor with the length of 14.3 km, Construction of protection system along the main tributaries of the Sava River, in fact the construction of new dikes along the main tributaries of the Sava River:
    - The right defence dike along the Una river in Kostajnica, with the length of 3 km,
    - The left dike along Mataruško field in Prijedor, with the length of 2.5 km,
    - The right defensive dike along the Sana river in Prijedor, with the length of 9.0 km,
    - The construction of the parapet walls along the Sana river in Prijedor, with the length of 1.6 km
- In the area of the Una River Basin at the territory of the Republika Srpska, it is necessary to regulate the river flow in the following locations: Una River (1.70 km), Una and Strigova Rivers (2.20 km), Una River (1.40 km), Sana River (18 km), Milosevica River (0.90 km) Puharska River (1.90 km) Gomjenica River(0.90 km) and Orlovača River (1.20 km).
- The functionality related to the protection against penetration of mountain streams into defended areas needs to be increased. It is necessary to build new and reconstruct the existing perimeter channels, in the following areas:
    - Prijedorsko field and Gomjenica (construction of new perimeter channels) perimeter channel Mataruško field with the length of 5.2 km and perimeter channel Saničani - Ćela 4.7 km.
- Reconstruction of the existing and construction of a new channel network for internal drainage. Internal drainage from reclamation areas will be raised to a higher level of functionality through the reconstruction of the existing and construction of a new drainage network per regions:

    - Prijedorsko field and Gomjenica: channel network in Orlovača and Gomjenica subsystems with the length of 20 km (construction of new channels).

- Construction of new pumping stations for inland water drainage is required to be done in the areas of:
    - Orlovača and Gomjenica in Prijedor, with the installed discharge of Qi = 2 × 3 m^3 / s

The estimated financial framework for the investment in infrastructure measures for flood protection in the Una River basin in the Republika Srpska, which would reduce the flood to an acceptable level, according to various strategic, planning and project documents is around 100 million KM. This financial assessment is largely based on the project documentation for flood protection in urban areas along the watercourses in the basin of the Una river such as Prijedor, Novi Grad, etc. Below is a Table showing the Planned Infrastructure flood protection measures for which the Detail Designs have been done:

Table 15-5: Planned Infrastructure flood protection measures for which detailed design exists – Una River basin

Ranking priorities	Investment measure	Detail Design	Cost (x10^6 BAM)
1	Regulation of the Bubnjarica stram in Kostajnica municipality	YES	1.3
2	Perimeter channel Mataruško field with the length of 5.2 km, Grad Prijedor	YES	2.7
3	Maintenance of the Gomjenica river stream channel, City of Prijedor	YES	6.0
Total:			**10.0**

The remaining part of the report includes a table with an overview of flood dangers in the reviewed basins in the Republika Srpska (source: Preliminary Flood Risk Assessment in the Republika Srpska, 2014 Institute for Water Management, Bijeljina)

Non-structural measures will significantly contribute to flood risk reduction in Una River basin in Republika Srpska, and will be identified throughout development of the following documents:

- Maps of erosion (implemented for Republika Srpska territory, but for some areas with extensive erosion process it should be updated),
- To develop Cadastre of torrential basins and
- Create Model of sensitivity to torrential floods occurrence and development,
- Organization of the river basin- forest and agricultural land and planning of anti-erosion measures on individual river basin areas.

Table 15-6: Estimated damages for flood risk areas in Sava sub-basins

No.	SAVA RIVER DISTRICT BASEMENT			ESSENTIAL DATA FOR A FLOOD EVENT											
				Flooded surf, (ha)	DAMAGE CAUSED BY FLOODING								ESTIMATED DAMAGE		
					Number of flooded objects				No of inhabitants affected by flooding						
	BASIN	SUB-BASIN	Surf, (km^2)		Housing objects	Communal housing,	Individual housing	Accompanying build	In the area	No of evac, households	Evacuated inhabitants	Killed	Direct (BAM)	Indirect (BAM)	Total (BAM)
1	REGION COVERED BY THE BOSNA RIVER BASIN	BOSNA RIVER MAIN RIVERBED	965	14,909	9,894	238	7,266	11,104	26,167	9,340	23,702	15	632,678,000	471,328,000	1,104,006,000
		BOSNA RIVER TRIBUTARIES	2,018	3,010	733	3	724	1,465	1,403	51	199		10,392,000	6,126,000	16,518,000
	TOTAL FOR "1":		**2,983**	**17,919**	**10,627**	**241**	**7,990**	**12,569**	**27,570**	**9,391**	**23,901**	**15**	**643,070,000**	**477,454,000**	**1,120,524,000**
2	REGION COVERED BY THE UKRINA RIVER BASIN	UKRINA RIVER MAIN RIVERBED	472	4,686	1,214	10	1,185	2,140	4,074	20	50	-	13,749,000	9,588,000	23,337,000
		UKRINA RIVER TRIBUTARIES	1,028	1,677	92	-	92	73	367	2	3	-	5,449,000	3,362,000	8,811,000
	TOTAL FOR "2":		**1,500**	**6,363**	**1,306**	**10**	**1,277**	**2,213**	**4,441**	**22**	**53**	**-**	**19,198,000**	**12,950,000**	**32,148,000**
3	REGION COVERED BY THE VRBAS RIVER BASIN	VRBAS RIVER MAIN RIVERBED	1,427	6,315	3,753	11	3,709	7,333	12,186	649	2,003	-	82,112,000	55,068,000	137,180,000
		VRBAS RIVER TRIBUTARIES	2,561	3,524	1,271	14	1,213	771	3,984	30	106	1	18,788,000	11,688,000	30,476,000

	TOTAL FOR "3":		**3,988**	**9,839**	**5,024**	**25**	**4,922**	**8,104**	**16,170**	**679**	**2,109**	**1**	**100,900,000**	**66,756,000**	**167,656,000**
4	REGION COVERED BY THE UNA RIVER BASIN	UNA RIVER MAIN RIVERBED	473	1,961	578	5	563	716	2,299	53	218	-	9,801,000	6,560,000	16,361,000
		UNA RIVER TRIBUTARIES	2,864	5,700	4,236	7	4,224	7,166	13,005	375	1,117	-	58,834,000	40,558,000	99,392,000
	TOTAL FOR "4":		**3,337**	**7,661**	**4,814**	**12**	**4,787**	**7,882**	**15,304**	**428**	**1,335**	**-**	**68,635,000**	**47,118,000**	**115,753,000**

15.2 TREBIŠNJICA RIVER DISTRICT BASIN IN THE REPUBLIKA SRPSKA

Trebišnjica and Neretva river basins at the territory of the Republika Srpska, has a total area of 4,058 km^2 and is located at the far south-east of Bosnia and Herzegovina. Out of this, 1,980 km^2 belongs to the Trebišnjica river basin and 2,078 km^2 to the Neretva river basin. This is a part of the Republika Srpska which belongs to the Mediterranean basin, while the remainder of its territory belonging to the Black Sea basin. This is a typical karst area with specific geological, geo-mechanical, geochemical, hydrological, climate and topographic features. It has specific geographic, urban, demographic, economic, cultural and historical characteristics. The main outlets of the Trebišnjica river district basin are the Trebišnjica and Neretva rivers.

The Trebišnjica river wells in the karst springs that are now submerged, and its basin is formed by several smaller watercourses in the so-called Gornji Horizonti which include: Gacko, Nevesinje, Dabar and Fatničko fields, with a number of smaller watercourses, including the largest Zalomka, Mušnica, Vrijeka. Waters from the Gacko plateau and Fatničko field use the underground hydrography to be drained towards the Trebišnjica (Bileca Lake). Nevesinjsko field with several karsts sinking creeks drains to the Buna River, the Bunica River and through them to the Neretva River. Dabarsko field, with the highest spring Vrijeka and the largest sinking creek Ponikve and permanent watercourse Vrijeka and its tributary Opačica, use the underground hydrography to be drained towards the Bregava River.

Karst fields are completely or partly flooded in rainy periods of the year, due to the impossibility of runoff evacuation due to the lack of drainage capacity of natural groundwater outlets in karst formations. Due to the fact that in the modified climatic conditions rain periods roughly start in the late autumn period and last until the beginning of spring, the flooding is seasonal and quite predictable. Thanks to the works carried out in the second half of the 20th century on the waterways of the Trebišnjica River District Basin river basin some burning issues related to the water regimes control have been solved. Due to the construction of Bileća and Trebinje impoundment in the scope of the HPP Trebinje system, as well as the first stage of HPP Dubrovnik and 90 m^3/s which is directed straight towards the sea, floods caused by the Trebišnjica river downstream (Trebinjsko and Popovo field) have been reduced. The construction of the HPP Čapljina (as a powerful outlet from Popovo field) and by channelling of the Trebišnjica river, the problem of prolonged Popovo field flooding has been partially solved.

However, this field is still flooded in the period when HPP Capljina cannot work in turbine mode due to high flow and high water levels in the Neretva river lower stream. The works on the construction of the tunnel between Dabar and Fatničko fields and Fatničko field and Bileca impoundment have all been finalized except for the cladding of the tunnel, and at the end of 2013 the works on the construction of balancing reservoir and canal in Fatničko field began and they have not yet been completed. These works have a primary task to regulate and make water regimes in Dabar and Fatničko field controlled and manageable and create conditions for further work on the water regime control in the fields in the Eastern Herzegovina area Gornji Horizonti. It is evident that the development of the remaining hydropower facilities in the system "Trebišnjica" can have positive effects on the accumulation of large volumes of high water during the periods of flood, but also their multi-purpose use in the conditions when low-level waters occur (irrigation, drainage of ecologically acceptable flows, etc)

According to the preliminary flood risk assessment at the territory of the Republika Srpska, it has been recorded that the area affected by flooding caused by the Trebišnjica River and the tributaries of the Trebišnjica River and Neretva River covered 7404 ha. About 250 households with about 3270 people who were in flooded areas were affected by flooding. Estimated direct damage caused by the floods was about 3 million KM. The extreme floods occurred in 2009, 2010 and 2011.

The estimated financial framework for the investment in infrastructure measures for flood protection in the Trebišnjica River basin in the Republika Srpska, which would reduce the flood to an acceptable level, according to various strategic, planning and project documents is around 30 million KM. This financial assessment is largely based on the project documentation for flood protection in urban areas along the watercourses in the basin of the Trebišnjica river in Trebinje.

Below is a Table showing the Planned Infrastructure flood protection measures for which it is necessary to produce project Terms of Reference (with the indicated cost of development of documentation).

Table 15-7: Planned Infrastructure flood protection measures for which detailed design exists – Trebišnjica and Neretva river basins

Ranking priorities	Investment measure	Design	Cost (x10^6 BAM)
1	Norther perimeter canal in Veliko Gatačko polje	**Detail Design**	0.6
2	Drainage of Mokro polje in Trebinje	**Detail Design**	0.35
3	Drainage of Popovo polje	**Preliminary and Detail Design**	0.25
Total:			**1.2**

15.3 Review of Planned and Existing Flood Protection in Federation of B&H

Due to the large highland areas with high rainfall intensity, expansive valleys of lowland watercourses, large cities and valuable properties on potentially endangered areas, and partly due to insufficiently built protection systems, the flood risk in the Sava River Basin in the FB&H is significant.

15.3.1 Action Plan for Flood Protection and River Management in FB&H 2014-2017

Floods that hit the Sava River Basin in the FB&H in mid- May 2014, were the worse ever recorded. According to the RNA report, damage to the population, settlements, and other economic activities in the Federation of B&H during the May floods was estimated at EUR 1.040 million. Following these catastrophic floods, a donor conference was held in Brussels, where significant financial resources were raised for recovery and remediation of damage. The EU delegation requested from the B&H to develop an Action Plan for Flood Protection and Water Management with concrete measures and steps in order to ensure the improvement of flood protection in a harmonised and coordinated manner, both within B&H and on a regional basis.

In reference to that, on 14 July 2014, the Ministry of Foreign Trade and Economic Relations of B&H established a working group for the development of the Action Plan. The Working Group members are nominated by the institutions responsible for flood protection and water management issues. This Action Plan was prepared under the title *Action Plan for Flood Protection and River Management in B&H for the period 2014-2017* and it includes an assessment of the measures and activities and resources needed for their implementation. The Plan also envisages strengthened coordination of B&H bodies on issues of flood protection. The Action Plan was adopted by the B&H Council of Ministers at its 119th Session held on 21 January 2015. The adoption of the Action Plan was a prerequisite for utilisation of EU funds for the recovery and rehabilitation of flood protection facilities and watercourses damaged in the 2014 May floods.

The aforementioned document, which was adopted at the level of B&H, defines 6 measures and a range of activities (structural and non-structural) for the purpose of its implementation. The implementation of measures and activities under the Action Plan will ensure the improvement of flood protection in a harmonised and coordinated manner within B&H and on a regional basis. Below is an overview of the measures defined by the Action Plan:

- Measure 1 – Reconstruction of damages caused by floods, erosion and torrents in 2014 on the existing water protection facilities, riverbeds and canals in the affected areas;
- Measure 2 – Harmonization of the B&H flood protection system with the EU Directive 2007/60/EC on the assessment and management of flood risks;
- Measure 3 – Adoption of technical solutions for the protection from floods, erosion and torrents in the towns and villages that had no water protection facilities, and construction of new facilities;

- Measure 4 – Establishment of a hydrological monitoring system in B&H;
- Measure 5 – Strengthening of the institutional capacities for water management and flood protection, ensuring adequate level of coordination and cooperation with other B&H institutions, and ensuring relevant participation in international bodies;
- Measure 6 – Water Management.

Due to its importance and achieved results, implementation deadline of the Action Plan was extended until 2021 when the 2nd Water Management Plan and the 1st Flood Risk Management Plan are expected to be adopted.

15.3.2 Flood protection areas with constructed protection facility systems

The basic concept of protection measures implemented in the Sava River Basin in FB&H can be divided in two segments according to the manner of active flood protection measures, the areas with constructed flood protection facilities and areas without constructed flood protection facilities.

Areas with constructed flood protection facilities owned by the Federation of B&H are two (Odžačka Posavina and Central Posavina) located directly next to the main stream of the Sava River. The Flood protection system is a protection zone along the Sava River and Bosna River (in the mouth of the Sava River), pumping stations, perimeter canals, flood protection centres, guard shacks and coastal defence.

Sava River defence dikes were built in the sixties and seventies of the twentieth century with the task of protecting the floodplains from the high water of the Sava River with the probability of occurrence of 1/100 years. In 1972, following more intense floods that took place in the 1960s, "Sava River Regulation and Training Study in Yugoslavia" was prepared (developed under UN technical assistance by the POLITECHNA-HYDROPROJEKT and CARLO LOTTI & CO designers from Prague and Rome), in which the problems of the Sava River are illustrated through a single approach for the entire catchment area. According to the aforementioned study, the necessary degree of protection for certain sections of the Sava River stream was defined, and for Sava defence dikes on the part of the Sava river stream in B&H the prescribed overtop is 1.20 meters above the high water level of the Sava River with the probability of occurrence of 1/100. The Republic of Bosnia and Herzegovina and Republic of Croatia at a time, have signed an agreement for reconstruction of the Sava River defence dikes with the aforementioned overtop.

Reconstruction or overtop of dikes was done both in Croatia and in Bosnia and Herzegovina. The Republic of Croatia pursued with continuity of construction even after the war events, so that the dikes were elevated over the entire length of the left bank of the Sava River.

By means of a decision of the FB&H Government of 14 June 2001, the right of management and use of flood protection facilities in the ownership of the Federation of B&H located in the municipalities of Odžak, Domaljevac-Šamac, Orašje and Gradačac, was transferred to the Public company for the Sava River Basin Sarajevo, whose legal successor is " Water Agency for Sava River Basin" Sarajevo.

Flood protection facilities in these floodplain areas include:

- 60,000 m of defence dikes along the Sava River,
- 6,000 m of defence dikes along the Bosna River,
- 4 pumping stations ("Svilaj", "Zorice I and II" and "Tolisa") with a total capacity of 35 m^3/s,
- 4 perimeter canals with a total length of 21,217 m,
- 8 coastal defense on the Sava River, with a total length 8,177 m,
- 2 Flood Protection Centres,
- 7 guard shacks
- 2 dams and reservoirs (Hazna and Vidara in Gradačac),
- Flood protection equipment.

All flood protection facilities are located in the Posavina Canton, with the exception of the mentioned dams and reservoirs located in Tuzla Canton.

After the war, in the Federation B&H, priority was given to the repair of the defence dikes damaged by warfare and long-term non-maintenance, as well as restoring of operation of pumping stations for evacuation of the hinterland water to Sava River.

Sava defence dikes were designed and built for protection against water with 1 in 100 years precipitation event (100-year flood). With the reconstruction and building of a freeboard of 1.20 m above the 100-year flood, with the proper and timely implementation of the measures of active flood protection, the protection from high water of the Sava River is ensured against 1 in 1000 years precipitation event (1000-year flood).

All post-war activities related to flood protection systems are exclusively implemented by the Agency's funds. These funds are provided from the relevant part of the funds collected from water fees. Thus, the preparation of Terms of Reference of the project and preparatory actions for the upcoming works on the reconstruction of the Sava River defence dikes were organized in a timely manner.

According to its own available resources, following the pace of investment so far, the dikes could be completely reconstructed and upgraded in the next 20 years. Therefore, the Agency independently, as well as through the Government of the Federation of B&H which owns these facilities, requested funds for setting the facilities as per the design – dike elevation to the prescribed height.

In 2014, disemboguing of Sava River defence dike happened on places where it wasn’t reconstructed or where the prescribed freeboard have not been built. After the withdrawal of the water, repair of the damage on the flood protection facilities was initiated – damage was remediated immediately on the localities where, due to the disemboguing over the dike top, the body of the dike itself (localities Prud and Kopanica) was swept away, the slopes and dike tops were rehabilitated, and the pumping stations were urgently repaired and put into operation.

During the period 2014-2018, activities were carried out and the sections of the Sava River defence dike which were lacking the necessary degree of protection were reconstructed. Funds for these activities were provided after the donor conference in Brussels through the implementation of several projects funded by the World Bank's International Organizations (FERP), the EU (IPA 2014 – Urgent flood recovery project). Significant funds for these projects, as local co-financing, were provided by the "Water Agency for Sava River Basin" Sarajevo. Out of the total length of about 70 km in the FB&H of the Sava River dikes and the dikes of the Bosna River as the continuation of the Sava River dikes in the zone of the mouth of the Bosna River, the reconstruction covered some 30 km of dikes.

It can be stated that in 2020, when the remaining activities on completion of reconstruction of the Sava River dikes are finalised, for the first time since their construction the same level of protection will be achieved on the entire line of Sava River dikes in the Federation B&H, i.e. 1.20 m above the level of the 1 in 100 years precipitation event of Sava River high water.

By achieving the abovementioned freeboard, with properly organized and timely implementation of the active flood protection measures foreseen in the Federal Operational Plan (FB&H Official Gazette, 97/15), the defence dikes will provide protection against flood water of the Sava River with probability of occurrence 1/1000, in the floodplains of Odžačka and Central Posavina, which would ultimately ensure for the local community a reduction of flood risk and safer life and performing day-to-day economic activities with the development potential.

The upcoming activity, by the end of the implementation of the Action Plan, which refers to the Sava River defence dike, is to consider the internal dike structure. Namely, in the period 1992-1995, the dikes were used as fortification facilities in which bunkers were set at a distance of 200-300 meters in the body of dikes. These facilities have been removed from the body of the dikes, however there is a fear that on some micro locations there are hollow spots in the dike structure. Therefore, through the use of modern technical achievements, it is necessary to perform a deep scanning of structures of the dikes and see if there are weak/hollow spots to be repaired. This activity will also be the basis for establishing an advanced and modern maintenance of the defence dikes implemented in the EU countries. Some progress has already been made in that respect, through cooperation with the competent Agency from the Kingdom of the Netherlands. First contacts have been made, dikes in B&H were visited, and a trip to the Netherlands is also expected soon when the employees of AVP Sava will be introduced to the standards and the method of inspections of the dikes applied in the Netherlands.

15.3.2.1 Flood protection areas without constructed protection systems

In other areas where there is no built flood protection system, protection of human lives and property is ensured by carrying out works on stabilization and regulation of natural riverbeds in urban areas where these damages could be greatest. Because of the length of the river network, the distribution to over sixty municipalities and the necessary financial resources for their implementation, those works cannot be implemented at once, but gradually in phases – by sections.

Although the works on regulation of riverbeds so far covered most of the urban and industrial areas with the largest watercourses in the Sava River Basin of FB&H (Una, Sana, Vrbas, Bosna, Drina) due to constant pressure on river valleys in terms of development and construction in inundation belt that represents the prolonged flow of high water flows, the extension of the sections of watercourses on which the riverbed has been regulated will continue in the forthcoming period. Below is a table of the priority projects of the riverbed regulation on the watercourses of category I in the Sava River Basin in FB&H.

Table 15-8: priority projects of the riverbed regulation on the watercourses of category I in the Sava River Basin in FB&H (LB-left bank, RB-right bank)

No.	Municipality	Watercourse	Designed length (m)	Implemented length (m)	Additional length required (m)	Estimated investment (BAM)
1	Ilidža	Željeznica	3,300	0	3,300	7,000,000
2	Ilidža, Novi Grad	Bosna	8,000	4,500	3,500	8,000,000
3	Vogošća	Bosna	1,200	600	600	600,000
4	Visoko	Bosna	1,500	1,000	500	500,000
5	Kakanj	Bosna LB	750	400	350	300,000
6		Bosna RB	700	600	100	400,000
7	Zenica	Bosna LB	2,150	1,750	400	400,000
8		Bosna RB	2,650	2,150	500	500,000
9	Zavidovići	Bosna LB	950	520	430	430,000
10		Bosna RB	950	200	750	750,000
11	Maglaj	Bosna LB	1,300	1,300	0	0
12		Bosna RB	1,100	400	700	700,000
13	Lukavac	Spreča	3,000	1,500	1,500	3,000,000
14	Gračanica	Spreča	2,500	0	2,500	5,000,000
15	Doboj Istok	Spreča	1,500	0	1,500	3,000,000
16	Tešanj, Usora, Doboj Jug	Usora	6200	0	6,200	8,000,000

It should be noted that for all the mentioned projects, the relevant Terms of Reference are prepared. Priority projects are those on the Spreča and Usora rivers.

For a longer period of time, there is an increasing pressure on occupying the space along the river valleys. There is an intensive settlement and urbanization of the area next to the watercourses. At the same time, the value of this space is increasing, and there is also an increasing number of interested parties for flood protection. Due to the inability to implement full flood protection, for various reasons, some areas along the watercourses are exposed to a high risk of flooding.

One of the most obvious examples is the sub-basin area of Una River. Due to the coincidence of the Una national park with the watercourse, there is a general objection to the application of both structural measures in the riverbed (removal of limestone deposits from the riverbed, construction of parapet walls and dikes, regulation of the Una riverbed), as well as the measures in terms of regulating hydrological flow regime and formation of reservoirs on the upstream part of the flow. In these areas where there is a high risk of flooding, the only option of protecting existing facilities is to apply *living with floods* strategy and in some way protect people and property through non-structural measures and compensate for possible damages through the development of flood protection mechanisms.

The problem of applying flood protection measures for watercourses that have been "cut off" by Entity line is worth mentioning. In this case, for the full implementation of flood protection activities, institutions of both Entities need to act in a harmonised manner and jointly, which in most of the cases is not possible. The most obvious example is the flow of the river Spreča downstream the Modrac reservoir.

The left bank of the river Spreča on this move is on the territory of the Republika Srpska while the right bank on is the territory of the Federation of Bosnia and Herzegovina. While in the part of the FB&H there are extremely significant zones with business entities, the flood protection of which is of greatest interest, there are no significant urban areas in the territory of the Republika Srpska, so there is no great interest in investing in the works on the regulation of the Spreča riverbed.

In the EU countries, in order to harmonize the two most important directives in the water sector, the Water Framework Directive and the Floods Directive, the possibility of applying natural retention is being largely considered lately in order to accumulate and reduce the peak waves of high water. In the Sava River Basin in FB&H, due to limiting topographic and morphological conditions, there is little adequate space for. implementation of this type of measure.

The largest area for this purpose is located right along the Sava River, but these areas are already included in the existing flood protection systems. An additional problem is the issue of property ownership. Namely, application of this kind of flood protection measure requires large areas. The situation is that there are no significant publicly owned surfaces that could be used as natural retentions. An obvious example is the Terms of Reference of the project, which was completed for the retention of Svilaj, i.e. the possibility of using polder of the Svilaj flood protection system in Odžačka Posavina for the purpose of natural retention. After the conducted analysis it was established that more than 90% of the planned investments are the costs of land expropriation for the purpose of forming the retention space.

Currently, there is great public resistance to the construction of larger dams and reservoirs in the Sava River Basin in FB&H. Although it is a measure that successfully tackles flood protection issues by levelling the flow and that does not have such effects as in the Adriatic Sea watershed, this measure has a negative context in the general public. After a long period of time, the construction of HPP Vranduk has started, which has a significant reservoir space, however during the construction there was a delay and therefore this project also got a negative connotation.

From the point of view of water management there is a support to planning and establishment of "multifunctional water systems" (where the effects of these facilities are manifested in broader area and a great number of important business and other facilities), primarily in cooperation with the sectors of energy, agriculture and spatial planning. When designing and managing reservoirs, it is necessary to pay attention to economic, social and environmental needs in order to minimize negative and achieve maximum positive effects.

Analysing the continuous increase of the design high water which comes as a result of anthropogenic activities (unplanned construction in the inundation area, unplanned forest harvesting in the upper parts of the river basin, surface urbanization) and climate change, in the definition of technical regulations for future flood protection facilities it is necessary to modify the current approach. Namely, it is not rational to go for protection from 1 in 100 years precipitation event with a protective overtop (freeboard) of 50-80 cm, because the new calculations, taking into account all the aforementioned reasons, will result in exceptionally large design flows. This will result in the construction of enormous protection facilities that will completely divide the watercourse from the surrounding terrain and create major problems related to evacuation of inland waters.

A more pragmatic approach would be to construct the flood protection facilities to the levels of the surrounding terrain, shape them to form an integral part of spatial planning of the space, allowing setting up of mobile flood protection systems. For the riverbeds arranged in this way the capacity of the existing riverbeds would be determined by hydraulic calculations. In this way, combination of the forecasting models and application of early warning system could ensure actions of wider effect, aimed at reducing flood risk.

For revetment of the regulation facilities, environmentally friendly materials would be used, that would fit into the spatial plans of the urban area under protection.

In *Water Management Strategy of the Federation of Bosnia and Herzegovina 2010 – 2022* strategic objectives have been defined with established operational objectives and measures for achieving those objectives. When it comes to water protection, a strategic objective 9 is defined: Reducing the risk at extreme hydrological phenomena.

In order to achieve the strategic objective Reducing the risk at extreme hydrological phenomena, the following operational objectives and measures for their implementation have been defined:

- Operational objective 24: Reconstruction and rehabilitation of the existing and construction and maintenance of the system of protection facilities with the aim of increasing the safety level in terms of protection against floods
- Operational objective 25: Development and adoption of plans for protection against adverse effects of water;
- Operational objective 26: Reduction of erosion;
- Operational objective 27: Setting out programmes to combat droughts;
- Operational objective 28: Prevention and preparedness in cases of disaster – dam demolition or disemboguing

Funds collected on the basis of general and special water management fees are insufficient to adequately and sufficiently invest in all water management segments, especially water protection. A big problem lies in the fact that the capital grants for water have not been included in the Budget of the FB&H for several years. The only major sources of funding are grants or credit lines of international financial institutions (EU, WB, UNDP, WBIF, GEF). In order to be able to use the funds, certain conditions have been set before the B&H institutions. The first condition was the development of an Action Plan that was successfully completed. It is now necessary to prepare a list of priority projects that could be financed from these funds. It is a prerequisite for the nominated projects to have the project Terms of Reference completed, defined investment value, resolved the issue of property and legal relations and to be in possession of the necessary authorisations and permits.

As part of a 2014 document which defines shortcomings in the implementation of the EU Floods Directive in B&H prepared for the purpose of the regional conference in Brussels held on 24 November, a list of structural measures was defined, i.e. projects to be implemented within the framework of risk reduction from flooding of urban areas for the entire B&H. Those projects were assigned with their status and estimated investments. This could be a pipeline in the flood protection segment.

15.3.3 Recommendations

The following recommendations are given:

- Identifying internal structure and adequate monitoring of the defence dikes along rivers Sava and Bosna;
- Complete flood protection lines to the degree of protection that corresponds to the importance of the area under protection and the extent of damage that might result from potential flooding of high water with a certain probability of occurrence. These include all measures on completion of the initiated construction of the facilities, reconstruction to fit the relevant parameters and dimensions in accordance with the adopted level of protection;
- Introduction of the "living with floods" strategy in areas where there is no economic feasibility or possibility of building flood protection facilities;
- Inclusion of the flood insurance system as a way of indemnity;
- Include in flood protection measures construction of multifunctional water management and other systems where the effects of flood protection facilities have an impact on the wider area and with a greater number of more significant business and other facilities;
- Determining technical standards and adequate materials for construction of flood protection in urban areas.

16 ANNEX C - DETAILED SPECIFICATION OF THE FLOOD FORECASTING MODELS AND PLATFORMS TO BE DEVELOPED BY THE GCF PROJECT FOR NERETVA BASIN.

16.1 Background Information

16.1.1 Neretva basin

Neretva is a river with significant hydropower potential as well as an important source of water for supply, irrigation and flood control. Most of the river area is situated in Bosnia and Herzegovina, while the lower area and mouth are in the Republic of Croatia.

The Neretva River basin is predominantly in the karst area, which is why it very difficult to establish the precise boundaries of the basin. The length of the river is 240 km, and the basin covers an area of about 11,800 km^2. The river has numerous tributaries that flow into the main basin either directly on the surface or indirectly by groundwater. The main level of the river basin is located at about 250 m a.s.l.

The climatic characteristics of the river basin vary with the distance from the sea. The climate is Mediterranean in the lower parts, closer to the sea, while the middle part has a continental climate, and higher areas a mountainous climate. The average precipitation is 1.650 l/m^2 and ranges between 1500 and 1800 l/m^2. The highest precipitation is in November, and the lowest in the summer, in July. Temperatures are between -29 and +43 °C, and annual evapotranspiration is 500-900 mm. The average runoff is 269 m^3/s while the minimum runoff is 44 m^3/s and maximum runoff is 2179 m^3/s.

The main characteristics of this river are the large catchment area, markedly heterogeneous basin, large number of tributaries, strong influence of karst in the entire basin which causes a significant difference between the orographic and hydrogeological catchment areas and the pronounced deterministic influences on flow caused by numerous hydroelectric power plants.

16.1.2 The Upper Neretva River

The Neretva River is formed of several strong springs in the Republic of Srpska, and Neretva enters the territory of the Federation of Bosnia and Herzegovina at a short distance downstream of the Ulog settlement. The main Neretva tributaries up to Konjic are the rivers: Ljuta, Rakitnica, Šištica (springing from the Boračko Lake), Bijela and Trešanica River, after which Jablanica Lake is formed. In its upper course, up to Konjic, the flow of the Neretva River is a stochastic process, which changes immediately downstream of the town of Konjic.

16.1.3 The Middle Neretva River

In the middle part of the Neretva River course, the flow is a stochastic-deterministic process, which is caused by the hydroelectric power plants: HPP Jablanica, HPP Rama, HPP Grabovica, HPP Salakovac and HPP Mostar. The low water regime is conditioned by the regime of operation of the hydro power plants. The influence of hydro power plants is manifested by low water being higher than in the natural flow regime (which is important for the dry season of the year), and high water surges being significantly reduced by the influence of artificial reservoirs, or by adequate use of storage space.

The tributaries of the Neretva River are the watercourses: Kraljušnica, Baštica, Neretvica, Rama, Doljanka, Bijela, Drežanjka, and the lakes are Jablaničko and Ramsko (artificial ones) and Blidinje Lake as the natural one.

16.1.4 The Lower Neretva River

Downstream of Mostar, the lower course is noticeably affected by karst. The characteristics of this part of the basin are: a significant number of strong karst springs (on tributaries and in the Neretva riverbed), inflow of water to springs from karst poljes by underground flow, additional deterministic influences from

HPP Čapljina (Krupa), HPP Peć Mlini (Trebižat) and numerous irrigation canals. All tributaries of the Neretva River in this part of the basin flow from karst poljes on the left and right sides of the Neretva River. The tributaries are: Jasenica (these are the waters of the Lištica River and waters of smaller watercourses ending in Mostarsko Blato), the tributary of Buna (waters from Nevesinjsko polje), the tributary of Bregava (waters from the Dabarsko and part of the Fatničko polje), the tributary of Trebižat (emerges in Imotsko polje). Also, along the tributaries there are strong karst springs: Klokun, Vrioštica, Grudsko Vrilo, Lištica spring, springs of Buna and Bunica.

Numerous hydrological stations, throughout the Neretva River basin, with a long-time series of systematic hydrological observations of water levels and flow measurements, make the Neretva River basin hydrologically investigated.

The past flood risk assessment presents the areas on the Neretva River basin with potentially significant flood hazards and risks. A methodology for preparation of flood hazard maps on the Neretva basin, which are the basis for flood risk assessment and preparation of flood risk maps, is presented at this stage of the project proposal. Through enclosed materials, input data were analysed by a combination of statistical processing of measurements at hydrological stations and hydrological and hydraulic calculations. Lack and unreliability of input data and measurements have a dominant effect on the accuracy and reliability of hazard maps.

There are 18 stations in the Neretva basin measure precipitation and temperature (type M). Besides, 13 stations can measure other hydrological variables as well as water level and water quality in the river (type HM).

Table 16-1: List of existing statins within Neretva river basin.

NAME	TYPE	OWNER	KOOR_X	KOOR_Y
HMS Humac	HM	AVPJMM	6461616.69	4782235.87
HMS Gračanica	HM	AVPJMM	6474356.78	4847097.38
HMS HPP Rama	HM	EPHZHB	6465958.16	4849653.22
HMS Donja Ljuta	HM	EPB&H	6525076.40	4825744.88
HMS Glavatičevo bridge	HM	EPB&H	6509035.03	4817527.78
HMS HPP Grabovica	HM	EPB&H	6477761.19	4827019.95
HMS Drežanka	HM	EPB&H	6476153.67	4820633.91
HMS Gorani	HM	EPB&H	6484898.60	4846050.93
HMS Jablanica-Doljanka	HM	EPB&H	6480776.29	4835574.40
HMS HPP Jablanica	HM	EPB&H	6478767.67	4838702.47
HMS Konjic-Hagenuk	HM	EPB&H	6497369.36	4833766.52
HMS Idbar	HM	EPB&H	6490814.66	4834229.69
HMS HPP Salakovac	HM	EPB&H	6487231.69	4811572.50
MS Čitluk	M	AVPJMM	6476416.94	4787054.37
MS Ivan Sedlo	M	AVPJMM	6503336.84	4845186.37
MS Mostar	M	AVPJMM	6483697.85	4800437.99
MS Posušje	M	AVPJMM	6447024.12	4813718.39
MS Prozor-Rama	M	AVPJMM	6468741.80	4853685.91
MS Široki Brijeg	M	AVPJMM	6466460.34	4803486.28
MS Stolac	M	AVPJMM	6496692.47	4770191.67
MS Beganovići Kozo	M	AVPJMM	6458027.52	4850219.75
MS Blidinje	M	AVPJMM	6465737.20	4834105.83
MS Čuhovići	M	AVPJMM	6511786.37	4832749.23
MS Jasenik	M	AVPJMM	6488162.95	4854525.62
MS Jasenjani	M	AVPJMM	6483584.23	4817383.48
MS Karaotok	M	AVPJMM	6480409.04	4768910.04

NAME	TYPE	OWNER	KOOR_X	KOOR_Y
MS Sovići	M	AVPJMM	6469676.17	4839886.10
MS Trešnjevica	M	AVPJMM	6495201.46	4844618.55
MS Umoljani	M	AVPJMM	6518806.34	4836047.80
MS HPP Peć Mlini	M	EPHZHB	6445189.00	4801198.86
MS Odžaci	M	EPB&H	6518900.21	4819430.01

The flood forecasting and early warning system depends, in addition to data from existing hydrometeorological stations, also on reservoir conditions, and on precipitation forecasting models. The Adriatic Sea River Basin District Agency currently uses the forecasting model ALADIN with a T+1 to T+72 hour forecast, with 6-hour precipitation and 8-km spatial resolution.

16.1.5 Hydrogeological characteristics of the catchment area of springs of the right bank of the Neretva river from Mostar to the mouth in the Adriatic sea

The catchment area of springs on the right bank of the Neretva River downstream of Mostar to the mouth in the Adriatic Sea covers an area of over 2000 km^2.

The entire area belongs to the so-called "high karst" with occurrences of several larger karst poljes:

- Raško polje, on the far north-west of the area, with an area of about 9 km^2
- Rakitno polje, in the north-west part of the area, with an area of 18.3 km^2 at a height between 880 and 920 m a.s.l.
- Posuško polje in the central part of the area, with an area of 16 km^2 at a height of about 600 m a.s.l.
- Kočerinsko polje with an area of 6.6 km^2 at a height of about 330 m a.s.l.
- Imotsko (Imotsko-Bekijsko) polje, with an area of 95 km^2 at a height of about 260 m
- Mostarsko Blato has an area of 42.5 km^2 at a height of 220 - 245 m a.s.l.
- Čitlučko polje with an area of about 37 km^2 and height of about 210 m a.s.l.
- Ljubuško polje at a height of about 80 m a.s.l. and area of 25 km^2
- Rastok polje at a height of about 60 m a.s.l. and 13 km^2
- Vrgoračko polje - A lake at an altitude of about 25 m a.s.l. and about 26 km^2.

Most of the remaining terrain belongs to the karstified area with gradual declivity of relief in the direction of southeast. There are two permanent surface flows in this area:

- The Lištica River from the spring to Mostarsko Blato, and
- The Vrljika-Matica River in the Imotsko polje, Tihaljina, Mlade in the Ljubuško polje and Trebižat to the confluence with the Neretva River.

The Lištica River is formed on karst springs of Lištica (Borak and Bilo vrilo). Permanent surface flow exists from the spring to the entry to Mostarsko Blato. In this part of the course there are major disappearances of water from the bed underground, so that in dry periods the watercourse of Lištica through Mostarsko Blato dries up.

The Vrljika - Matica - Tihaljina - Mlade - Trebižat River (hereinafter: V.T.M.T.) is a unique course that has four different names in its four sections. It flows through the central part of the study area over different hydrogeological units, among which also a considerable part over karstified limestones through which sinking and underground runoff also occur.

This permanent flow is formed by several intermittent and permanent smaller discharges and karst springs emerging along the northeastern edge of the Imotsko polje.

There are two larger intermittent streams: Ugrovača and Ričina.

Ugrovača is formed in the area of Promina conglomerates in the Rakitno polje and as it flows to karstified limestones, it sinks and flows away underground for the most part towards the Lištica spring. Ugrovača is active over its entire course only in short periods of very high water.

The largest intermittent river course is Ričina, which is formed by permanent watercourses of Ružički and Močilo streams, however as is enters the Snježnica and Radovan mountains massif, it sinks and during more intense precipitation in autumn and spring it flows underground and on the surface.

The same case is with its tributary Topala in the Posuško polje. On its watercourse, which is generally directed towards the northwest, Ričina receives the Studeni stream, which sinks in the upper course in the dry period, and the Žukovica stream in the Virsko polje. After entering the Ričica field, it receives the right tributary Vrbica, from where it enters the Badnjevica canyon, which under the name Suvaja enters the Imotsko polje, where it is brought into Pološko Blato by an artificial channel.

Suvaja is an intermittent stream and only flows on the surface for a brief period during high water waves.

Flooding of the Posuško polje, Kočerinsko polje and southeastern parts of the Imotsko and Grudsko polje occurs during extreme precipitation in the upper northern part of the basin.

The main permanent flow of Vrljika is formed by the water of the broken spring of Opačac (Opatovo vrelo). There is a total of five larger springs of which Opačac is the largest one.

The Tihaljina-Mlade-Trebižat watercourse also occasionally floods parts of the surrounding land that are not protected by flood embankments. According to data of the Institute for Water Management, floods reflect in different ways in certain watercourse sections. In the upper upstream part, Tihaljina floods a narrow belt of alluvial cover in sides around the bed. In the area of Vitinsko - Ljubuško polje, the Mlade watercourse is regulated by embankments and part of surface water flows out through a channel toward the Rastok polje.

Downstream of Humac, the flood water wave expands to larger areas, which is especially pronounced downstream from the Studenčica mouth to the settlement of Struge.

On the Tihaljina watercourse, left tributaries are shorter watercourses that are formed on the left hinterland such as Krupa, Nevidin, Jakšenica, Nezdravica, while Zloriba and Meljava and other smaller streams around Klobuk are on the right side.

On the left bank, the Mlade watercourse is joined by the Vrioštica River, which emerges from the same-named karst spring, followed by a stream that is formed in the Donji Proboj.

On the right side, the intermittent stream of Studeni Potok is in the Kladnik polje, which occasionally becomes active when the karst spring Banja near Šipovača starts running, and its confluence is near Koćuša.

More downstream on the Trebižat watercourse is the left tributary Studenčica near Studenci, which is joined by the intermittent watercourse Lukoča from the direction of Čitluk and Stube in Čitlučko polje. Studenčica is formed by three larger karst springs: Kajtazovina, Vakuf and Mlinica.

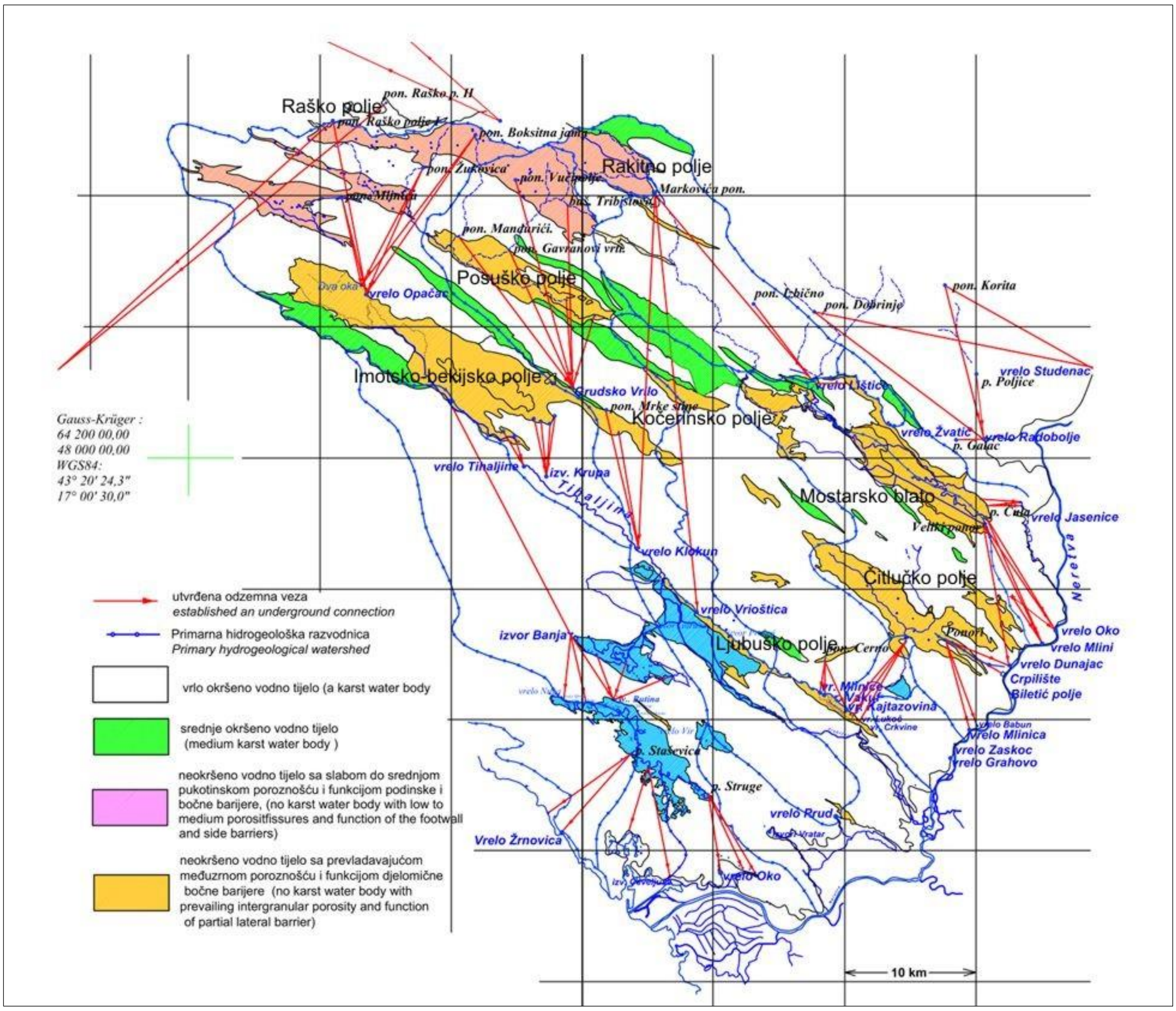


Figure 16-1: Established underground connections

16.1.6 Description of integrated multipurpose hydropower system Trebišnjica

Multipurpose system of Trebišnjica, as an integrated development project, is a system with very complex configuration, which is under gradual development. The current configuration of the system was implemented in several phases and stages. The expansion of its current configuration to the so-called *Gornji horizonti* zone is foreseen and some works have already started, in accordance with the design defined under the Preliminary design of HPP Dabar (Energoinvest, Sarajevo, 1984), Conceptual designs and the Main designs produced in the period 1954-1986 and after 2004.

The general concept of this integrated development multipurpose project is designed to level off the pronounced differences and inequalities in the precipitation quantities in the basin during a hydrological year (flooding periods – from November to April and dry periods without precipitation – from May to October), by means of building reservoirs. Through water retention and its accumulation 'on the surface', with the longest possible displacement of accumulated water from 'one cascade to the other' in the periods of high water and low water (whereby karst fields occasionally assume the function of temporary reservoirs, that is, they become submerged under water due to extreme precipitation intensity and inflow), the conditions are met for the use of water for water management, energy and other needs. Through development and completion of this integrated development project and rational water management, the following is achieved:

- contribution to the protection from flooding of agricultural zones during growing seasons (karst fields) and the protection from flood of settlements and urban zones;
- water for irrigation of agricultural land is ensured;
- water for water supply to population and technical purposes is ensured;

- conditions for low water ‘replenishment’ in the low water period are ensured;
- conditions are created for optimum energy use of water resources, which are considered as ecologically acceptable/renewable energy sources (reduction of CO_2 and greenhouse gases emission);
- conditions are ensured for use of water for other purposes (tourism, water sports, recreation, etc.);
- conditions are ensured for social, socioeconomic and any other progress of the population, the region, etc.

The part of the system built so far can only partially respond to the stated requirements and objectives, and as such it is regarded as ‘semi-controlled’ hydropower and water management system. Taking into account the character of the climate, especially in the karst area, as well as evident climate change which is manifested through even more significant variations and precipitation and drought intensity (e.g. occurrence of consecutive dry years), constructing reservoir spaces imposes itself as perhaps the only solution aimed at reducing the aforementioned impacts on people and the environment.

The current configuration of the system includes: reservoirs of Bilećko Lake and Trebinje, as well as hydropower plants which use settled water: HPP Trebinje 1, HPP Trebinje 2, HPP Dubrovnik 1 and HPP Čapljina. Since they became both physical and management reality, two already constructed tunnels (‘Dabarsko polje – Fatničko polje’ and ‘Fatničko polje – Bileća reservoir’) are being included in that configuration, through which the streams from Fatničko polje and Dabarsko polje are routed towards Bilećko Lake. At the entrance, the tunnels are equipped with shutters that enable the use or closure of the tunnels, depending on the hydrological conditions and the tasks of protection from high water to be performed at the downstream of Trebišnjica, especially on the move through the city of Trebinje.

The planned configuration of the Trebišnjica hydropower system is expanded with the new reservoirs and hydropower plants in the zone of Gornji horizonti (HPP Dabar, HPP Nevesinje and HPP Bileća), which are defined by Preliminary and Main designs, as well as HPP Dubrovnik II in the area of Donji Horizonti.

16.2 Current Configuration and System Parameters

The basic concept and configuration of the system for use, regulation and protection of water in the wider area of the Trebišnjica River – as a multipurpose system – was adopted by the Water Management Master Plan in 1958 and was renewed by the new Water Management Master Plan of 1967. As a system under continuous development, the Trebišnjica multipurpose system was built gradually, and so far, 4 hydropower plants have been constructed with the characteristics provided in Table 16-2: Technical characteristics of constructed hydropower plants and hydrological parameters (1946-1985)

Table 16-2: Technical characteristics of constructed hydropower plants and hydrological parameters (1946-1985)

Hydropower plant	No. of gen.	Nominal power		Power at the threshold	Mean annual generation	Mean annual flow	Reservoir storage capacity	Max gross head
		MVA	MW	MW	GWh	m^3/s	$\times 10^6\ m^3$	m
Trebinje I	3	3×67	3×60	180	479,4	66,5	1.082,3	104,15
Trebinje II	1	10	8	7,6	12,5	79,7	9,3	22
Dubrovnik	2	2×140	2×126	2×105	1.391,1	79,7	9,3	295
HPP Čapljina	2		2×220	440	451	28,9	6,5	227

In the first stage of the first phase, the following facilities were built: HPP Dubrovnik with a headrace tunnel, Gorica dam and distribution switchgear (the facilities were commissioned in 1965). In the second stage of the first phase, which was implemented three years later, due to the great complexity and dynamics of the construction of the key facilities of the system – Grančarevo dam and HPP Trebinje, two generators of HPP Trebinje 1 were commissioned (1968). Commissioning of the third generator of HPP Trebinje in 1975 represents the completion of the third stage, in which way the implementation of the first phase of the construction of the Trebišnjica multipurpose system is completed, with a task of ensuring production, economic, organizational and systemic basis for further development of the planned multipurpose system.

In the second phase, the following facilities were built: HPP Čapljina with the headrace canal (the facilities were commissioned in 1979), HPP Trebinje 2 (the generator was commissioned in 1981).

In the first stage of the third phase – within the sub-system of the Gornji horizonti zone – the following facilities have been constructed so far: I phase of the Fatničko polje tunnel – Bileća reservoir was commissioned in 2006, the Dabarsko polje tunnel – Fatničko polje was commissioned in 1986.

The hydropower plant system on Trebišnjica was built as a unique technological system. The facilities of the hydropower plants system on Trebišnjica are now used by: Elektroprivreda Republike Srpske (ERS, electric utility company) – HPP Trebinje 1 and HPP Trebinje 2, as well as one generator in HPP Dubrovnik G2, Elektroprivreda Herceg-Bosne (EP HZ HB, electric utility company) – HPP Čapljina and Hrvatska elektroprivreda (HEP, electric utility company) – one generator in HPP Dubrovnik, which makes the system management conditions quite complex, and it implies important constraints related to production and economic valorisation, as well as in view of meeting water management needs.

HPP Trebinje 1 – the first step on the surface part of the Trebišnjica River, is located about 18 km downstream from its source and about 17 km upstream of the city of Trebinje. The plant which utilises the water from Bileća reservoir with the total volume of 1280 million cubic meters is a plant with dam toe powerhouse. The main structures of the plant include: Grančarevo arch dam, high water evacuation systems, basic drainage systems, pressure pipes with entry structures, machine hall, drainage ducts, administrative building and the building for structure behaviour investigation system. Three generators with Francis turbines with the flow of 70 m3/s were installed in the machine hall.

HPP Trebinje 2 is a hydropower plant with dam toe powerhouse, and it was built subsequently, in the second phase of the system development, through its routing towards the natural course of Trebišnjica river. In the machine hall of Trebinje 2, one generator was installed with Kaplan turbine with the power of 8 MW. The installed flow through the generator is 45 m3/s. Ensuring an environmentally-friendly flow is accomplished through the Johnson flow control valve, which allows flexible flow regulation.

HPP Dubrovnik is a high-pressure derivative plant located on the coastline in Plat. The headrace tunnel for HPP Dubrovnik with a reinforced concrete pipeline through the part of the karst field is sized with the installed flow of 95 m3/s, it is 16.57 km long, of which 0.82 km is on the territory of the Republic of Croatia. On the left bank, two entry structures were built within Gorica dam. One is in the function of HPP Dubrovnik – phase 1 and the other is foreseen for HPP Dubrovnik, phase 2. Implementation of the second intake structure ensured the possibility that the subsequent implementation of HPP Dubrovnik 2 is performed without extensive discharges of the Trebinje Lake and without disrupting the operation of the plant HPP Dubrovnik 1.

In the underground machine hall of the HPP Dubrovnik, two generators were installed with Francis turbines. These two generators are considered as HPP Dubrovnik 1. The turbines are installed for the nominal flow of 45 m3/s.

HPP Čapljina is a reversible pumped-storage hydropower plant with its own natural inflow to the Hutovo upper compensation reservoir. The powerplant uses the water of its own catchment area downstream of Gorica dam, as well as the discharged water on Gorica dam. In addition to the pumped-storage, HPP Čapljina can also operate as a compensator.

The headrace canal to HPP Čapljina is 67,82 km long, out of which 41,716 km is on the territory of Republika Srpska. The canal is made of concrete and it was built for a nominal flow of 45 m3/s. The canal connection with the compensation reservoir was achieved through the Klek tunnel.

Two reversible Francis generators have been installed in the HPP Čapljina with the installed power of 210 MW, and the installed flow in turbine regime =225 m3/s. Generators can operate at a technical minimum of 140 MW. The total volume of the Hutovo reservoir is 7.23 million m3, and the storage capacity of the reservoir is 6.47 million m3. The Svitava reservoir is used as lower compensation reservoir.

Constructed facilities of the systems of Gornji horizonti. The expansion of the system to the Gornji horizonti zone represents a continuation of the development of the integrated multipurpose system in the Trebišnjica basin according to the issued water legislation of Federal Republic of B&H and Republika Srpska (Figure 1).

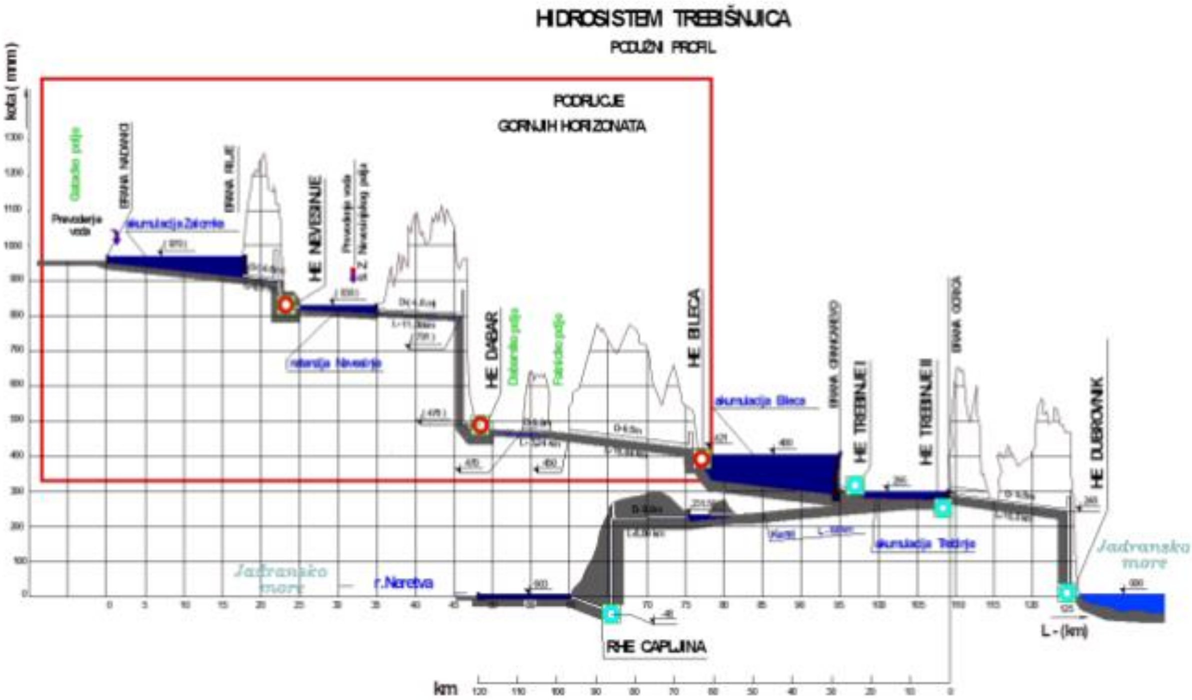


Figure 16-2: Configuration of the planned Trebišnjica multipurpose system

So far, several facilities have been constructed in the Gornji horizonti system. The headrace tunnel 'Fatničko polje – Bileća reservoir' is an important structure in the HET system. In the first phase of the construction (current state) the headrace tunnel is used for the controlled transfer of water of Dabarsko polje and Fatničko polje into Bileća reservoir. The tunnel is partially covered with a concrete coating, and the concrete works on the tunnel are underway. The tunnel begins at Fatničko polje with the entry structure and it ends in Čepelica with the discharge heading, ending in Bileća reservoir.

In this phase, the headrace tunnel 'Dabarsko polje – Fatničko polje' has the function of transferring a part of the water of the Dabarsko polje to Fatničko polje. After the construction of the Gornji horizonti system, it will also have the function of transferring the water that comes through the canal from the HPP Dabar. The coating of this tunnel is partly made of concrete.

Table 16-3: Automatic water level and meteorological stations of the HPP system on Trebišnjica

No.:	Station:	Installation year:	
1	Orah	2012	automatic meteorological
2	Plana	2012	
3	Stepen	2012	
4	Vojine	2012	

5	Vučija	2012	
6	Berkovici	2014	
7	Čemerno	2014	
8	Dubljani	2014	
9	VS Do Bregava	2006	Automatic water level stations
10	Srdjevići Mušnica	2006	
11	Stolac	2008	
12	Gorica Prag	2009	
13	Dražin Do	2009	
14	Dabar Kuti	2010	
15	Jazina	2010	
16	Dobromani	2011	
17	Padjeni	2011	
18	Srdjevići 2	2011	
19	Gorica Brana	2013	
20	Mareva ljut	2013	
21	Trebinje Most Iva Andrića	2013	
22	Jasovica	2014	
23	Šabanov ponor	2014	
24	Ključka rijeka	2014	
25	Vrijeka	2014	
26	Mokro polje	2016	
27	Šnjetica	2017	

The table below provides the lists of stations on which automatic groundwater level meters are installed.

Table 16-4: Automatic water level and meteorological stations of the HPP system on Trebišnjica

Table 16-5. **No.:**	**Piezometer type:**	**Installation year:**
28	PB1	2011
29	F2	2012
30	F3	2012
31	F5	2012
32	F6	2012
33	L1	2012

Table 16-5. **No.:**	**Piezometer type:**	**Installation year:**
34	OK2	2012
35	BT 4	2013
36	K1	2013
37	PL1	2013
38	PB2	2014
39	F7	2014

In addition to the stations equipped with automatic data collection equipment and remote data transmission to the watershed management centre, there are also classic stations for manual reading. List of these stations is given in Table 16-6.

Table 16-6: Classic water level and precipitation stations in the area of Trebišnjica river district

No.	**Station**	**Year of establishment -revitalization**	**Station type**
1	Nevesinje	2003	Precipitation
2	Čemerno	2000	
3	Bileća	1997	
4	Grančarevo	1990	
5	Gorica	2012	
6	Trebinje	2014	
7	Čepelica	2014	
8	Pađeni	2014	
9	Podtuhor	2007	
10	D.Crkvice	2007	
11	Berkovići	1997	
12	Ljubinje	2000	
13	Ukšići	1997	
14	Jasenik	1997	
15	Kokorina	2008	
16	Brićevići	2008	
17	Šipačno	2008	
17	Braićević	2008	
18	Slato	2008	

No.	Station	Year of establishment -revitalization	Station type
19	D.Drežanj	2008	Precipitation
20	Kifino selo	2008	
21	Bežđeđe	2008	
22	Trusina	2008	
23	Slivlja	2008	
24	Preraca	2008	
25	Avtovac	2008	
26	Hodžići	2008	
27	Rioci	2008	
28	Plana	2008	
29	Krstače	2008	
30	Vraska	2008	
31	Krtinje	2008	
32	Domaševo	2008	
33	Mirilovići	2008	
34	Taleža	2008	
35	Kremeni do	2008	
36	Bogojevića selo	2008	
37	Grab	2008	
38	Tuli	2008	
39	Rast	2008	
40	Vraćanovići	2008	
41	Mosko	2008	
42	Krekavice	2016	

16.2.1 Project flood hazard maps and risk maps in Bosnia and Herzegovina

In an effort to support Bosnia and Herzegovina in the implementation of the EU Floods Directive, the Western Balkans Investment Framework (WBIF) has approved in December 2014 a grant application worth EUR 4.88 million including support for the development of floods hazard and flood risk maps for the entire territory of Bosnia and Herzegovina. Implementation of the Project has started in April 2017.

16.2.2 Preliminary selection criterion for 1D/2D hydraulic modelling

Activities 9 and 10 of the project Flood hazard and risk maps in Bosnia and Herzegovina include the preparation and calibration of hydraulic models of watercourse sections in the framework of APSFR / AFA. A total of 181 APSFRs / AFAs for hydraulic modelling were confirmed in the Initial Report and the relevant maximum flows of the return periods Q20, Q100 and Q500 as input parameters for each APSFR / AFA were confirmed in the hydrological working document. Topographic data necessary for modelling are available in the form of new DTM and cross sections of watercourses and characteristic floods in each APSFR / AFA, made during LiDAR and geodetic surveys of a 2200 km^2 area during spring and summer 2018 (Phase I). During Phase II, in the autumn of 2018, it is expected that additional 3300 km^2 will be surveyed (Figure 1).

The key step before modelling is to establish the criteria that will determine where 1D modelling and where 2D modelling are needed. This Technical Concept represents the criteria proposed by the Consultant in order to facilitate the decision for each modelled watercourse section. The criteria were tested and finished on the preliminary model of the Neretva River.

The initial report confirmed the strategy and methodology of hydraulic modelling that will be used in the following manner:

- "Rough" modelling of watercourses with SCALGO that would indicate where 1D or 2D modelling is needed for the purposes of flood mapping;
- Guided by SCALGO, formulating detailed criteria that will be used to estimate each watercourse to be modelled in order to confirm where 1D and 2D modelling is required;
- Testing the criteria by comparing 1D and 2D models on a pilot watercourse;
- Preparing and calibrating the models;
- Running the models with relevant maximum flows: Q20, Q100 and Q500.

About 130 hydraulic models, covering 181 APSFR / AFA, will be prepared. For efficient management of this extensive task, models and input sets of data will be distributed in four sub-zones corresponding to the main river basins in B&H.

- LiDAR sub-zone 1, which covers the Neretva River basin and adjacent areas,
- LiDAR sub-zone 2, which covers the Bosna River basin and adjacent areas,
- LiDAR sub-zone 3, which covers the Drina River basin and adjacent areas,
- LiDAR sub-zone 4, which covers the Una River basin and adjacent areas.

Sub-zones 1 and 2 were modelled first and that will be presented in the first draft report, which is planned in January 2019. Then, sub-zones 3 and 4 were modelled and presented in the draft report scheduled in May 2019.

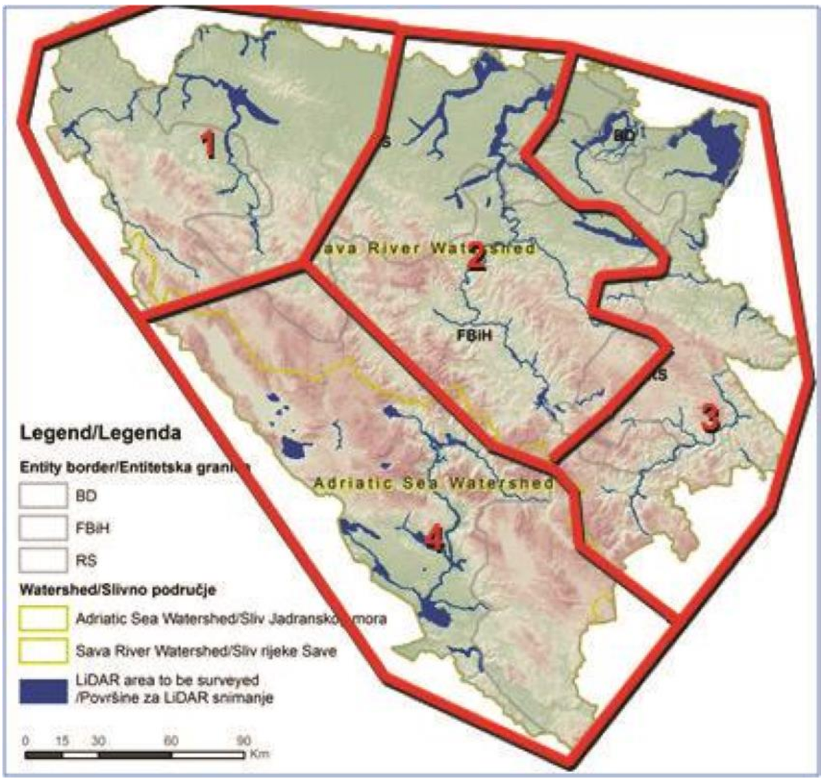


Figure 16-3: Phase I LiDAR areas with sub-zones that will also apply to Phase II

16.2.3 Preliminary modelling using SCALGO

The initial report states that SCALGO can be used:

"For fast mapping of potential floods by selecting three reference flood water levels corresponding to 20-, 100-, and 500-year maximum flows. Appropriate depth of water in flood plain areas is mapped for each relevant flow. The analysis will be used for two purposes:

- The results will provide indicative values of water depth during flood and include floods which, together with land use data, can identify high risk areas - which require more detailed modelling (1D or 2D);
- The results will provide indications allowing for simple assessment of targeted sections in order to determine whether 1D or 1D + 2D models should be used"

... "SCALGO will be used as the first step in making the decision whether to use 1D or 2D models (see Section 5.10.1 Initial report). SCALGO will give general hydraulic variables (depth h, width of flood area B) that will be used as initial criteria to make the decision about whether 2D modelling is needed. If the B / h ratio is greater than the threshold value ("X"), 2D modelling can be useful. The value "X" will be established based on 1D and 2D model on one or two pilot watercourse sections. An appropriate relationship will be established for which differences in results show that 2D modelling is needed, and will be used in further decisions in this regard.

SCALGO does not represent hydraulic modelling, but gives a rough estimate of the possible reach of flood by mapping selected flood depths on any existing DTM. Taking a technical view, DTM intersects the inclined plane that is parallel with valley bottom, at a certain predefined distance above it, e.g. 2m, 4m or 6m. This approach is used because the flood B / h ratio is indicative of the nature of flow, i.e. it quickly shows where the valley is wide and shallow, and thereby the flow can have a significant lateral component. The B / h ratio is estimated from the previously determined depth (h) and width (B) of the flood water along the flood surface as shown by SCALGO.

It is clear that the precision of flood width shown by SCALGO depends on the precision of the DTM used. Therefore, it is important to note that the SCALGO estimate for this project is based on rough 20x20m DTM which may not take into account all characteristics of the terrain, such as the depth of the river channel and the branching canals in the flood area. For this reason, for this project SCALGO with DTM 20x20m provides only indicative parameters pointing to areas with significant flood coverage.

However, based on consultant's comparison of the SCALGO results with the existing 1D hydraulic models of 100-year maximum flows on rivers in B&H, SCALGO proved to be very useful for the preliminary assessment of flood coverage. Eight existing hydraulic models are selected on the following rivers.

Comparison of SCALGO results with the results of these hydraulic modellings shows that, due to the roughness of DTM 20x20m, SCALGO tends to provide larger flood areas than those obtained by hydraulic models (which are based on DTM 5x5m and surveyed cross sections). DTMs 5x5m and cross sections for the entire country were not available for this project.

Based on the analysis of results of these models and SCALGO of the same river sections, two characteristic ratios are determined:

- river length / maximum width of flood (L / BMAX)
- maximum width of flood / depth (BMAX / h).

Differences between model results and SCALGO results were analysed in order to determine the ratio threshold values that can be used to make preliminary decisions between 1D and 2D modelling. These threshold values are based on 100-year flood, which is most often the reference flood, and for this project the ratio threshold values will be also applied to 20-year and 500-year floods.

As stated in the initial report, in SCALGO it was worked with flood depths of 2 m, 4 m and 6 m. The depths of 4 m and 6 m in SCALGO resulted in significantly wider flood polygons than those obtained with eight models for 100-year floods (Q1 / 100), while the depth of 2 m in SCALGO provided best agreements.

The ratio of maximum length / width (L / Bmax) and the ratio of maximum width / depth (Bmax / h) were measured for each of the eight hydraulic models and eight SCALGO models, and then the mean values and standard deviations were calculated for L / Bmax values of the models and of SCALGO. The ratio of these two averages is shown in Table 1 and shows that SCALGO represents the L / BMAX ratio very well, but overestimates BMAX / h. This overestimation should be kept in mind when choosing criteria that are based solely on SCALGO results, since most watercourse sections that need to be modelled in this project do not have other sources of information on B and h. It should be also kept in mind that SCALGO results are based on 20x20m DTM.

Table 16-7: Comparison of characteristic ratios from SCALGO and models

1	2	3	4	5
Ratio	**Average SCALGO 2m depth**	**Average Models Q1/100**	**Average SCALGO/Models**	**σ**
L/B_{MAX}	27.40	32.70	0.97	0.43
B_{MAX}/h	716.11	224.50	3.97	2.11
BSCALGO/BMODEL	-	-	1.19	0.45

Table 25-7 shows that the average of eight individual ratios (SCALGO L / BMAX) / (Model L / BMAX) is 0.97 with a standard deviation of 0.43, while the average of eight individual ratios (SCALGO BMAX) / (model BMAX) is 1.19 with a standard deviation of 0.45, that is, L / BMAX of SCALGO is on average only 3% less than L / BMAX of models and BMAX of SCALGO is on average 19% wider than the modelled one. This means that SCALGO (based on h = 2m and 20x20m DTM) produces flood polygons that roughly correspond to the polygons from the Q1 / 100 flood model in terms of length and width.

However, although the average maximum widths (BMAX) are similar between SCALGO and models, the average of individual ratios (SCALGO BMAX / h) / (model BMAX / h) is 3.97, i.e. the modelled depth h is almost four times deeper than the SCALGO depths h (2 m). Since the average ratio of BMAX / h per model is 224.5, this suggests that the threshold value of SCALGO BMAX / h, which is greater than 4x224.5 ≈ 900, would be a reasonable threshold value below which 1D modelling could be adequate and above which 2D modelling may be necessary. In order to allow variations in BMAX / h between different basins and the probability that the representative value of width for each model will be slightly lower than BMAX, a lower limit value SCALGO BMAX / h of 800 was selected to indicate the difference between the 1D I 2D models.

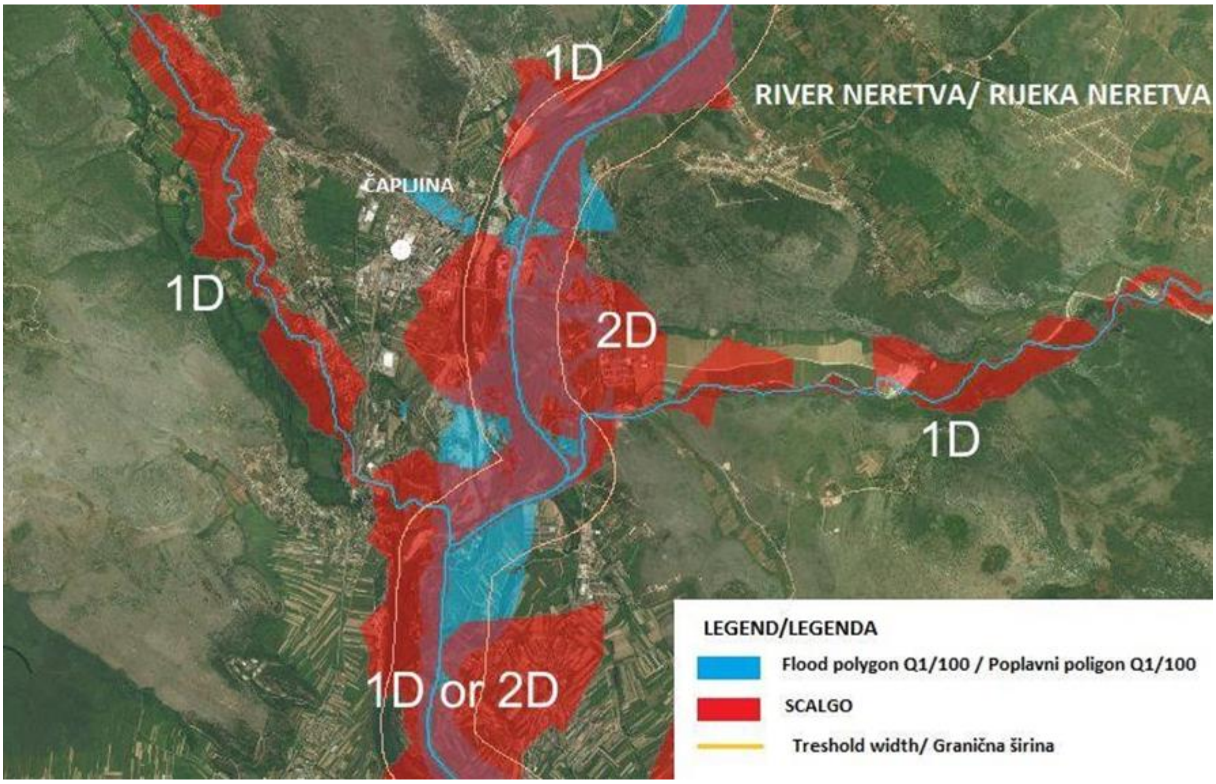


Figure 16-4: Recommended criteria applied in part of the Neretva River and section near Čapljina

16.2.4 Overall objective

The overall objective is to support the development of integrated flood risk management in B&H in line with the EU Floods Directive, thus reduce the risk to human life, environment, economic and material damages caused by extreme weather and hydrological events.

The specific objective is to support the implementation of measures of the Action Plan for flood protection and river management, through consistent and coordinated development and implementation of cutting edge tools and technologies for flood forecasting and strengthening capacities of Hydro-Meteorological Services (HMSs) and Water Agencies in B&H.

Indicators of achievement of specific objective will be number of cross sections in Neretva and Trebišnjica River Basin where quantitative predictions of flow rates and water levels are available.

16.2.5 Purpose

The purpose of this activity is:

- to integrate information and communication infrastructure, and observation system in B&H to enable automatic, accurate, reliable, timely and consistent hydro-meteorological data acquisition services, data-collections store and improve access to databases and information on weather and hydrological conditions;

- to establish consistent Flood forecasting and early warning system for Neretva and Trebišnjica on a common IT platform to provide synoptic meteorological and hydrological services, hourly forecasts and informing on potential hazardous flood events to the responsible governmental bodies at the state and entity levels, institution in charge for flood and civil protection, and thus increase social, economic and environmental safety.

16.2.6 Results to be achieved

The results to be achieved are:

Result 1: Assessment Report on legal, institutional, organisational, financial and technical environment, issues and gaps, as well as data availability and systems at HMSs.

Result 2: A logical and physical database model for new and historic meteorological and hydrological data collections is developed.

Result 3: The tools and services for online and offline data and metadata acquisition, quality and quantity control, database feed, post-processing and reporting are fully functional.

Result 4: Developed and calibrated hydrological model for Neretva river Basin

Result 5: Developed and calibrated hydrological model for Trebišnjica river Basin

Result 6: Developed and calibrated hydrodynamic models and real time hydrological flood forecasting system for Neretva River are established and are fully functional.

Result 7: Developed and calibrated hydrodynamic models and real time hydrological flood forecasting system for Trebišnnjica River are established and are fully functional.

Result 8: All models fully integrated in existing FFEWS platform, which allredy have models for Vrbas and Una-Sana models.

Result 9: The staff of the two Hydro-meteorological services (HMSs), Agency for Adriatic sea basin and PI VS, is competent to use and manage the Flood Forecasting Early Warning System (FFEWS) for Neretva and Trebišnjica River.

16.2.7 Overall result

A reliable forecasting capability is fundamental to an early-warmng system for meteorological, hydrological, and climate-related hazards. Accurate early warnings of hydro-meteorological hazards are crucial to give people time to flee from a flash flood, or other natural extreme phenomena, by providing information on the occurrence of a public health hazard. These warnings are vital because weather hazards and related events - such as storms, heat waves, cold waves, windstorms, floods, and droughts - jointly cause more economic damage and losses of lives than other natural disasters ll. In recent decades, such damage has been increasing, and climate change may make such events even more dangerous 12. In other words, although exposure to hazards cannot be avoided, the potential ensuing disasters can be mitigated. Thanks largely to advances in weather forecasting and risk assessments people can be better prepared for natural disasters.

17 ANNEX D – RESULTS OF SOCIO-ECONOMIC ANALYSIS BY MUNICIPALITY

Table D1. Flood-affected population per basin and municipalities under climate changes and under current conditions

Basin	Municipality	UNDER CLIMATE CHANGES						CURRENT CONDITIONS					
		Population number	Number of households	Men	Women	Citizens to 15 years of age	Citizens over 65 years of age	Population number	Number of households	Men	Women	Citizens to 15 years of age	Citizens over 65 years of age
UNA	RIBNIK	1,286	495	654	632	213	228	968	372	490	478	165	165
	KOZARSKA DUBICA	10,703	3,878	5,179	5,524	1,384	1,676	10,703	3,878	5,179	5,524	1,384	1,676
	OŠTRA LUKA	225	81	117	108	37	52	225	81	117	108	37	52
	NOVI GRAD	15,675	5,462	7,661	8,014	2,023	2,551	11,381	3,965	5,454	5,927	1,452	1,839
	PRIJEDOR	39,311	13,650	18,831	20,480	5,091	6,655	32,803	11,390	15,617	17,186	4,145	5,712
	KOSTAJNICA	4,190	1,406	2,030	2,160	515	627	4,190	1,406	2,030	2,160	515	627
	BIHAĆ	42,911	13,977	20,419	22,492	6,445	5,343	40,147	13,077	19,064	21,083	5,964	5,017
	BOSANSKA KRUPA	13,677	4,107	6,638	7,039	2,170	1,601	13,670	4,105	6,634	7,036	2,169	1,600
	KLJUČ	9,508	2,838	4,660	4,848	1,316	1,191	7,710	2,301	3,762	3,948	1,087	994
	SANSKI MOST	19,487	5,583	9,512	9,975	2,810	2,299	16,913	4,846	8,227	8,686	2,418	1,978
	TOTAL UNA	**156,973**	**51,477**	**75,701**	**81,272**	**22,004**	**22,223**	**138,710**	**45,421**	**66,574**	**72,136**	**19,336**	**19,660**
VRBAS	MRKONJIĆ GRAD	1,364	525	635	729	218	261	1,364	525	635	729	218	261
	ŠIPOVO	554	203	290	264	72	126	0	0	0	0	0	0
	SRBAC	7,539	2,740	3,621	3,918	1,054	1,348	4,400	1,599	2,161	2,239	605	872
	BANJA LUKA	144,296	52,281	68,343	75,953	21,245	21,099	136,887	49,596	64,715	72,172	20,014	20,210
	JEZERO	771	269	380	391	102	119	575	201	278	297	68	89
	ČELINAC	7,232	2,395	3,523	3,709	1,157	814	5,538	1,834	2,655	2,883	879	620
	LAKTAŠI	8,298	2,749	4,090	4,208	1,322	1,154	6,428	2,129	3,180	3,248	1,065	752
	KOTOR VAROŠ	10,127	3,235	4,958	5,169	1,823	1,024	7,743	2,473	3,775	3,968	1,403	770
	BUGOJNO	18,453	5,525	8,970	9,483	2,833	2,406	16,845	5,044	8,171	8,674	2,576	2,203
	DONJI VAKUF	6,979	2,090	3,347	3,632	1,154	750	6,743	2,019	3,222	3,521	1,103	734
	GORNJI VAKUF	8,127	2,208	3,982	4,145	1,410	862	5,650	1,535	2,740	2,910	962	607
	TOTAL VRBAS	**213,740**	**74,220**	**102,139**	**111,601**	**32,390**	**29,963**	**192,173**	**66,955**	**91,532**	**100,641**	**28,893**	**27,118**
BOSNA	TRNOVO (FB&H)	27	11	17	10	1	4	0	0	0	0	0	0
	TRNOVO (RS)	1,183	477	545	638	127	252	1,183	477	545	638	127	252
	PETROVO	3,905	1,568	1,879	2,026	482	882	2,817	1,131	1,355	1,462	318	659
	TUZLA	6,774	2,616	3,268	3,506	984	847	4,825	1,863	2,323	2,502	704	636
	LUKAVAC	2,186	819	1,024	1,162	271	372	0	0	0	0	0	0
	DOBOJ	31,465	11,741	14,973	16,492	4,640	4,943	25,945	9,681	12,278	13,667	3,926	3,893
	SOKOLAC	237	88	126	111	35	50	237	88	126	111	35	50
	ISTOČNO NOVO	8,223	3,034	3,869	4,354	1,317	1,195	8,223	3,034	3,869	4,354	1,317	1,195

Basin	Municipality	UNDER CLIMATE CHANGES						CURRENT CONDITIONS					
		Population number	Number of households	Men	Women	Citizens to 15 years of age	Citizens over 65 years of age	Population number	Number of households	Men	Women	Citizens to 15 years of age	Citizens over 65 years of age
	SARAJEVO												
	SARAJEVO-NOVI GRAD	118,553	42,492	55,735	62,818	18,761	15,759	118,553	42,492	55,735	62,818	18,761	15,759
	BREZA	6,123	2,186	2,927	3,196	867	770	3,960	1,414	1,890	2,070	550	502
	TESLIĆ	10,290	3,661	4,872	5,418	1,705	1,393	8,906	3,169	4,213	4,693	1,468	1,197
	MODRIČA	10,898	3,851	5,206	5,692	1,570	1,884	10,319	3,646	4,918	5,401	1,493	1,727
	PALE (RS)	13,356	4,719	6,279	7,077	1,864	1,889	13,314	4,704	6,258	7,056	1,861	1,876
	VUKOSAVLJE	1,660	584	838	822	319	179	1,660	584	838	822	319	179
	ZENICA	76,748	27,024	37,319	39,429	11,267	10,272	71,514	25,181	34,689	36,825	10,394	9,739
	ISTOČNA ILIDŽA	232	81	117	115	33	56	0	0	0	0	0	0
	OLOVO	3,019	1,037	1,479	1,540	404	349	3,019	1,037	1,479	1,540	404	349
	ŠAMAC	6,707	2,304	3,225	3,482	835	1,192	6,707	2,304	3,225	3,482	835	1,192
	ZAVIDOVIĆI	11,309	3,796	5,411	5,898	1,690	1,409	8,334	2,797	3,897	4,437	1,227	1,117
	GRAČANICA	14,978	5,009	7,136	7,842	2,344	1,754	12,882	4,308	6,133	6,749	1,968	1,564
	VOGOŠĆA	1,204	403	592	612	192	129	1,204	403	592	612	192	129
	MAGLAJ	9,213	3,060	4,413	4,800	1,281	1,270	8,764	2,911	4,195	4,569	1,222	1,153
	KAKANJ	17,645	5,767	8,672	8,973	3,087	1,738	16,789	5,488	8,235	8,554	2,928	1,680
	ILIJAŠ	7,178	2,338	3,315	3,863	1,164	835	5,950	1,938	2,743	3,207	965	719
	VISOKO	16,835	5,448	8,077	8,758	2,760	2,178	13,906	4,500	6,637	7,269	2,221	1,874
	ŽIVINICE	19,606	6,264	9,482	10,124	3,018	2,012	16,788	5,364	8,068	8,720	2,603	1,694
	VITEZ	11,088	3,532	5,392	5,696	1,976	1,174	6,329	2,016	3,014	3,315	1,075	689
	BUSOVAČA	2,732	862	1,443	1,289	482	267	2,004	632	1,043	961	377	179
	TEŠANJ	8,359	2,604	4,151	4,208	1,507	716	5,378	1,675	2,658	2,720	954	458
	ODŽAK	10,899	3,375	5,369	5,530	1,579	1,459	10,899	3,375	5,369	5,530	1,579	1,459
	OSMACI	933	282	463	470	124	146	933	282	463	470	124	146
	KALESIJA	7,843	2,319	3,874	3,969	1,363	611	5,776	1,708	2,844	2,932	978	445
	USORA	531	156	251	280	76	53	531	156	251	280	76	53
	ŽEPČE	8,450	2,471	4,151	4,299	1,520	839	5,859	1,713	2,846	3,013	1,057	612
	TOTAL BOSNA	**450,389**	**155,979**	**215,890**	**234,499**	**69,645**	**58,878**	**403,508**	**140,071**	**192,729**	**210,779**	**62,058**	**53,176**
NERETVA	KALINOVIK	1,015	406	474	541	126	182	1,015	406	474	541	126	182
	MOSTAR	974	316	488	486	132	174	0	0	0	0	0	0
	NEVESINJE	6,221	1,975	3,010	3,211	1,025	988	5,450	1,730	2,613	2,837	898	855
	JABLANICA	890	279	479	411	128	102	471	148	250	221	56	61

Basin	Municipality	UNDER CLIMATE CHANGES						CURRENT CONDITIONS					
		Population number	Number of households	Men	Women	Citizens to 15 years of age	Citizens over 65 years of age	Population number	Number of households	Men	Women	Citizens to 15 years of age	Citizens over 65 years of age
	BERKOVICI	409	127	204	205	76	99	409	127	204	205	76	99
	BILEĆA	7,695	2,397	3,819	3,876	1,183	1,274	7,606	2,369	3,775	3,831	1,181	1,249
	ČAPLJINA	14,661	4,457	7,173	7,488	2,407	2,419	10,099	3,070	4,899	5,200	1,610	1,689
	LJUBUŠKI	9,850	2,612	4,854	4,996	1,755	1,532	2,030	537	1,022	1,008	353	343
	ČITLUK	3,312	865	1,602	1,710	611	378	3,312	865	1,602	1,710	611	378
	GRUDE	5,198	1,357	2,545	2,653	971	725	5,198	1,357	2,545	2,653	971	725
	TOTAL NERETVA	**50,225**	**14,791**	**24,648**	**25,577**	**8,414**	**7,873**	**35,590**	**10,609**	**17,384**	**18,206**	**5,882**	**5,581**
TREBIŠNJICA	TREBINJE	25,185	8,422	12,221	12,964	3,940	4,370	23,945	8,008	11,598	12,347	3,794	4,066
	LJUBINJE	145	47	63	82	20	42	0	0	0	0	0	0
	GACKO	5,789	1,838	2,934	2,855	927	776	5,316	1,688	2,692	2,624	864	666
	RAVNO	460	133	233	227	60	107	203	59	100	103	26	44
	TOTAL TREBIŠNJICA	**31,579**	**10,440**	**15,451**	**16,128**	**4,947**	**5,295**	**29,464**	**9,755**	**14,390**	**15,074**	**4,684**	**4,776**

Table D2. Damages to flood-affected households per basin and municipalities under climate changes and under current conditions

Basin	Municipality	Under climate changes			Under current conditions		
		Number of households	Total assets value of affected households per municipality (USD)	Damage on household assets (USD)	Number of households	Total assets value of affected households per municipality (USD)	Damage on household assets (USD)
UNA	RIBNIK	495	35,442,514	5,791,307	372	26,635,586	4,352,255
	KOZARSKA DUBICA	3,878	277,668,823	45,371,086	3,878	277,668,823	45,371,086
	OŠTRA LUKA	81	5,799,684	947,668	81	5,799,684	947,668
	NOVI GRAD	5,462	391,084,867	63,903,267	3,965	283,898,113	46,388,952
	PRIJEDOR	13,650	977,354,161	159,699,670	11,390	815,535,816	133,258,552
	KOSTAJNICA	1,406	100,671,059	16,449,651	1,406	100,671,059	16,449,651
	BIHAĆ	13,977	1,000,767,700	163,525,442	13,077	936,326,767	152,995,794
	BOSANSKA KRUPA	4,107	294,065,461	48,050,296	4,105	293,922,259	48,026,897
	KLJUČ	2,838	203,203,744	33,203,492	2,301	164,753,987	26,920,801
	SANSKI MOST	5,583	399,748,592	65,318,920	4,846	346,978,627	56,696,308
	TOTAL UNA	**51,477**	**3,685,806,604**	**602,260,799**	**45,421**	**3,252,190,722**	**531,407,964**
VRBAS	MRKONJIĆ GRAD	525	37,590,545	6,142,295	525	37,590,545	6,142,295
	ŠIPOVO	203	14,535,011	2,375,021	0	0	0
	SRBAC	2,740	196,186,843	32,056,930	1599	114,490,059	18,707,676
	BANJA LUKA	52,281	3,743,373,839	611,667,285	49,596	3,551,125,053	580,253,834
	JEZERO	269	19,260,679	3,147,195	201	14,391,809	2,351,622
	ČELINAC	2,395	171,484,485	28,020,565	1,834	131,316,303	21,457,084
	LAKTAŠI	2,749	196,831,252	32,162,227	2,129	152,438,609	24,908,469
	KOTOR VAROŠ	3,235	231,629,356	37,848,237	2,473	177,069,366	28,933,134
	BUGOJNO	5,525	395,595,732	64,640,343	5,044	361,155,633	59,012,830
	DONJI VAKUF	2,090	149,646,168	24,452,184	2,019	144,562,495	23,621,512
	GORNJI VAKUF	2,208	158,095,091	25,832,738	1,535	109,907,592	17,958,901
	TOTAL VRBAS	**74,220**	**5,314,228,999**	**868,345,018**	**66,955**	**4,794,047,462**	**783,347,355**
BOSNA	TRNOVO (FB&H)	11	787,611	128,696	477	34,153,695	5,580,714
	TRNOVO (RS)	477	34,153,695	5,580,714	0	0	0
	PETROVO	1,568	112,270,427	18,344,988	1,131	80,980,773	13,232,258
	TUZLA	2,616	187,308,314	30,606,179	1,863	133,392,733	21,796,373
	LUKAVAC	819	58,641,250	9,581,980	0	0	0
	DOBOJ	11,741	840,667,781	137,365,115	9,681	693,169,643	113,263,920
	SOKOLAC	88	6,300,891	1,029,566	88	6,300,891	1,029,566
	ISTOČNO NOVO SARAJEVO	3,034	217,237,548	35,496,615	3,034	217,237,548	35,496,615
	NOVI GRAD SARAJEVO	42,492	3,042,471,283	497,139,808	42,492	3,042,471,283	497,139,808
	BREZA	2,186	156,519,868	25,575,346	1,414	101,243,867	16,543,248
	TESLIĆ	3,661	262,131,398	42,832,270	3,169	226,903,688	37,076,063
	MODRIČA	3,851	275,735,595	45,055,196	3,646	261,057,383	42,656,776
	PALE (RS)	4,719	337,885,296	55,210,457	4,704	336,811,280	55,034,963
	VUKOSAVLJE	584	41,815,006	6,832,572	584	41,815,006	6,832,572
	ZENICA	27,024	1,934,946,436	316,170,248	25,181	1,802,985,724	294,607,867
	ISTOČNA ILIDŽA	81	5,799,684	947,668	0	0	0
	OLOVO	1,037	74,250,276	12,132,495	1,037	74,250,276	12,132,495
	ŠAMAC	2,304	164,968,790	26,955,900	2,304	164,968,790	26,955,900
	ZAVIDOVIĆI	3,796	271,797,538	44,411,718	2,797	200,268,102	32,723,808
	GRAČANICA	5,009	358,649,597	58,603,344	4,308	308,457,269	50,401,918
	VOGOŠĆA	403	28,855,218	4,714,943	403	28,855,218	4,714,943
	MAGLAJ	3,060	219,099,175	35,800,805	2,911	208,430,620	34,057,563
	KAKANJ	5,767	412,923,183	67,471,648	5,488	392,946,493	64,207,457
	ILIJAŠ	2,338	167,403,226	27,353,687	1,938	138,762,811	22,673,843
	VISOKO	5,448	390,082,452	63,739,473	4,500	322,204,668	52,648,243
	ŽIVINICE	6,264	448,508,899	73,286,354	5,364	384,067,965	62,756,705
	VITEZ	3,532	252,894,864	41,323,021	2,016	144,347,691	23,586,413
	BUSOVAČA	862	61,720,094	10,085,063	632	45,251,856	7,394,153
	TEŠANJ	2,604	186,449,102	30,465,783	1,675	119,931,738	19,596,846
	ODŽAK	3,375	241,653,501	39,486,182	3,375	241,653,501	39,486,182
	OSMACI	282	20,191,493	3,299,290	282	20,191,493	3,299,290
	KALESIJA	2,319	166,042,806	27,131,395	1,708	122,294,572	19,982,933

Basin	Municipality	Under climate changes			Under current conditions		
		Number of households	Total assets value of affected households per municipality (USD)	Damage on household assets (USD)	Number of households	Total assets value of affected households per municipality (USD)	Damage on household assets (USD)
	USORA	156	11,169,762	1,825,139	156	11,169,762	1,825,139
	ŽEPČE	2,471	176,926,164	28,909,735	1,713	122,652,577	20,041,431
	TOTAL BOSNA	**155,979**	**11,168,258,219**	**1,824,893,393**	**140,071**	**10,029,228,916**	**1,638,776,005**

NERETVA	**KALINOVIK**	**406**	**29,070,021**	**4,750,041**	**406**	**29,070,021**	**4,750,041**
	MOSTAR (GRAD)	316	22,625,928	3,697,077	0	0	0
	NEVESINJE	1,975	141,412,049	23,106,729	1,730	123,869,795	20,240,325
	JABLANICA	279	19,976,689	3,264,191	148	10,596,954	1,731,542
	BERKOVICI	127	9,093,332	1,485,850	127	9,093,332	1,485,850
	BILEĆA	2,397	171,627,687	28,043,964	2,369	169,622,858	27,716,375
	ČAPLJINA	4,457	319,125,824	52,145,160	3,070	219,815,185	35,917,801
	LJUBUŠKI	2,612	187,021,910	30,559,380	537	38,449,757	6,282,690
	ČITLUK	865	61,934,897	10,120,162	865	61,934,897	10,120,162
	GRUDE	1,357	97,162,608	15,876,370	1,357	97,162,608	15,876,370
	TOTAL NERETVA	**14,791**	**1,059,050,945**	**173,048,924**	**10,609**	**759,615,406**	**124,121,157**
TREBIŠNJICA	TREBINJE	8,422	603,023,937	98,534,111	8,008	573,381,108	93,690,473
	LJUBINJE	47	3,365,249	549,882	0	0	0
	GACKO	1,838	131,602,707	21,503,882	1,688	120,862,551	19,748,941
	RAVNO	133	9,522,938	1,556,048	59	4,224,461	690,277
	TOTAL TREBIŠNJICA	**10,440**	**747,514,831**	**122,143,923**	**9,755**	**698,468,120**	**114,129,691**

Table D3. Total damages to agriculture per basins and municipalities under climate changes and under current conditions

Basin	Municipalities	Under climate changes		Under current conditions	
		Landsize in ha of flooded agriculture crops	Damages in agriculture (USD)	Landsize in ha of flooded agriculture crops	Damages in agriculture (USD)
UNA	Drvar	0.2	19	0.1	10
	Bihać	23.9	2,290	14.2	1,361
	Bosanska Krupa	38.8	3,718	21.5	2,060
	Cazin	115.8	11,097	80.4	7,704
	Ključ	34.1	3,268	18.8	1,802
	Sanski Most	60.6	5,807	42.1	4,034
	Velika Kladuša	44.6	4,274	27.9	2,674
	Kostajnica	106.1	10,167	62.4	5,980
	Kozarska Dubica	219.5	21,034	137.1	13,138
	Krupa na Uni	14.1	1,351	7.2	690
	Novi Grad	251.3	24,081	155.8	14,930
	Oštra Luka	54.7	5,242	36.2	3,469
	Prijedor	2,631	252,118	2,631	252,118
	Ribnik	3.4	326	1.3	125
	TOTAL UNA	**3,598**	**344,792**	**3,236**	**310,093**
VRBAS	Bugojno	22	4,676	11	2,339
	Donji Vakuf	1	213	0.4	85
	Gornji Vakuf-Uskoplje	20	4,251	8	1,701
	Banja Luka	111	23,595	70	14,881
	Čelinac	51	10,841	23	4,890
	Gradiška	3	638	0.3	64
	Jezero	5	1,063	3	638
	Kotor Varoš	8	1,701	5	1,063
	Laktaši	1,640	348,604	1,332	283,171
	Mrkonjic Grad	54	11,478	42	8,929
	Šipovo	3	638	1	213
	Srbac	972	206,612	822	174,750
	TOTAL VRBAS	**2,890**	**614,309**	**2,318**	**492,722**
BOSNA	Ilidža	17.9	2,980	11.4	1,897.97
	Ilijaš	3.6	599	1.6	266
	Novi Grad Sarajevo	17.1	2,847	10.1	1,682
	Trnovo - FB&H	0.4	67	0.2	33
	Vogošća	1.1	183	0.5	83
	Odžak	467.8	77,877	364.7	60,719
	Busovača	10.5	1,748	4.9	816
	Travnik	0.1	17	0	0
	Vitez	37.4	6,226	17.9	2,980
	Doboj-Istok	66.6	11,087	52.4	8,724
	Gračanica	199.8	33,262	141	23,475
	Kalesija	511.4	85,135	412.1	68,610
	Lukavac	282.3	46,996	206	34,297
	Tuzla	49.4	8,224	26.4	4,395
	Živinice	439.6	73,182	380.2	63,299
	Breza	10.8	1,798	6.1	1,016
	Doboj-Jug	26.3	4,378	17.4	2,897
	Kakanj	7.1	1,182	3.2	533
	Maglaj	19.5	3,246	11.1	1,848
	Olovo	0.3	50	0.1	17
	Tešanj	261.8	43,583	211.4	35,196
	Usora	314.1	52,290	246.5	41,040
	Visoko	38.2	6,359	22.2	3,696
	Zavidovići	13.5	2,247	6.1	1,016
	Zenica	19.9	3,313	9.2	1,532
	Žepče	39.7	6,609	23.2	3,863

Basin	Municipalities	Under climate changes		Under current conditions	
		Landsize in ha of flooded agriculture crops	*Damages in agriculture (USD)*	*Landsize in ha of flooded agriculture crops*	*Damages in agriculture (USD)*
	Doboj	1,161.00	193,278	934.1	155,517
	Istočna Ilidža	2.2	366	1	166
	Istočno Novo Sarajevo	0.5	83	0.2	33
	Modriča	1,347.50	224,325	1,183.70	197,073
	Osmaci	45.6	7,591	28.7	4,778
	Pale - RS	2.9	483	1	166
	Petrovo	157.5	26,220	131	21,810
	Šamac	542.9	90,379	496.4	82,645
	Sokolac	0.3	50	0.1	17
	Teslić	26.7	4,445	15.4	2,564
	Trnovo - RS	0.6	100	0.2	33
	Vukosavlje	657.3	109,424	610	101,558
	TOTAL BOSNA	**6,801**	**1,132,230**	**5,588**	**930,290**
NERETVA	**Čapljina**	1,202	1,097,873	1,202	1,097,873
	Čitluk	3	2,740	2	1,827
	Grad Mostar	7	6,394	6	5,480
	Jablanica	2	1,827	1	913
	Ljubuški	87.7	80,103	87.7	80,103
	Široki Brijeg	17	15,527	15	13,701
	Berkovići	3	2,740	3	2,740
	Kalinovik	0	0	0	0
	Konjic	85.3	77,911	85.3	77,911
	Nevesinje	21	19,181	13	11,874
	TOTAL	**1,428**	**1,304,295**	**1,415**	**1,292,421**
TREBIŠNJICA	**Neum**	4	3,653	3	2,740
	Ravno	13	11,874	12	10,960
	Bileća	13	11,874	10	9,134
	Gacko	6	5,480	4	3,653
	Ljubinje	1	913	0	0
	Trebinje	310	283,145	310	283,145
	TOTAL TREBIŠNJICA	**347**	**316,940**	**339**	**309,633**

Table D4. Damages on public buildings/facilities per sectors per basins and municipalities

	Number of buildings/facilities per sectors							
Municipality	***Health***	***Education***	***Judiciary, administration and social welfare***	***Police and defence***	***Culture, information and sport***	***Culture-historical heritage***	***Public infrastructure***	***Total***
Una								
Bihać			1		6	4		11
Bosanska Krupa		4			4	1	1	10
Drvar		1						1
Ključ		2	2	1	4	2		11
Kostajnica							1	1
Kozarska Dubica	1	2	5	1	5	6	1	21
Novi Grad					1			1
Prijedor		1			2	5	2	10
Sanski Most		1	3	1	5	9	1	20
Una Total	1	11	11	3	27	27	6	86
Vrbas								
Banja Luka	3		1		5	3		12
Bugojno					1		1	2
Čelinac	1	3	7	1	7	6	3	28
Donji Vakuf	1	1	5		8	10		25
Gornji Vakuf	1				1			2
Jajce					1		2	3
Jezero	1				1			2
Kotor Varoš					6		1	7
Laktaši	2	1	1	1	2	3	2	12
Srbac		2	5		7	8	1	23
Šipovo					1		3	4
Vrbas Total	9	7	19	2	40	30	13	120
Bosna								
Breza					1			1
Doboj		9	6	3	12	9	9	48
Doboj Jug		1		1				2
Gračanica					1			1
Ilidža					1	1		2
Ilijaš		1		1	1	1	1	5
Istočna Ilidža						1		1
Istočno Novo Sarajevo		1						1
Jelah		1			2	2		5
Kakanj			1		1	3		5
Kalesija	1					3		4
Maglaj	1	5	1		1	4		12
Modriča						2	1	3
Novi Grad-Sarajevo			1				1	2
Odžak		2	1		2	2		7
Olovo		1	1		2			4
Petrovo		1	1			2		4
Šamac						1		1
Teslić						1	2	3
Trnovo (RS)			1	1	1	2		5
Tuzla	1	1	1		2	3	2	10
Usora		1	1		1			3
Visoko		1	1		4	4	2	12
Vogošća						2		2
Zavidovići					3	2	1	6
Zenica	1	6	1		5	8	1	22
Žepče		1	2		1		1	5
Živinice	1	1	2		1	2	1	8
Bosna Total	5	33	21	6	42	55	22	184
Neretva								
Čapljina		3	4		6	7	9	29
Čitluk	1	3			2			6

Grude		2	4		1	3		10
Jablanica		1	1					2
Ljubuški		2	5		3	8	2	20
Široki brijeg							1	1
Neretva Total	1	11	14		12	18	12	68
Trebišnjica								
Neum							3	3
Trebinje		4	7		11	13	9	44
Trebišnjica Total		4	7		11	13	12	47
Total all basins	16	66	72	11	132	143	65	505

Damages on public buildings/facilities per sectors per basins and municipalities

Municipality	*Health*	*Education*	*Judiciary, administration and social welfare*	*Police and defence*	*Culture, information and sport*	*Culture-historical heritage*	*Public infrastructure*	*Total*
Una								
Bihać	-	-	61,782	-	370,691	247,127	-	679,600
Bosanska Krupa	-	247,127	-	-	247,127	61,782	61,782	617,818
Drvar	-	61,782	-	-	-	-	-	61,782
Ključ	-	123,564	123,564	61,782	247,127	123,564	-	679,600
Kostajnica	-	-	-	-	-	-	61,782	61,782
Kozarska Dubica	61,782	123,564	308,909	61,782	308,909	370,691	61,782	1,297,417
Novi Grad	-	-	-	-	61,782	-	-	61,782
Prijedor	-	61,782	-	-	123,564	308,909	123,564	617,818
Sanski Most	-	61,782	185,345	61,782	308,909	556,036	61,782	1,235,636
Una Total	61,782	679,600	679,600	185,345	1,668,108	1,668,108	370,691	5,313,233
Vrbas								
Banja Luka	185,345	-	61,782	-	308,909	185,345	-	741,381
Bugojno	-	-	-	-	61,782	-	61,782	123,564
Čelinac	61,782	185,345	432,472	61,782	432,472	370,691	185,345	1,729,890
Donji Vakuf	61,782	61,782	308,909	-	494,254	617,818	-	1,544,544
Gornji Vakuf	61,782	-	-	-	61,782	-	-	123,564
Jajce	-	-	-	-	61,782	-	123,564	185,345
Jezero	61,782	-	-	-	61,782	-	-	123,564
Kotor Varoš	-	-	-	-	370,691	-	61,782	432,472
Laktaši	123,564	61,782	61,782	61,782	123,564	185,345	123,564	741,381
Srbac	-	123,564	308,909	-	432,472	494,254	61,782	1,420,981
Šipovo	-	-	-	-	61,782	-	185,345	247,127
Vrbas Total	556,036	432,472	1,173,854	123,564	2,471,271	1,853,453	803,163	7,413,813
Bosna								
Breza	-	-	-	-	61,782	-	-	61,782
Doboj	-	556,036	370,691	185,345	741,381	556,036	556,036	2,965,525
Doboj Jug	-	61,782	-	61,782	-	-	-	123,564
Gračanica	-	-	-	-	61,782	-	-	61,782
Ilidža	-	-	-	-	61,782	61,782	-	123,564
Ilijaš	-	61,782	-	61,782	61,782	61,782	61,782	308,909
Istočna Ilidža	-	-	-	-	-	61,782	-	61,782
Istočno Novo Sarajevo	-	61,782	-	-	-	-	-	61,782
Jelah	-	61,782	-	-	123,564	123,564	-	308,909
Kakanj	-	-	61,782	-	61,782	185,345	-	308,909
Kalesija	61,782	-	-	-	-	185,345	-	247,127
Maglaj	61,782	308,909	61,782	-	61,782	247,127	-	741,381
Modriča	-	-	-	-	-	123,564	61,782	185,345
Novi Grad-Sarajevo	-	-	61,782	-	-	-	61,782	123,564
Odžak	-	123,564	61,782	-	123,564	123,564	-	432,472
Olovo	-	61,782	61,782	-	123,564	-	-	247,127
Petrovo	-	61,782	61,782	-	-	123,564	-	247,127
Šamac	-	-	-	-	-	61,782	-	61,782

Teslić	-	-	-	-	-	61,782	123,564	185,345
Trnovo (RS)	-	-	61,782	61,782	61,782	123,564	-	308,909
Tuzla	61,782	61,782	61,782	-	123,564	185,345	123,564	617,818
Usora	-	61,782	61,782	-	61,782	-	-	185,345
Visoko	-	61,782	61,782	-	247,127	247,127	123,564	741,381
Vogošća	-	-	-	-	-	123,564	-	123,564
Zavidovići	-	-	-	-	185,345	123,564	61,782	370,691
Zenica	61,782	370,691	61,782	-	308,909	494,254	61,782	1,359,199
Žepče	-	61,782	123,564	-	61,782	-	61,782	308,909
Živinice	61,782	61,782	123,564	-	61,782	123,564	61,782	494,254
Bosna Total	308,909	2,038,799	1,297,417	370,691	2,594,835	3,397,998	1,359,199	11,367,847
Neretva								
Čapljina	-	185,345	247,127	-	370,691	432,472	556,036	1,791,672
Čitluk	61,782	185,345	-	-	123,564	-	-	370,691
Grude	-	123,564	247,127	-	61,782	185,345	-	617,818
Jablanica	-	61,782	61,782	-	-	-	-	123,564
Ljubuški	-	123,564	308,909	-	185,345	494,254	123,564	1,235,636
Široki brijeg	-	-	-	-	-	-	61,782	61,782
Neretva Total	61,782	679,600	864,945	-	741,381	1,112,072	741,381	4,201,161
Trebišnjica								
Neum	-	-	-	-	-	-	185,345	185,345
Trebinje	-	247,127	432,472	-	679,600	803,163	556,036	2,718,398
Trebišnjica Total	-	247,127	432,472	-	679,600	803,163	741,381	2,903,744
Total all basins	**988,508**	**4,077,597**	**4,448,288**	**679,600**	**8,155,195**	**8,834,794**	**4,015,816**	**31,199,798**

List of affected public buildings/facilities in target basins of B&H

No.	Basin	Municipality	Residential place	Name of institution	Type
1	Una	Bihać	Pokoj	BH Post Pokoj	E
2	Una	Bihać	Bihać	Veni Vidi Pools	E
3	Una	Bihać	Bihać	Sport complex Stens	E
4	Una	Bihać	Bihać	Bathing-place Beton	E
5	Una	Bihać	Bihać	Radio Bihać	E
6	Una	Bihać	Bihać	Hatinačka Mosque	F
7	Una	Bihać	Bihać	Local community Bakšaiš	C
8	Una	Bihać	Bihać	Cemetery in the street of the Baksais Squad	F
9	Una	Bihać	Bihać	Chapel of Saint Lucia	F
10	Una	Bihać	Bihać	Football club KAMENICA	E
11	Una	Drvar	Drvar	Primary school Drvar	B
12	Una	Bihać	Kulen Vakuf	The Sultan Ahmed Mosque Kulen Vakuf	F
13	Una	Ključ	Ključ	Stadium NK Ključ	E
14	Una	Ključ	Ključ	Radio Ključ	E
15	Una	Ključ	Ključ	Community Center	E
16	Una	Ključ	Ključ	Gymnasium Kljuc	B
17	Una	Ključ	Ključ	Primary school "Ključ"	B
18	Una	Ključ	Ključ	Municipality of Kljuc	C
19	Una	Ključ	Ključ	Municipal court in the Sanskom Mostu	C
20	Una	Ključ	Ključ	Orthodox Church Kljuc	F
21	Una	Ključ	Ključ	Town mosque	F
22	Una	Ključ	Ključ	Police station Ključ	D
23	Una	Ključ	Ključ	BH Post	E
24	Una	Sanski Most	Sanica	Football stadium Sanica	E
25	Una	Sanski Most	Sanica	Mosque	F
26	Una	Sanski Most	Sanski Most	Public swimiming pool Water Park	E
27	Una	Sanski Most	Sanski Most	Saints Peter and Paul Orthodox Church	F
28	Una	Sanski Most	Sanski Most	Police station Sanski Most	D
29	Una	Sanski Most	Sanski Most	Football stadium	E
30	Una	Sanski Most	Sanski Most	Church of the Holy Apostles Peter and Paul	F
31	Una	Sanski Most	Sanski Most	First sanska elementery school	B
32	Una	Sanski Most	Sanski Most	Church of the Assumption og Mary	F
33	Una	Sanski Most	Sanski Most	RTV " Sana "	E
34	Una	Sanski Most	Sanski Most	Small park at the Zdena	F
35	Una	Sanski Most	Sanski Most	Monument "Logoraš"	F
36	Una	Sanski Most	Sanski Most	Central City Park Sanski Most	F
37	Una	Sanski Most	Sanski Most	Hamzibegova Mosque	F
38	Una	Sanski Most	Sanski Most	City market	G
39	Una	Sanski Most	Sanski Most	Helath Insurance Fund Una-sana canton	C
40	Una	Sanski Most	Sanski Most	BH Post	E
41	Una	Sanski Most	Sanski Most	Municipalitie of Sanski Most	C
42	Una	Sanski Most	Sanski Most	Park Square Ljiljana	F
43	Una	Sanski Most	Sanski Most	Municipal court in Sanski Most	C
44	Una	Prijedor	Ališići	Primary school Desanka Maksimović	B
45	Una	Prijedor	Gomjenica	Church of Saint Petka	F
46	Una	Prijedor	Prijedor	Mosque Zagrad	F
47	Una	Prijedor	Prijedor	Football stadium in Pristina street	E
48	Una	Prijedor	Prijedor	Market Eko Komunalije	G
49	Una	Prijedor	Orlovača	Cemetery	F
50	Una	Prijedor	Orlovača	Playground	E
51	Una	Prijedor	Orlovača	Heating plant	G
52	Una	Prijedor	Čirkin Polje	Cemetery	F
53	Una	Prijedor	Donja Puharska	Mosque Donja Puharska	F
54	Una	Bosansk a Krupa	Bosanska Krupa	Bus station	G
55	Una	Bosansk a Krupa	Bosanska Krupa	Second primary school	B
56	Una	Bosansk a Krupa	Bosanska Krupa	Soccer stadium with auxiliary terrain	E
57	Una	Bosansk a Krupa	Bosanska Krupa	Third primary school	B
58	Una	Bosansk a Krupa	Bosanska Krupa	Combined secondary school "Safet Krupić"	B
59	Una	Bosansk a Krupa	Bosanska Otoka	City Mosque Otoka	F
60	Una	Bosansk a Krupa	Bosanska Otoka	Football stadium	E

No.	***Basin***	***Municipality***	***Residential place***	***Name of institution***	***Type***
61	Una	Bosansk a Krupa	Bosanska Otoka	Community Center	E
62	Una	Bosansk a Krupa	Bosanska Otoka	BH Post	E
63	Una	Bosansk a Krupa	Bosanska Otoka	Primary school Otoka	B
64	Una	Novi Grad	Novi Grad	Stadium Mlakve	E
65	Una	Kostajni ca	Kostajnica	Market	G
66	Una	Kozarska Dubica	Kozarska Dubica	Beach Blato	E
67	Una	Kozarska Dubica	Kozarska Dubica	Border crossing Kozarska Dubica	C
68	Una	Kozarska Dubica	Kozarska Dubica	Municipalitie of Kozarska Dubica	C
69	Una	Kozarska Dubica	Kozarska Dubica	Sports Centre	E
70	Una	Kozarska Dubica	Kozarska Dubica	City Mosque	F
71	Una	Kozarska Dubica	Kozarska Dubica	Park of folk heroes	F
72	Una	Kozarska Dubica	Kozarska Dubica	Community Center	E
73	Una	Kozarska Dubica	Kozarska Dubica	Ambulance	A
74	Una	Kozarska Dubica	Kozarska Dubica	Church of the Holy Cross	F
75	Una	Kozarska Dubica	Kozarska Dubica	Saints Peter and Paul Church	F
76	Una	Kozarska Dubica	Kozarska Dubica	Radio Feniks	E
77	Una	Kozarska Dubica	Kozarska Dubica	Police station Kozarska Dubica	D
78	Una	Kozarska Dubica	Kozarska Dubica	Combined secondary school Nikola Tesla	B
79	Una	Kozarska Dubica	Kozarska Dubica	Public Institutuion "Center for Social Work"	C
80	Una	Kozarska Dubica	Kozarska Dubica	Fire station Kozarska Dubica	C
81	Una	Kozarska Dubica	Kozarska Dubica	Electrical distribution and distribution plant	G
82	Una	Kozarska Dubica	Kozarska Dubica	Puhalska Mosque	F
83	Una	Kozarska Dubica	Kozarska Dubica	Cemetery	F
84	Una	Kozarska Dubica	Kozarska Dubica	Primary school Saint Sava	B
85	Una	Kozarska Dubica	Kozarska Dubica	City sports hall	E
86	Una	Kozarska Dubica	Kozarska Dubica	Border crossing Gradina Donja	C
87	Bosna	Trnovo (RS)		Trnovo Mosque	F
88	Bosna	Trnovo (RS)		Pošte Srpske	C
89	Bosna	Trnovo (RS)		Police station Trnovo	D
90	Bosna	Trnovo (RS)		Library	E
91	Bosna	Trnovo (RS)		Cemetery	F
92	Bosna	Istočna Ilidža	Krupac	Necropolis with tombstones and nisan in Krupcu	F
93	Bosna	Istočno Novo Sarajev o	Tilava	District school Saint Sava	B
94	Bosna	Ilidža	Stup	Kasindolska Mosque	F
95	Bosna	Ilidža	Bojnik	Stadium Bojnik	E
96	Bosna	Novi Grad- Sarajev o	Rajlovac	Elektroprijenos B&H	G
97	Bosna	Novi Grad- Sarajev o		Local community Rječica	C
98	Bosna	Vogošć a	Semizovac	Mosque	F
99	Bosna	Vogošć a	Semizovac	Memorial martyrs and the fallen soldiers	F
100	Bosna	Ilijaš		Bus Station Ilijaš	G
101	Bosna	Ilijaš		Police Station Ilijaš	D
102	Bosna	Ilijaš		Highschool Center Nedžad Ibrišimović	B
103	Bosna	Ilijaš		Parish of St. Mark the Evangelist	F
104	Bosna	Ilijaš		Football stadium	E
105	Bosna	Breza		Football stadium	E
106	Bosna	Visoko	Svinjarevo	Equestrian club	E
107	Bosna	Visoko	Svinjarevo	Football stadium	E
108	Bosna	Visoko	Svinjarevo	Shooting club Visoko	E
109	Bosna	Visoko		Municipality of Visoko	C
110	Bosna	Visoko	Svinjarevo	Bus station	G
111	Bosna	Visoko	Svinjarevo	Franciscan classical gymnasium	B
112	Bosna	Visoko	Svinjarevo	Church of Saint Bonaventure	F
113	Bosna	Visoko		City park	F
114	Bosna	Visoko		Franciscan monastery	F
115	Bosna	Visoko		Mesdžid Ozrakovići Mosque	F
116	Bosna	Visoko		Train station Visoko	G
117	Bosna	Visoko	Dobrinje	Football stadium	E
118	Bosna	Kakanj	Čatići	Chapel of St. Nikole Tavelića	F
119	Bosna	Kakanj	Doboj	Football stadium FK "Mladost"	E

No.	Basin	Municipality	Residential place	Name of institution	Type
120	Bosna	Kakanj	Doboj	Fire station Doboj	C
121	Bosna	Kakanj	Alagići	Mosque	F
122	Bosna	Kakanj	Zgošća	Zgošća Mosque	F
123	Bosna	Olovo		Municipality of Olovo	C
124	Bosna	Olovo		Mixed hight school "Musa Ćazim Ćatić"	B
125	Bosna	Olovo		Sports hall Olovo	E
126	Bosna	Olovo		Football stadium	E
127	Bosna	Zenica		Tennis court	E
128	Bosna	Zenica		Poljice Mosque	F
129	Bosna	Zenica	Radakovo	International primary and secondary school Zenica	B
130	Bosna	Zenica	Radakovo	Technical school	B
131	Bosna	Zenica	Radakovo	Secondary mixed school "Mladost"	B
132	Bosna	Zenica	Radakovo	Sports Hall BILMIŠĆE Zenica	E
133	Bosna	Zenica	Jalija	Primary school Edhem Mulabdić	B
134	Bosna	Zenica	Jalija	Jalijska Mosque	F
135	Bosna	Zenica	Jalija	Sultan-Ahmedo Mosque	F
136	Bosna	Zenica	Jalija	Sultan-Ahmed Mosque medresa, architectural ensemble	F
137	Bosna	Zenica		Zenica City Museum	F
138	Bosna	Zenica		Turkish Park	F
139	Bosna	Zenica		Government of Zenica- Doboj Canton	C
140	Bosna	Zenica		Kamberovića Polje	F
141	Bosna	Zenica		First Gymnasium	B
142	Bosna	Zenica		BH Post	E
143	Bosna	Zenica		Sports fields	E
144	Bosna	Zenica		Primary schooll Musa Ćazim Ćatić	B
145	Bosna	Zenica	Nova Zenica	Stadium Bilino polje	E
146	Bosna	Zenica	Nova Zenica	Bus Station	G
147	Bosna	Zenica	Blatuša	Blatusa ambulance	A
148	Bosna	Zenica	Begov Han	Mesdžid u džematu Dubac- Polje	F
149	Bosna	Žepče	Žepče	Municipality of Žepče	C
150	Bosna	Žepče	Žepče	Croatian post	E
151	Bosna	Žepče	Žepče	Municipal court in Žepče	C
152	Bosna	Žepče	Žepče	Bus station Žepče	G
153	Bosna	Žepče	Žepče	Catholic school center "Don Bosco"	B
154	Bosna	Zavidovi ći	Zavidovići	City monument	F
155	Bosna	Zavidovi ći	Zavidovići	Community Center	E
156	Bosna	Zavidovi ći	Zavidovići	Bus station Zavidovići	G
157	Bosna	Zavidovi ći	Zavidovići	Donji Kovači Mosque	F
158	Bosna	Zavidovi ći	Zavidovići	BH Post	E
159	Bosna	Zavidovi ći	Zavidovići	Community Center Kovači	E
160	Bosna	Maglaj	Maglaj	City Stadium Maglaj	E
161	Bosna	Maglaj	Maglaj	Primary school Maglaj	B
162	Bosna	Maglaj	Maglaj	Municipality of Maglaj	C
163	Bosna	Maglaj	Maglaj	Medical centre Maglaj	A
164	Bosna	Maglaj	Maglaj	First primary school	B
165	Bosna	Maglaj	Maglaj	Gymnasium Edhem Mulabdić	B
166	Bosna	Maglaj	Maglaj	Primary school Ozren	B
167	Bosna	Maglaj	Šije	Šije Mosque	F
168	Bosna	Maglaj	Šije	Old Bosnian House- čardaklije	F
169	Bosna	Maglaj	Koprivci	Mosque džemata Karadaglije-Koprivci-Oruče	F
170	Bosna	Maglaj	Jablanica	Primary school "Gazi Ferhad-beg"	B
171	Bosna	Maglaj	Jablanica	Dzemata Jablanica Mosque	F
172	Bosna	Doboj	Pridjel Gornji	Stadium Bare	E
173	Bosna	Doboj	Doboj	City heating plant	G
174	Bosna	Doboj	Doboj	Sports Hall	E
175	Bosna	Doboj	Doboj	Highschool Center	B
176	Bosna	Doboj	Doboj	Temple of Nativity of the Virgin	F
177	Bosna	Doboj	Doboj	Adventist church	F
178	Bosna	Doboj	Doboj	Memorial park	F
179	Bosna	Doboj	Doboj	Primary school Sveti Sava	B
180	Bosna	Doboj	Doboj	High business technical school	B

No.	Basin	Municipality	Residential place	Name of institution	Type
181	Bosna	Doboj	Doboj	Police station Doboj	D
182	Bosna	Doboj	Doboj	Bus station Doboj	G
183	Bosna	Doboj	Doboj	Sports and recreational complex Dzungla	E
184	Bosna	Doboj	Doboj	Elektro Doboj	G
185	Bosna	Doboj	Doboj	Tennis Club Doboj	E
186	Bosna	Doboj	Doboj	Government office	C
187	Bosna	Doboj	Doboj	Republika Srpska Railways	G
188	Bosna	Doboj	Doboj	Police department Doboj	D
189	Bosna	Doboj	Doboj	Park of folk heroes	F
190	Bosna	Doboj	Doboj	City government Doboj	C
191	Bosna	Doboj	Doboj	Šume RS - Šumsko gazdinstvo Doboj	G
192	Bosna	Doboj	Doboj	Stadium of sports games	E
193	Bosna	Doboj	Doboj	Gymnasium "Jovan Dučić"	B
194	Bosna	Doboj	Doboj	Primary school Dositej Obradović	B
195	Bosna	Doboj	Doboj	Dobojski Info	E
196	Bosna	Doboj	Doboj	Vodovod a.d. Doboj	G
197	Bosna	Doboj	Doboj	Football stadium FK Sloga	E
198	Bosna	Doboj	Doboj	Flea market	G
199	Bosna	Doboj	Doboj	Regulatory board of railways of B&H	G
200	Bosna	Doboj	Doboj	Sports complex CAC Doboj 2017	E
201	Bosna	Doboj	Doboj	Fire station	C
202	Bosna	Doboj	Doboj	Green Market	G
203	Bosna	Doboj	Doboj	Slobomir University	B
204	Bosna	Doboj	Doboj	Pošte Srpske	C
205	Bosna	Doboj	Doboj	Cultural artistic society	E
206	Bosna	Doboj	Doboj	National library Doboj	E
207	Bosna	Doboj	Doboj	Tombstones of Bosnian Bogumils	F
208	Bosna	Doboj	Doboj	Regional museum Doboj	F
209	Bosna	Doboj	Doboj	JP RTV Doboj d.o.o	E
210	Bosna	Doboj	Doboj	Primary school Vuk Karadžić	B
211	Bosna	Doboj	Doboj	Jewish Cultural Center "Bejt Šalom"	F
212	Bosna	Doboj	Doboj	Sacred Heart Church	F
213	Bosna	Doboj	Doboj	Traffic police	D
214	Bosna	Doboj	Doboj	Faculty of Transportation Doboj	B
215	Bosna	Doboj	Doboj	Football club Željezničar	E
216	Bosna	Doboj	Doboj	Pošte Srpske	C
217	Bosna	Doboj	Doboj	Kindergarten Majke Jugovića	B
218	Bosna	Doboj Jug	Doboj Jug	Police station Doboj Jug	D
219	Bosna	Doboj Jug	Doboj Jug	Primary school 21. mart	B
220	Bosna	Usora	Tešanjka	Stadium Topolik	E
221	Bosna	Usora	Tešanjka	Mixed hight school "Stjepan Radić"	B
222	Bosna	Usora	Tešanjka	Croatian post d.o.o. Mostar	C
223	Bosna	Jelah		Lake Jelen with sports grounds	E
224	Bosna	Jelah	Ćemani	Jelah Polje Mosque	F
225	Bosna	Jelah		Association of sports fishermen "BLINKER" Kološević - Tešanj	E
226	Bosna	Jelah		Primary school Abdulvehab Ilhamija	B
227	Bosna	Jelah	Jorgići	Chapel of Saint Ive Vrela	F
228	Bosna	Teslić		Zoo	G
229	Bosna	Teslić	Stenjak	Bus station Teslić	G
230	Bosna	Teslić	Stenjak	Stenjak Mosque	F
231	Bosna	Doboj		Pošte Srpske	C
232	Bosna	Doboj		St. Nikola Ortdox Church	F
233	Bosna	Modriča		Auto-moto savez Republike Srpske	G
234	Bosna	Modriča	Modrički Lug	Modrički Lug Mosque	F
235	Bosna	Modriča		Church of St. Basil of Ostrog	F
236	Bosna	Šamac	Zasavica	Church of the Saint spirit	F
237	Bosna	Odžak		High school Pere Zečevića	B
238	Bosna	Odžak		Primary school Vladimira Nazora	B
239	Bosna	Odžak		Croatian cultural society Napredak	E
240	Bosna	Odžak		Football stadium	E
241	Bosna	Odžak		Croatian post d.o.o. Mostar	C

No.	Basin	Municipality	Residential place	Name of institution	Type
242	Bosna	Odžak	Novo Selo	Church of the Saints Petar and Pavle	F
243	Bosna	Odžak	Posavska mahala	Chapel and cemetery	F
244	Bosna	Petrovo	Karanovac	St. Ilija Orthodox Church	F
245	Bosna	Petrovo	Kakmuž	Primary school "Sveti Sava"	B
246	Bosna	Petrovo	Kakmuž	Church of the Holy Trinity	F
247	Bosna	Petrovo		Pošte Srpske	C
248	Bosna	Gračani ca		Football stadium NK Orahovica	E
249	Bosna	Tuzla	Mramor Novi	Football stadium	E
250	Bosna	Tuzla	Milešići	Milešići Mosque	F
251	Bosna	Tuzla	Lipnica	Primary school Lipnica	B
252	Bosna	Tuzla	Lipnica	Memorial "RUDNIK LIPNICA"	F
253	Bosna	Tuzla	Lipnica	Football stadium	E
254	Bosna	Tuzla	Bukinje	Veterinary clinic Bukinje	A
255	Bosna	Tuzla	Simin Han	Bus station "Simin Han"	G
256	Bosna	Tuzla	Simin Han	Simin Han Mosque	F
257	Bosna	Tuzla	Simin Han	Local community Simin Han	C
258	Bosna	Tuzla	Simin Han	Market "Simin Han"	G
259	Bosna	Kalesija	Vukovije Gornje	Ambulance	A
260	Bosna	Kalesija	Rainci Gornji	Mosque	F
261	Bosna	Kalesija	Prnjavor	Prnjavor Mosque	F
262	Bosna	Kalesija	Kalesija Selo	Kalesija Selo Mosque	F
263	Bosna	Živinice		First primary school	B
264	Bosna	Živinice		Stadium FK "Slaven"	E
265	Bosna	Živinice		Veterinary clinic Živinice	A
266	Bosna	Živinice		Elektro Živinice	C
267	Bosna	Živinice		B&Hamk	C
268	Bosna	Živinice	Sjever	Church of St. Ivana Baptist	F
269	Bosna	Živinice	Strašanj	Strašanj Mosque	F
270	Bosna	Živinice		Crushing waste water	G
271	Neretva	Jablanic a	Glogošnica	Primary school Suljo Čilić – district school with playground(17 students, 216m2)	B
272	Neretva	Jablanic a	Glogošnica	Post/Bank	C
273	Neretva	Široki brijeg	Ljuti Dolac	Stadium	G
274	Neretva	Čitluk	Čitluk	Primary school fra Didaka Buntića	B
275	Neretva	Čitluk	Čitluk	High school fra Slavka Barbarića	B
276	Neretva	Čitluk	Čitluk	Sposts Hall	E
277	Neretva	Čitluk	Čitluk	Medical centre Čitluk	A
278	Neretva	Čitluk	Čitluk	Children's kindergarten Čitluk	B
279	Neretva	Čitluk	Čitluk	City Stadium	E
280	Neretva	Grude	Drinovci	Parish Office / Museum	F
281	Neretva	Grude	Drinovci	Local community	C
282	Neretva	Grude	Drinovačko Brdo	District school	B
283	Neretva	Grude	Tihaljina	Parich Office / Local community	C
284	Neretva	Grude	Tihaljina	District school	B
285	Neretva	Grude	Grude	Sports Hall	E
286	Neretva	Grude	Grude	Parish Office	F
287	Neretva	Grude	Grude	Cemetery	F
288	Neretva	Grude	Grude	Local community	C
289	Neretva	Grude	Grude	Police department Grude	C
290	Neretva	Ljubuški		Bridge on river Mlade	G
291	Neretva	Ljubuški	Vitina	Post office	C
292	Neretva	Ljubuški	Veljaci	Natural water park Koćuša	F
293	Neretva	Ljubuški	Veljaci	Parish office/Church	F
294	Neretva	Ljubuški	Veljaci	Cemetery	F
295	Neretva	Ljubuški	Veljaci	Local Office	C
296	Neretva	Ljubuški	Otok	Local Office	C
297	Neretva	Ljubuški	Otok	Primary school	B
298	Neretva	Ljubuški	Otok	Sports Center (MZ)	E
299	Neretva	Ljubuški	Orahovlje	Cemetery	F
300	Neretva	Ljubuški	Orahovlje	Church	F
301	Neretva	Ljubuški	Orahovlje	Local office	C
302	Neretva	Ljubuški	Grabovnik	Local office	C

No.	***Basin***	***Municipality***	***Residential place***	***Name of institution***	***Type***
303	Neretva	Ljubuški	Grabovnik	District school	B
304	Neretva	Ljubuški	Vašarovići	Cemetery	F
305	Neretva	Ljubuški	Vašarovići	Church	F
306	Neretva	Ljubuški	Ljubuški	Bridge over the river Trebižat	G
307	Neretva	Ljubuški	Ljubuški	Bathing place / recreation zone Trebižat	E
308	Neretva	Ljubuški	Ljubuški	Bathing place / recreation zone Čeveljuša-Mandića Jaz	E
309	Neretva	Ljubuški	Kravice	Protected area of nature - Kravice waterfalls	F
310	Neretva	Čapljina	Čapljina	Football stadium	E
311	Neretva	Čapljina	Čapljina	Old bridge (Tasovčići)	F
312	Neretva	Čapljina	Čapljina	Cinema Mogorjelo	E
313	Neretva	Čapljina	Čapljina	Whole sale market	G
314	Neretva	Čapljina	Čapljina	Bridge (Tasovčići M6)	G
315	Neretva	Čapljina	Čapljina	Economic zone (Street. G. Šuška)	G
316	Neretva	Čapljina	Čapljina	Park recreation zone (Ušće Trebižata)	E
317	Neretva	Čapljina	Čapljina	Local community Tasovčići	C
318	Neretva	Čapljina	Čapljina	Local community Čeljevo	C
319	Neretva	Čapljina	Čapljina	Primary school, District school Čeljevo	B
320	Neretva	Čapljina	Čapljina	Post - Višići	C
321	Neretva	Čapljina	Čapljina	Bridge on the Tresani	G
322	Neretva	Čapljina	Čapljina	Bridge at the Krupa / Dračevo	G
323	Neretva	Čapljina	Čapljina	Rt Kula	F
324	Neretva	Čapljina	Gabela	Historical area	F
325	Neretva	Čapljina	Gabela	Football stadium NK GOŠK	G
326	Neretva	Čapljina	Gabela	Church of the Nativity of Mary	F
327	Neretva	Čapljina	Doljani	International border crossing	G
328	Neretva	Čapljina	Doljani	Community Center	E
329	Neretva	Čapljina	Hutovo Blato	Nature Park (J-I dio)	E
330	Neretva	Čapljina	Gnnjilišta	Church of the Sacred Heart	F
331	Neretva	Čapljina	Dračevo	Church	F
332	Neretva	Čapljina	Dračevo	Primary school	B
333	Neretva	Čapljina	Višići	Local community	C
334	Neretva	Čapljina	Višići	Football stadium	E
335	Neretva	Čapljina	Višići	Primary school Lipanjske zore	B
336	Neretva	Čapljina	Nadinići	Bridge (river Mušnica)	G
337	Neretva	Čapljina	Kula	Mosque	F
338	Neretva	Čapljina	Bukov Potok	Accumulation lake (irrigation?)	G
339	Trebišnjica	Neum	Ponikva / Neum	Accumulation lake Vrutak (irrigation?)	G
340	Trebišnjica	Neum	Ravno	Bridge on the river Trebišnjica	G
341	Trebišnjica	Neum	Ravno	Accumulation lake Konjska čatrnja (irrigation ?)	G
342	Trebišnjica	Trebinje	Orašje Popovo	Local community	C
343	Trebišnjica	Trebinje	Dobromani	Bridge (river Trebišnjica)	G
344	Trebišnjica	Trebinje	Staro Slano	Bridge (river Trebišnjica)	G
345	Trebišnjica	Trebinje	Gornja Kočela	Bridge (river. Trebišnjica)	G
346	Trebišnjica	Trebinje	Gomiljani	Church of St. Petka	F
347	Trebišnjica	Trebinje	Gomiljani	Purifier water (?)	G
348	Trebišnjica	Trebinje	Trebinje	Secondary Technical School (Center of secondary schools)	B
349	Trebišnjica	Trebinje	Trebinje	Territorial fire station (unit)	C
350	Trebišnjica	Trebinje	Trebinje	Football stadium 1	E
351	Trebišnjica	Trebinje	Trebinje	Bus station	G
352	Trebišnjica	Trebinje	Trebinje	Church of Nativity of Saint John	F
353	Trebišnjica	Trebinje	Trebinje	Cultural Center Trebinje	E
354	Trebišnjica	Trebinje	Trebinje	City park	G
355	Trebišnjica	Trebinje	Trebinje	Police station	C
356	Trebišnjica	Trebinje	Trebinje	Faculty of Management	B
357	Trebišnjica	Trebinje	Trebinje	City government	C
358	Trebišnjica	Trebinje	Trebinje	Consulate of R. Srbije	C
359	Trebišnjica	Trebinje	Trebinje	Herzegovinian house	F
360	Trebišnjica	Trebinje	Trebinje	Church	F
361	Trebišnjica	Trebinje	Trebinje	Old town	F
362	Trebišnjica	Trebinje	Trebinje	Herzegovina museum / Old Town	F

No.	Basin	Municipality	Residential place	Name of institution	Type
363	Trebišnjica	Trebinje	Trebinje	Elektroprivreda RS - Uprava	C
364	Trebišnjica	Trebinje	Trebinje	Olympic Pool Banje	E
365	Trebišnjica	Trebinje	Trebinje	Arslanagića bridge	F
366	Trebišnjica	Trebinje	Trebinje	Church of Nativity of Saint. Jovan and cemetery	F
367	Trebišnjica	Trebinje	Trebinje	Sports and recreation center	E
368	Trebišnjica	Trebinje	Trebinje	Railway bridge	G
369	Trebišnjica	Trebinje	Trebinje	Bridge at the hydroelectric power plant	G
370	Trebišnjica	Trebinje	Trebinje	Main city bridge	G
371	Trebišnjica	Trebinje	Trebinje	Old Town	F
372	Trebišnjica	Trebinje	Trebinje	JU for childrens education "Naša radost"	B
373	Trebišnjica	Trebinje	Trebinje	Cathedral Churc	F
374	Trebišnjica	Trebinje	Trebinje	Cultural Center Trebinje / Community Center	E
375	Trebišnjica	Trebinje	Trebinje	Primary school J.J.Zmaj Trebinje	B
376	Trebišnjica	Trebinje	Trebinje	Stadium "A. Masleša"	E
377	Trebišnjica	Trebinje	Trebinje	Sports Hall "M. Mrdžić"	E
378	Trebišnjica	Trebinje	Trebinje	Little football stadium "Bregovi"	E
379	Trebišnjica	Trebinje	Trebinje	Regional Chamber of Commerce	C
380	Trebišnjica	Trebinje	Trebinje	Sports camp "Bregovi"	E
381	Trebišnjica	Trebinje	Trebinje	Swimming pool Bregovi	E
382	Trebišnjica	Trebinje	Trebinje	Basketball camp	E
383	Trebišnjica	Trebinje	Varina Gruda	Church of St. Barbarians	F
384	Trebišnjica	Trebinje	G. Čićevo	Cemeteries and chapels	F
385	Trebišnjica	Trebinje	Zgonjevo	Necropolis – Church of St. Petar and pavle	F
386	Vrbas	Banja Luka	Banja Luka	Center for Mental Health Dolac	A
387	Vrbas	Banja Luka	Banja Luka	Family medicine clinic - "KUCA ZDRAVLJA"	A
388	Vrbas	Banja Luka	Banja Luka	Activities of dental practise - ZU "Dr MARCETA"	A
389	Vrbas	Banja Luka	Bočac	Local community Bočac	C
390	Vrbas	Banja Luka	KRUPA NA VRBASU	School playground	E
391	Vrbas	Banja Luka	KRUPA NA VRBASU	Football stadium	E
392	Vrbas	Banja Luka	REKAVICE	Rafting klub Kanjon	E
393	Vrbas	Banja Luka	BANJA LUKA	Diving klub Buk	E
394	Vrbas	Banja Luka	BANJA LUKA	School playground,primary school Bora Stanković	E
395	Vrbas	Banja Luka	BANJA LUKA	Cemetery by the Kastel	F
396	Vrbas	Banja Luka	KULJANI	Cemetery	F
397	Vrbas	Banja Luka	KULJANI	Church	F
398	Vrbas	Bugojno	Bugojno	Stadium Jaklić	E
399	Vrbas	Bugojno	Bugojno	City heating plant for the settlement Vrbas	G
400	Vrbas	Čelinac	Čelinac	High school	B
401	Vrbas	Čelinac	Čelinac	Primar school "Miloš Dujić"- central	B
402	Vrbas	Čelinac	Čelinac	Kindergarten	B
403	Vrbas	Čelinac	Čelinac	Medical centre Čelinac	A
404	Vrbas	Čelinac	Čelinac	Municipal administration Čelinac	C
405	Vrbas	Čelinac	Čelinac	Red Cross Čelinac	C
406	Vrbas	Čelinac	Čelinac	Employment Institute Čelinac	C
407	Vrbas	Čelinac	Čelinac	Health insurance fund Čelinac	C
408	Vrbas	Čelinac	Čelinac	Pension and invalidity insurance fund Čelinac	C
409	Vrbas	Čelinac	Čelinac	Cultural media center (NVO)	E
410	Vrbas	Čelinac	Čelinac	Police station Čelinac	D
411	Vrbas	Čelinac	Čelinac	Center for Social Work Čelinac	C
412	Vrbas	Čelinac	Čelinac	Association of pensioners Čelinac	C
413	Vrbas	Čelinac	Čelinac	Urban extra court and football field (sports centre Tukovi)	E
414	Vrbas	Čelinac	Čelinac	Tennis courts	E
415	Vrbas	Čelinac	Čelinac	Post	E
416	Vrbas	Čelinac	Čelinac	Movie theater	E
417	Vrbas	Čelinac	Čelinac	Cultural Center	E
418	Vrbas	Čelinac	Čelinac	National library "Ivo Andrić"	E
419	Vrbas	Čelinac	Čelinac	Religious building	F
420	Vrbas	Čelinac	Čelinac	Religious building	F
421	Vrbas	Čelinac	Čelinac	Cemetery	F

No.	Basin	Municipality	Residential place	Name of institution	Type
422	Vrbas	Čelinac	Čelinac	Cemetery	F
423	Vrbas	Čelinac	Čelinac	Monument	F
424	Vrbas	Čelinac	Čelinac	Monument	F
425	Vrbas	Čelinac	Čelinac	Pump station for sewage water (Planed)	G
426	Vrbas	Čelinac	Čelinac	Sewage treatment plant (planed)	G
427	Vrbas	Čelinac	Čelinac	Elektroprenos B&H	G
428	Vrbas	Donji Vakuf	Donji Vakuf	Nine-year primary school	B
429	Vrbas	Donji Vakuf	Torlakovac	Regional ambulance	A
430	Vrbas	Donji Vakuf	Donji Vakuf	Municipal building of Donji Vakuf	C
431	Vrbas	Donji Vakuf	Donji Vakuf	Fire station	C
432	Vrbas	Donji Vakuf	Donji Vakuf	Employment office	C
433	Vrbas	Donji Vakuf	Donji Vakuf	Center for Social Work	C
434	Vrbas	Donji Vakuf	Donji Vakuf	Building societies and political parties	C
435	Vrbas	Donji Vakuf	Donji Vakuf	Cinema	E
436	Vrbas	Donji Vakuf	Donji Vakuf	Hall	E
437	Vrbas	Donji Vakuf	Donji Vakuf	School halls	E
438	Vrbas	Donji Vakuf	Donji Vakuf	School playground	E
439	Vrbas	Donji Vakuf	Donji Vakuf	Post	E
440	Vrbas	Donji Vakuf	Donji Vakuf	Chess club	E
441	Vrbas	Donji Vakuf	Donji Vakuf	Radio club	E
442	Vrbas	Donji Vakuf	Donji Vakuf	Bathing area Zelenac	E
443	Vrbas	Donji Vakuf	Torlakovac	Monument	F
444	Vrbas	Donji Vakuf	Krivače	Cemetery	F
445	Vrbas	Donji Vakuf	Donji Vakuf	Mosque	F
446	Vrbas	Donji Vakuf	Donji Vakuf	Orthodox Church	F
447	Vrbas	Donji Vakuf	Donji Vakuf	Ibrahim beg Malkoč square	F
448	Vrbas	Donji Vakuf	Donji Vakuf	Building of the Islamic religious community	F
449	Vrbas	Donji Vakuf	Donji Vakuf	Monument	F
450	Vrbas	Donji Vakuf	Donji Vakuf	Mosque	F
451	Vrbas	Donji Vakuf	Donji Vakuf	Monument	F
452	Vrbas	Donji Vakuf	Donji Vakuf	Cemetery and building for the provision of funeral services	F
453	Vrbas	Gornji Vakuf	Krupa	Krupa Medical centre	A
454	Vrbas	Gornji Vakuf	Donja Ričica	Sports playground	E
455	Vrbas	Jajce	Jajce	Bare playground	E
456	Vrbas	Jajce	Podmilačje	Water sources Mrtvalj	G
457	Vrbas	Jajce	Podmilačje	Pumping station for water	G
458	Vrbas	Jezero	Jezero	Regional ambulance „Stara ambulanta“	A
459	Vrbas	Jezero	Jezero	Children playground	E
460	Vrbas	Kotor Varoš	Kotor Varoš	Excursion Black river	E
461	Vrbas	Kotor Varoš	Kotor Varoš	City beach Brana	E
462	Vrbas	Kotor Varoš	Kotor Varoš	Decorated promenade 2	E
463	Vrbas	Kotor Varoš	Kotor Varoš	Decorated promenade	E
464	Vrbas	Kotor Varoš	Kotor Varoš	Walking trail	E
465	Vrbas	Kotor Varoš	Kotor Varoš	Building and footpath bath Bjeline	E
466	Vrbas	Kotor Varoš	Kotor Varoš	Water intake Brana	G
467	Vrbas	Laktaši	Jakupovci	District school "Klašnice"	B
468	Vrbas	Laktaši	Trn	ZU Specialist pediatric clinic "DR Bošnjak"	A
469	Vrbas	Laktaši	Trn	Z.U. " NADADENT"	A
470	Vrbas	Laktaši	Trn	Special police and training center	D
471	Vrbas	Laktaši	Laktaši	Home for children without parental care	C
472	Vrbas	Laktaši	Jakupovci	Cemetery	F
473	Vrbas	Laktaši	Jakupovci	Church	F
474	Vrbas	Laktaši	Laktaši	Cemetery 2	F
475	Vrbas	Laktaši	Jakupovci	School playground	E
476	Vrbas	Laktaši	Čardačani	Sports playground	E
477	Vrbas	Laktaši	Trn	Pump station for water supply	G
478	Vrbas	Laktaši	Kriškovci	Source	G
479	Vrbas	Srbac	Glamočani	Primary school "Dositej Obradović"-district school	B
480	Vrbas	Srbac	Srbac	Kindergarten "Naša radost"	B
481	Vrbas	Srbac	Glamočani	Building local communities 2	C
482	Vrbas	Srbac	Srbac	Tourist Organization municipality of Srbac	C

No.	*Basin*	*Municipality*	*Residential place*	*Name of institution*	*Type*
483	Vrbas	Srbac	Srbac	Office of the Red Cross	C
484	Vrbas	Srbac	Srbac	Fire station	C
485	Vrbas	Srbac	Srbac	Home for children with special needs	C
486	Vrbas	Srbac	Glamočani	School hall	E
487	Vrbas	Srbac	Glamočani	School playground	E
488	Vrbas	Srbac	Inađol	Tennis court	E
489	Vrbas	Srbac	Srbac	School playground	E
490	Vrbas	Srbac	Srbac	Gym	E
491	Vrbas	Srbac	Srbac	Post	E
492	Vrbas	Srbac	Srbac	Sports hall	E
493	Vrbas	Srbac	Srbac	City park	F
494	Vrbas	Srbac	Glamočani	Cemetery 2	F
495	Vrbas	Srbac	Glamočani	Church 2	F
496	Vrbas	Srbac	Glamočani	Memorial	F
497	Vrbas	Srbac	Bajinci	Cemetery	F
498	Vrbas	Srbac	Bajinci	Church	F
499	Vrbas	Srbac	Bajinci	Church 2	F
500	Vrbas	Srbac	Srbac	Parochial home	F
501	Vrbas	Srbac	Srbac	Pumping station	G
502	Vrbas	Šipovo		Excursion Ada Sokočnica	E
503	Vrbas	Šipovo	Šipovo	Pump station for sewage water	G
504	Vrbas	Šipovo	Majevac	Water intake to the pump station for 1000 people	G
505	Vrbas	Šipovo	Stupna	Source Smrdeljac	G
Type: A- Health B- Education C- Court, municipality, administration (fire brigades, etc.) D- Police, army E- Culture, information, sport F- Culture-historical heritage (religious facilities, cemeteries, monuments) G- Infrastructure facilities					

Table D5. Businesses affected by floods per basins and municipalities in B&H

Basin	*Municipalities*	*No.of the affected businesses*	*Total value of assets of the affected businesses (USD)*	*Damages on business assets (USD)*
Una	**Una total**	**394**	**434,938,935**	**73,939,619**
	BIHAĆ	90	86,962,128	**14,783,562**
	BOSANSKA KRUPA	39	67,626,896	**11,496,572**
	KLJUČ	47	42,784,860	**7,273,426**
	KOSTAJNICA	2	6,858,540	**1,165,952**
	KOZARSKA DUBICA	48	72,930,366	**12,398,162**
	NOVI GRAD (RS)	15	41,403,820	**7,038,649**
	PRIJEDOR	74	61,350,462	**10,429,579**
	RIBNIK	5	2,978,979	**506,426**
	SANSKI MOST	74	52,042,882	**8,847,290**
Vrbas	**Vrbas total**	**443**	**146,337,426**	**24,877,362**
	BANJA LUKA	122	68,997,426	**11,729,562**
	ČELINAC	130	2,723,462	**462,989**
	DONJI VAKUF	56	5,177,268	**880,136**
	GORNJI VAKUF-USKOPLJE	18	502,118	**85,360**
	JAJCE	20	8,416,529	**1,430,810**
	KOTOR VAROŠ	3	15,088	**2,565**
	LAKTAŠI	68	46,365,174	**7,882,080**
	SRBAC	26	14,140,362	**2,403,862**
Bosna	**Bosna total**	**1613**	**2,112,269,979**	**359,085,896**
	BREZA	11	39,341,682	**6,688,086**
	BUSOVAČA	7	7,640,905	**1,298,954**
	DOBOJ	252	224,060,985	**38,090,367**
	DOBOJ ISTOK	4	11,293,300	**1,919,861**
	DOBOJ JUG	55	74,102,763	**12,597,470**
	GRAČANICA	9	39,962,047	**6,793,548**
	ILIDŽA	238	432,781,966	**73,572,934**
	ILIJAŠ	90	146,451,589	**24,896,770**
	ISTOČNA ILIDŽA	30	12,153,226	**2,066,048**
	ISTOČNO NOVO SARAJEVO	27	14,028,321	**2,384,815**
	KAKANJ	24	16,475,975	**2,800,916**
	LUKAVAC	4	34,236,495	**5,820,204**
	MAGLAJ	34	15,713,981	**2,671,377**
	MODRIČA	19	19,428,711	**3,302,881**
	NOVI GRAD (FB&H)	26	60,772,770	**10,331,371**
	ODŽAK	57	51,234,055	**8,709,789**
	OLOVO	10	7,005,665	**1,190,963**
	PALE (RS)	26	12,651,074	**2,150,683**
	PETROVO	2	13,299,894	**2,260,982**
	SOKOLAC	1	2,047,441	**348,065**
	ŠAMAC	1	54,612	**9,284**
	TESLIĆ	28	49,002,466	**8,330,419**
	TEŠANJ	137	77,959,987	**13,253,198**
	TUZLA	46	19,277,866	**3,277,237**
	USORA	40	31,975,044	**5,435,757**
	VISOKO	83	103,081,086	**17,523,785**
	VITEZ	65	219,330,845	**37,286,244**
	VOGOŠĆA	1	322,968	**54,905**
	ZAVIDOVIĆI	32	111,830,408	**19,011,169**
	ZENICA	164	170,759,974	**29,029,196**
	ŽEPČE	58	39,944,631	**6,790,587**
	ŽIVINICE	32	54,047,248	**9,188,032**
Neretva	**Neretva total**	**284**	**329,051,436**	**55,938,744**
	ČAPLJINA	109	115,180,919	**19,580,756**
	ČITLUK	82	107,230,633	**18,229,208**
	GACKO	2	1,707,776	**290,322**
	GRUDE	56	82,368,305	**14,002,612**
	JABLANICA	1	101,991	**17,338**

	LJUBUŠKI	34	22,461,812	**3,818,508**
Trebišnjica	**Trebišnjica total**	**91**	**199,554,269**	**33,924,226**
	RAVNO	5	4,970,592	**845,001**
	TREBINJE	86	194,583,677	**33,079,225**
Grand Total		**2,825**	**3,222,152,045**	**547,765,848**

18 ANNEX E - RISK AND VULNERABILITY MODELLING AND MAPPING IN B&H

18.1 EXISTING LEGISLATION ON METHODOLOGY FOR RISK ASSESSMENT IN B&H

The Framework Law on protection and rescue of people and goods from natural and other disasters in Bosnia and Herzegovina includes the of the "Methodology for risk assessment natural hazards and other disasters in B&H". Under Article 2, it is stated that risk assessment is developed for different administrative-territorial units of B&H separately with a note that Methodology for Risk assessment in entities and Brcko District (BD) has been prescribed by relevant institutions of and administrative authorities of entity's civil protection and BD. IT also states that risk assessment is based on the principle of risk universality – inclusion of all risks (B&H and risks with cross border effects); and the principle of compatibility of Risk assessment with guidelines, directives and other documents of UN and EU. The purpose of the methodology is to provide guidelines for identification and analysis of risks, elements exposed to hazards, risk reduction measures for building and strengthening security of the people and material goods against natural and other accidents, while the goals are the identification of main hazards of all types that can cause natural or other disasters (in B&H and cross border); assessment of exposure of the people, goods, critical infrastructure to all main hazard and based on assessment of hazard, exposure to hazards and vulnerability, the systematic dimensioning (actual locating) of risks will be done (in B&H and cross border), probability, causes and consequences (expressed in human, material and financial losses).

The legislation in Part II provides the methodological framework including general assessment as well as specify assessment components. Under general assessment it includes a requirement for receptor data on all objects that may be at risk from hazards to provide the general overview. Under special assessment, the requirements for identification of hazards and analysis, response capacity assessment is provided and includes the main hazards to be identified and analysed, identification and analysis of risks from natural hazards: hydro meteorological, geological, biological and environmental, which should consist data on the following hazards.

Table 18-1: General and Specific information to be presented in a risk assessment[42]

General Assessment – Information required
· Characteristics of the territory:
· Surface and administrative territorial scheme,
· Geographic and pedological characteristics, relief, agro-pedo soil composition, vegetation,
· Hydrographic network,
· Climate and meteorological characteristics,
· Other data relevant for assessment.
· Population:
· No. Of inhabitants
· Density and spatial distribution,
· Other relevant population data,
· Distribution and structure of residential area and other buildings:
· Housing as a risk element (buildings structure factors, education institutions, shopping malls);
· Accommodation for care;
· Health capacities (clinics, hospitals...);

[42] The Framework Law on protection and rescue of people and goods from natural and other disasters in Bosnia and Herzegovina

·	Business, culture and other facilities that could be used for the purpose of protection and rescue in the area under potential risk.
·	Material, culture goods and environment:
·	Culture (culture-historical heritage, monuments...),
·	Agriculture and other areas,
·	National and nature parks,
·	Forests (from the aspect of the fire risks),
·	Transport and other facilities/installations of critical infrastructure:
·	Roads and railways and junctions, river communication, airports,
·	Water supply facilities,
·	Bridges...tunnels... (considering tectonic, geological and traffic risks),
·	Thermal and hydro PP and installations, transformers, distribution infrastructure (location and arrangement),
·	Hydrological facilities (dams and water accumulations, age....considering hydrological, seismic geol. And other risks),
·	Oil and gas distribution facilities,
·	Gas stations
·	Facilities of chemical and petrochemical industry,
·	Post and communication systems,
·	Pharmacy facilities,
·	Food industry,
·	Surface and underground mines.
Specific Assessment - Information required on flood hazards	
· Hydrographic indicators– watercourse (description, and watercourse profile size with obligatory basins analysis (basin approach) flow surfaces, watercourses with cross-border influence, water accumulations that can be cause of the floods or cases of dam breach/overflow hazards of river, or flash floods considering positions in the river walleyes, existence of the dykes, overview of endangered settlements with number and structure of population;	
· Hydrometeorology. conditions– water level, ice, average annual precipitation, long term statistics ... (for the certain watercourses, precipitation intensity, average monthly precipitation and water levels with extreme values;	
· Defence facilities –functionality of the protective water management facilities with numerical indicators -number, type, etc.	
· Description of the flood area socio-economic indicators: size and development of flood area (urban and rural settlements) influence on traffic, agriculture, industry ...other economic activities, environment;	
· Overview of the other HM statistic indicators – drought (index, the most critical period of the year...), storms.....(...), ice, hail…snowdrifts….□	
· Overview of the most common causes and consequences of the floods and other HM hazards;	
· Necessary provision of the suitable maps in annex Assessment -map of flood areas, map of areas endangered by floods, map of lowlands in the main basins, hydro-geological map, map of vegetation areas etc.	

It should be noted that there is no specification of the data collection methods, particularly for socio-economic data required for flood risk and vulnerability modelling, mapping and assessment.

18.2 OVERVIEW OF METHODOLOGIES AND MODELS FOR FLOOD RISK AND VULNERABILITY MODELLING AND MAPPING IN B&H

The Vrbas project developed and piloted a GIS-based risk and vulnerability modelling and mapping and cost-benefit options appraisal methodology for B&H based on the EUFD methodology. As detailed in the Economic Analysis Annex, the methodology has been extended to include all basins in B&H for the assessment of socio-economic impact of floods and undertaking cost-benefit analysis of intervention options for the purpose of development of this proposal. It should be noted that, since detailed hazard mapping was only available for the Vrbas basin, the model will be improved for the other basins during implementation when the detailed hazard mapping for all basins data are available. This section details the key principles of methodology.

The FLOODsite programme is listed by the EU as one of several methods that support the implementation of the EU Floods Directive.

The FLOODsite methodology is focussed on the derivation of proportional loss curves for selected receptors (people, property, infrastructure and the environment). The process to be adopted for this project utilises the FLOODsite philosophy.

Stage 1:	Screening and quantification of flood risk by people, social and agricultural and environmental drivers, allows prioritisation of the basin flood risk by community or municipalities. This highlights the 'riskiest' communities or municipalities where further economic analysis and improved data gathering would be justified. This process of flood risk scoring is a form of Multi Criteria Analysis (MCA). This phase defines the key areas of risk.
Stage 2:	Identification of economic damage within especially high-risk flood areas as identified in Stage 1.
Stage 3:	Combination of economic and non-economic risk factors to select those communities for further strategic optioneering and economic assessment.
Stage 4:	Project appraisal and discounted cash flow for preferred flood mitigation options in line with **Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks**

The methodology is selected for its ease of use, flexibility and acknowledged compliance with EU Directives.

18.3 Stage 1: Development of Flood Scores

The risk scoring approach is based on several criteria relating to People, Property, Agriculture and Environmental factors at risk of flooding. This approach allows comparison of total risk between different locations (communities or municipalities) within the basin based on comparative risk criteria (also known as drivers or receptors).

The application of this process allows identification of high flood risk areas within the basin that may be progressed for further strategic economic appraisal during option development stages of the investigation.

The implications of damages and losses to the community as a result of future flooding would be extensive due to the wide floodplain, extreme nature of flash flooding with very real potential for disruption to daily life on a catastrophic scale.

A screening methodology used in catchment flood management planning in the United Kingdom will be adapted for this project with enumeration procedures based on, but modified from, the Environment Agency (UK) draft procedure for Catchment Flood Management Planning receptor assessment and enumeration. This approach has been also satisfactorily applied in the Prut Barlad Master Plan study in Eastern Romania. Risk factors will be defined as "People" "Agriculture" and "Environment", each containing a number of receptors exhibiting a variety of risk attributes.

A receptor is defined as a category of impact (e.g. property, infrastructure, agriculture, etc.) with a likelihood of flooding that can be separately enumerated and has the potential to be quantified in economic terms. The impact and likelihood of flooding, known as risk, for each receptor, will contribute to the identification of relative flood risk within discrete geographical areas (communities or municipalities). These locations will ultimately help define future flood risk management objectives.

This method enables risk-ranking for each community or municipality.

18.3.1 Flood Risk Scores for Communities and Municipalities

Risk is a combination of likelihood of flooding and impact caused by flooding to each receptor (property, agriculture, infrastructure, environment).

The method to be adopted for this project will produce a flood risk score based on scale of risk (e.g. depth of the flood, velocity of flood flow) and the return period (or frequency/likelihood/probability) of successive flooding events.

Flood risk scores are calculated for:

- Flood risk to people (risk to life, disruption to community and disruption to daily life), using people as a metric
- Flood risk to infrastructure, also using people as a metric
- Flood risk to roads, also using people as a metric
- Flood Risk to Agriculture, using hectares as a metric
- Flood risk to the environment, using both objects at risk and hectares as a metric

Where “People” is used as a common metric then total flood risk to people, infrastructure and roads can be combined to give an overall flood risk for a community or a municipality.

This analysis is for fluvial flooding only, or the kind of flooding that has the largest impact in flat low-lying areas. The model can be used to include flash flooding risk and landslide risk once the criteria for risks to people, agriculture, infrastructure and environment are established.

A GIS model will be developed to calculate flood risk for people, infrastructure, roads, agriculture and the environment and compare risk for each of these receptors for the municipalities which are either fully or partly in the flood extreme flood plain. The GIS model also allows comparative flood risk to people, infrastructure and roads for separate communities.

18.3.2 Development of Risk Score – Likelihood Assessment

3 flood return periods were modelled for Vrbas basin:

- 1 in 20 years (5% per year)
- 1 in 100 years (1% per year)
- 1 in 500 year (0.2% per year)

It is recommended that the following return period should be additionally run.

- 1 in 2 years (50% chance of flooding per year)
- 1 in 50 years (2% per year)
- 1 in 1000 years (0.1% per year)

This will provide a better basis for deriving the annual average damages which is assessed against a number of different flood return periods (usually 6 events, but a minimum of 3 can be used).

18.3.3 Development of Flood Risk Scores for 7 Receptor groups

The following primary flood risk receptors groups (or impact data) will be assessed and attributes of these receptors classified as ***High, Medium and Low consequence*** as a result of flooding.

- Loss of Life
- Infrastructure/Utility
- Community
- Daily Life
- Heritage and landscape
- Agriculture
- Transport/Communications

In developing the total flood score, it is assumed that the weighting factors for High, Medium and Low impact receptor attributes (see below) will be as follows:

- High 9
- Medium 3
- Low 1

That is, each level of impact severity is seen as three times more significant than the preceding level.

Risk to life is determined by exposure to property and community flooding with respect to the following attributes:

1) Combination of ***flood depth*** in each property with ***velocity*** in each property to give flood hazard per property and for each community.

2) ***Speed of the onset of flooding*** in the community

3) ***Nature of the community*** (that is, type of building, e.g. single storey, apartments)

4) Extent and development of ***Flood warning*** and ***emergency / evacuation plans*** in the Community

5) Socially Vulnerable Families to evaluate ***Community Social Vulnerability***

Flood Depth (D) and Velocity (V) at each property:

High	if	V x D > 0.6 (Building collapse at >1.0)
Medium	if	0.4 < V x D < 0.6
Low	if	V x D < 0.4

Depth is in metres and velocity is in cubic metres per second

The following table was developed to assist classification of consequence:

Velocity (m/s)	Depth (m) 0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.00				L	L	L	M	M	M	M	H	H
0.10				L	L	M	M	M	M	M	H	H
0.25				L	M	M	M	M	M	H	H	H
0.50				M	M	M	M	M	M	H	H	H
1.00			L	M	M	M	M	H	H	H	H	H
1.50			L	M	M	M	H	H	H	H	H	H
2.00		L	L	M	M	H	H	H	H	H	H	H
2.50		L	L	M	H	H	H	H	H	H	H	H
3.00		L	L	H	H	H	H	H	H	H	H	H
3.50		L	M	H	H	H	H	H	H	H	H	H
4.00		L	M	H	H	H	H	H	H	H	H	H
4.50	L	L	M	H	H	H	H	H	H	H	H	H
5.00	L	L	M	H	H	H	H	H	H	H	H	H

Total Community Hazard is derived as follows:

L	More than 75% properties in Low Hazard
M	25% to 75% properties in Low Hazard
H	Less than 25% properties in Low Hazard

Speed of Onset of flooding:

Low if onset of flooding is very gradual (more than 20 hours)

Medium if onset of flooding is gradual (10 to 20 hours)

High if onset of flooding is rapid (<10 hours)

Nature of Community

Low (No Low consequence score for nature of community)

Medium if predominantly multi storey residential

High if predominantly residential

Extent and development of Flood warning and emergency / evacuation plans

Low if flood warning and emergency plans are in place

Medium if either a flood warning plan OR an emergency plan is in place

High if neither flood warning NOR emergency plan are in place

Community Social Vulnerability

Low if Less than 25% Households with socially vulnerable families are within less than 57001criteria

Medium if between 25 and 50% Households with socially vulnerable families are within less than 57001 criteria

High if More than 50% Households with socially vulnerable families are within less than 57001 criteria

18.3.4 Risk to life

Risk to Life is a People metric so the Risk to Life Flood Score is measured by the number of people exposed to each of the flood return periods and the weighted score for each attribute associated with risk to life as illustrated in the boxes below:

BOX 1

For a 20 % event:

No. of people exposed to flooding hazard (Total Occupancy): 970

Put "1" in the boxes below that describe the hazard
(fill only one box per line)

	Low	Med	High
Source factors:			
Depth & Velocity fac	1	0	0
Speed of onset facto	1	0	0
Receptor factors:			
Nature of area	0	0	1
Flood Warning	0	0	1
Socially Vulnerable	0	0	1

Thus, community depth times velocity and speed of onset are low consequence and nature of area, flood warning/evacuation and social vulnerability are High consequence for a 20% flood event with 970 people exposed to flood risk.

BOX 1.1

Defined weightings of 'hazard attribute'
& 'receptor' factors

	Low	Med	High
Source factors:			
Depth & Velocity factor	1	3	9
Speed of onset factor	1	3	9
Receptor factors:			
Nature of area	1	3	9
Flood Warning	1	3	9
Socially Vulnerable	1	3	9
Community Disruption	1	3	9

The weightings are set for each hazard attribute and receptor attribute

BOX 1.2

For a 20% event:

No. of people exposed to following hazard: 970

The components of the hazards are calculated below:

	Low	Med	High		
Source factors:				**Total Source factors:**	2
Depth & Velocity factor	1	0	0		
Speed of onset factor	1	0	0		
Receptor factors:				**Total Receptor factors:**	27
Nature of area	0	0	9		
Flood Warning	0	0	9		
Socially Vulnerable	0	0	9		

The consequence weights and scores are calculated for each hazard and receptor attribute

BOX 1.3

Total Hazard Score: 29

Risk for this probability of event:

(Prob. of event X No. of People X Hazard)

5626

The total hazard score (29) is multiplied by the number of people (970) affected by the 20% flood and this is multiplied by the probability of occurrence (0.2) =5,626. This is the people flood risk score for risk to life for the selected community.

Population statistics for each community can be derived from census or electoral data and a population spreading algorithm used to estimate the population affected by each of the modelled floods if not readily available from census data.

BOX 1.4

Overall Community Risk: Risk to Life

Risk for a 0.1% even	**213**
Risk for a 1% event:	**1,291**
Risk for a 2% event:	**4,370**
Risk for a 10% event	**5,626**

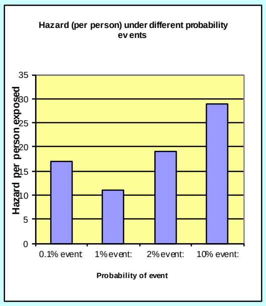
No. of people		Hazard		Consequence
12,556	x	17	=	213,452
11,736	x	11	=	129,096
11,499	x	19	=	218,481
970	x	29	=	28,130

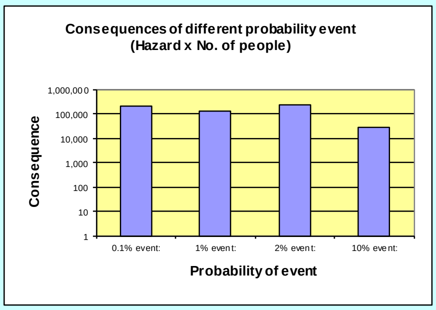
Overall Risk: 11,500
(Risk for 10% + 2% +1% + 0.1% events)

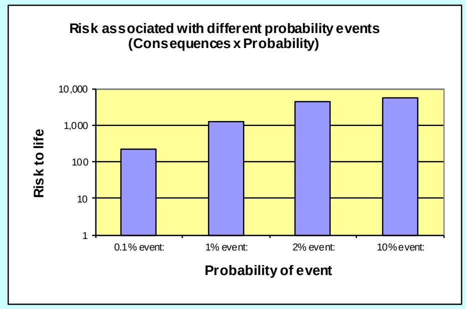
Hazard (per person) under different probability events

Consequences for different probability events (Hazard x No. of People)

Risk under different probability events (Consequences x Probability)







Overall Risk to Life Flood score for 4 flood return periods (0.1%, 1%, 2%, 10%) is 11,500. This score is compared with other communities to rank the risk to life attributes for all communities.

18.3.4.1 Risk to Infrastructure: Population served by Utilities and shared emergency facilities

Low if hotels, restaurants, churches

Medium if Municipality buildings, hospitals (beds), schools (pupils), Large electricity sub stations affected many people, water & sewage treatment works

High if Emergency Services (Fire, Ambulance, Police), Power supply and distribution

18.3.5 Risk to Community

Extent of flooding to each community for each flood zone

Isolated if less than 5% of community affected

Limited if less than 15% of community affected

Extensive if 15% to 50% of community affected

Catastrophic if greater than 50% of community affected

Duration of flooding

Very short if less than 12 hours

Short if between 12 and 24 hours

Long if between 1 and 2 days

Very Long if greater than 2 days

High, Medium and Low consequences are based on a combination of extent of flooding and duration of flooding as follows:

Duration and extent of flooding

	Duration of flooding			
Extent of flood	< 12 hrs	12-24 hrs	1-2 days	>2 days
Isolated: Less than 5% of properties affecte[d]	L	L	L	M
Limited: Less than 15% affected	L	L	M	M
Extensive: From 15 to 50% affected	M	M	M	H
Catastrophic: More than 50%	M	H	H	H

18.3.6 Risk to Daily Life

Number of residential properties exposed to flooding in each risk zone

Number of commercial properties exposed to flooding in each risk zone

18.3.7 Risk to Landscape and Heritage

Protected Areas exposed to flooding (Metric is Hectares)

Low if protected landscape

Medium if managed reserve, natural monument

High if 'strict' nature reserve and national park

Cultural Heritage (Manmade monuments/buildings) exposed to flooding (Metric is number)

Low if Local significance

Medium if National monument

High if UNESCO global heritage

18.3.8 Risk to Agriculture (metric is hectares)

Low if Pastureland for grazing and grass production, Forest

Medium if Arable crops e.g. corn, wheat

High if Horticulture/ vegetables e.g. watermelons, beans, vineyards

18.3.9 Risk to Transport/Communications (roads) (people metric)

For roads crossing flooded areas a population buffer of 1km is set to determine the people living adjacent to disrupted roads. Two receptor attributes are used to calculate a people risk score.

Duration of Flood

Low if less than 10 hours

Medium if between 10 and 20 hours

High if greater than 20 hours

Length of Road

Low if less than 1km

Medium if between 1km and 5km

High if greater than 5km

18.3.10 Risk Scores: People attributes

Table 1 below summarises the process of developing people flood scores at both community and municipality levels

PEOPLE RISK SCORE		
		Flood depth at each property
combines:		*Flood velocity at each property*
Probabilty of flooding		*Speed of onset of flooding in community*
and		*Type of property (Commercial or residential)*
Consequences of Flooding	for	*Type of property (Single or multiple storey)*
	these	
for	attributes	*Flood warning for each community*
People and Property		*Evacuation plans for each community*
for		*Social vulnerability of each household*
6 Flood frequencies		*Flood duration in each community*
		Extent of flooding in each community

18.4 Stage 2: Identification of Economic Damage and Loss

The initial screening assessment allows a systematic identification of high, medium or low geographical risk which may then be subjected to an economic damage appraisal to enable comparison of damages and losses associated with "Doing Nothing", or ""Maintaining Existing flood management strategies" with flood reducing Intervention options, whether structural or non-structural (e.g. construction of embankments or storage or introduction of flood warning or land management initiatives, and insurance as a financial incentive to manage flooding; or a combination of multiple options).

Receptor flood damages and losses are developed from using two separate techniques:

1) Damages to property derived from application of proportional loss curves – Lack of existing depth damage data, specifically for Bosnia, is the driver to use depth damage curves derived from other countries (UK, Germany) and adjusted to reflect average Bosnian property and inventory values
2) Damage to agriculture derived from a knowledge of broad productivity measures for selected crop types and their vulnerability to flooding reducing crop yield and market prices and in extreme cases replanting permanent crops. Seasonality of flooding and stage of crop growth can also be factored into the calculation of agricultural damages.

18.4.1 Economic Appraisal of Community and Municipality Property Damages

High Risk communities and municipalities are defined via the Flood Risk Scoring process in Stage 1. Baseline "Existing/current" damages are calculated for property using proportional loss curves and using agricultural yield and production data for agricultural land.

The identification of high-risk communities and municipalities in Stage 1 is an overview process and identifies areas where more detailed analysis of potential damages is required. During optioneering and solution appraisal, it may be necessary to split the communities at most risk into smaller and more detailed damage assessment areas. In pre-strategic appraisal studies in UK and Western Europe, both hydraulic modelling data and economic analysis are done usually with less detailed modelling and less comprehensive data. For example, EU Floods Directive Preliminary Flood Risk assessments only model three flood events (10%, 1% and 0.1% annual expected probabilities -AEP) and use less detailed damage and land use data sets. **Taking only, 10%, 1% and 0,1% AEPs, wholly exaggerates the calculation of annual average damages and will exaggerate the level of benefit ascribed to flood mitigation options** and is only appropriate to identify high risk 'hot spots' to inform the development of a long-term strategy and identification of options.

A GIS-based model enables calculation of event damages and annual average damages to property and agriculture. As such damages associated with each of the defined return periods are calculated for all municipalities and communities.

18.4.2 Introduction to damages estimation

Guidance on the estimation of flood damages is provided, based on experience across Europe. FloodSite[43] states that due to the variety of factors which determine the selection of a proper flood damage evaluation method, it is not possible to recommend one single method of flood damage evaluation. Their guidelines aim at revealing the basic steps of the flood damage evaluation process, emphasising and

[43] http://www.floodsite.net/html/partner_area/project_docs/T09_06_01_Flood_damage_guidelines_D9_1_v2_2_p44.pdf

explaining important economic evaluation principles and supporting the selection of appropriate flood damage methods for specific applications. FloodSite guidelines are summarised here.

There are 4 steps in determining the appropriate method to be applied for flood damage calculation:

Step 1 - Selection of an appropriate approach.

Step 2 - Determination of the direct, tangible damage categories to be considered

Step 3 - Gathering of necessary information

Step 4 – Calculation and presentation of expected damages

Step 1 - Selection of an appropriate approach

The choice of damages method used depends very much on a) the scale, b) the study objective, c) the availability of resources, and d) the availability of pre-existing data. A detailed approach has been adopted for the damages method for the following reasons:

1) The national scale of GCF project be considered to be meso scale, while the scale of the individual basins are miso-scale and resources can be considered to be available for a detailed assessment.
2) The damage model will be used to prioritise investment, identify cost-effective FRM options (cost-benefit analysis) and as input to flood insurance scheme development which requires a high precision, detailed approach
3) Resources and time are not major restrictions to the level of detail to be used.
4) All of the necessary land use, socio-economic data as well as every flood hazard and risk modelled data will be available at a very high spatial resolution for a detailed assessment. While depth-Damage curves are not available for Bosnia they have been developed by method of transfer from other counties (UK and Germany) and adjustment for the B&H context and verified.

Step 2 - Determination of the direct, tangible damage categories to be considered

The damage categories considered are focussed on those which have the greatest impact upon the total damage. Usually, direct, tangible damage contributes a significant proportion of the total damage. Nevertheless, indirect and intangible damage categories are also considered, too. Direct tangible damage can further be divided into several categories (buildings, inventories, infrastructure, cars, etc.). However, some damage categories − especially buildings and inventories − usually dominate the total amount of damage. Therefore, it can be reasonable to include only the most important damage categories to reduce the effort of the study. Damage categories which have only a small influence on the total damage amount can nevertheless be included in a more approximate way, e.g. by a typical share of the total damage.

Flood damage encompasses a wide range of harmful effects on humans, their health and their belongings, on public infrastructure, cultural heritage, ecological systems, industrial production and the competitive strength of the affected economy. Although the terminology differs occasionally, flood damages are mostly categorised firstly in direct and indirect damages and secondly in tangible and intangible damages (Smith & Ward 1998; Parker et al. 1987; Penning-Rowsell et al. 2003; Messner & Meyer 2005).

- **Direct/indirect damages**: direct flood damage covers all varieties of harm which relate to the immediate physical contact of flood water to humans, property and the environment. This includes, for example, damage to buildings, economic assets, loss of standing crops and livestock in agriculture, loss of human life, immediate health impacts, and loss of ecological goods. Direct damages are usually measured as damage to stock values. Indirect flood damages are damages caused by disruption of physical and economic linkages of the economy, and the extra costs of emergency and other actions taken to prevent flood damage and other losses. This includes, for example, the loss of production of companies affected by the flooding, induced production losses of their suppliers and customers, the costs of traffic disruption or the costs of emergency services. Indirect damages are often measured as loss of flow values.

- **Tangible/intangible damages:** damages, which can be easily specified in monetary terms, such as damages on assets, loss of production etc. are called tangible damages. Casualties, health effects or damages to ecological goods and to all kind of goods and services which are not traded in a market are far more difficult to assess in monetary terms. They are therefore indicated as intangibles.

Furthermore, Smith & Ward (1998) distinguish between primary damages, which result from the event itself, and secondary damages, which are at least one causal step removed from the flood. For example, the loss of production of a firm which is flooded and therefore is unable to carry on with their production would refer to as primary indirect loss. The induced losses of production of customers or suppliers in- and outside the affected area due to backward and forward linkages would be indicated as secondary indirect damages.

In addition, macro-economic impact of flood need to be considered.

Step 3 – Gathering necessary data for damage calculation

Step 3 deals with the major tasks of flood damage evaluation: the estimation and calculation of economic values of potentially damaged tangible goods and the gathering of sound information for this task.

Generally speaking, four main factors are important in this respect:

a) the intensity of inundation, b) the number, type and elevation of properties affected (assets at risk), c) their value, d) and their susceptibility against inundation.

a) Data on the intensity of a studied flood scenario. The area and depth of inundation are the most important information to be sampled here, but also the duration, time of occurrence, velocity or the toxicological load of flooding water could have a significant influence on damage. As these guidelines focus on the socio-economic component of damage evaluation, inundation characteristics are regarded here as an input for damage evaluation.

- Detailed flood modelling such as completed for Vrbas and which will be completed for all other basins in B&H, provides all of the information required at a very high level of detail and accuracy to meet this requirement.

b) Information on the location, number and type as well as the elevation of properties which could be affected by a certain flood event (the elements at risk) needs to be gathered. Such information is normally given by land use data. This can be either primary data from field surveys or secondary data, i.e. data from already existing sources. Furthermore, the spatial resolution and level of categorisation can be highly diverse. It ranges from broadly aggregated land use information (e.g. industrial area, residential area) to detailed information on the type of every single building or property.

- This data was collected for Vrbas and will be systematically collected for all other basins to the level of individual properties and aggregated to ‘communities’ in the socio-economic data collection.

c) In order to measure damage in monetary terms, information on the **value of assets** at risk needs to be quantified. This information can be integrated in the process of damage evaluation in two different ways:
   - First, the total value of all assets at risk in a study area is estimated. The damaged share of this total value is then calculated by relative damage functions.
   - Second, the value of elements at risk (or at least parts of them) is integrated in absolute damage functions, showing the absolute damage depending on magnitude of inundation characteristics.
   - Monetary values have been assigned to all properties and assets within the socio-economic database.

d) Finally, **damage functions** are needed to provide information on the susceptibility of elements at risk against inundation characteristics. They show either the damaged share (therefore it is here referred to as relative damage functions) or the absolute monetary amount of damages per property or square metre (therefore it is here referred to as absolute damage functions) of a certain group of elements at risk as a function of the magnitude of certain inundation characteristics. In the current state-of-the-art the main inundation parameter considered in these damage functions is inundation depth (depth-damage functions). Others, like velocity, duration and time of occurrence are rarely taken into account. As the susceptibility of elements at risk depends on their type and attributes (e.g. mode of construction), properties of similar type are grouped and expressed by one approximate damage function. The extent of this aggregation and categorisation varies among the different approaches.

   Further factors like risk perception of the people in flood prone areas and their preparedness to be flooded can also influence the susceptibility of elements at risks and, hence, the potential flood damage amount. Up to now such factors have not been included in damage functions − at least not explicitly.

   Damage functions are not developed for Bosnia. Section 2.6.1 provides an example of how damage function can be developed using UK Proportion loss curves.

Step 4 – Calculation and presentation of expected damages

Step 4 serves to bring all information gathered in step 3 together and to calculate the damages to be expected from a certain event. Two basic approaches of damage evaluation can be distinguished here, considering the way the monetary value is integrated in the calculation:

a) The absolute or direct damage estimation approach: Here, the total value of assets at risk is not calculated at any time. Instead, information on the value of assets and on their susceptibility against certain inundation depths is used to develop absolute damage functions. Combined with data on inundation depth and land use information, these absolute damage functions enable a direct estimation of the absolute damage amount for each property or unit of property.
b) The percentage of property value approach (relative damage function approach): By bringing together land use information and asset values the total value of assets at risk is calculated. This maximum damage potential is then overlaid with data on the specific flooding scenario, especially inundation depth. The resulting damage for each asset or unit of assets is then calculated by means of relative damage functions, showing the damaged share of the total value as a function of inundation depth (or other inundation characteristics).

The approach is chosen depends on the kind of available data. I.e. if detailed data on the value of assets is at hand the percentage of property approach may be convenient. If on the other hand a comprehensive set of absolute damage functions already exists, the absolute damage estimation approach could be more appropriate. However, relative damage functions can be better (but nevertheless carefully) transferred to other regions.

Developing relative damage function using UK Proportional Loss Curves to evaluate property damages

The data gathering and data assessment stage of the Vrbas project identified a lack of consistent and defined data with which to develop actual depth damage curves as used by many western European countries. This is primarily a result of this methodology not being previously used. Data is therefore not available in order to generate the loss/damage curves for different receptor types (property and agriculture) within the timescale of the project.

In order to generate the curves for Bosnian conditions, UK proportional loss curves have been adjusted for Bosnian building fabric and inventory values as a reasonable approximation and in line with FLOODsite recommendations.

Synthetic damage functions were derived for Vrbas basin using the following steps:

1. selection of representative residential buildings and assessment of their values, as well as the value of movables in those buildings;
2. determining, utilizing expert calculations, the value of characteristic flood levels above and below the ground level;
3. expert assessment of damage in representative buildings on specific flood levels in buildings;
4. determining the damage value in buildings taking into consideration the increase of damage with flood depth, in fact determining the damage function.

To select the representative residential buildings and estimate their value, the phone interviews were conducted with 3500 households from all settlements within the Vrbas river basin exposed to flood risk. In addition to general questions, the interview included the questions about residential and support buildings and their features (type of residence, dimensions, year of construction and heated area, number of floors, type of material on outside walls and fences, type of joinery, water supply and waste water drainage, etc.), way of heating, fuels and their quantities, electrical appliances, furniture, vehicles, agricultural machinery and equipment, etc. That way, combined with the value of individual assets, the average value of assets per household per settlement is presented.

To determine the value of characteristic flood levels, the flood hazard map and flood risk map for the Vrbas river basin were made by the consortium of water management companies.

The expert assessment of risk in representative buildings at characteristic flood levels of building was conducted at representative residential buildings in the Vrbas river basin. The damages on building are assessed from civil engineering and electrical-machinery aspect in a way that levels – flood depths in fact water depths in building are set to every half meter, e.g. from 0.5 m to 5 m. Depending on the water depth in the building, the works to return the building into functional or initial condition, in fact building reconstruction costs are considered.

From civil engineering aspect, the following types of works were considered: repair outside fence, clean the well and repair the hydro pack, empty the septic holes, dry the walls, remove the existing inside wooden joinery and purchase and install new PVC joinery, remove the existing outside wooden joinery and purchase and install new PVC joinery, paint the walls and ceiling twice including purchase of all necessary material, remove the existing wooden floor (parquette, ship floor) and purchase and install new floor including final processing.

From electrical-machinery aspect, the following types of works were considered:

- Purchase of material and electro-installation works including calculation per piece/set, where contractor provides all material for: rooms in the house (per room – socket, switch and two single-phase plug boxes), kitchen or niche in the house (two sockets, one serial switch, three-phase plug box and two single-phase plug box), hall in the house (socket, switch and outside waterproof lamp), bathroom (bathroom set including indicator, waterproof plug box and ceiling lamp and installation for boiler) in accordance with technical specification and IMG standard, including all necessary works.

- Purchase of material and installation of main electrical box GRP with all necessary installations for electricity protection and space for installation of meter and counter, as well as PVC pipes Ø 32mm from the box to the connection to LV network in the attic along facade (in accordance with valid regulations of the relevant electro-distribution company), and installation of the appropriate apartment plate set including all necessary works, as well as grounding works and installations of 2" probe and zinc coated tape 25 m long.
- Purchase and installation of single-phase, two-tariff meter 10-40A with electronic reading, in accordance with regulations of the relevant electro-distribution organisation.
- Purchase of material and balancing the potential for water installations in bathroom and kitchen, including all necessary works (Cu connectors for zinc coated pipes, pf wire 6mm yellow-green)
- Making the certified test certificate and registration of electro-installation testing in house (according to regulations of the relevant electro-distribution company).
- Repair the heating boiler (e.g. main electronic panel, inside fan, screw mechanism motor, circulation pump and control board).

The damage value in building is determined in a way that the reconstruction costs at all flood levels in building were summed up (from 0,5 m to 5m) and per all types of above-mentioned works. That way the unified damage function was established, pertaining to representative buildings in the Vrbas river basin. The usual practice is to present the damage as percentage of total building value, which was done compared to the average value of representative buildings in the Vrbas river basin, in fact:

$$\%\ damage = \frac{\text{reconstruction costs}}{\text{total value of representative building}}.$$

In addition, the obtained amount of damage per defined damage function for building without movables complies with the damage level that could be compensated in case of contracting the basic flood insurance package for households in Bosnia and Herzegovina.

To determine the damage function in representative building and its movables, in addition to reconstruction costs, the costs of replacement of significant electrical appliances are included (laundry machines, dish washer, TV set, refrigerator, freezer, electrical cooking stove and other electrical appliances), furniture (tables, beds, closets and other furniture), agricultural equipment (milking machines, mowing machines, trimmers and similar) and other movables. In this case, the damage is presented as percentage of total assets value in household, in fact

$$\%\ damage = \frac{\text{reconstruction costs} + \text{replacement of movables}}{\text{total value of household assets}}.$$

Since the average value of assets in household is determined for each of 13 municipalities in the Vrbas river basin, 13 damage functions were established based on the value assets. All 13 damage functions per municipalities were analysed and it was concluded that it is possible to establish three similar groups of municipalities to be presented with three damage functions[44]. One damage function is related to Banja Luka city, another damage function to the municipalities of Gradiška, Jajce, Kotor Varoš, Laktaši and Srbac and the third damage function to the municipalities of Bugojno, Čelinac, Donji Vakuf, Gornji Vakuf, Jezero, Šipovo and Mrkonjić Grad. In addition, the obtained amount of damage per defined damage function for building with movables complies with the damage level which would be compensated in case of contracting expanded flood insurance package for households in Bosnia and Herzegovina. Household insurance with movables has not been calculated yet but will be done in the proposed new project.

Hence, damage function depending on flood depth for **representative buildings without movables** has been obtained based on the average value of representative building in the Vrbas river basin, reconstruction costs at all flood levels in building (from 0, m to 5m) per all types of necessary civil engineering and electrical-machinery works. The average value of representative building in the Vrbas river basin is 94.415 KM and it includes civil engineering and electrical-machinery value of building without movables. Based on the analysis of reconstruction costs at all flood levels in building (from 0.5 m to 5m) per all types of necessary civil engineering and electrical machinery works, the following table was made.

Table 18-2: Reconstruction costs for representative building in the Vrbas river basin.

Water depth in building (x)	Reconstruction costs
0.5 m	7,924 KM
1.0 m	11,870 KM
1.5 m	12,618 KM
2.0 m	12,885 KM
2,5 m	13,204 KM
3.0 m	16,306 KM
3.5 m	16,339 KM
4.0 m	18,759 KM
4.5 m	18,824 KM
5.0 m	19,000 KM

Considering the average value of representative building in the Vrbas river basin, the percentage of damage value is obtained, as presented in the following table and graph.

Table 18-3: Percentage of damage value for representative building in the Vrbas river basin (without movables).

Water depth in building (x)	% damage to building value *(without movables)*
0.5 m	8.3%
1.0 m	12.4%
1.5 m	13.2%
2.0 m	13.5%
2.5 m	13.8%
3.0 m	17.1%
3.5 m	17.1%
4.0 m	19.7%
4.5 m	19.7%

[44] Damage function per groups of municipalities is established as an average of individual municipal damage functions.

5.0 m	19.9%

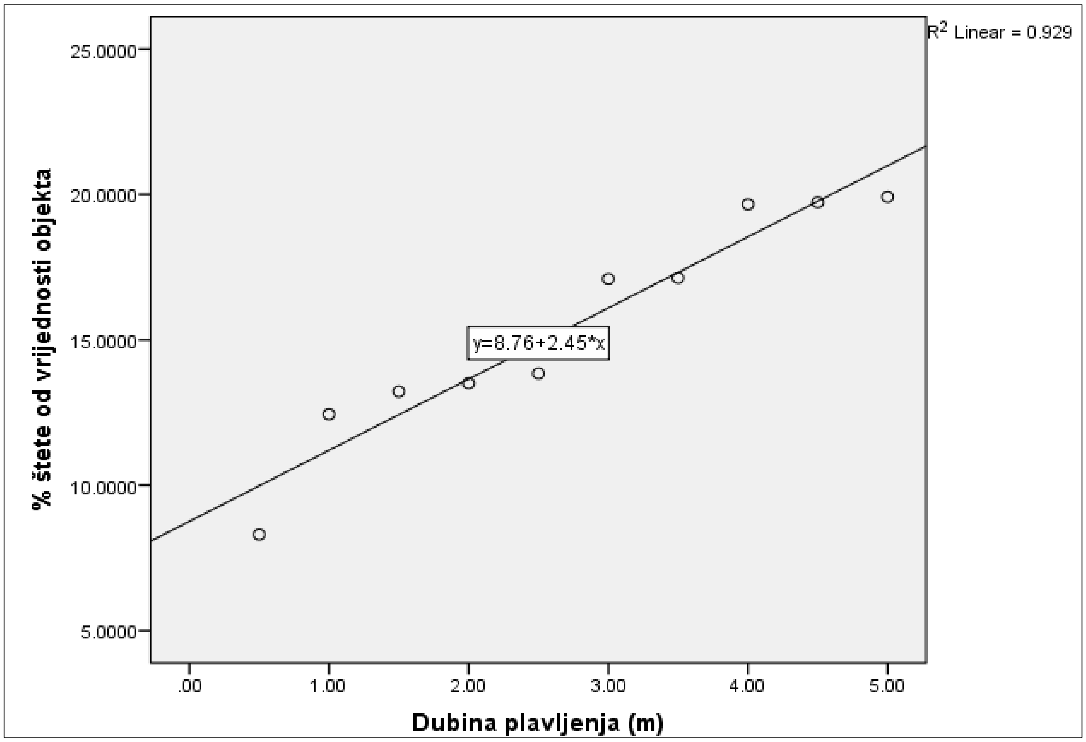


Figure 18-1: Damage function (curve) as share of assets value depending on water depth in building excluding movables.

To conduct interpolation and/or extrapolation of any damage value against the flood depth it is necessary to present the damage function depending on flood depth in building without movables. Therefore, the damage function depending on flood depth in building without movables in the Vrbas river basin reads as follows:

$y_{BP} = 2{,}45 \cdot x + 8{,}76$, where

y_{BP} - % of building value damage and

x – flood depth in fact water depth in building expressed in meters.

After consulting the relevant literature in order to compare the obtained damage functions with the damage functions determined in other countries, it has been concluded that according to authors, the literature presents the damage functions including the movables in addition to buildings, but not those that include only the damage in the building. Therefore, it is impossible to compare those damage functions (which include only the damages on building) with the others, but it will be possible in the following chapter about the damages in buildings with movables.

Damage function depending on flood depth for **representative buildings with movables** has been obtained based on the average value of assets in households within the Vrbas river basin per municipalities, reconstruction costs at all flood levels in building (from 0.5 m to 5m) per all types of necessary civil engineering and electrical-machinery works as well as the costs of replacement of movables and significant electrical appliances, furniture, agricultural equipment and other movables.

As noted in the description of methodology for establishment of damage functions, it has been concluded that it is possible to establish three groups of municipalities to be presented with three damage functions. One damage function is related to Banja Luka city, another to the municipalities of Gradiška, Jajce, Kotor Varoš, Laktaši and Srbac, and the third damage function to the municipalities of Bugojno, Čelinac, Donji Vakuf, Gornji Vakuf, Jezero, Šipovo and Mrkonjić Grad. The damage functions for each group of municipalities are presented in the tables below:

Table 18-4: Reconstruction costs for representative building and replacement of movables in Banja Luka city and groups of municipalities.

Water depth in building (x)	Costs of reconstruction and replacement of movables (KM) – Banja Luka	Costs of reconstruction and replacement of movables (KM) - municipalities of Gradiška, Jajce, Kotor Varoš, Laktaši and Srbac	Costs of reconstruction and replacement of movables (KM) - municipalities of Bugojno, Čelinac, Donji Vakuf, Gornji Vakuf-Uskoplje, Jezero, Šipovo And Mrkonjić Grad
0.5 m	13,479 KM	15,243 KM	15,040 KM
1.0 m	17,425 KM	19,189 KM	18,987 KM
1.5 m	18,173 KM	19,937 KM	19,735 KM
2.0 m	18,440 KM	20,204 KM	20,002 KM
2.5 m	18,759 KM	20,523 KM	20,321 KM
3.0 m	21,861 KM	23,625 KM	23,423 KM
3.5 m	21,894 KM	23,658 KM	23,456 KM
4.0 m	24,314 KM	26,078 KM	25,876 KM
4.5 m	24,379 KM	26,143 KM	25,940 KM
5.0 m	24,555 KM	26,319 KM	26,117 KM

Considering the average assets value in households, the percentage of damage to assets value is obtained, as presented in the following table for Banja Luka City and two groups of municipalities. Proportional damage functions were fitted to each using regression analysis.

Table 18-5: Percentage of damage to assets value in households for Banja Luka city and groups of municipalities.

Water depth in building (x)	% damage to assets value - Banja Luka City	% damage to assets value - municipalities of Gradiška, Jajce, Kotor Varoš, Laktaši and Srbac	% damage to assets value - Municipalities Of Bugojno, Čelinac, Donji Vakuf, Gornji Vakuf-Uskoplje, Jezero, Šipovo and Mrkonjić Grad

0,5 m	9.25%	12.10%	18.10%
1,0 m	11.95%	15.24%	22.85%
1,5 m	12.47%	15.83%	23.75%
2,0 m	12.65%	16.04%	24.07%
2,5 m	12.87%	16.30%	24.45%
3,0 m	15.00%	18.76%	28.19%
3,5 m	15.02%	18.79%	28.23%
4,0 m	16.68%	20.71%	31.14%
4,5 m	16.72%	20.76%	31.22%
5,0 m	16.85%	20.90%	31.43%

Based on research of property damage surveys for other countries and comparing them with the damage functions derived for the Vrbas river basin, the following conclusions were made for 1metre flood-depth:

- similar damage values in Banja Luka and the region around Rheine river of about 11% of assets value,
- similar damage values for the municipalities Gradiška, Jajce, Kotor Varoš, Laktaši and Srbac with damage function used in the studies of the US Army Corps of Engineers of about 14% of assets value,
- similar damage values for the municipalities Bugojno, Čelinac, Donji Vakuf, Gornji Vakuf, Jezero, Šipovo and Mrkonjić Grad and the region around Elba river of about 20% of assets value.

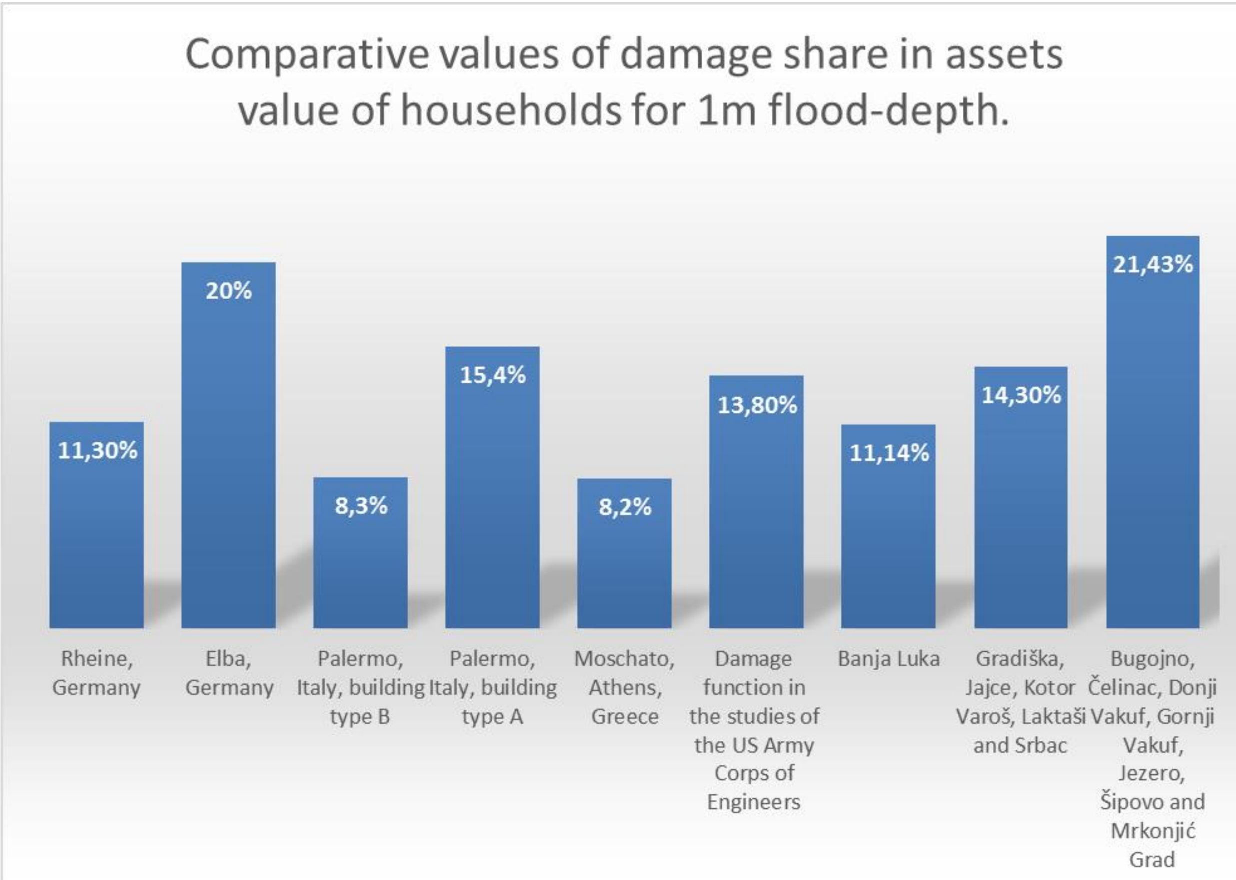


Figure 18-2: Comparison of damage curves for Vrbas basin with curves for other countries

18.5 CALCULATING DAMAGE

The formula for the calculation of the total damage amount for a certain event depends on the type of approach chosen and the type of data used. In a general and simple form this can be described by:

$$Damage_{total} = \sum_{i=1}^{n}\sum_{j=1}^{m} (value_{i,j} \times susceptibility_{i,j})$$

Such a calculation leads to a single direct, tangible damage amount in monetary units for each flooding scenario considered. This damage value can be used for the calculation of flood risk (the annual average damage) and for the calculation of net benefits or cost-benefit ratios in the context of economic assessments of flood protection measures by means of CBA.

[Susceptibility] i,j = f [(characteristics entity) i,j, (inundation characteristics)k , (socioeconomic characteristics)l]

i = category of tangible elements at risk (n categories possible)

j = entity in a elements-at-risk category (m entities possible)

k = flood type/specific flood scenario

l = type of socio-economic system

susceptibility: measured in percent

Since flooding events and their damages are usually highly spatially diverse, it is advisable not only to present the results in terms of one monetary number, but also to prepare maps to show the spatial distribution of damages. This is possible by means of geographical information systems (GIS).

The GIS model was used to calculate community and municipality event damages for each return periods and the annual average damage (AAD) for all events up to and including the extreme event (Figure 18-3).

The annual average flood damage is the area under the graph of flood damages plotted against exceedance probability (the reciprocal of the return period in years). This graph should be derived from an analysis of several future floods with a range of severities, or the results will be unreliable (at least 3 and preferably 6 flood events should be used).

Annual average damages are weighted towards more frequent events, so it is important to model accurately those events. Annual average damage is a better indicator of overall flood damage from all modelled events.

Damages can be represented using proportional loss curves as well as showing spatial distribution of damages on a map, examples of which are shown below.

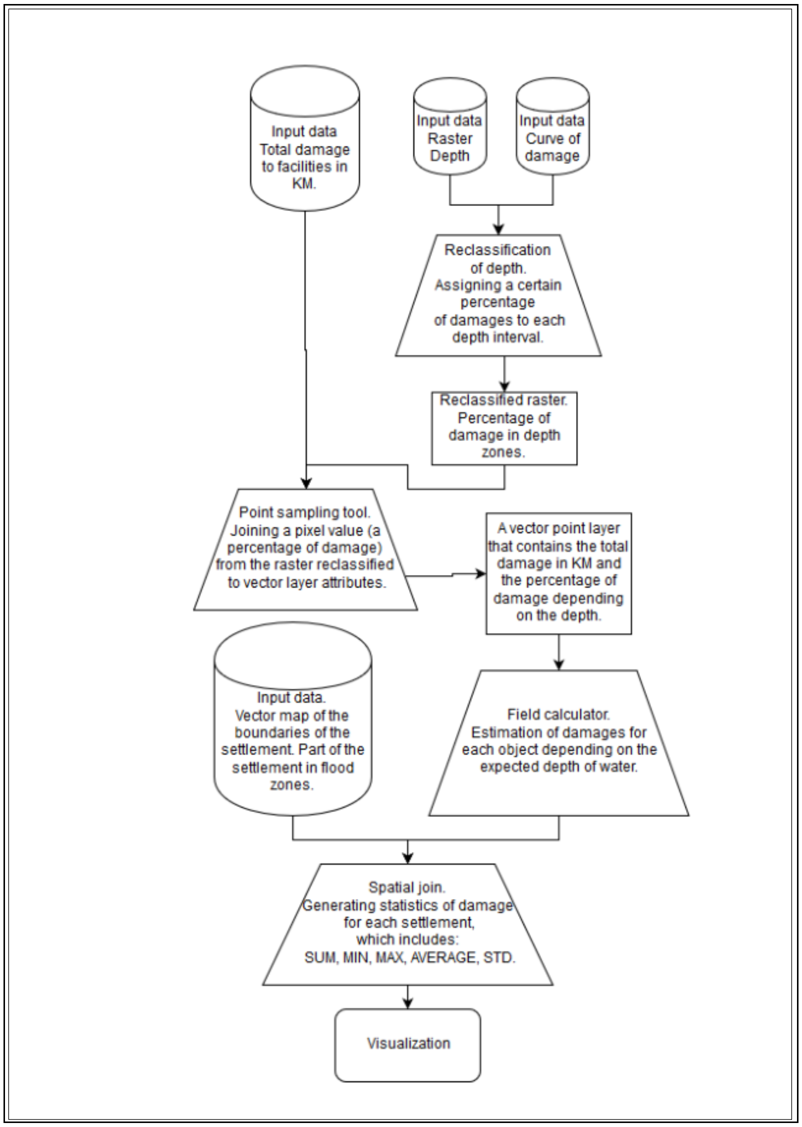


Figure 18-3: Flow chart representing GIS model calculation of property damage

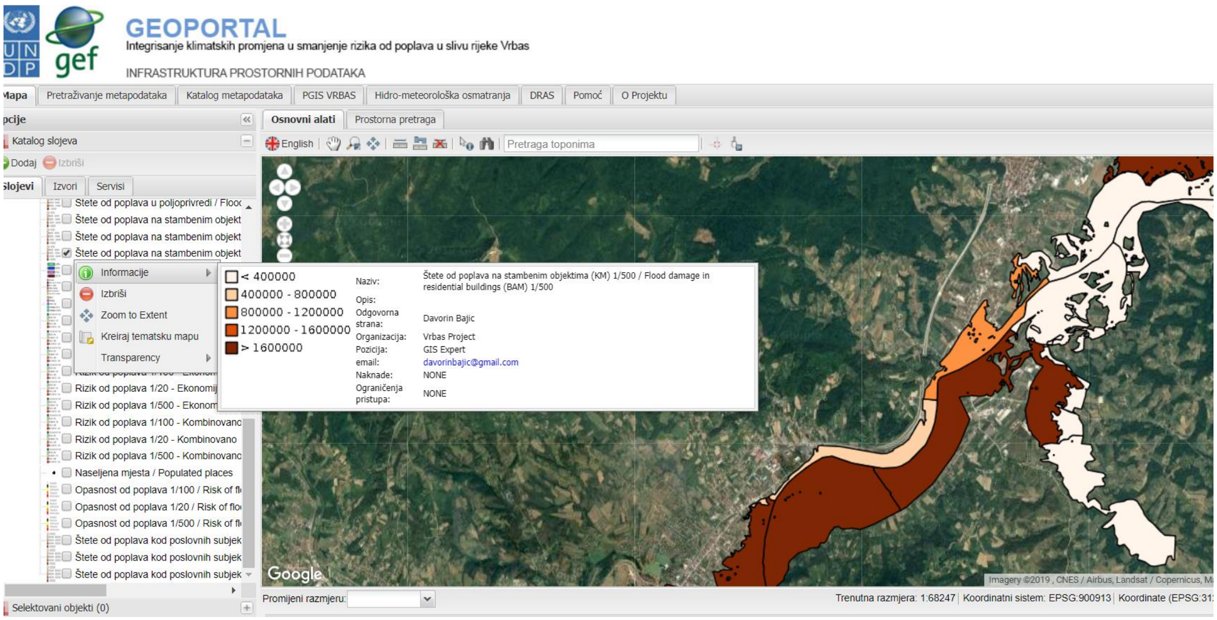


Figure 18-4: Flood damage model visualisation in GIS-properties (Vrbas GeoPortal)

18.5.1 Calculating Agricultural damages

The GIS-based socio-economic damage and loss model incorporates a methodology for converting agricultural flood risk to monetary damage per hectare using yields and producer prices each crop. Producer price losses are weighted according to seasonality (January to December) of flooding and yield loss through the growing period. Cadastre data for agriculture (e.g. pasture, cereals, forest etc.), detail of crops grown in each land use parcel and the percentage of crop type (arable, horticultural etc.) at municipality level is used.

Since crop yields and outputs fluctuate with market forces year on year, the analysis of potential crop loss is based on the most recent agricultural information from government statistics, and data must be regularly updated to reflect market prices and yields fluctuations.

An added complication is that yields are affected by seasonal flooding and the probability of flooding through the year varies spatially. The market price of each crop is therefore adjusted to reflect these two factors. For example, reduction in the yield of wheat as a result of flooding would be different in the winter as against just before harvesting.

Flood seasonality is estimated as the percentage of time that the maximum daily discharge was recorded in any given month for all gauges covering the different regions of the catchment (upper, middle and lower). For simplicity, an aggregate flood seasonality monthly series can be used.

Yield loss per month is multiplied by monthly seasonality and the product multiplied by the producer price to give a weighted flood loss in hectares per year.

As for property, damages for crops are estimated by the GIS model for each of the modelled flood events and converted to give an annual average damage for each municipality.

The total agricultural flood damage in the Vrbas River Basin is the result of the sum of losses in the floodplain for the following crops: wheat, maize, barley, potatoes, apple, plum and pear. These are the crops mainly represented in the relevant area, for which the Entity Statistics Institutes collect, synthesize and publish the data on sown areas, yields and similar, at the level of municipalities. The authors of the methodology are aware of the fact that in the area of the Vrbas River Basin there are also other crops (arable, fruit and vegetable crops), however there are no official records by municipalities and therefore these were not included in the assessment of agricultural flood damage.

Damages to individual crops mentioned above are the result of losses due to reduction in yields resulting from flooding, expressed in KM per hectare (KM/ha) and the surface area of crops in the floodplain expressed in hectares (ha).

Loss due to flood-related reduction of yields by municipalities (KM/ha)

For calculation of losses due to flood-related reduction in yields, the following tables were used, by municipalities:

Bugojno	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x BxC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	4,3	0,35	683
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	4,6	0,34	820
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,2	0,38	542
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	14,7	0,47	3.620
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	11,9	0,57	3.064
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	10,4	0,63	2.947
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Donji Vakuf	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,9	0,35	626
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	3,7	0,34	652
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,0	0,38	516
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	5,6	0,47	1.371
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Gornji Vakuf / Uskoplje	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															

Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,3	0,35	533
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	3,3	0,34	582
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,4	0,38	578
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	6,1	0,47	1.507
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Jajce	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B x C**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,0	0,35	474
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	1,9	0,34	336
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,8	0,38	480
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	9,6	0,47	2.377
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Banja Luka	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,7	0,35	440
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	3,1	0,34	554
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,5	0,38	432
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	11,1	0,47	2.740
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	34,6	0,57	8.873
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	21,8	0,63	6.154
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	24,4	0,89	9.708

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Jezero	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,1	0,35	341

Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	2,1	0,34	366
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	1,7	0,38	284
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	7,1	0,47	1.754
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Kotor Varoš	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,0	0,35	477
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	4,1	0,34	729
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,9	0,38	499
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	12,6	0,47	3.118
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Laktaši	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,8	0,35	456
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	2,8	0,34	496
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,3	0,38	559
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	12,5	0,47	3.091
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	12,9	0,57	3.305
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	16,5	0,63	4.669
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	7,3	0,89	2.923

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Mrkonjić Grad	**Months**												Weighted loss expressed in	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipa
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				

	Maximum flood damage in % or reduction in yield in % vs. expectations, by months												percentages **(A)**			lity KM/ha **(D)=A x B xC**
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	1,2	0,35	193
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	1,1	0,34	198
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	1,2	0,38	210
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	4,1	0,47	1.001
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Srbac	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,3	0,35	524
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	4,0	0,34	713
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,8	0,38	488
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	6,3	0,47	1.554
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Čelinac	**Months**												Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**				
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,3	0,35	522
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	4,6	0,34	823
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	3,3	0,38	562
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	7,7	0,47	1.903
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

Šipovo	**Months**				

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	Weighted loss expressed in percentages **(A)**	Average yield t/ha **(B)**	Average price KM/kg **(C)**	Losses of crops at the level of municipality KM/ha **(D)=A x B xC**
Probability of flooding %	4	12	8	12	18	10	10	2	6	4	4	10				
	Maximum flood damage in % or reduction in yield in % vs. expectations, by months															
Winter wheat	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,9	0,35	469
Maize	0	0	0	100	100	100	80	70	30	30	0	0	52,4	2,8	0,34	505
Winter barley	20	20	50	69	100	100	20	0	0	0	0	0	45,5	2,3	0,38	390
Potatoes	0	0	10	50	100	100	100	100	100	0	0	0	52,8	6,4	0,47	1.589
Apple	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,57	-
Plum	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,63	-
Pear	0	0	50	55	73	100	100	50	0	0	0	0	44,7	-	0,89	-

Note: Weighted loss expressed in percentages (A) is the sum of products of probability of flooding and the percentage of crop yield damage by months and it is expressed in %.

In the tables above, probability of flooding is calculated on the basis of the annual maximum flow (m^3/s).

Maximum damages from floods (%) in relation to crop yields by months, i.e. reduction in yields in % vs. expectations were taken from the Second Technical Report on Agriculture in the Vrbas River Basin[45]. For the aforementioned crops belonging to the category of winter grains (wheat and barley), the maximum flood damage or reduction in yield in % vs. expectations were taken, as a result of excessive soil moisture over a period longer than 15 days. Data for periods of excessive soil moisture of crops were taken by applying the same principle, therefore 15 days were used for maize, 11 days for potatoes, while for fruit crops 15 days were used. Thus, the results represent the potential maximum agricultural damage in the event of high waters. These two values give a weighted loss expressed in percentages that is calculated as the sum of products of probability of flooding and the percentage of crop yield damage by months.

Average yields for each municipality, expressed as t/ha, are calculated as 10-year average yield for the period 2006-2016. The yields and the surface areas by years, crops and municipalities, was taken from the Statistics Yearbooks published by the Entity Statistics Institutes. In addition, the prices of crops were taken from the Statistics Bulletins and they also represent 10-year average.

Losses of crops at the level of municipalities are expressed in KM/ha, and they are calculated as a product of weighted loss expressed in percentages, average crop yields and average prices. Based on this formula, calculation of the expected flood losses in KM per ha of the surface area is made, for each municipality.

As noted on the GIS flood model in the Vrbas River Basin, only in the municipalities/cities Bugojno, Banja Luka and Laktaši there are orchards in the floodplain. Thus, the losses for crops: apples, plums and pears are shown only for the three mentioned municipalities/cities. The Statistics Yearbooks in Republika Srpska in the field of fruit growing do not indicate the surface areas of crops in ha, but the total production in tons and yield per tree, from which the total number of trees is generated. For the needs of this analysis, it is assumed that there are 2000 trees on one *ha* of orchards. By further calculations, the surface area of orchards is calculated in *ha* and the yield in *t/ha*.

[45] Second Technical Report on Agriculture in the Vrbas River Basin, Čustović, of March 2017

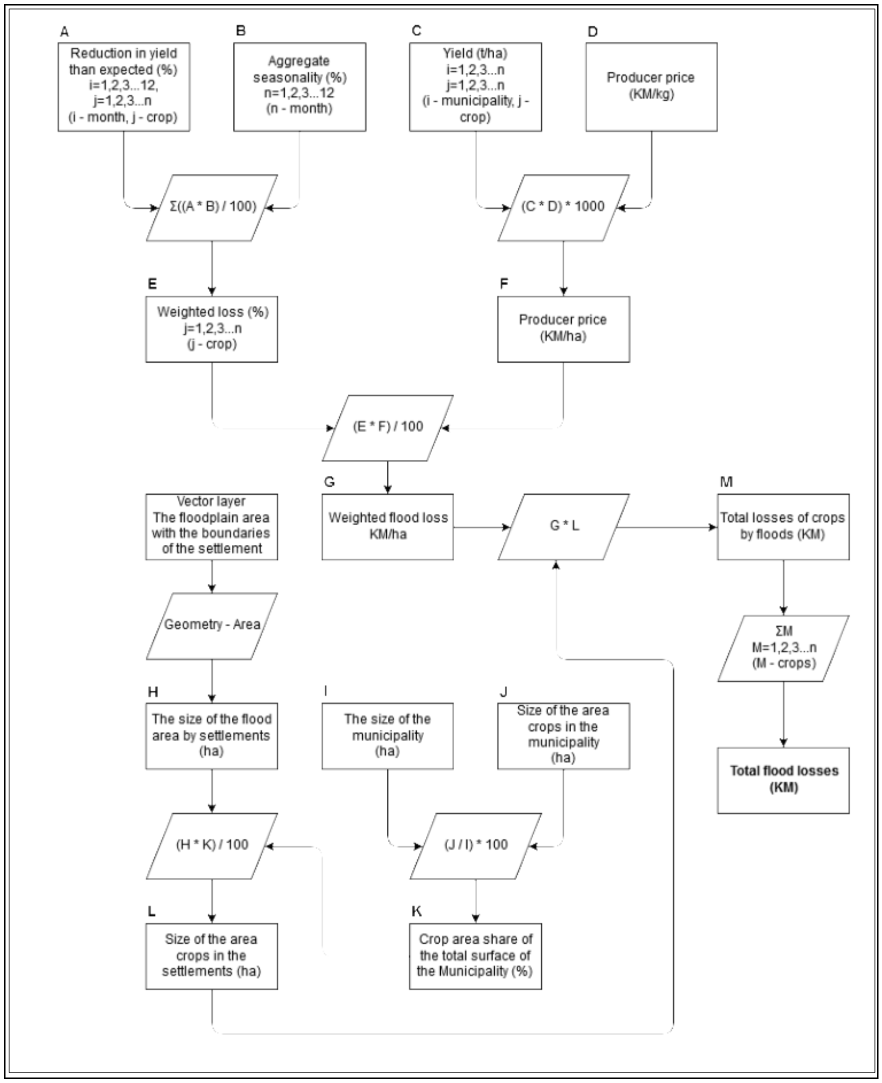


Figure 18-5: Flow chart representing GIS model calculation of damage in agriculture

Surface areas of crops in floodplain (ha)

The second element needed for calculation of total losses is the surface area of crops in the floodplain by municipalities. The software tool QGIS was used for calculation, through which the total flooded areas were identified and calculated by municipalities. Out of these total flooded areas, some are occupied by the aforementioned crops.

The total areas under the aforementioned crops were taken for the entire municipality and were put in relation to the total surface area of the municipality. Thus, for the area of one municipality, a share/percentage of the surface area of each crop was obtained, which was then mapped to flooded areas by municipalities. In this way, the areas of crops expressed in *ha* are formed/calculated on the flooded area.

Total agricultural flood damage in the Vrbas River Basin

The total agricultural flood damages in the Vrbas River Basin are the result of the sum of losses in the floodplain for the following crops: wheat, maize, barley, potatoes, apple, plum and pear, by municipalities or settlements. By multiplying the losses due to reduction in yields resulting from flooding expressed in KM/ha, and the surface areas of crops in floodplain (ha), the total flood damage is obtained, taking into account the aforementioned assumptions.

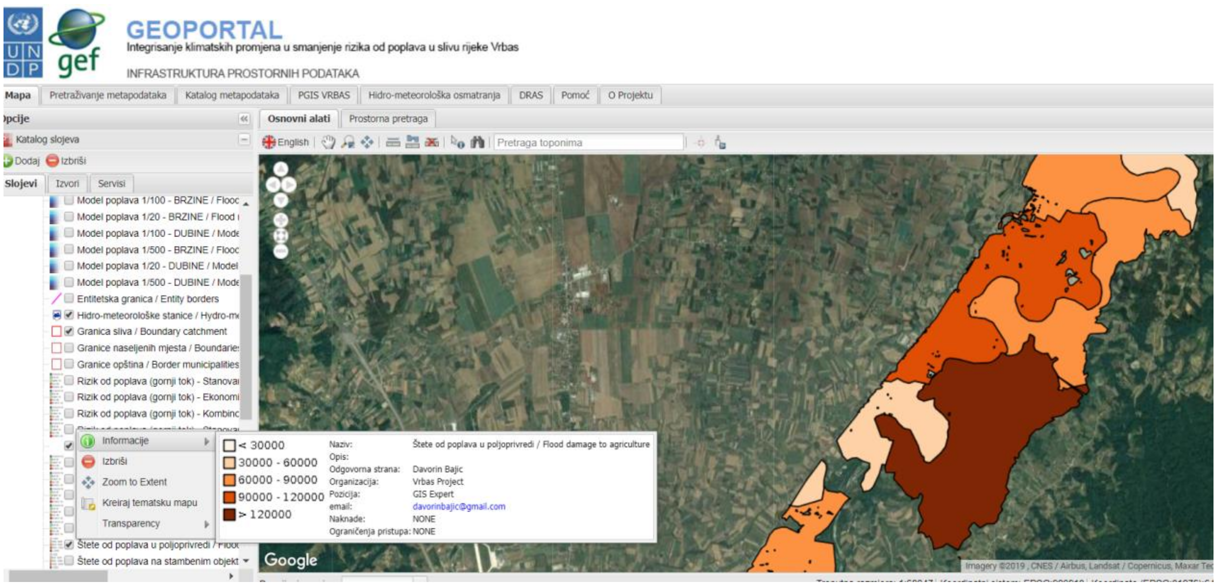


Figure 18-6: Flood damage model visualisation in GIS- agriculture (Vrbas GeoPortal)

18.6 Stage 3: Selection for Further Optioneering and Economic Assessment

The communities or municipalities that reflect both high risk using ranking criteria and high economic damage will be selected for consideration of flood mitigation solutions. These high-risk areas may be subject to detailed economic review of the relative cost-benefit ratio of the solutions identified during optioneering to identify the most appropriate solutions.

18.7 Stage 4: Project Appraisal and Discounted Cash Flow

The damages, allowing for the effects of climate change, over a 30-year time horizon assuming no improvements to flood risk in the high-risk flood areas identified will be compared with residual damages associated with flood risk management options to minimise flood damages. The difference between these two scenarios represents the benefits of adopting specific flood management policies.

Under the current EU recommendations, annual average damage avoided (benefits of scheme options) are derived from the selected return periods assessed and are converted to the Present Value of Benefit according to the standard criteria of 10% discount rate and 30-year project time horizon. The method does not predict changes in the receptors currently at risk from flooding.

18.8 DATASETS THAT ARE AVAILABLE FOR RISK AND VULNERABILITY ASSESSMENTS.

Table 18-6: Socio-economic datasets and sources of data

Type of information	Unit	Who has the information	Document/database/records for source of information
1. Information about citizens and residence			
Population and households structure	Municipality	Entity institutes of statistics	Statistic annual reports and preliminary census results
	Settlement	Entity institutes of statistics	Preliminary census results
Information about migration of population	Municipality	Entity institutes of statistics	Statistic annual reports and preliminary census results
	Settlement	Additional assessment (through municipality)	Not applicable
Information about permanent movement of population to and outside of the municipality due to floods	Municipality	Additional assessment (through municipality)	Records of the department for social affairs / Civil protection department
	Settlement	Additional assessment (through municipality)	Records of the department for social affairs / Civil protection department
Structure and types of buildings	Municipality	Additional assessment (through municipality and questionnaire)	Records of the utilities department
	Settlement	Additional assessment (through municipality and questionnaire)	Records of the utilities department
Structure and value of movables in residential buildings	Municipality	Additional assessment (utilizing questionnaire)	Not applicable
	Settlement	Additional assessment (utilizing questionnaire)	Not applicable
2. Information about labour market			
Number of employees	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes
	Settlement	Additional assessment (through municipality and questionnaire or eventually census results if available)	Not applicable
Number of unregistered unemployed persons per age	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes
	Settlement	Additional assessment (through municipality and questionnaire or eventually census results if available)	Not applicable
3. Information about economic activities			
Mineral and ore mines	Municipality	Additional assessment (through municipality)	Records of the departments for economic affairs
	Settlement	Additional assessment (through municipality)	Records of the departments for economic affairs
Electricity production	Municipality	Additional assessment (through entity ministries of energy)	Ministry records
	Settlement	Additional assessment (through entity ministries of energy)	Ministry records
Type and status of business infrastructure (buildings, facilities, etc.)	Municipality	Additional assessment (through municipality)	Records of the departments for economic affairs
	Settlement	Additional assessment (through municipality)	Records of the departments for economic affairs
Structure and value of movables in business buildings	Municipality	Additional assessment (through municipality and questionnaire)	Not applicable
	Settlement	Additional assessment (through municipality and questionnaire)	Not applicable
	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes

Number of registered business entities (including businesses/crafts) per classification of business	Settlement	Additional assessment (through municipality)	Records of the departments for economic affairs
10 biggest business entities per scope of activities, in fact per significance for the area (number of employees, turnover amount, etc.)	Municipality	Additional assessment (through municipality)	Records of the departments for economic affairs
	Settlement	Additional assessment (through municipality)	Records of the departments for economic affairs
Achieved investments	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes
	Settlement	Additional assessment (through municipality)	Records of the departments for economic affairs
Arrival and overnight stay of tourists	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes
	Settlement	Additional assessment (through municipality and tourist associations)	Records of the departments for economic affairs / Records of tourist associations
Catering sales	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes
	Settlement	Additional assessment (through municipality and tourist associations)	Records of the departments for economic affairs / Records of tourist associations
4. Information about agriculture and forestry			
Number of agricultural producers	Municipality	Additional assessment (through municipality)	Records of department for agricultural affairs
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Agricultural infrastructure (buildings, production facilities, irrigation systems, storages, etc.)	Municipality	Additional assessment (through municipality)	Records of department for agricultural affairs
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Land categories and exposure to floods	Municipality	Additional assessment (through municipality)	Records of department for agricultural affairs
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Structure of agricultural land according to business solvency classes	Municipality	Additional assessment (through municipality)	Records of department for agricultural affairs
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Generated income from crops	Municipality	Entity institutes of statistics	Statistic annual reports and other reports of statistic institutes
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Generated income from fruits	Municipality	Entity institutes of statistics	Statistic annual reports
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
No. of cattle	Municipality	Entity institutes of statistics	Statistic annual reports
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Production of milk, wool, eggs and honey	Municipality	Entity institutes of statistics	Statistic annual reports
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Total income of individual agriculture sector. Generated gross values of agricultural production	Municipality	Additional assessment (through municipality)	Records of department for agricultural affairs
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs

Production of fish and fishponds	Municipality	Additional assessment (through municipality)	Records of department for agricultural affairs
	Settlement	Additional assessment (through municipality)	Records of department for agricultural affairs
Average gross wood mass (m3)	Municipality	Additional assessment (through municipality)	Records of the departments for economic affairs
	Settlement	Additional assessment (through municipality)	Records of the departments for economic affairs
5. Information about budgetary allocations for flood protection			
Total planned and achieved expenditures of municipal budget aimed for flood protection	Municipality	Additional assessment (through municipality)	Records of finance departments
Total distribution of compensation to the flood affected citizens	Municipality	Additional assessment (through municipality)	Records of finance departments
6. Information about public infrastructure and public services			
General structure of assets owned by municipality, entity, state	Municipality	Additional assessment (through municipality)	Records of departments for general affairs
	Settlement	Additional assessment (through municipality)	Records of departments for general affairs
Road network in municipality	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Railroad network in municipality	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Public lights	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Status of power distribution network in the municipality	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Water supply (sources, network, pump stations, reservoirs,...)	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Wastewater	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Heating	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Telecommunications	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs

Transport of garbage and waste	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Cemeteries	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Parking	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
Local transport	Municipality	Additional assessment (through municipality)	Records of departments for utility affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utility affairs
7. Local administration, citizens and COS - flood protection			
Administrative services from the aspect of flood protection	Municipality	Additional assessment (through municipality or civil protection department)	Records of relevant departments
Overview of posts in local administration / services for flood protection, whose job descriptions include flood protection-related tasks	Municipality	Additional assessment (through municipality)	Records of departments for general affairs
List of active civil society organisations/unofficial groups of citizens in the municipality, participating in flood protection	Municipality	Additional assessment (through municipality)	Records of departments for general affairs
Average number of citizens in the municipality participating in flood protection (making the barriers, evacuation, etc.)	Municipality	Additional assessment (through municipality)	Records of departments for general affairs
8. Education			
Overview of educational institutions (pre-school and elementary education, high and university education)	Municipality	Additional assessment (through municipality and ministries of education at entity and cantonal level)	Records of departments for social affairs
	Settlement	Additional assessment (through municipality)	Records of departments for social affairs
9. Health			
Number and structure of health care in the municipality	Municipality	Additional assessment (through municipality and ministries of health at entity and cantonal level)	Records of relevant departments
	Settlement	Additional assessment (through municipality)	Records of departments for social affairs
The most dangerous diseases in the municipality	Municipality	Additional assessment (through hospitals / health centres)	Records of hospitals and health centres
	Settlement	Additional assessment (through hospitals / health centres)	Records of hospitals and health centres
10. Marginalized groups			
Structure of marginalized groups (Persons with psychic and	Municipality	Additional assessment (through centres of social welfare and municipality)	Records of centres for social welfare and departments for social affairs

physical disturbances, Persons in various social-protection needs, Persons with disability, Persons with no material insurance and persons unable to work, elderly without family care, military invalids, civilian victims of war, returnees, pensioners, etc.)	Settlement	Additional assessment (through centres of social welfare and municipality)	Records of centres for social welfare and departments for social affairs
Public social infrastructure facilities	Municipality	Additional assessment (through centres of social welfare and municipality)	Records of centres for social welfare and departments for social affairs
	Settlement	Additional assessment (through centres of social welfare and municipality)	Records of centres for social welfare and departments for social affairs
11. Culture, sport as well as natural and historic heritage			
Overview and structure of culture, sport and historic heritage institutions	Municipality	Additional assessment (through municipality)	Records of departments for utilities and social affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utilities and social affairs
Protected areas	Municipality	Additional assessment (through municipality and ministry of environment at entity and cantonal level)	Records of relevant departments and departments for social affairs
	Settlement	Additional assessment (through municipality)	Records of departments for utilities and social affairs
12. Defence			
Overview of military facilities	Municipality	Additional assessment (through municipality and state ministries)	Records of relevant ministries and municipalities
	Settlement	Additional assessment (through municipality and state ministries)	Records of relevant ministries and municipalities

18.9 SOCIO-ECONOMIC ASSESSMENT AND OPTIONS APPRAISAL OF EBA AND NON-STRUCTURAL MEASURES FOR GCF PROJECT

18.9.1 Technical benefits of EbA measures in Vrbas basin

Under the Vrbas project, the FRMP was prepared in line with the EUFD requirements, and therefore identified and evaluated the combination of structural, non-structural and EbA measures which are required to effectively address flood risk in the basin in the future. Flood hazard (hydrological and hydraulic) and risk models (socio-economic, loss and damage) and maps were developed for Vrbas river basin, as part of the Vrbas project. In addition, erosion and torrent susceptibility maps were also prepared. Figure 10-9 shows the erosion intensity and the erosion risk management priority map for Josavaka sub-catchment of the Vrbas which is susceptible to erosion leading to torrential flooding. Using the hydraulic, model mathematical calculations of flood risk with and without FRM measures were performed, by inserting the measures into the existing hydraulic model, and correcting the digital terrain model, coefficients of roughness etc. The flood hazard and risk with the measures was calculated and, using the improved (with measure) model, new flood hazard and risk maps generated and compared to the without measure maps, to assess the reduction of the flood water depths and velocities. Based on this, the number of receptors (households, business, public, agricultural assets) and users that will directly benefit from the proposed measures, was assessed. This is summarised in the flood risk management plan for the Vrbas River basin.

The figures show the flood map for climate change scenario without measures (Figure 18-8) and the flood map for the climate change scenario with a structural measure on the Vrbas main river (Figure 10-11 a) and with the structural measure on the Vrbas main river, plus the 5 combined EBA measures on the Josavka tributary. Figure 10-11 (b) shows that under the climate change scenario, the EbA measures are effective in reducing flood risk on the Josavaka tributary which is highly susceptible to torrential flooding. It also shows that this combination of EbA measures complement the structural measure on the main river, thus also having an overall reduction on flood risk at the confluence of the main river and tributary.

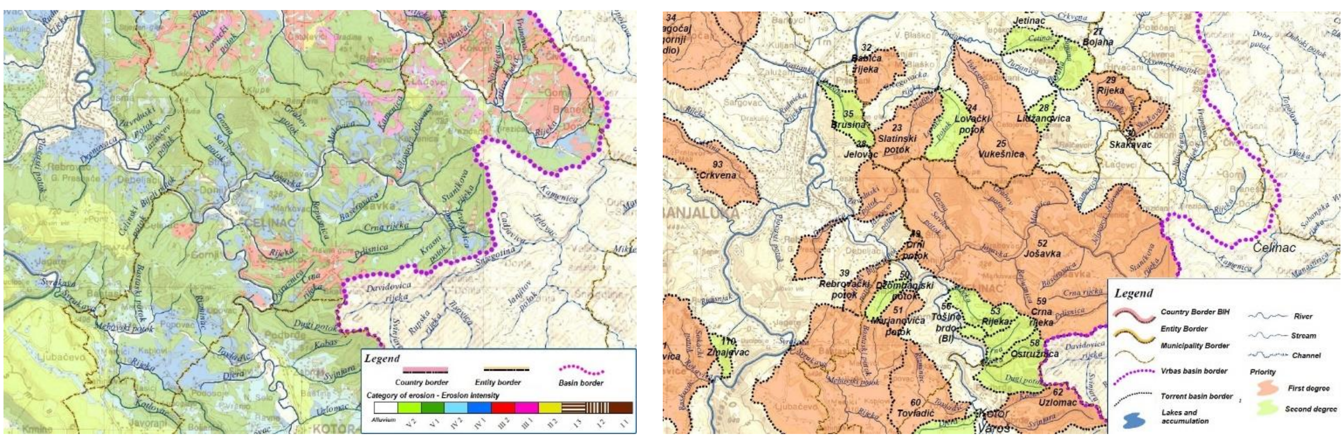


Figure 18-7: Soil Erosion (a) and Torrent hazard (b) maps of Josavaka sub-catchment

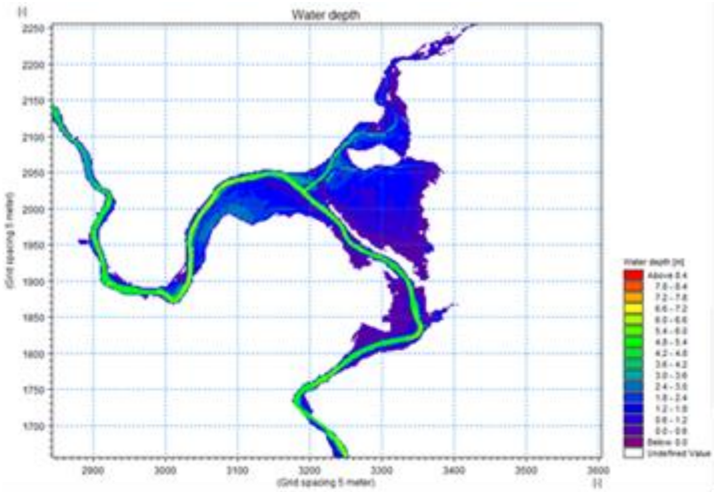


Figure 18-8: Flood map for climate change scenario - without measures

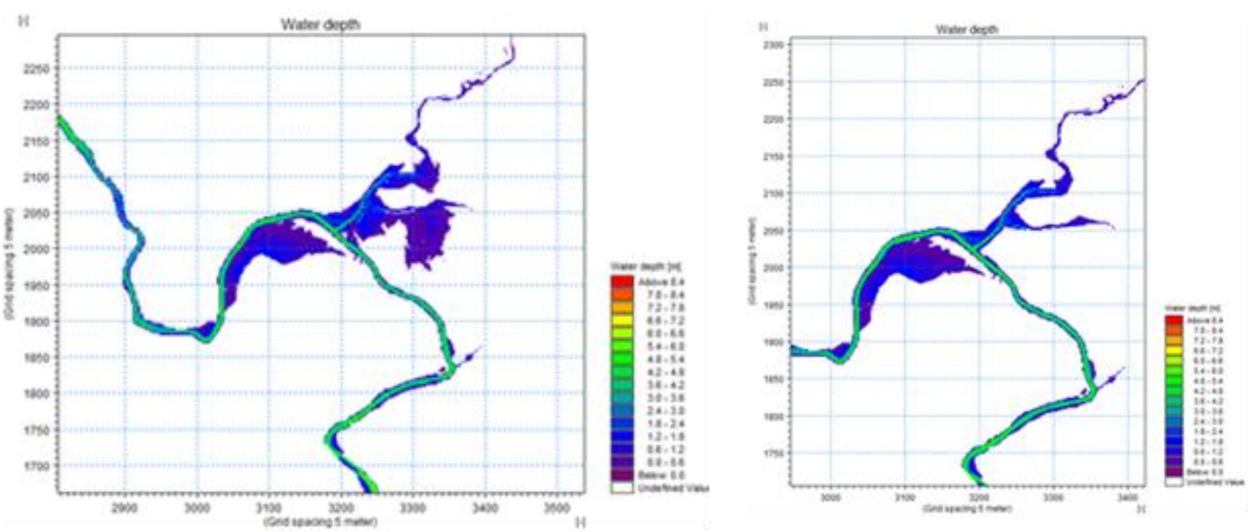


Figure 18-9: Flood map for climate change scenario - a) with structural measure on main Vrbas river and; b) with structural measure on Vrbas main river and EBA on Josavka tributary

18.9.2 Identification of benefit areas for non-structural measures

All measures were individually geographically referenced and an assessment was made of the benefit to cost ratio of the measures in each of the 5 sub-basins included in the proposed project by identifying the areas in each sub-basin which would benefit from the proposed measures, and offsetting against the capital and O&M costs. In addition, all measures underwent the Social and Environmental Screening and Assessment in line with GCF requirements which involved site inspection and consultation with the local authorities (see Annex VI).

For basins other than the Vrbas, no detailed flood models of flood maps were available. Hence PFRA flood outline maps were used for assessment of the technical benefit of structural measures using the climate change outline (estimated 500 year plus climate change). Thus a combination of engineering judgement and GIS analysis was used to identify and assess the benefit areas and the beneficiaries, which was then used as input to CBA. The technical engineering details (length, height etc.) of the measures were utilised to identify the benefit areas of each measure within the GIS tool, utilizing the flood outline for the climate change scenario, overlain onto a DEM, physical assets (individual properties with attributes such as type, occupancy, number of floors, value of assets etc.) and socio-economic data (based on the 2013 Census), for all receptors in each basin (residential, commercial, public sector, private sector and agriculture). Within the benefit polygons (e.g. Figure 18-10 below) for each measure the following information was identified and calculated within the GIS: (1) number of household dwellings; (2) number of commercial (industrial and manufacturing) entities; (3) number of public buildings, including but not limited to schools, police and fire stations, and health establishments; and (4) hectares of land devoted to agriculture production. The overall benefits (net benefits) assessment methodology is based on assessing avoided losses and damages for those private and public assets as well as agricultural production located in areas benefiting from reduced exposure to floods, offset against the cost of the investment per measure as well as operating and maintenance cost per year for 30 years. See Annex E for the detailed methodology for damage calculation.

The average value of assets and the average depth-damage functions and proportional loss curves for Vrbas basin were used for all other basins, which are based on the annual average damages per sector derived for a number flood return periods for the Vrbas basin. As flood depth data for different return periods is not available for other basins, it has been assumed that the Vrbas basin annual average damages is representative for all other basins. Similarly, the averted agricultural damages are also calculated based on Vrbas basin methodology and depth damage data per crop (See Annex E and Section 18.5 for detail of the methodology).

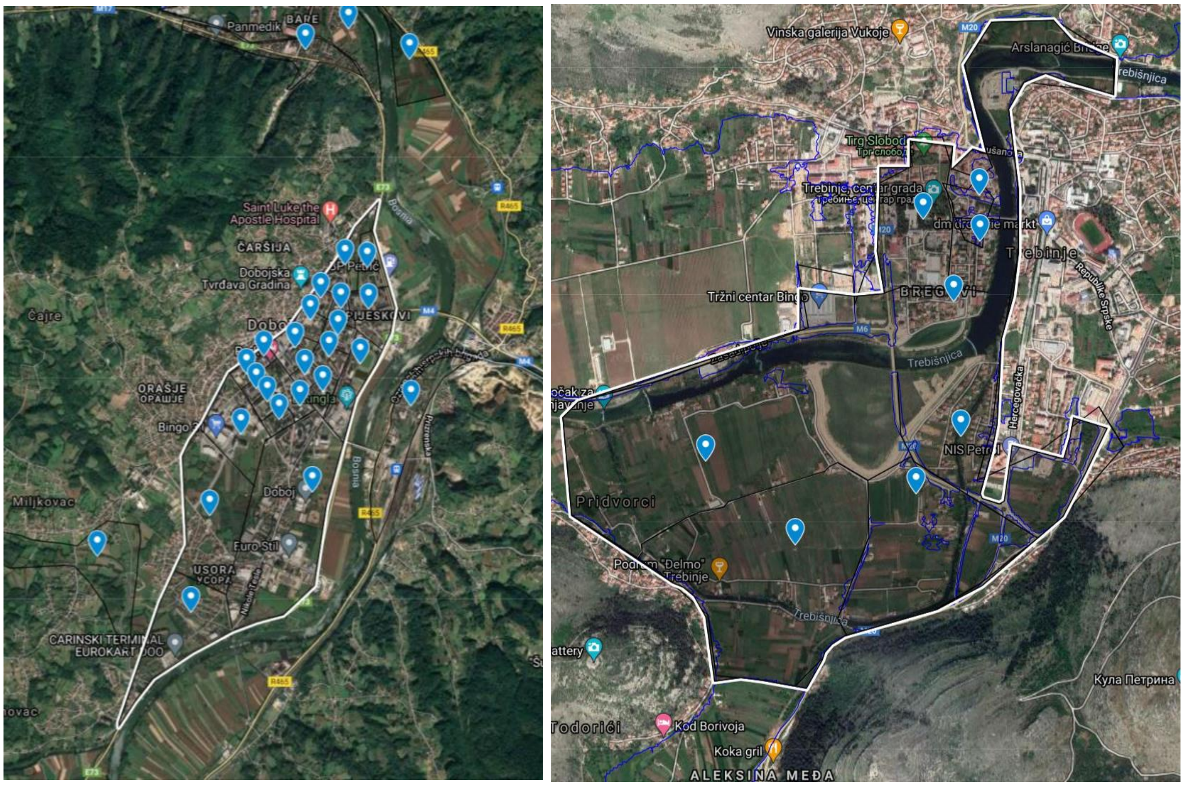


Figure 18-10: Benefit polygons for - a) Measure 5; b) Measure 21

18.9.3 CBA of individual non-structural measures

The CBA analysis per measure was undertaken using the benefit areas identified for each measure. The cost per measure was based on the capital cost of the measure combined with a distribution of the institutional and organizational measures (IOM) which are pre-conditions for effective and more efficient implementation and sustainability of the measures. Hence cost include the following:

Costs

- Initial value of the measure plus allocated institutional and organizational measures (IOM) in USD - Capex
- Operating and maintenance cost in USD/year- Opex

Benefits

Benefits for population and households - Avoided damages for households and population after implementation of measure

- No. of protected households - Identified and counted on maps showing flood protection areas for each proposed measure
- Protected population - based on the number of protected households and census data for the relevant municipality per categories of population.
    - Population number
    - No. of men, No. of women
    - Population number to 15 years of age
    - Population number over 65 years of age)

- Total value of assets of the affected households in USD - based on the number of households and the average value of household assets of 121,722 BAM (obtained from a survey of 3,500 participants)
- Protected households assets in USD - based on the number of households, the average value of household assets of 121,722 BAM and the average value from damage functions for households from Vrbas Project (1.05% of the value of the household assets)

Benefits for business sector - Avoided damages for companies after implementation of measure

- Total value of assets of the affected companies in USD - based on the database of companies in B&H which includes value of assets, number of employees etc. This is the sum of value of assets for all identified companies.
- Protected companies assets in USD - based on the total value of assets of the affected and identified companies and the average value from damage functions for companies from Vrbas Project (8.62% of the value of the companies' assets).

Benefits for agriculture sector - Avoided damages for agricultural producers after implementation of measure

There are two types of positive effects of the measures on agriculture sector. The first is that the measure reduces flooding in a particular area. Second positive effect of the measure relates to the protection of agricultural land from erosion.

Floods

- Protected landsize in ha - Identified and calculated using GIS tools on maps showing flood protection areas for each proposed measure.
- Net revenues (revenues minus production costs) in USD/ha - For each municipality, gross agricultural revenue per ha was calculated based on the methodology (See Annex E Section 18.5). Production costs are excluded from gross revenues per crop type. Information on production costs for various types of crops was obtained from the study "Economics of primary agricultural production and agricultural policy measures in the Federation of B&H" by the Faculty of Agriculture and Food Sciences, University of Sarajevo, Bosnia and Herzegovina.
- Total avoided damages for agricultural producers in USD - Protected landsize in ha multiplied by average net revenues per municipality in BAM/ha

Soil Erosion Protection

- Protected landsize in ha - Identified and calculated using GIS tools on maps showing flood protection areas for each proposed measure.
- Average price of agricultural land in USD/ha - Average price of agricultural land for entities was obtained from the reports: - Report on the State of the Real Estate Market in the Federation of B&H for 2018, issued by the Tax Administration of the Federation of B&H; - Report of the Real Estate Registry of the Republika Srpska for 2018 issued by The Republic Administration for Geodetic and Property Affairs
- Total avoided damages for agricultural producers in USD - Protected landsize in ha multiplied by average price of agricultural land in BAM/ha

Benefits for public sector - Avoided damages for public institutions after implementation of measure

- No. of public buildings - Public buildings and other public facilities were identified on maps showing flood protection areas for each proposed measure. For measures where public buildings and other public facilities were identified, there are lists with names and types of public institutions, buildings and facilities
- Average area of a building in m^2 - Average area of a public building in m^2 is available in the Typology of Public Buildings in Bosnia and Herzegovina. The typology was prepared as part of the Green Economic Development project, implemented by UNDP.

- Average reconstruction costs in USD/m^2 - Average reconstruction costs in BAM/m^2 were calculated based on internal CRP methods (See Annex E) and bills Of Quantities for public buildings affected by the 2014 floods
- Total avoided damages for public institutions in USD - No. of public buildings multiplied by average area of a building in m^2 and multiplied by average reconstruction costs in BAM/m^2 present total avoided damages for public institutions in BAM.

18.9.4 Total benefits per year - Avoided expected annual damages in USD/year

Total benefits for all sectors = Protected households assets + Protected companies assets + Total avoided damages for agricultural producers from floods + Total avoided damages for agricultural producers from soil erosion + Total avoided damages for public institutions.

The Table below summarises the results of the CBA for non-structural measures and shows that a positive net benefit was achieved for all measures from year 4- 6 onwards (i.e. before or by the last year of project implementation). The one individual measure which shows a negative net benefit in all years is one component of a wider measure which in total has a net positive benefit.

Name of the measure	Initial value of the measure including allocated institutional and organizational measures (IOM) in USD Capex	Operating and maintenance cost in USD/year Opex	Total benefits per year - Avoided expected annual damages in USD/year	*Project implementation*						Calculation of net benefits																							
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Riverbed cleaning and rehabilitation of damaged banks of the Neretva River at the Struge-Čapljina section	1,051,079	5,624	686,542		-525,539	-525,539	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917	680,917
Rehabilitation of the right defensive embankment on the Krupa River in Višići settlement	1,051,079	1,125	1,217,942		-315,324	-735,755	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818	1,216,818
Construction of protective structures in Dobor settlement: • Regulation of the main riverbed of the Bosna River at a length of 2,500 m • Construction of a protective embankment along the Bosna River at a length of 2,900 m • Construction of an embankment along the Dusa River with a length of 250 m and the structure on the mouth of the Dubokovac canal.	9,554,950	42,745	1,095,097		-2,388,738	-3,821,980	-1,910,990	-1,433,243	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352	1,052,352
Construction of a bank revetment on the left bank starting from the New-Japanese Bridge in Doboj towards downstream at a length of approximately 1,0 km.	513,339	11,249	909,939			-154,002	-205,336	-154,002	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690	898,690
Regulation of the riverbed and construction of the protective embankment of the river Bosna from the bridge in Bare, profile P31 (1 + 487,91), upstream to profile P66 (3 + 266,25), at a length of 1,778.34 m	4,520,489	36,558	1,924,325		-1,130,122	-1,808,196	-904,098	-678,073	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767	1,887,767
Regulations of the Liješanj and Grab streams in Doboj.	1,796,863	14,061	1,228,553		-539,059	-718,745	-539,059	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493	1,214,493
Regulation of the canal of the Gomjenica River in the area of the City of Prijedor from the confluence with the Sana River and upstream at a length of approximately 17.5 km.	1,643,912	25,309	2,401,416			-657,565	-657,565	-328,782	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107	2,376,107
Regulation of the riverbed of Trebišnjica River in Trebinje. • Regulation of the main bed of the Trebišnjica River from Perović Bridge to the confluence with Pridvorački krak at a length of 2.30 km • Regulation of Pridvorački krak in the length of 2.89 km	3,575,557	16,873	2,047,901		-893,889	-1,430,223	-715,111	-536,334	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028	2,031,028
Regulation of the water regime of the Vrbanja River from the bridge near Incel and upstream at a length of 1,5 km and rehabilitation of the right embankment in the settlement Česma in the length of 100 m	4,298,156	21,518	615,766		-1,074,539	-1,719,262	-859,631	-644,723	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248	594,248
Completion of flood protection line in urban areas (Sava River Basin) - Maglaj	468,026	4,134	1,527,049			-140,408	-187,210	-140,408	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915	1,522,915
Completion of flood protection line in urban areas (Sava River Basin) - Gračanica	3,343,043	29,528	10,088			-1,337,217	-1,002,913	-1,002,913	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440	-19,440
Completion of flood protection line in urban areas (Sava River Basin) - Lukavac	2,005,826	17,717	317,514			-601,748	-802,330	-601,748	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798	299,798
Completion of flood protection line in urban areas (Sava River Basin) -Tešanj----Doboj Jug	3,226,082	28,494	590,392		-806,520	-806,520	-806,520	-806,520	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897	561,897
Completion of flood protection line in urban areas (Sava River Basin) -Zavidovići	853,963	7,543	112,596		-213,491	-213,491	-213,491	-213,491	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054	105,054
Completion of flood protection line in urban areas (Sava River Basin) - Zenica	569,309	5,028	753,612		-142,327	-142,327	-142,327	-142,327	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583	748,583
Completion of flood protection line in urban areas (Sava River Basin) - Kakanj	506,052	4,470	240,541		-126,513	-126,513	-126,513	-126,513	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072	236,072
Completion of flood protection line in urban areas (Sava River Basin) - Visoko	316,283	2,794	53,426		-79,071	-79,071	-79,071	-79,071	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633	50,633
Completion of flood protection line in urban areas (Sava River Basin) - Vogošća	379,539	3,352	46,196		-94,885	-94,885	-94,885	-94,885	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844	42,844
Completion of flood protection line in urban areas (Sava River Basin) - Novi Grad	5,060,520	44,697	47,996		-1,265,130	-1,265,130	-1,265,130	-1,265,130	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299	3,299
Completion of flood protection line in urban areas (Sava River Basin) - Ilidža	4,427,955	39,110	83,616		-1,106,989	-1,106,989	-1,106,989	-1,106,989	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506	44,506
Completion of flood protection line in urban areas (Sava River Basin) - Doboj-Istok	1,897,695	16,761	20,589		-474,424	-474,424	-474,424	-474,424	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827	3,827

18.10 SOCIO-ECONOMIC ASSESSMENT AND OPTIONS APPRAISAL OF STRUCTURAL MEASURES FOR GCF PROJECT

18.10.1 Identification of benefit areas for structural measures

All measures were individually geographically referenced and an assessment was made of the benefit to cost ratio of the measures in each of the 5 sub-basins included in the proposed project by identifying the areas in each sub-basin which would benefit from the proposed measures, and offsetting against the capital and O&M costs. In addition, all measures underwent the Social and Environmental Screening and Assessment in line with GCF requirements which involved site inspection and consultation with the local authorities (see Annex VI).

For basins other than the Vrbas, no detailed flood models of flood maps were available. Hence PFRA flood outline maps were used for assessment of the technical benefit of structural measures using the climate change outline (estimated 500 year plus climate change). Thus a combination of engineering judgement and GIS analysis was used to identify and assess the benefit areas and the beneficiaries, which was then used as input to CBA. The technical engineering details (length, height etc.) of the measures were utilised to identify the benefit areas of each measure within the GIS tool, utilizing the flood outline for the climate change scenario, overlain onto a DEM, physical assets (individual properties with attributes such as type, occupancy, number of floors, value of assets etc.) and socio-economic data (based on the 2013 Census), for all receptors in each basin (residential, commercial, public sector, private sector and agriculture). Within the benefit polygons (e.g. **Error! Reference source not found.** below) for each measure the following information was identified and calculated within the GIS: (1) number of household dwellings; (2) number of commercial (industrial and manufacturing) entities; (3) number of public buildings, including but not limited to schools, police and fire stations, and health establishments; and (4) hectares of land devoted to agriculture production. The overall benefits (net benefits) assessment methodology is based on assessing avoided losses and damages for those private and public assets as well as agricultural production located in areas benefiting from reduced exposure to floods, offset against the cost of the investment per measure as well as operating and maintenance cost per year for 30 years. See Annex E for the detailed methodology for damage calculation.

The average value of assets and the average depth-damage functions and proportional loss curves for Vrbas basin were used for all other basins, which are based on the annual average damages per sector derived for a number flood return periods for the Vrbas basin. As flood depth data for different return periods is not available for other basins, it has been assumed that the Vrbas basin annual average damages is representative for all other basins. Similarly, the averted agricultural damages are also calculated based on Vrbas basin methodology and depth damage data per crop (See Annex E and Section 18.5 for detail of the methodology).

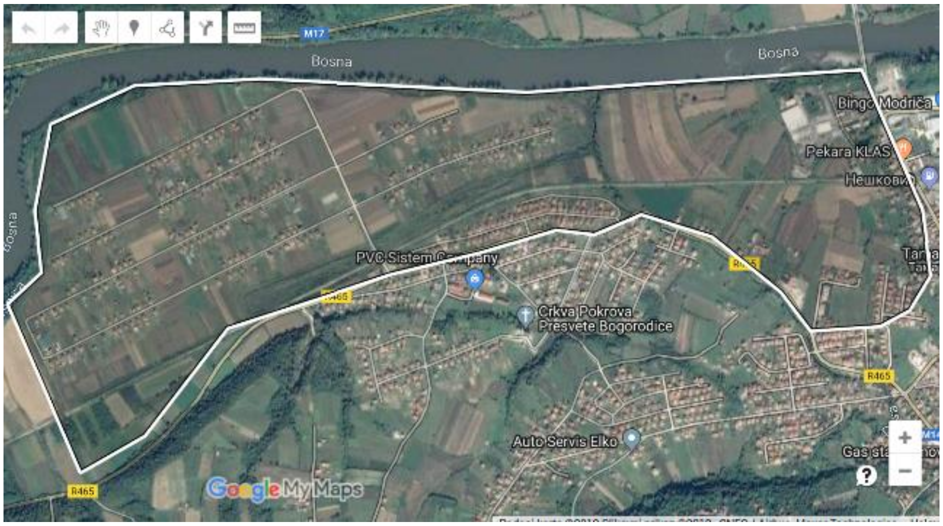


Figure 18-11: Benefit polygons for Modrica Municipality, Bosna River Sub-Basin

18.10.2 CBA of individual structural measures

The CBA analysis per measure was undertaken using the benefit areas identified for each measure. The cost per measure was based on the capital cost of the measure combined with a distribution of the institutional and organizational measures (IOM) which are pre-conditions for effective and more efficient implementation and sustainability of the measures. Hence cost include the following:

Costs

- Initial value of the measure plus allocated institutional and organizational measures (IOM) in USD - Capex
- Operating and maintenance cost in USD/year- Opex

Benefits

Benefits for population and households - Avoided damages for households and population after implementation of measure

- No. of protected households - Identified and counted on maps showing flood protection areas for each proposed measure
- Protected population - based on the number of protected households and census data for the relevant municipality per categories of population.
    - Population number
    - No. of men, No. of women
    - Population number to 15 years of age
    - Population number over 65 years of age)
- Total value of assets of the affected households in USD - based on the number of households and the average value of household assets of 121,722 BAM (obtained from a survey of 3,500 participants)
- Protected households assets in USD - based on the number of households, the average value of household assets of 121,722 BAM and the average value from damage functions for households from Vrbas Project (1.05% of the value of the household assets)

Benefits for business sector - Avoided damages for companies after implementation of measure

- Total value of assets of the affected companies in USD - based on the database of companies in B&H which includes value of assets, number of employees etc. This is the sum of value of assets for all identified companies.
- Protected companies assets in USD - based on the total value of assets of the affected and identified companies and the average value from damage functions for companies from Vrbas Project (8.62% of the value of the companies' assets).

Benefits for agriculture sector - Avoided damages for agricultural producers after implementation of measure

There are two types of positive effects of the measures on agriculture sector. The first is that the measure reduces flooding in a particular area. Second positive effect of the measure relates to the protection of agricultural land from erosion.

Floods

- Protected landsize in ha - Identified and calculated using GIS tools on maps showing flood protection areas for each proposed measure.
- Net revenues (revenues minus production costs) in USD/ha - For each municipality, gross agricultural revenue per ha was calculated based on the methodology (See Annex E Section 18.5). Production costs are excluded from gross revenues per crop type. Information on production costs for various types of crops was obtained from the study "Economics of primary agricultural production and agricultural policy measures in the Federation of B&H" by the Faculty of Agriculture and Food Sciences, University of Sarajevo, Bosnia and Herzegovina.
- Total avoided damages for agricultural producers in USD - Protected landsize in ha multiplied by average net revenues per municipality in BAM/ha

Soil Erosion Protection

- Protected landsize in ha - Identified and calculated using GIS tools on maps showing flood protection areas for each proposed measure.
- Average price of agricultural land in USD/ha - Average price of agricultural land for entities was obtained from the reports: - Report on the State of the Real Estate Market in the Federation of B&H for 2018, issued by the Tax Administration of the Federation of B&H; - Report of the Real Estate Registry of the Republika Srpska for 2018 issued by The Republic Administration for Geodetic and Property Affairs
- Total avoided damages for agricultural producers in USD - Protected landsize in ha multiplied by average price of agricultural land in BAM/ha

Benefits for public sector - Avoided damages for public institutions after implementation of measure

- No. of public buildings - Public buildings and other public facilities were identified on maps showing flood protection areas for each proposed measure. For measures where public buildings and other public facilities were identified, there are lists with names and types of public institutions, buildings and facilities
- Average area of a building in m^2 - Average area of a public building in m^2 is available in the Typology of Public Buildings in Bosnia and Herzegovina. The typology was prepared as part of the Green Economic Development project, implemented by UNDP.
- Average reconstruction costs in USD/m^2 - Average reconstruction costs in BAM/m^2 were calculated based on internal CRP methods (See Annex E) and bills Of Quantities for public buildings affected by the 2014 floods
- Total avoided damages for public institutions in USD - No. of public buildings multiplied by average area of a building in m^2 and multiplied by average reconstruction costs in BAM/m^2 present total avoided damages for public institutions in BAM.

18.10.3 Total benefits per year - Avoided expected annual damages in USD/year

Total benefits for all sectors = Protected households assets + Protected companies assets + Total avoided damages for agricultural producers from floods + Total avoided damages for agricultural producers from soil erosion + Total avoided damages for public institutions.

The Table below summarises the results of the CBA for structural measures and shows that a positive net benefit was achieved for all measures from year 5- 6 onwards (i.e. before or by the last year of project implementation).

Measure No.	Name of the measure	Initial value of the measure including allocated institutional and organizational measures (IOM) in USD Capex	Operating and maintenance cost in USD/year Opex	Total benefits per year - Avoided expected annual damages in USD/year	Project implementation						Calculation of net benefits			
					1	2	3	4	5	6	7	8	9	10
5	Rehabilitation of the pumping station "Svitava" in the Svitava polder	1,051,079	5,624	116,988		-210,216	-315,324	-315,324	-210,216	111,363	111,363	111,363	111,363	111,363
7	Rehabilitation of the left embankment upstream above Koćuša	775,686	4,151	51,805		-155,137	-232,706	-232,706	-155,137	47,654	47,654	47,654	47,654	47,654
10	Rehabilitation of damaged banks of the Neretva River in Konjic Municipality, locality Glavatičevo	1,261,293	6,749	120,702		-252,259	-378,388	-378,388	-252,259	113,953	113,953	113,953	113,953	113,953
70	Revitalization of Borna channel in Gradiska Municipality	1,007,059	5,477	269,970		-251,765	-402,824	-201,412	-151,059	264,493	264,493	264,493	264,493	264,493
71	Rehabilitation of channels network in area of PS Đurići (Tinja-Tolisa)	900,665	6,952	197,198		-225,166	-360,266	-180,133	-135,100	190,246	190,246	190,246	190,246	190,246
72	Rehabilitation and raising of dyke on the GOK channel in the City of Bijeljina	2,860,159	22,077	983,766		-858,048	-1,144,063	-858,048	961,689	961,689	961,689	961,689	961,689	961,689
73	Construction of channel (Selište - Dašnica)	972,505	7,506	666,058		-243,126	-389,002	-194,501	-145,876	658,551	658,551	658,551	658,551	658,551
74	Construction of the Lateral channel in west part of Prijedor	4,460,050	19,553	655,126		-1,115,012	-1,784,020	-892,010	-669,007	635,573	635,573	635,573	635,573	635,573
SM	Development of flood forecasting system in Neretva and Trebišnjica rivers	7,540,678	59,055	2,047,901	-840,968	-2,824,533	-3,465,906	-297,142	-56,065	-56,065	1,988,846	1,988,846	1,988,846	1,988,846

Measure No.	Calculation of net benefits																			
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
5	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363	111,363
7	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654	47,654
10	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953	113,953
70	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493	264,493
71	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246	190,246
72	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689	961,689
73	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551	658,551
74	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573	635,573
SM	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846	1,988,846

19 Annex F - ANALYSIS OF LEGISLATIVE FRAMEWORK FOR FLOOD AND WATER MANAGEMENT IN B&H

19.1 INTRODUCTION

This section is focused on comprehensive functional analysis of relevant legislative framework in Bosnia and Herzegovina relating on water management and flood risks, spatial planning and zoning, and defining of natural hazard zones, as well as related sector policies (agriculture, forestry, hydropower). In addition, the legislative analysis contains strategic and supporting acts relating to these areas and sectors, as well as all relevant by laws (sub-legal acts) adopted by state, entity and cantonal bodies and administrative organizations.

It is evident that existing legislative framework in B&H does not provide a basis that would adequately treat the impact of climate change on floods and other natural hazards. This creates an additional problem in adapting sector policies (primarily in areas of water management, flood risk management, and spatial planning and zoning) to changing climatic conditions and climate scenarios. Experience of natural disasters in Bosnia and Herzegovina (e.g. floods in 2014) has shown a very different approach must be used in terms of normative regulation of respective areas. As a response to future challenges, it is necessary to continue the process of amending current legislation in Bosnia and Herzegovina, toward full integration of EUFD and necessary harmonization of the regulatory framework, sectoral policies and plans in the most vulnerable sectors.

Climate change must be considered as an influencing factor, and distinctive recognition of this issue in normative regulation of water resources management and spatial planning and zoning in B&H will certainly affect preventive action in future and long-term planning of process of flood risk management.

19.2 LEGISLATIVE FRAMEWORK OF BOSNIA AND HERZEGOVINA-B&H (STATE LEVEL)

Relevant B&H ministries at the state level in the areas of water management and flood risk, and spatial planning and zoning, have limited constitutional and legislative competences. In that context there are two most important documents. The first one is the *Framework Law on protection and rescue of people and goods from natural and other disasters in Bosnia and Herzegovina* (Official Gazette of B&H, No. 50/08), and the other one is *Action plan for flood protection and river management in B&H 2014-2017*, adopted by the Ministry of Foreign Trade and Economic Relations of B&H.

The *Framework Law on protection and rescue of people and goods from natural and other disasters in Bosnia and Herzegovina* present the basis for “limited jurisdiction” of the Ministry of Security of B&H in areas of floods and other disasters in Bosnia and Herzegovina. It is also a framework for arrangement of the protection of people and property in B&H and coordination actions of the institutions and bodies of Bosnia and Herzegovina, entity’s civil protection and the competent authority of the civil protection of Brčko District. In this regard, the Ministry of Security in coordination with the relevant state and entity institutions prepares and propose to the Council of Ministers the following documents:

1) The Methodology for the risk assessment development,
2) Risk Assessment and
3) Plan of protection and rescue of people and goods from natural and other disasters in Bosnia and Herzegovina.

In addition, the *Framework Law* has established the Operation and Communications Centre of B&H (112) which has been formally operating since January 2010 and which acts on the basis of the commitments of Bosnia and Herzegovina in accordance with the prescribed procedure and application of standard forms of accidents stipulated by international conventions, treaties and agreements, and cooperate with the entity's operational and communication centres, in case of a threat or occurrence of natural or other disasters. Furthermore, the Framework Law provides the base for the establishment of a *Coordinating Body of Bosnia and Herzegovina for Protection and Rescue*, which consists of representatives of the BH Council of Ministers, the Entity governments (RS and FB&H) and the Government of Brčko District.

Six key measures are identified with accompanying sub-measures in *Action plan for flood protection and river management in B&H 2014-2017* as a strategic document, aiming to repair the damage on protective water facilities and watercourses caused by floods, harmonize the BH flood protection system with EU legislation, establish a reliable hydrological forecasting system in B&H and create conditions for the sustainable flood protection system and strengthen inter-sectoral cooperation and coordination in B&H and the whole region.

19.3 Legislative Framework on Entity Level

19.3.1 Republika Srpska (RS)

The most important laws, bylaws and strategic acts within legislative framework of Republica Srpska related to water resources management and flood risk, as well as spatial planning and zoning, are:

1) WATER LAW (Official Gazette of RS, No. 50/06, 92/09 and 121/12)

This Law regulates the process of integrated water management within the territory of the Republica Srpska. The legal provisions include the protection of water and water use, as well as protection from the water harmful effects and regulation of watercourses and other water facilities. In addition to planning the water resources management, this Law has a purpose of organization of flood protection and protection of other negative impacts that may be caused by water (*Article 94-108*). Also, this Law regulates wider public participation in decision-making process related to water management including public access to full, accurate and timely information related on water resources and corresponding actions taken by the competent authorities and institutions in Republica Srpska.

The provisions of this Law are in the line with *EU Directive 2000/60/EC* (Water Framework Directive, October 2000) in establishing a framework for Community action in water policy.

The *Article 25* stipulates the adoption of the Water Management Strategy, which defines the policy framework of integrated water management in Republica Srpska[46]. This Strategy should include, among other issues, a general description of the situation in water management sector, framework goals and directions for water use and protection of water, as well as protection from the water harmful effects and sustainable water use.

During 2017, the Law on Water of Republika Srpska is aligned with the EU Flood Directive, which defines the method of flood risk assessment and management in order to reduce the harmful effects that floods pose to humans, economic activity and the environment. By incorporating this Directive into the legislative framework in the water management sector in Republika Srpska, a legal basis for better flood risk management was created.

The amendments to the RS Law on Water now define the process of preliminary risk assessment, development of flood hazard and risk maps, establishing forecasting and early warning systems, as well as regulating the development of Flood Risk Management Plan. The amended Law has been officially adopted in July 2017 after which a number of bylaws/regulatory documents has been created and adopted in order to make the Floods Directive fully incorporated into national legislation.

One of the most important documents followed Water Law amendment is Decree on Content and Key Elements of Flood Risk Assessment and Management which is adopted in December 2017. This

[46] In accordance with the Water Law, the RS Government formulated in November 2015 a draft of new "Strategy for integrated water management 2015-2024" (available on the website of the Ministry of Agriculture, Water Management and Forestry of RS). This strategic document gives a particular importance on climate change factor in system of integrated water management.

document regulates content and procedure for Preliminary Flood Risk Assessment (PRFA), process of flood hazard and risk mapping, content and appearance of the maps, goals of flood risk mapping and measures for their achievement, programme of activities for preparation of Flood Risk Management Plan (FRMP), content of the Plan and necessary elements for its update and other issues related to flood risk assessment and management. Based on new regulation the first FRMP in B&H has been prepared for Vrbas basin and was finalized in the second half of 2019.

2) FRAMEWORK PLAN FOR DEVELOPMENT OF WATER MANAGEMENT OF REPUBLICA SRPSKA, 2006

In addition to the *Water Law in RS*, a very important document that governs the water resources management in Republica Srpska is *Framework plan for development of water management of Republica Srpska* (hereinafter: Framework Plan). It is a strategic document with role of "interphase or temporary document" in the process of developing the final Strategy of integrated water management. Framework Plan aims to define the criteria, conditions and limitations for the further development of water infrastructure and to manage the entire water sector in Republica Srpska, in areas of water usage and water regulation, flood protection, water protection and water management.

Chapter 1.1 "The relevant climatic factors" (page 18-19) consider climate characteristics and effects in Republika Srpska and the influence to strategic decision-making process in water management sector. The most important part of Framework Plan is Chapter III "Framework strategic guidelines for further development of water management in Republica Srpska", Sub-chapter 2.2 "The strategy of protection against water harmful effects" which consider the issue of protection from harmful water effects. This part of the Framework Plan is focused on issues of basic principles in flood protection process, risk assessment for certain areas in Republica Srpska and preventive, predictive, preparative, physical and institutional measures to eliminate or mitigate the flood risks (pages 74-76). Beside this, the part of Framework Plan entitled "Climate changes and floods" (page 80) is dedicated to the issue of climate change and its impact on flood risks in the RS. However, the importance of climate change as a dynamic factor of influence and appropriate application of regional climate models as possible predictive tools is not considered.

Chapter 3.1.2 "Irrigation of agricultural land" (pages 32-34) elaborates the issue of dynamic influence of climate change and changes in precipitation on the development of irrigation systems and agriculture in Republica Srpska but does not consider the effects of climate change and the importance of regional climate models. Having in mind that National Assembly of the Republica Srpska has adopted new Strategy of integrated water management of the Republica Srpska at beginning of 2016, consequently this temporary document has lost the relevance for strategic and legislative framework for water management in Republica Srpska.

3) STRATEGY OF INTEGRATED WATER MANAGEMENT OF REPUBLICA SRPSKA 2015-2024 (2016)

The Strategy of integrated water management of the Republika Srpska is adopted by the National Assembly of RS in February 2016.

The highest strategic goal in this Strategy is to create an integrated, managed and fully harmonized water regime in Republica Srpska territory, on each of its two river basins. This strategic objective is divided into important target groups, such as: provision of adequate water resources for the population and all economic needs; protection of the population, settlements and material goods from floods and other water harmful effects; arranging river basins in order to protect the environment, protect the water management and other systems, as well as to improve economic functions of areas in the RS which are affected by erosion; providing reliable spatial planning for zoning of other facilities and systems in order to define the criteria, capabilities and limitations arising on water infrastructure, as spatial beneficiary which has the most stringent requirements in terms of location which are necessary for the development; planning of specific aspects of public involvement in process of adopting the strategic guidelines for the development of integrated systems, etc.

Several sections elaborate issue of *climate change impact*. Chapter 2.3 “The relevant climatic indicators” (page 31) highlights that *the climate change phenomenon should be given much more attention, and that is essential to have a much more detailed review of potential climate change scenarios which are based on “B&H national reports on climate change and international forecasts”, and in accordance with available projections of climate change scenarios create “targeted responses” and plan the solutions*. However, this document does not offer proposals or activities that need to use relevant climate change models, in order to develop strategic plans in sector of water management and flood risk management.

Chapter 2. of Strategy “Climatic factors relevant for the development of Strategy” (pages 28-33) explains the general climate characteristics of the whole territory of Republica Srpska and its parts, then precipitation as the key basic component of water balance, and finally other relevant climatic influences including the part that refers to climate change as a dynamic factor of influence. The last section in Chapter 2 is partly focused on climate change, but without clear explanation of impact of climate change factors on elements such as precipitation and temperature, and appropriate use of regional climate models as adequate predictive tools. However, issues like *climate change* and *adaptation to climate change* in all aspects of water use in Republica Srpska are not elaborated with necessary significance.

EU Flood Directive, which has been transposed to the RS Water Law in 2017 is not reflected in this Strategy.

4) LAW ON AGRICULTURAL LAND RS (Official Gazette of RS, No. 93/06, 86/07, 14/10, 5/12)

This Law regulates the issues of planning, protection, regulation, use and management of agricultural land in Republika Srpska, as well as other issues which are important for agricultural land as common good.

In this regard, the most important section in this Law is Chapter II “Planning” which regulates zoning of agricultural land on state and municipal level. Articles 6-8 define procedures of adoption of planning documents (basic protection for development and use of agricultural land, the so-called “The Land Basis of the RS” and “The Municipal Land Basis” for the territory of the municipality, define purpose of use of agricultural land in RS, and must be aligned with spatial, urban and other plans. However, these “land basis” are not taking in consideration existing flood risk information (PFRA, flood hazard and flood risk maps or CC models) as relevant indicators.

5) BASIS OF PROTECTION, USE AND PLANNING OF AGRICULTURAL LAND IN REPUBLICA SRPSKA (“Land Basis”), AS A COMPONENT OF PROCESS OF PLANNING OF LAND USE (2009)

This is a document with strategic importance, and it is harmonized with *Law on agricultural land in RS*, the *Regional Spatial Plan of RS* and the *Strategy of the development of Agriculture until 2015*. This document defines issues of inventory and analysis of the current state of land resources in the Republika Srpska, protection measures, use of agricultural land and the institutional structure.

It should be noted that the inventory and analysis of land resources in RS in this document is digitalized in GIS database on: land, land area, climate, method of use of agricultural land and current protection.

Section A.2. “Climate data” (pages 28-29) elaborates the processing of climate data for RS and GIS layers of selected climatic parameters that are most important for agricultural production (start and duration of the vegetation period, no-frost period, temperature and precipitation, etc.). Climate change and adaptation issues are not considered.

6) LAW ON SPATIAL PLANNING AND CONSTRUCTION (Official Gazette of RS, No. 40/13, 2/15, 106/15, 3/16)

Law on Spatial Planning and Construction, among others, regulates the system of spatial planning and spatial development in RS and issues such as location conditions (location permit), development of constructions land area, preparation, creation and adoption of spatial planning documents and natural risk zones (flood areas, landslides, avalanche areas, forest fires zones, earthquake areas, etc.).

Beside this, it should be noted that the Law on Spatial Planning and Construction of RS, as well as related by-laws in RS, are one of the few B&H legislative acts in the field of spatial planning, which explicitly treat the term “climate change” as a dynamic factor of influence. All other legal acts in Bosnia and Herzegovina, on the other hand, focus on term “climate” as a factor of influence on a particular economic activity or geographic area, which means the basic static parameters (temperature, atmospheric pressure, precipitation, etc.

Law on Spatial Planning and Construction RS in Chapter II “Spatial planning” - Article 11 “Principles of spatial planning, urban planning and landscaping” states that spatial planning is based on following principles:

a) to protect the area in accordance with the principles of sustainable development,

b) integrated planning, which combines all important factors of development and taking into account the dynamics of the needs and changes in the area and combining the resolving of conflicts of interest in area by harmonization of functional, aesthetic, energetic, economic and other criteria in planning, designing and construction of buildings,

c) ***harmonization of the natural values with human activity*** *(using renewable energy sources, construction of energy efficient buildings, proper location selection and inclusion of bioclimatic factors,* ***taking into account climate change****, protection against earthquakes and other natural disasters and technical failures, etc.), ...*

The Law on Spatial Planning and Construction of the RS in its provisions treats the issue of flood risk and floodplains. Article 14 states that, among other issues, natural hazard zones are also identified, including "floodplains". Article 31 defines the content of the spatial plan of the unit of local government, where, among other necessary plan elements, "rehabilitation measures for the endangered areas" are also specified, including "floodplains". Finally, Article 54 states that the Uniform Spatial Information System includes available "data on vulnerable areas", including floodplains.

Republika Srpska has adopted an entity Spatial Plan with a planning period until 2025. This document in the chapter "Flood defence and river regulation" in the textual section (page 270) provides several planning solutions that address flood protection:

- discouraging and ban the construction of residential, commercial and catering facilities in vulnerable zones through regulations and fiscal policy;
- continuation of passive protection measures in the most endangered areas, reconstruction and construction of embankments, coastal works, regulation works and the formation of protective cassettes;
- undertaking complex water management activities in the upper and middle parts of the basins, building reservoirs and reserving suitable areas for retention that can affect the reduction and negative effects of the flood wave (active protection measures).

However, both Entity Laws on Water (RS and FB&H) prohibit construction of facilities that does not serve as flood protection in flood areas at the area of 100 years return period water line, unless the owner or user is conditioned to build the structure by undertaking previous protective measures to prevent or reduce adverse effects from the water. It should be noted that, in contrast to the same RS law, the FB&H Law on Water in Article 42 clearly defines the relationship between documents of spatial planning and water management plans, which reduces the possibility of sectoral incompatibility.

7) RULE BOOK ON METHODS OF DRAFTING, THE CONTENT AND CREATING THE SPATIAL PLANNING DOCUMENTS (Official Gazette of RS, No. 69/13) (‘’Methodology’’)

This by-law, which was adopted on the basis of Law on Spatial Planning and Construction, defines the methods of drafting and content of spatial planning documents, general methodological procedure for the preparation of spatial planning documents, as well as the process of creation and the contents of spatial planning documents from jurisdiction of relevant Ministry and local governments.

This legal act, same as the Law on Spatial Planning and Construction, deal with the term “climate change” as a dynamic factor of influence, within the section which governs the general methodological procedure for creating spatial planning documents. In its provisions, the Methodology does not emphasize in particular the problems of flood risk. According to this by law act, the graphical part of the documentary basis, as the first phase of the development of a spatial plan, should contain a map of the situation concerning natural disasters, while the graphical part of the spatial plan of the local government unit should have a map of protected areas that would deal with, among other things, the natural risk and vulnerability zones. For the textual part of the documentary basis, the Methodology defines the analysis of issues of natural disasters in the part treating endangered areas where, among other, the “floodplains” are specified. These topics should be addressed in terms of analysis and assessment of the situation, problems of development, goals and planning solutions ("improvement of devastated and endangered areas").

Regarding urban plans and implementation documents of spatial planning, the Methodology defines text part on "measures for the protection of people and goods in case of natural disasters, war disasters and technological accidents" and, "conditions for the protection of people and goods in case of natural disasters, war disasters and technological accidents", while for the graphical part development of special maps that deals with the issue of protection from natural disasters is not prescribed.

The analysis of subordinate legislation, which regulates the content of spatial planning/planning documents, clearly indicates that flood risk issues and flood risk maps has not found the appropriate place in this regulation and that this issue is addressed indirectly through the thematic area of natural disasters or endangered areas.

8) LAW ON PROTECTION AND RESCUE IN EMERGENCY SITUATION (Official Gazette of RS, No. 121/12)

The provisions of *Law on protection and rescue in emergency situations* do not regulate directly the sector of integrated water resources management in Republica Srpska. However, this Law has great significance for water resources management in RS because part of its provisions is related to the flood risk management and the development of flood risk management plan in Republica Srpska, which is governed by *Water Law in RS* as well.

This Law regulates the system of protection and rescue in emergency situations in RS; main stakeholders and subjects of protection and rescue in RS; rights and obligations of the republic and administrative authorities and other agencies, local governments, companies and other entities; emergency and crisis situations; organization and activities of civil protection units in system of protection and rescue in RS and emergency response in case of natural and other disasters.

The Law identifies the Republic Administration of Civil Protection (RACP) as a key institution in Republika Srpska (RS) which reacts in case of emergencies and which establishes *Republic operations centre*, *regional operations centres* and *operational centres of cities/municipalities*, in order to implement the tasks of monitoring, notification and alerting. Accordingly, an early warning system in Republica Srpska is organized as a single system at the level of Republic and the level of city/municipality. The civil protection system in RS is developing on three operational levels (entity, regional and municipal level). The Law also stipulates that the short number 121 will be used for the functioning of operations and communications centre of Republica Srpska, until the establishment of a single European emergency number 112.

RACP is positioned within the organizational structure of RS Government. At the national level RACP coordinates its activities primarily with the relevant Ministries of Government of RS (primarily with the Ministry of Interior, the Ministry of Agriculture, Water and Forestry, the Ministry of Spatial Planning, Construction and Ecology and Ministry of Transport and Communications), then with relevant republic administrative organizations and public enterprises (PI “Water of Srpska”, Republic Hydrometeorological Institute, PE “Forests of the Republica Srpska”, PE “Roads of RS”, “Power Grid Transmission”, etc.).

In addition, according to Law provisions, RACP is responsible for drafting a *Plan for protection and rescue from natural disasters (floods and landslides) and other disaster on territory of Republic* and for the drafting of *Methodology for developing a plan for protection and rescue from natural disasters and other disasters*, and which is adopting as final document by the Government of Republika Srpska.

9) LAW ON FORESTRY (Official Gazette of RS, No. 75/08)

This Law regulates the policies and planning, forests management and forest land management, protection of forests, forest cadastre and forest land cadastre, and information system in forestry, as well as other issues important for the forest and forest land.

When it comes to flood risk management and function of the forest in order to prevent those risks, this Law defines in Article 6. a multi-beneficial forest functions (ecological and economic functions of forests), and also generally defines the term of *protective forests* that serve to protect the land and water, settlements, infrastructure and buildings and other assets. However, this Law does not elaborate further concept and function of these protective forests in detail, as is the case with a similar Law in the Federation of B&H.

It should be emphasised that the Law in Article 80 (chapter *Forest Infrastructure*) provides that planning of forest infrastructure, building and use of this infrastructure should be done in manner that:

- does not endanger the watercourses,
- does not cause erosion processes,
- does not prevent the normal flow of water from the flash floods, and
- does not disturb the balance of unstable land and does not increase the risk of landslides.

19.3.2 Federation of B&H (FB&H)

19.3.2.1 FEDERAL LEVEL OF GOVERNMENT

1) WATER LAW IN FB&H (Official Gazette of FB&H, No. 70/06)

As in Republica Srpska, the *Water Law in Federation of B&H* is the basic legal act that governs the sector of water resources management. This Law regulates water management within the territory of Federation of B&H (including water protection, water use, protection against water harmful effects and regulation of watercourses and other water), as well as other issues such as: water resources and public water resources, water facilities, legal entities and other institutions responsible for specific sectors in water management and other issues related to water in Federation of B&H.

Drafting of amendments to the Water Law FB&H started in 2013. One of the goals of the proposed amendment is “additional improvement of protection from harmful effects of waters based on experiences of 2014 floods and requirements of the EU Flood Directive”. Proposed legislative changes pay attention to the financial aspects of water sector management, issuing of water licenses and full harmonization with EU Water Framework and Flood Directive. The Draft Amendment was officially submitted to the FB&H Parliament at the end of 2017 but has not advanced through the process of regulative changes.

The provisions of the current Law are mostly in line with EU Directive 2000/60/EC (Water Framework Directive) in establishing a framework for local activities related to water management issues. Having in mind that the same situation is in RS regarding legislative conformity, it could be concluded that water management legislative framework in both entities (RS and FB&H) have a very similar structure and strategic approach to water policy.

The provisions in Article 24 of Water Law in FB&H provide also the basis for adoption of *Water Management Strategy of FB&H* which determines water management policy in Federation of B&H, while Article 25 defines *Water Management Plans* for the area of Sava River and Adriatic Sea.

When it comes to flood risk management, the Chapter VII is certainly the most important part of Water Law in FB&H which deals with regulation of watercourses and other water bodies and protection water harmful effects. However, this chapter does not define flood hazard and flood risk mapping, and climate change factors as a predictive element.

2) STRATEGY OF WATER MANAGEMENT IN FEDERATION OF BOSNIA AND HERZEGOVINA 2010 – 2022 (March 2012)

This Federal Strategy has been recognized as a basic long-term planning document for development of water management which governs the issues such as water management policy in FB&H, and particularly: water use and water status, institutional and economic framework, protection of water and protection from the water harmful effects, sustainable water use, strategic objectives in water management and measures, etc.

Based on previous, defining the strategic goals and accompanying measures, the future legal, institutional and economic framework of action shall be determined for water management sector in Federation of Bosnia and Herzegovina, as well as a framework of action for water use, water protection and protection against water harmful effects.

When it comes to impact of climate change on flood risk and other important factors (primarily precipitation and temperature extremes), this Strategy consider the relevant impact of climate change in few chapters (as well as Strategy in RS). Thus, the *Chapter 4.3.2.1.1 The reasons for the revision of water law and water legislation* elaborates that there is need to reform the system of water management in Federation, due to the necessity of an effective response on consequences of climate change which occur in form of floods and increased droughts in last recorded period.

Furthermore, when explaining the strategic objectives in the field of protection against water harmful effects (Chapter 4.3.7.), this Federal Strategy is considering in good manner the impact of climate change on risk reduction of extreme hydrological phenomena and proposes appropriate operational objectives in order to adequately prevent flood risk and extreme drought (pages 251-253), in terms of transposition of provisions of EU Directive 2007/6/EC in legislation system of Federation.

Among others, the following measures are proposed within the Strategy:

1) Development and implementation of operational plans for protection against flood and ice,
2) Development of a Preliminary flood risk assessment, Flood hazard maps and Flood risk maps and preparation of Flood risk management plans.

3) DECREE ON THE TYPE AND CONTENT OF PLANS OF PROTECTION AGAINST WATER HARMFUL EFFECTS (OFFICIAL GAZETTE OF FB&H 26/09)

This Federal Decree establishes the types, content and method of preparation, the process of harmonizing, adopting, updating and saving of plans of protection against water harmful effects in Federation of B&H. Basically, this is a subordinated legislative act, adopted on the basis of *Water Law in FB&H*, further elaborates provisions of EU Directive 2007/60/EC, governing the scope of the water harmful effects into a legislation of FB&H.

4) LAW ON AGRICULTURAL LAND IN FB&H (Official Gazette of FB&H, No. 52/09)

This Law defines the basic principles and issues related to agricultural land, such as: governing, protection, use and planning of agricultural land and register of agricultural land, as well as other important issues related to agricultural land in the territory of Federation of B&H.

Unlike of the Law in Republica Srpska, this Federal Law has no specific chapter devoted to planning of agricultural land and its zoning. Instead, this issue is considered within the section on protection of agricultural land (*Chapter IV in Law*) which defines that *Program of agricultural land management* include preparation of zoning, monitoring, use and protection of agricultural land in territory of Federation of B&H. In addition, within this Law, the creation of Land Information System of FB&H (*Article 29-30*) is defined as a unique system for recording and monitoring of agricultural land which, among other issues, includes a Federal Hydro meteorological Institute database on climate.

Comparing to the Law on Agricultural Land of RS, FB&H Law does not define a legal base and the criteria for the zoning of agricultural land in FB&H (adjustment of agricultural zoning according to the maps of endangered areas).

5) STRATEGY OF AGRICULTURAL LAND MANAGEMENT IN FB&H (2011)

This strategic document, which was adopted by the Government of FB&H is based on *Law on agricultural land in FB&H*, points out key tasks in strategic management of agricultural land and provides recommendations and conservation measures, rational and purposeful use, increase production capacity and improve the agricultural land management. It is necessary to emphasize that the Strategy is considered the relation

of agriculture and EU Water Framework Directive, the consequences of flooding and soil erosion, monitoring of agricultural land in FB&H, land information system and the protection of agricultural land against flooding.

6) GUIDELINE ON UNIFORM METHODOLOGY FOR THE CLASSIFICATION OF AGRICULTURAL LAND IN QUALITY CATEGORIES (Official Gazette of FB&H, No. 78/09)

This is a technical regulation adopted by the Ministry of Agriculture, Water management and Forestry of FB&H which defines criteria for the classification of agricultural land in quality categories and make the basis for spatial planning and land use in the Federation of B&H, and respectively determines the convenience level of use of agricultural land for agricultural production.

In this regard, the Guideline defines that categorization of agricultural land in the FB&H is performed on the basis of affiliation in climate-production area, altitude, degree of flooding, water retention degree, etc.

Furthermore, the criteria and elements for land categorization which considers flood risks, are very precise. Besides that, it is important to note that within this Guideline (Article 21) is established commitment to include the overview map of water repose strata, flood maps and soil erosion maps in quality studies.

Therefore, it can be concluded that this technical document presents a very good base for adequate spatial planning of agricultural land in Federation of B&H and defines the area of specific flood risk.

7) LAW ON SPATIAL PLANNING AND LAND USE AT THE LEVEL OF FEDERATION OF B&H (Official Gazette of FB&H, No. 2/06, 72/07, 32/08, 4/10, 13/10, 45/10)

This Law regulates issues such as: planning of land use in Federation of Bosnia and Herzegovina through the development and adoption of planning documents and their enforcement; type and content of planning documents; land use at the Federal level; monitoring of implementation of the planning documents that are important for Federation; etc.

Unlike the similar legislative act in Republika Srpska, this Law does not address the concept of climate change as a direct or indirect factor of influence on spatial planning in Federation of B&H. This Law only stipulates that planning at all levels of FB&H must comply with specific regulations in the field of environment, soil, water, forests, etc.

Law on Spatial Planning and Land Use at FB&H level is considerably more general in relation to the same law in RS. Flood risk issues are not mentioned in the specific sense, except in Article 31, where is only stated that the Unique Information System includes data on "areas where the danger of the consequences of natural and man-made accidents and disasters and of warfare is particularly pronounced", among which are also floodplains. However, this law clearly stipulates that all planning documents must contain "measures to protect residents and material goods from natural and man-made disasters and war activities". Article 17 states that the area of special characteristics of the FB&H for which spatial plan is developed, among other things, establishes "particularly vulnerable areas", including floodplains.

8) RULE BOOK ON UNIFORM METHODOLOGY FOR THE PREPARATION OF PLANNING DOCUMENTS (Official Gazette of FB&H No. 63/04, 50/07, 84/10)

This bylaw was adopted in accordance with *Law on spatial planning and land usage at the level of Federation of B&H* and it determines the process of preparation, drafting and content of planning documents at all levels of spatial planning in Federation of B&H.

It is a substantially similar document such as the *Rule book on methods of drafting, the content and creating the spatial planning documents in Republica Srpska*.

The Rule book on a “uniform methodology for the preparation of planning documents” similarly approaches to flood risk issues that are primarily addressed through the endangered area topics, while in the development of spatial and urban plans in the textual part it prescribes "an assessment of the vulnerability of the area from war actions, natural disasters and technical disasters to the end of the planning period”, and "measures to mitigate the negative effects of natural and man-made disasters and catastrophes".

Defined protective measures, conditions for the construction of protection facilities, must be an integral part of each Decision on the implementation of the planning document. The regulation also prescribes that within the textual part of the spatial base of the urban plan and the urbanistic base of the regulatory plan, an analysis of the constraints in the area is also carried out, including “floodplains”. Regarding the graphical part of the planning documents, in the case of zoning plans, the development of a map of protective zones is envisaged, which, among other things, includes a flood protection zone, while in the case of spatial plans it is required to show flood protection measures on the map of waters and aquatic areas.

9) LAW ON PROTECTION AND RESCUE OF PEOPLE AND GOODS FROM NATURAL AND OTHER ACCIDENTS IN FB&H (Official Gazette of FB&H No. 39/03, 22/06, 43/10)

This Law regulates the system of protection and rescue of people, material, cultural and other resources and the environment from natural disasters, technological, environmental and other disasters as well as regulates the rights and duties of citizens and the relevant public bodies of Federation of B&H, cantons and municipalities, companies and other legal entities in emergency situations. This is substantially the same legislation as the *Law on protection and rescue in emergency situation in Republica Srpska*.

This Federal Law determines the individual duties of relevant bodies at all levels of government in Federation of B&H, and at the federal, cantonal and municipal level, by giving the original legal authority for all three levels of government in Federation of B&H (adoption of regulations and programs for the development of protection and rescue in the respective territory; risk assessment implementation; funding of civil protection system; the establishment and financing of operational-communications centres, etc.).

A key responsibility in the protection and rescue system in FB&H belongs to Federal Administration of Civil Protection (FACP) which operates as an independent federal administration under the direct control of the Government FB&H. FACP performs administrative, professional and other activities in the field of protection and rescue (acts in emergency situations to rescue people and property, preparing the risk and hazard assessment for the Federation of B&H, proposes a plan of protection and rescue from natural and other disasters in the Federation; organizing, preparing and training staffs and civil protection units and services for protection and rescue, etc.).

FACP is consisted out of ten cantonal administration of civil protection (in each canton by one administration) together with the cantonal civil protection operational centres. In addition, the Law stipulates the establishment of Federal Civil Protection Operations Centre with area code 112, as well as ten operational centres in each of the cantons, which have to operate continuously 24 hours during the year.

10) LAW ON FORESTRY (Official Gazette of FB&H, No. 20/02, 37/04)

This Law regulates the preservation and protection of forests, enhancing their ecological functions, forest planning and forest management, economic functions of forests in the territory of the Federation of B&H, and other relevant issues.

Same as the *Law on Forestry of RS*, this federal Law defines the multi-beneficial functions of forests, such as economic, social and environmental (protection of land and water). Beside this, the Article 13 of Law defines that the construction and using of *forest transport infrastructure* should be done in manner that:

- does not threaten the water springs,
- does not cause erosion processes,
- prevents overflow of water from the flash floods,
- and does not disturb the balance on unstable soil and increase the risk of landslides.

It should be noted that this Law defines the concept and function of *protective forests* (Article 39) manner, as follows:

a) forests that primarily serve to protect soil on steep slopes and soil subject to erosion, flash floods, landslides and harsh climatic conditions that threaten the existence of the forests;
b) forests, whose main function is protection of inhabited areas, industrial and other facilities such as roads, power plants, telecommunication and infrastructure, protection of springs and watercourses, banks of water reservoirs, as well as forests established as a protection belts and serve as a protection against natural disasters and catastrophic effects of human activity.

Status of protective forests in this Article is declared by the Government of the Federation of B&H based on the proposal of the federal ministry, or cantonal governments based on the proposal of the cantonal ministry.

20 Annex G - FLOOD RISK MANAGEMENT INSTITUTIONAL CAPACITY

20.1 INTRODUCTION

This chapter details the key findings and recommendations of an institutional capacity assessment of the key institutions involved in flood risk management which was undertaken under the Vrbas project. It discusses findings and recommendations under the main components of a flood risk management system.

20.2 RISK MANAGEMENT

B&H institutions and professionals do not have long experience in identifying hazard and assessing vulnerability and risk from natural disasters in line with international standards. Complex institutional structure in a country requires involvement of a large number of institutions, but also strong coordination and cooperation is of utmost importance for successful implementation of those actions.

20.2.1 Organizational Arrangements

20.2.1.1 Lack of coordination between administrative structures in B&H

Already established institutional structure - Disaster Risk Reduction Platform (permanent forum for the exchange of opinions and proposals and provision of achievements contributing to disaster risk reduction in all areas of human activities), consisting of state Ministry of Security B&H and relevant Entities' and Brčko District should act as national coordination body serving to strengthen cooperation among different institutions and provide their work to be in compliance with regional and international standards in this field.

Disaster Risk Reduction Platform should be strengthened to become coordination body for: a) Disaster Risk Management (DRM) and b) (EWS) Early Warning System and in the country.

This should include:

- Providing political support for establishment of "task force" or "working group" within the Platform including all relevant experts and institutions to deal with:
  a) identifying hazard risk and vulnerability and risk assessment; b) early warning system
- Preparation of Scope of work for task force relevant for: a) identifying hazards and vulnerability and risk assessment, b) early warning system
- Plan of budgetary funds for implementation of "task force".

20.2.1.2 Lack of national standards for the systematic collection, sharing and assessment of hazard and vulnerability data

Activities of "task force" relevant for risk management should include:

- Coordination of work of relevant institutions/experts, in designing standards for collection, sharing and assessment of hazard and vulnerability data;
- Ensuring exchange of data based on development of GIS data bases and SDI relevant for hazard and vulnerability between all institution's members of this body, including municipal civil protection structures.
- Through the member institutions and experts (including international), elaboration of common Guidelines and standards for elaboration of hazard and vulnerability Studies, including analysing of natural hazards and historical data evaluation, hazard maps and integrated hazard maps development.

20.2.2 Identification of natural Hazard

20.2.2.1 Lack of established and maintained centralized data "library" or GIS data bases

Taking into account that Entities Geodetic Administrations (FAGPA and RAGPA) have already become the holders of Spatial Data Infrastructure (SDI) in both entities, they should take a role of managing centralized data base or GIS data base relevant for assessments and identification of hazards at entities' level.

In that context, they should

- Become a member of B&H DRR Platform / task force; as a key factor for introducing protocols for data collection, publication and sharing among relevant institutions at national and entities' level, and to the public relevant for hazard and vulnerability assessment. This would enable full cooperation between entities and Brčko district, through the B&H Platform, in systematic data collection and sharing.
- Capacity development of FAGPA and RAGPA in order to implement goals, set up by their respective Strategies on Spatial Data Infrastructure (SDI) as well as their programs

Strengthening of entities Geodetic Administration should include:

- Assessment of human, software and equipment needs in geodetic administrations for fulfilling tasks relevant for establishment of functional SDI
- Trainings held of additional staff for technical implementation of SDI
- Purchase of additional equipment necessary for establishment full and functional SDI.

Increased efficiency of using WIS and GIS data basis of Water Information system in Water Agencies is needed. Therefore, Water Agencies should be strengthened as following:

- Assessment of human, software and equipment needs in Water Agencies necessary for fulfilling tasks relevant for WIS and GIS data basis in terms of hazard, vulnerability and risk assessment;
- Trainings held for staff who should work on WIS and GIS databases in terms of hazard, vulnerability and risk assessment;
- Purchased additional equipment necessary for establishment of full and functional WIS and GIS data base.

20.2.2.2 Lack of available hazard and vulnerability data and information to the public and international community

Strengthening capacities of Municipal civil protection services in establishing and maintaining data bases relevant for hazard, vulnerability and risk assessment including:

- Assessment of human, software and equipment needs in Municipal civil protection services for developing data basis in terms of hazard, vulnerability and risk assessment;
- Trainings held for staff who should work on databases in terms of hazard, vulnerability and risk assessment;
- Purchased equipment and software necessary for establishment of data bases and linkage with modules of SDI relevant for hazard and vulnerability assessment.

20.2.2.3 Limited scientific and technical knowledge on hazard identification and vulnerability assessment

Strengthening capacities of scientific, engineering and technician experts is of utmost importance in order to become capable to identify hazards and asses vulnerability from natural disasters in accordance to international standards. Civil protection sector and water sector experts also require capacity development on this subject.

It is particularly important that staff from entities' Water Agencies and Hydro Meteorological Institutes strengthen their capacities in this field. They play the main roll in coordinating flood hazard and vulnerability assessments in both entities, developing terms of references for the projects, financing some of them and supplying institutions with data and information necessary for developing studies. Their knowledge on this subject should be raised on high level in order to be capable to provide instructions, monitor and supervise quality of work done by engaged institutions/experts, and ensure good quality baseline data and information needed.

This should include different types of training courses (teaching courses and workshops including case Studies), serial of seminars, on – the job trainings. It should be organized mostly by international experts including but not limited to the following subjects:

- Assessing and review the accuracy of risk data and information;
- Developing hazard and vulnerability Studies;
- Developing hazard maps;
- Developing integrated hazard maps to asses interaction of multiple natural hazards.

20.2.3 Community engagement and vulnerability assessment

20.2.3.1 Missing Community engagement and vulnerability assessment

Taking into account that vulnerability assessments in B&H is not developed specifically for community level and those communities are not trained in vulnerability assessment techniques, this aspect need to be developed in B&H from the start. Municipal authorities and municipal civil protection structures should take the key role in mobilizing communities for participating in those activities.

Municipal authorities should integrate risk knowledge into local regulation and policies and need to have strong political support and financial means from the higher political levels for those actions.

Branch offices of Water Agencies could take important role in the field, in mobilizing and educating communities in flood risk assessment.

Starting action should be the following:

- Engagement of professionals to elaborate documents such as:
    - Strategies for active engagement of communities in analysing local hazards and vulnerabilities as well as,
    - Guidelines for vulnerability capacity and assessment,

- Based on identification of vulnerable communities, and identification of communities with a strong interest in participating in those activities provide trainings, workshops, exercises, games (for children) discussions, etc to:
    - undertake community mapping of all hazards and vulnerability and areas/buildings that could serve as shelters outside the hazard's expected impact zone
    - Identifying on the maps of the homes of all the most disadvantaged households or individuals
    - Learn how to keep track of each future hazard and their impacts etc.

20.2.4 Risk assessment and management

20.2.4.1 Lack of scientific and technical knowledge on risk assessment and management in line with international standards

The most important aspect for improvement of risk assessment and management in B&H is strengthening capacities of scientific, engineering, technician experts as well as economy sector and communities, both for identification of hazard and vulnerability assessment and for risk assessment and management.

It is particularly important that staff from entities' Water Agencies, Hydro Meteorological Institutes and civil protection strengthen their capacities in the assessment and management of risk. They play the main roll in coordinating flood risk assessments in both entities, developing terms of references for the projects, financing some of them and supplying institutions with data and information necessary for developing Studies. Their knowledge on this subject should be raised on high level in order to be capable to provide instructions, monitor and supervise quality of work done by engaged institutions/experts.

This should include different types of training courses (teaching courses and workshops including case Studies), serial of seminars, on – the job trainings. It should be organized mostly by international experts including but not limited to the following subjects:

- Assessing interactions of hazard and vulnerabilities to determine risks in each region and community;
- Identifying and evaluating activities that increase risks;
- Integration of results of risks assessment in management plans and warning massages;
- Design and implementation of intervention measures;
- Managing residual risk and risk transfer.

20.3 Monitoring and Warning

B&H institutions and professionals has long experience in monitoring and warning but are at the beginning of a process of adopting and applying early warning system in line with international standards. Complex institutional structure and lack of technical knowledge in the country to deal with this specific issue result in quite inefficient application of early warning system in country.

Some of the most important factors which could contribute to introduction and application of effective early warning system are: coordination among all institutions involved as well as strengthening of human capacities. It is therefore proposed that already established Disaster Risk Reduction Platform be more engaged in dealing with early warning system.

This proposal will be elaborated within the following recommendations, where applicable.

20.3.1 Institutional Mechanism established

20.3.1.1 Lack of clear coordination for issuing warnings and protocols for information exchange

Institutional arrangements for early warning has been discussed in detailed in Section 12 above. In general, the following strengthening activities are required:

- Coordination of work of relevant institutions/ experts to design proposals/ guidelines, based on current laws and policies on: a) standardize processes, roles and responsibilities for all institutions generating, issuing and disseminating warnings; b) international standards on issuing of data and warning products; c) consistency of warning language and communication channels; d) roles and responsibilities of cross-border early warning centres; e) communication arrangements with international and regional organization; f) Volunteer network trained to receive and widely disseminate hazard warnings to remote households and communities;
- Organization of hearings and series of workshops for all interested groups to discuss all subjects elaborated by Proposal / Guidelines, agree upon them and be incorporated in relevant entities', cantonal and municipal regulation in order to be operational;
- Organization of serial of training programs for institutions / staff responsible for all subjects elaborated in Proposal / Guidelines.

20.3.1.2 Missing Operational centres and lack of adequate equipment and staff in OCs

Increasing effectiveness and efficiency of OCs at Cantonal and Municipal level is needed. Therefore, OCs should be strengthened as following:

- Assessment of human, software and equipment needs in OCS for fulfilling tasks of warning and information exchange;
- Trainings held for staff of OCs for warning and information exchange;
- Purchased additional equipment necessary for providing full and functional warning and information exchange in all OCs;

20.3.2 Monitoring systems

20.3.2.1 Limited hydrological and rain / meteorological monitoring network and lack of funds for maintenance and operation of gauge stations:

The hydrometric network has already been discussed in detail above. Existing number of hydrological and rain / meteorological gauge stations owned and operated by FHMI and RHMI is not adequate and sufficient for extensive measurement, strategic risk assessment, early warning, planning and etc. Therefore the following activities need to be done:

- Elaboration of Strategy for obtaining, reweaving and disseminating data on vulnerabilities;
- Assessment of FHMI's and RHMI's programs / plans for the extension of hydrological and meteorological stations in FB&H territory in terms of number and locations foreseen;
- Purchase and installation of hydrological and meteorological stations in FB&H and RS, upon revision of FHMI's program / plan;
- Trainings for the staff of FHMI's and RHMI's who should work on observing, maintenance and operation of hydrological and meteorological stations.

20.3.2.2 Missing GIS data bases and trained staff and need to improve Hydro meteorological Information system

The Hydrometeorological Information Systems have already been discussed in detail. Usage of GIS data base and Hydro meteorological Information system (HMIS) in FHMI is necessary for effective and efficient work in data processing, modelling, forecasting, warning, risk assessment etc.

Therefore, FHMI and RHMI should be strengthened as following:

- Assessment of human, software and equipment needs in FHMI necessary for fulfilling tasks which require usage of GIS data basis and Hydro meteorological Information system.
- Trainings held for staff who should work on GIS databases and Hydro meteorological Information system.
- Purchased additional equipment, necessary for establishment of functional GIS data basis and Hydro meteorological Information system.

20.3.3 Forecasting and warning (Hydro meteorological Institutes)

20.3.3.1 Lack of application of warning standards and trained staff

Hydro Meteorological Institutes, as warning centres, need to be strengthened in all aspect s of warning and forecasting. They need financial and technical assistance support in establishing modern and reliable warning centres. The following actions should be made in order to increase efficiency and effectiveness of HMI s in performing warning activities:

- Organization of series of training programs for the responsible staff in all warning centres in B&H on international standards and protocols including issuing of data and warning products.

20.3.3.2 Lack of staff, knowledge and equipment for forecasting and modelling and fail-safe system

For good quality warning it is important that HMI's warning centres are equipped, so the warnings can be generated and disseminated in an efficient and timely manner, what is far from reality in B&H.

Increasing effectiveness and efficiency of warning centres in HMIs is needed through:

- Assessing possibilities of allocation of responsibility for hydraulic modelling to Hydro-meteorological Institutes in terms of current regulation, additional staff employment, software and equipment purchase.
- Assessment of human, software and equipment needs in HMIs necessary for weather modelling and runoff modelling;
- Trainings held for staff who should work on weather forecasting and runoff modelling;

- Purchased additional equipment, necessary for weather forecasting and runoff modelling;
- Purchased additional equipment for ensuring fail-safe systems.

20.4 DISSEMINATION AND COMMUNICATION

20.4.1 Organisational and decision making processes Institutionalized

Discussed in detail under Section 12.3.3.

20.4.2 Communication System and Equipment Installed

20.4.2.1 Lack of Communication System and Equipment, including warning devices

To address this the following activities should be conducted:

- Preparation of exhausted inventory of communication systems and equipment in the whole country for all administrative levels of civil protection, including warning devices for municipalities and local communities
- Assessment of needs, in accordance to local conditions and international standards, including engagement of international organizations and experts;
- Preparation of Strategy and priority investment Plan for equipping of all levels of civil protection, municipalities and local communities, with support of international organizations and experts;
- Engagement of professionals to select / propose adequate types of equipment to be purchased.

20.4.3 Warning massages recognized and understood

20.4.3.1 Lack of proper Warning communication System

Warning communication is an essential link between monitoring and response capability. Development of improved and successful warning communication system in B&H requires engagement of specialist, local if available, or international, who would elaborate comprehensive Handbook specifically targeted for B&H or part of B&H.

Handbook should cover all aspects of successful communication system (warning alert tailored to the specific needs and concerns of those at risk, warnings target only areas/ people at risk, alerts recognizable and consistent over time, developed mechanisms .to inform communities when threat is over etc).

Handbook should further be disseminated and presented at workshops, seminars and training courses to all entities responsible for communication with population, particularly living in communities (e.g. remote villages) as they are the most vulnerable during natural disasters.

20.5 RESPONSE

20.5.1 Warnings respected

20.5.1.1 Lack of advanced approach to warnings

Development of systematic approach to improved and advanced warning modalities in B&H require engagement of specialist, local if available, or international, who would analyse deeply, public perception of warning services in B&H and elaborate Strategy for building credibility and trust in warnings.

Strategy should be a base for educating people to understand the difference between forecast prediction and warning which is essential for building credibility and trust in developed warnings.

20.5.2 Disaster preparedness and response plans Established

20.5.2.1 Lack of disaster preparedness and "response plans"

Preparation of up- to date emergency preparedness and response plans which would be negotiated at the community level would be of utmost importance for disaster preparedness. These Plans should clearly define "who does what", "when and how" in an emergency. Also, early warning part of the plan should clearly detail "who does what" "when and how" in response to the first, second and/or third warnings received for each pertinent hazard.

Drills and simulations would also be very important tool for testing if the response options and response plans are adequate and if the community as a whole is prepared to use it effectively.

Municipal Civil protection sector should have a leading role in initiating capacity building programs on the above subjects for its employees, ensuring community participation as well.

This should include different types of training courses (teaching courses and workshops), and on – the job trainings. They should hold trainings possibly by international experts on the following subjects:

- Preparation of hazard and vulnerability maps (based on created Guidelines);
- Preparation of up-to-date emergency preparedness and response Plans;
- Performing Regular tests and drills to test the effectiveness of the early warning dissemination processes and responses are not undertaken in B&H.

20.5.3 Community engagement and vulnerability assessment

20.5.3.1 Missing Community Response capacities

Taking into account that community response capacities are at the very low level in B&H, as they do not participate in any capacity building programs, so are not introduced to basic aspects of respond to early warning or disaster, this aspect need to be developed in B&H from the start.

Municipal authorities and municipal civil protection structures should mobilize communities for participating in those activities.

Municipalities need to have strong political support and financial means from the higher political levels for those actions.

The following activities should be undertaken:

- Engaging expert to elaborate Capacity building Strategy;
- Engage experts to develop community education and training programs;
- Municipal authorities should find out communities who has strong interest in participating in those activities and create community – based organizations to assist with capacity building;
- Organization of education exercise on analysing response from previous disasters.

20.5.4 Public Awareness and education Enhanced

20.5.4.1 Improving Public Awareness and education

Municipal authorities and municipal civil protection structures should organize elaboration of Public awareness Strategy and Programs, based on which, different educational programs, including active participation of community members should be designed and implemented.

Summary of capacity building and equipment needs explained within the above text are presented in the ffollowing Tables:

Table 20-1: Summary of capacity building needs

Type	Target group /s
Identification of natural Hazard	
Trainings of additional staff for technical implementation of SDI	Entities' Geodetic Administration
Trainings on WIS and GIS databases in terms of hazard, vulnerability and risk assessment	Entities' Water Agencies
Trainings on establishing and maintaining databases relevant for hazard, vulnerability and risk assessment	Municipal Civil protection services
Training courses (teaching courses and workshops including case Studies), serial of seminars, on – the job trainings etc., on identification of natural hazard and vulnerability assessment	Civil protection sector, Water sector - particularly staff from entities' Water Agencies and Hydro Meteorological Institutes, scientific, engineering and technician experts/institutions.
Community engagement and Vulnerability assessment	
Trainings, workshops, exercises, games (for children) discussions, etc., on vulnerability assessment techniques	Municipal civil protection services, Communities
Risk assessment and management	
Training courses (teaching courses and workshops including case Studies), serial of seminars, on – the job trainings on identification of risk assessment and management vulnerability assessment	Civil protection sector, Water sector - particularly staff from entities' Water Agencies and Hydro Meteorological Institutes, scientific, engineering and technician experts/institutions.
Monitoring and warning **Institutional Mechanism**	
Organization of serial of training programs for institutions / staff responsible for dissemination, communication, warning (within Disaster risk Platform "task force")	Civil Protection sector, particularly Operational centres; Water sector - particularly Hydro Meteorological Institutes; Volunteers' networks
Trainings on warning and information exchange	Operational Centres of Civil protection sector , particularly Cantonal (in F B&H) and Municipal
Trainings on observing, maintenance and operation of hydrological and meteorological stations.	Entities' Hydro Meteorological Institutes
Trainings on GIS databases and Hydro meteorological Information system establishment and maintenance	Entities' Hydro Meteorological Institutes
Trainings on weather forecasting and runoff modelling;	Entities' Hydro Meteorological Institutes
Workshops, seminars and training courses on introducing proper recognition and understanding of warning massages	Civil protection sector, trustees in local communities, volunteers' networks
Disaster preparedness and response plans	
Training courses (teaching courses and workshops), and on – the job trainings on elaboration of up- to date emergency preparedness and response Plans; on hazard and vulnerability maps. etc.	Municipal Civil protection sector including Community participation.

Type	Target group /s
Tests and drills to test the effectiveness of the early warning dissemination processes and responses	Municipal Civil protection sector including Community participation
Community engagement and vulnerability assessment	
Education and training programs on vulnerability assessment; on analysing response from previous disasters	Municipal Civil protection sector , Communities
Public Awareness and education Enhanced	
Educational programs raised from developed Public awareness Strategy and Programs.	Municipal authorities and municipal civil protection, including active participation of Communities

Table 20-2: Types of equipment needed

Type	Target group /s
Identification of natural Hazard	
Additional equipment necessary for establishment of full and functional SDI.	Entities' Geodetic Administration
Additional equipment necessary for establishment of full and functional WIS and GIS.	Entities' Water Agencies
Equipment and software for establishment of data bases and linkage with modules of SDI relevant for hazard and vulnerability assessment.	Municipal Civil protection services, operational centres
Monitoring and warning **Institutional Mechanism established**	
Additional equipment necessary for providing full and functional warning and information exchange	All Operational centres of Civil protection
Installation of additional hydrological and meteorological stations	Entities' Hydro Meteorological Institutes
Additional equipment for establishment of functional GIS data basis and Hydro meteorological Information system.	Entities' Hydro Meteorological Institutes
Additional equipment, necessary for weather forecasting and runoff modelling;	Entities' Hydro Meteorological Institutes
Additional equipment for ensuring fail-safe systems	Entities' Hydro Meteorological Institutes
Communication System and Equipment	

Type	Target group /s
Communication equipment and warning devises	Civil protection sector, Municipalities, Local Communities

21 ANNEX H - INSURANCE AS A FLOOD RISK TRANSFER MECHANISM IN B&H

21.1 INTRODUCTION

Insurance against natural disasters, in particular events where location can be predicted such as floods, reduces economic and social impacts and generally changes behaviour towards flooding. Even if there is very little physical flood management, only post-event intervention insurance ensures the follow-on economic impacts of extreme events are minimised, enables faster recovery, stabilizes the income and consumption stream of the affected, and ultimately reduces vulnerability and impacts.

It is estimated that losses from weather events are doubling globally every 12 years. Even though the observed increase in losses is dominated by socio-economic factors (such as population growth, increased number of habitations in vulnerable areas, increased wealth, increased amount and value of vulnerable infrastructure), there is evidence that changing patterns of natural disasters are also drivers.

In Europe, 64% of all loss events since 1980 are directly attributable to weather and climate events (storms, floods and heatwaves) and 25% to wildfires, cold spells, landslides and avalanches, which are also linked to weather and climate. Some 95% of the overall losses and 78% of all deaths caused by disastrous events result from such weather and climate-related events. The annual average number of these weather- and climate-related events in Europe increased during the period 1998–2007 by about 65% compared with the 1980s. This means that future extreme events will result in an increased level of risk in the insurance sector and there will be an increase in regions being re-categorised as ineligible for insurance, necessitating greater state intervention.[47]

There are three key approaches to the provision of insurance and compensation in Europe:

1) ***Traditional (private) insurance systems***. These systems are in place in most European countries and are set up and managed by private companies, where the cover is financed from premiums that are paid before the event (ex-ante). Some of these systems may have support from the government, for instance through state-guaranteed reinsurance. Countries where at least half the population has taken out flood insurance are: Portugal, Spain, France, the United Kingdom, Hungary, Norway and Sweden. Countries where less than half of the population has taken out flood insurance are: Italy, Greece, Austria, Slovakia, the Czech Republic Germany, Poland, Finland;

2) **Insurance or pooling systems** in which the government has a considerable role, through setting up and managing the pool. Cover is provided through ex ante premiums or ex ante taxes on insurance policies. This is the case in Belgium, Denmark and Switzerland. In Belgium, however, a compulsory insurance system has been put in place since late 2005

3) **Systems administered by the government**, consisting of ex post compensation of flood losses. These systems are not considered to be insurance, as the basic property of ex ante premium or tax collection is not present. Rather, loss compensation is paid from tax money, either ad hoc or through budget reservations. At present only the Netherlands adopts this approach to compensation.

Throughout Europe, private insurance premiums are typically based on historic claims and flood mapping procured on behalf of the insurer. This means that properties that have repeatedly flooded or are predicted to be at a high risk of flooding will pay higher premiums than those who have not flooded

[47] The base information of this text was taken from http://www.climateadaptation.eu/france/insurance-and-business/

or have a perceived lower risk. In some instances, taking flood reduction measures can reduce premiums. Private insurance does not typically accommodate high risk properties, and these liabilities often fall to the state or special vehicles are created to manage the higher risks. Private insurance systems ("bundle system" or the "option system") are distinguished from government solutions (ex post compensation by the government, paid from tax revenues).

21.2 Insurance as a Non-structural Climate Change Adaptation Measure

Insurance is one of the most important ex ante flood risk management tools within which flood damage is compensated from the cover provided by the insurers, based on pre-paid premiums by policyholders. However, the development of insurance against flooding in underdeveloped and developing countries is not at a satisfactory level, which can be explained by a large number of reasons. On the one hand, insurance companies are not motivated for affirmation and development of this type of insurance because of the high costs relative to incomes, difficulty to achieve dispersion of risk (in floodplains floods can be frequent and affect most of the inhabited population), underdeveloped mechanisms of prevention of floods, but also the problem of lack of quality statistical database on which adequate tariff systems would be based. On the other hand, there are very narrow financial possibilities of the population to pay insurance premiums from flooding in these countries. If the tariff rates were unified, insurers would be faced with the problem of adverse selection, because the population in the areas most affected by floods is most interested in this insurance. Alternatively, if tariff rates were commensurate with the actual risks, this insurance would become inaccessible for the poor sections of the population in the flooded areas that need it most.

These problems can be partially mitigated by subsidizing flood insurance premiums by the state and local governments, by reinsurance, as the most important instrument of risk management for insurers themselves, providing assistance by local governments in collecting data on claims caused by floods that are necessary for the formation of actuarial funded premium as well as by raising awareness of local people about the importance of flood insurance, through education and promotion of this type of insurance.

Insurance is a mechanism for spreading losses over time, for a relatively large number of entities exposed to the risk, in a similar manner. It does not reduce the risk, but it provides financial compensation to policy holders in the event of loss. The annual premium paid for the insurance must cover the average annual loss over a longer period of time, as well as all administrative costs. Population living in the flood zone is being insured from floods with an insurance company that requires at least annual premiums. In the insurance program, primarily it is necessary to identify the flood zone, which is threatened by high water of a certain probability of occurrence. Insurance companies then set the premium level. In case of insurance from floods, damages are determined based on the flood water depth on the field. If a water depth on a certain place is known, then it is possible to estimate the damage to the buildings of a particular type, and thus estimate the level of the corresponding premium for insurance. The flood insurance system should be adapted to the economic situation of the country.

The insurability of natural disasters and extreme weather events may be affected by increases in the frequency, severity, or unpredictability of these events as well as changing demographics. In relation to flooding there is a potential for increased development in flood prone areas, as well as a change in the patterns of flooding. This presents both technical and market-based risks to the insurers and those wishing to obtain insurance, which are summarised below:

Technical Risks

- Shortening times between loss events, such as more windstorms per season,
- Changing absolute and relative variability of losses,
- Changing structure of types of events,
- Shifting spatial distribution of events,
- Damages that increase exponentially or nonlinearly with weather intensity,
- Widespread geographical simultaneity of losses

- Increased difficulty in anticipating "hot spots" (geographic and demographic) for particular hazards,

Market-based Risks

- Historically-based premiums that lag behind actual losses,
- Failing to foresee and keep up with changing customer needs arising from the consequences of climate change,
- Unanticipated changes in patterns of claims, and associated difficulty in adjusting pricing and reserve practices to maintain profitability,
- Responses of insurance regulators,
- Reputation risks falling on insurers who do not, in the eyes of consumers, do enough to prevent losses arising
- Stresses unrelated to weather but conspiring with flood impacts to amplify the net adverse impact. These include draw-downs of capital and surplus due to earthquakes or terrorist attacks and increased competition from self-insurance or other competing methods of risk-spreading.

21.3 DESCRIPTION OF THE INSURANCE SCHEME THAT HAS BEEN DEVELOPED FOR VRBAS BASIN

Flood insurance is advocated as a long-term non-structural measure for building resilience among flood victims and is one of a broad scope of risk management approaches that can be used as a financial instrument to help zone development away from high risk areas. However, experience shows that in developing countries, the use of flood insurance has been unsatisfactory, due to the lack of flood insurance schemes or the limited coverage and negligible impact as a flood mitigation measure. The reasons for this include the reluctance of insurance companies to promote flood insurance because of the high cost of operating and administering them, compared to the revenue to be earned by them. Also, the capacity of flood affected people in developing countries to pay high premiums is limited,

The current state of the insurance sector in Bosnia and Herzegovina, existing flood risk management techniques, modalities of financing this risk in B&H, institutional and legal environment for the insurance market in B&H were analysed to assess the feasibility of implementing flood insurance in B&H. Flood insurance schemes in developed countries and in countries at the similar level of development as B&H have also been taken into consideration. Analysis of socio-economic damages and losses in the Vrbas basin provided the risk-based inputs to the development of the flood insurance model. The flood insurance model/scheme developed for Vrbas river basin includes the following elements:

- type of insurance,
- type of risks,
- development of insurance products,
- determining possible distribution channels,
- establishment of the disaster insurance pool,
- establishment of guaranty/protection fund,
- adaptation of existing regulations.

Based on this model, the insurance product for individual households has been fully developed. It is designed as compulsory insurance which includes risks of floods, landslides, earthquakes and storms. The terms and conditions for this product were calculated on the basis of different market penetration shares and capacity for retention of the risk.

On the basis of the same model, insurance products for public institutions, businesses and agriculture are to be developed within the GCF project.

21.4 WILLINGNESS TO PAY FOR DISASTER RISK INSURANCE

A study was implemented within the GCF project formulation titled “Willingness to pay for natural disasters insurance scheme in Bosnia and Herzegovina”, in order to prepare the local communities, citizens, business subjects and agricultural producers to manage the flood risks through transfer and adaptation of technologies, focusing on selection of adequate method for risks funding. In that context, in order to prepare adequate insurance products, it was necessary to consider other risks from natural disasters as well, such as landslides, earthquake, hail and drought, which are adequate for designing of coverage through specific insurance products. Four market segments have been identified (households, public institutions, business subjects and agricultural producers) as the subjects of interest for this study. The main study question is: “Is it possible to manage the risks from natural disasters through insurance, as a special method of risks funding, taking into consideration the needs of target segments and key features of the insurance products package for natural disasters?”. Study results on readiness of households to pay the insurance for building and related assets from natural disasters are given in this section. Of natural disasters, the following were included in the study: flood, landslide and earthquake.

21.4.1 Willingness of households to Pay for insurance from natural disasters

Size of the sample was 1005 households, of which 61.6% lives in the FB&H, and 38.4% in RS. Households with places of residence in the following river basins were included: Bosna (44%), Korana/Glina (3.3%), Neretva (10.2%), Sava/Drina (5.4%), Trebišnjica (1.7%), Ukrina (3.3%), Una (13.6%) and Vrbas (18.5%).

Structure of the sample was such that most of the respondents said that they lived in house (83.6%) and in rural environment (44.6%). Heads of households were dominantly men (73.8%) with high school degree (59.9%). The average age of heads of household is 61.27 years (st. dev. = 12.43), with youngest head of household aged 24, and the eldest 90 years old. Households, in average, have 3.14 members (st. dev. = 1.57). The structure of sample regarding total monthly income of the whole household is as follows: to 500 KM (35.5%), 500 - 999 KM (27.2%), 1000 – 1499 KM (16.7%) and over 1500 KM (20.5%).

Study results indicate that the insurance from natural disasters is alternative to compensation of the damages, compared to the own sources, credits or donations. The key needs for insurance from natural disasters were identified. Financial aspects of potential damages from the assessed disasters were evaluated. The key features of insurance of building and related assets from natural disasters were generated in terms of obligation, anticipated premium amount and compensation for the damage. Among identified needs of citizens and their socio-demographic features, on one side and obligation and willingness to pay the insurance from the target natural disasters, on the other side, the significant relationship was determined.

21.4.2 Identification of household needs for insurance from natural disasters

The covered dimensions of needs for insurance from natural disasters are related to the experience with damages, awareness on exposure to risks from natural disasters, willingness to insure houses/apartments/residential buildings from natural disasters, inclination to purchasing commercial insurance products for assets and inclination to the risk retention.

Study results showed that citizens significantly need the insurance from natural disasters, particularly in terms of awareness on exposure to risks demonstrated through willingness to pay insurance from flood and landslides. The least needed insurance was the insurance from damages caused by earthquake.

Significant aspects of identification of needs for insurance from the mentioned natural disasters pertain to the experience and assessment of exposure to risks. Based on analysis of experience with damages and awareness on exposure to risks from natural disasters, it was determined that there was a higher level of respondents' awareness on exposure to risks from natural disasters compared to the own experience. So, 17.2% respondents experienced the flood damages, while 32.7% are aware of the risk from this disaster. While 11.3% respondents experienced landslides, 28.6% are aware of this risk. The least of respondents, 3.8% of them, experienced the earthquake, while 10.6% are aware of this risk. Time aspects of extreme hazardous disaster events were determined. Majority of flood damages (153 of 167) and landslide damages (92 of 106) happened in 2014, while most of the damages caused by earthquake happened in 1969 (18 of 32 damages). The relationship of experience with the damage caused by natural disasters and awareness on belonging to the danger zone for all three assessed natural disasters was determined.

Regarding the willingness to pay the insurance from natural disasters, the willingness to pay the insurance from flood was determined (26.3% respondents), as well as from landslides (25.9%) and earthquake (14.6%). Significant number of respondents had indifferent attitude towards the willingness to pay insurance (about 1/3 respondents), which may be explained with insecurity, not being ready to respond or lack of knowledge. Significant relationship between experiences with damage and willingness to insure the residential houses/buildings for all three assessed natural disasters was demonstrated. More specifically, the connection between experience with flood damages and willingness to insure the residential building/house from this risk was determined. This also applies to the damage caused by landslides. For damages caused by earthquake, Chi-squared test assumptions were not met.

Willingness to purchase commercial insurance products was analysed based on the following features: possession of insurance policy for residential building/house, inclination to the risk retention and assessment of insurance system security. The share of respondents who have the insurance policy for residential building/house or related assets is relatively small (13.4%), and only at 15.4% of them the flood risk was included. However, regarding the structure of inclination to the risk retention from natural disasters, it was determined that 83.6% respondents were not inclined to the risk retention, 9.4% were indifferent to risk and 7.1% were inclined to risk. Exceptionally high percentage of respondents not inclined to the risk retention represents a potential for change of their attitude and behavior towards the insurance from natural disasters. Regarding the assessment of the insurance system security in terms of compensation for the damage caused by natural disasters, 37.4% respondents believe in the system, 24.9% do not believe, while 37.7% are indifferent. It implies the conclusion that majority of respondents do not have clear attitude or has negative attitude towards the security of compensation for the damages caused by natural disasters.

There is a significant connection between inclination to purchasing commercial insurance products for assets, inclination to the risk retention and perception of the insurance system security, on one side, and willingness to insure the residential building/house from all three assessed natural disasters, on the other side. More specifically, the relationship between inclination to purchasing commercial insurance products on one side and willingness to insure residential buildings/houses and/or assets from floods, landslides and earthquakes on the other side was determined. Relationship between inclination to the risk retention on one side and willingness to insure the residential building/house and/or assets from floods, landslides and earthquakes on the other side was determined. At the same time, relationship between perception of insurance system security and willingness to insure the residential building/house and/or assets from floods, landslides and earthquakes were determined. Besides, relationship between the willingness to insure residential building/house and belonging to the entity was also determined.

21.4.3 Financial aspects of damages caused by natural disasters to households

Financial aspects of damages contain the dimensions pertaining to the assessment of the amount of anticipated damages on residential building/house and assets in the building/house and possibilities to cover the damage outside of the insurance system.

The average value of the expected damage on construction part of the building/house, in case of eventual damages caused by flood, landslide or earthquake would total 46455 KM (st. dev. = 50020), while for assets in the building/apartment this value would be 12436 KM (st. dev. = 16006). Median value for the damages on construction part of the building/house totals 45000 KM, while for the assets in the building/apartment it totals 10000 KM.

It was determined that the respondents may compensate from their own resources in average 12.26% of the amount of damage caused by assessed natural disasters. If they took the loans in banks or microcredit organisations, they would be able to cover in average 12.39% of total damage. In case of hazardous event caused by the assessed natural disasters, 66% respondents expect to get donor grants (from international and local institutions and similar), while 18.6% does not expect to get the support, and 15.4% are indifferent.

21.4.4 Concept of insurance products from natural disasters for households

Dimensions of the concept of insurance product from natural disasters included the reliability of insurance, amount of insurance premium for construction part of the residential building/house and assets in them and the amount of expected insured sum (amount of expected compensation for the damage for the construction part and assets).

Study results confirmed the positive attitudes of respondents towards the obligatory insurance for residential buildings/houses by lower price compared to the commercial one. Majority of respondents demonstrated positive attitude towards the obligatory insurance from flood (49%), landslides (48.2%) and earthquake (34%). In the structure of responses, the percentage of indifferent attitudes is high, from 25.1 to 31.3%, which may be explained with insecurity, unwillingness to respond or lack of knowledge.

It should be emphasized that relationship between the attitude towards the obligatory insurance of residential buildings/houses and willingness to pay the insurance was determined. At the same time, there is a significant relationship between experiences with the damage and attitude towards the obligatory insurance of residential buildings/houses for all three assessed natural disasters. The results indicate the connection between exposure to risk and attitude towards the obligatory insurance. This relationship is particularly emphasized in danger zone from landslides and earthquake.

In case of attitude towards the obligatory insurance and possession of insurance policy, there is no relationship only in case of earthquake, while in case of other two natural disasters that relationship was identified.

There is relationship in attitude of respondents towards the obligatory insurance and their inclination to the risk retention. Besides, there is a relationship between the attitudes towards obligation to pay insurance and belonging to an entity. Similarly, connection was detected in case of perception of insurance system security and attitude of respondents towards the obligation to pay insurance.

The respondents are ready to pay for insurance of their residential building/house (construction part) from at least one of three natural disasters, in average the insurance premium in the amount of 126 KM (st. dev. = 317). Median value of insurance premium the respondents are ready to pay is 60 KM. When it comes to the insurance for assets in residential building/house from at least one of three natural disasters, the respondents said that they were ready to pay in average per year the insurance premium in the amount of 55 KM (st. dev. = 144), while median value totals 10 KM.

Maximum expected compensation from the insurer for the damage on the construction part of the building caused by at least one of three natural disasters that the respondents expect is about 10417 KM (st. dev. = 15321), while median value totals 5000 KM. When it comes to assets, the maximum expected compensation totals 4402 KM (st. dev. = 4949). Median value in this case is 500 KM. This may be used as the basis for future determining the potential average premium and insured sum for the package of insurance from natural disasters.

If the variable annual premium was applied, it would be possible to determine the variable expected compensation for the damage on construction part of building/house, as well as the damage on assets, as presented in the following tables.

Table 21-1: Expected premium and insured sum for the damages on construction part of building/house caused by natural disasters

Description	Amount (in KM)			
Annual insurance premium for construction part of the building/house	<= 30	31 60	61 - 100	101+
Expected compensation for insured construction part of building/house	3257	6483	11696	18539

Note: N = 524

Table 21-2: Expected compensation from insurance of assets in the building

Description	Amount (in KM)		
Annual insurance premium for assets in building/house	1-10	11 - 30	31+
Expected compensation for insured assets in building/house	864	3291	6445

Note: *N = 363*

One can notice that with increase of maximum amount of annual premium, the expected compensation from insurance increases as well, for both construction part of building/house and assets in building/house.

21.5 WILLINGNESS OF PUBLIC INSTITUTIONS TO PAY THE INSURANCE FROM NATURAL DISASTERS

Study results on willingness of public institutions to pay the insurance for building and related assets from natural disasters, such as floods, landslides and earthquakes are given in the second chapter of the reports.

The sample includes 135 public buildings, 61.7% being in the FB&H, and 38.3% in the RS. The public institutions from the following river basins were included: Bosna (50.4%), Korana/Glina (3%), Neretva (7.5%), Sava (0.8%), Sava/Drina (5.3%), Trebišnjica (2.3%), Ukrina (0.8%), Una (15.8%) and Vrbas (14.3%).

The sample structure is such that 64.6% respondents are located in urban area, 15.9% in suburban area and 19.5% in rural area. According to the activity, most of the interviewed public institutions, 69.1%, are related to education sector, followed by public administration 23.5% and 4.9 and 2.5% in health and culture, respectively.

The average number of employees in public institutions included in this this study is 71.5, with standard deviation 72, and median value 52.5. Besides, the average number of buildings/facilities within public institution is 3.6 (standard deviation is 3.7, and median value 2), one being the minimum number of buildings and 25 being the maximum number.

The text below provides descriptive statistical analyses about identification of needs of public institutions for insurance from natural disasters, financial aspects of damages caused by natural disasters and concept of insurance from natural disasters.

Important to note is that the data analysis for public sector institutions, the Chi-squared test assumptions were not met, so that eventual mutual relationships could not be objectively noticed, which may be used as a guidance in some future assessment and study.

21.5.1 Identification of public institutions needs for insurance from natural disasters

The covered dimensions of needs for insurance from natural disasters are related to the experience with damages, awareness on exposure to risks form natural disasters, willingness to insure buildings from natural disasters, inclination to purchasing commercial insurance products for assets and inclination to the risk retention.

Study results showed that public institutions significantly need the insurance from natural disasters, demonstrated through willingness to pay insurance from flood and earthquake. The need for insurance from landslides was smaller.

Significant aspects of identification of needs for insurance from the mentioned natural disasters pertain to the experience and assessment of exposure to the risks. Based on analysis of experience with damages and awareness on exposure to the risks from natural disasters, it was determined that there was a higher level of respondents' awareness on exposure to risks from natural disasters compared to the experience with damages. So, 40.7% respondents experienced the flood damages, while 43.9% are aware of the risk from this disaster. Landslides were experienced by 10.2% respondents, while 12.2% are aware of this risk. The least of public institutions, 5.5% of them, experienced the earthquake, while 35.4% are aware of this risk. Time aspects of extreme hazardous disaster events were determined. Majority of flood damages (33 of 46), landslide damages (7 of 10) and earthquake damages (2 of 4) happened in 2014.

Specifically, when it comes to willingness to pay the insurance from natural disasters, 70.9% of respondents are ready to pay insurance from earthquake, 65.1% from flood and 41.9% from landslides. Considering the share of indifferent attitudes in the structure of replies (19.8% for earthquake, 14% for floods and 12.8% for landslides) the highest lack of willingness to pay insurance was noticed for landslides (45.3%).

Inclination to purchasing commercial insurance products was analysed based on the following features: possession of insurance policy for construction part of building or equipment, inclination to the risk retention and assessment of insurance system security. The share of respondents who have the insurance policy for building or equipment is 34.1%, and at 46.4% of them the flood risk was included. However, regarding the structure of inclination to the risk retention from natural disasters, it was determined that even 70.2% respondents were not inclined to the risk retention, 17.9% were indifferent to risk and only 11.9% were inclined to the risk retention. Exceptionally high percentage of respondents not inclined to the risk retention in the public institutions represents a potential for change of attitude towards the insurance from natural disasters.

Regarding the assessment of the insurance system security in terms of compensation for the damage caused by natural disasters, 15.6% respondents believe in the system, 35.4% do not believe, while 49% are indifferent. It implies the conclusion that majority of respondents do not have clearly defined attitude or has negative attitude towards the security of compensation for the damages caused by natural disasters.

21.5.2 Financial aspects of damages caused by natural disasters to public institutions

In case of flood, landslide or earthquake risks, the average value of anticipated damage on construction part of the building's totals 366756 KM (st. dev. = 775250), while for equipment in building this value totals 178803 KM (st. dev. = 578644). Median value for the damages on construction part of the building totals 100000 KM, and for equipment in the building 50000 KM.

It was determined that the respondents may compensate from state, entity, cantonal or institution budget in average 43.3% of the amount of damage caused by assessed natural disasters. In case of damages caused by the assessed natural disasters, 62.5% respondents expects to get donations (from international and local institutions and similar), while 6.3% does not expect to get the support, and 31.3% are indifferent.

21.5.3 Concept of insurance products from natural disasters for public institutions

Dimensions of the concept of insurance from natural disasters included the obligation of insurance, amount of insurance premium for construction part of the building and equipment and the amount of expected insured sum (amount of expected compensation for the damage on construction part and equipment).

Study results confirmed the positive attitudes of respondents towards the obligatory insurance for public building and equipment by lower price compared to the commercial one. Majority of respondents demonstrated positive attitude towards the obligatory insurance from flood and earthquake (73.3% each) and landslides (66.3%). In the structure of responses, the percentage of indifferent attitudes is not negligible (20.9% for floods and 23.3% for landslides and 23.3% for earthquake), which may be explained with lack of knowledge or unwillingness to respond.

The respondents are ready to pay for insurance of the construction part of the building from at least one of three natural disasters, in average, the insurance premium in the amount of 854 KM (st.dev. = 1170). Median value of insurance premium the respondents are ready to pay is 500 KM. When it comes to the insurance for equipment in building from at least one of three natural disasters, the respondents said that they were ready to pay in average per year the insurance premium in the amount of 681 KM (st. dev. = 1346), while median value totals 300 KM.

Maximum expected compensation from the insurer for the damage on the construction part of the building caused by at least one of three natural disasters that the respondents expect is about 158029 KM (st. dev. = 250379), while median value totals 50000 KM. When it comes to the equipment, the maximum expected compensation totals 106768 KM (st. dev. = 193630). Median value in this case is 40000 KM. This may be used as the basis for future determining the potential average premium and insured sum for the package of insurance from natural disasters.

21.6 WILLINGNESS OF BUSINESS SUBJECTS TO PAY THE INSURANCE FROM NATURAL DISASTERS

This chapter of the report includes the study results on willingness of business subjects to pay insurance for business buildings, equipment and commodities in building. Of natural disasters, the following were included in the study: flood, landslide and earthquake. Of insured objects, the following are addressed: construction part of building, equipment and stock in building.

Sample size is 490 business entities (18 of 508 delivered questionnaire were not fulfilled correctly), 55.7% from the FB&H, and 44.3% from the RS. Business located in the following river basins are included: Bosna (44%), Vrbas (18.6%), Una (12.3%), Neretva (9.4%), Sava/Drina (6.6%) and others (.

In urban area there are 44.6% assessed business entities, 44.3% being in suburban and 11.1% in rural settlements. Looking at the activity of the assessed businesses, 51.9% are involved in provision of services, 33.7% production and 14.4% trade. Majority of the businesses (51.3%) has less than 10 employees. Owners/Managers/Decision makers in the companies are dominantly male (83.8%), with university degree (48.5%). The average age of decision makers is 48.65 years (st. dev. = 9.622), where the youngest decision maker is aged 25, and the eldest 73. The average generated income in the last business year for the assessed businesses totals 10221351 KM (st. dev. = 45581927), where the lowest generated income totals 100 KM, and the highest 523880345 KM.

The study determined that insurance from natural disasters is an adequate alternative to compensation for the damage in terms of the own resources, credits and donations. Significant aspect of needs of business subjects for insurance from natural disasters have been identified. Financial outcomes of potential damages caused by the assessed natural disasters have been estimated. The key features of insurance products package for business buildings, equipment and stocks in building for business subjects have been identified, pertaining to obligation, anticipated amount of premium and compensation of damage.

21.6.1 Identification of needs of business subjects for insurance from natural disasters

Analysis of needs of business subjects for insurance from natural disasters include the aspects pertaining to the experience with damages, awareness on exposure to risks from assessed natural disasters, willingness to insure business buildings and equipment/stock from natural disasters, inclination to purchasing commercial insurance products for assets and inclination to the risk retention.

The obtained results show that the business subjects have a significant need for insurance from natural disasters, particularly in terms of the awareness on exposure to risks demonstrated through willingness to pay the insurance from the assessed natural disasters.

To identify the needs for insurance from the assessed natural disasters, the experience and estimated exposure to risks have been observed. The flood damages are experienced by 30.4% businesses, while 31.9% of them are aware of risk from this natural disaster. 5.2% businesses experienced landslides, while 9.4% are aware of the risk from this natural disaster. The earthquake experienced 1.3% assessed business subjects, while 18.5% are aware of this risk. Based on those results, it was demonstrated that there is a higher level of awareness of respondents on mentioned risks, compared to the own experience. The time aspect of the natural disaster damages was analysed. It was determined that majority of flood damages (119 of 171) and landslide damages (16 of 38) happened in 2014. For the damages caused by earthquake, the year of extreme hazard was not determined. There is a relationship between the experience with flood damage and awareness of belonging to the danger zone of this natural disaster. For remaining two natural disasters, the conditions for use of Chi-squared test were not met.

Regarding the willingness of businesses to pay the insurance from natural disasters, the willingness to pay the insurance from flood was determined at 39.8% respondents, from landslides at 25.6% and earthquake at 30.9% respondents. About 16% of respondents had indifferent attitude towards the willingness to pay insurance. There is significant relationship between experiences with flood damage and willingness to insure the business buildings and equipment/stocks from this risk. For the damages caused by landslides, the conditions have not been met for application of the Chi-squared test.

To analyse the willingness of businesses to purchase commercial insurance products the following features have been assessed: possession of insurance policy for business building or equipment/stocks, inclination to insurance, inclination to the risk retention and assessment of insurance system security.

It should be particularly noted that 46.9% business subjects have insurance policy, 45.5% with included flood risk. Regarding the inclination to insurance, it was demonstrated that 39.3% respondents have positive attitude towards the insurance policy with flood risk included, regardless the fact that premium amount would increase. As for inclination to the risk retention from natural disasters, the results showed that 15.3% businesses are inclined to the risk retention, 28% are indifferent and 56.8% are not inclined to risk. The significant percentage of respondents with indifferent attitude represents the potential for change of their attitude and behaviour towards the insurance from natural disasters. In the context of perception of insurance system security, it was determined that there is relatively small percentage of respondents who have confidence in the system (25.7%), while 36.6% of them had negative attitude, and 37.6% were indifferent. Based on that, the conclusion is that majority of respondents does not have clear attitude or has not confidence in the insurance system when it comes to the compensation of the damages caused by natural disasters.

There is a significant connection between willingness to pay insurance for business building and equipment/stocks in building for all three assessed disasters and the following variables:

Inclination to purchasing commercial insurance products, Inclination to the risk retention and Perception of insurance system security.

21.6.2 Needs of large enterprises for early warning system and insurance from natural disasters

For seven business subjects estimated as in need for the early warning system on possible floods and/or torrents threatening their business operations, the questionnaire included two questions in which the business subjects were expressing their attitudes about the need for this type of information. On question on willingness to pay for regular receipt of high-quality information on hydrometeorology and climate conditions aimed at better performance of business operations, three companies responded positively, one being hydro power plant saying that it was already paying for such information. In addition, one airport specified that they already had that information available, considering the type of activity they perform. Two businesses (one mine and one airport) specified they were not ready to pay, and one business did not respond at all to this question. All business subjects responded the same the question on interest in payment for information related forecasts/early warning about coming flood and/or torrent threatening performance of business operations.

Three of those seven enterprises suffered the flood and landslide damages (all hazards happened in 2010). In one company involved in construction and maintenance of roads, the damages happened also in 2015, 2017 and 2018. Four business subjects are aware of exposure to flood risk, three are aware of exposure to landslides risk, and only one business is aware of exposure to earthquake risk. Three business subjects demonstrated positive attitude towards the obligation of insurance from floods and landslides, and two towards the insurance from earthquake. Not a single business was inclined to risk keeping, but confidence in the insurance system was present at three businesses only. Despite the expressed inclination to insurance, only three business subjects showed the willingness to pay insurance from floods and landslides, and only one business was ready to pay insurance from earthquake.

21.6.3 Financial aspects of damages caused by natural disasters to businesses

Financial aspects of damages caused by natural disasters at businesses were analysed through assessment of the amount of anticipated damages on business building, equipment in building and stock in business building. In addition, possibilities of business subjects to cover the damages outside of the insurance system were also assessed.

The average value of the damage on construction part of the building, in case of eventual damages caused by flood, landslide or earthquake would total 382318 KM (st. dev. = 1156608), while for equipment in the building this value would be 274337 KM (st. dev. = 1002987) and for stocks 208017 KM (st. dev. = 1007619). Median value for the damages on construction part of business building totals 60000 KM, while for equipment in the building it totals 40000 KM and for stocks in the building 30000 KM.

It was determined that 35.03% businesses may compensate from their own resources the damages caused by assessed natural disasters. In average, 42.48% businesses would be able to cover the damages by taking the loans. Regarding expectations in terms of financial support by donors (international and local institutions, and similar) in case of damages caused by natural disasters, 25.5% respondents expect to get donation, 40.1% does not expect to get donation and 34.4% are indifferent.

21.6.4 Concept of insurance product from natural disasters for businesses

Concept of insurance from natural disasters of previously analysed segments, for the segment of businesses is a bit expanded. The following aspects are included: obligation of insurance, amount of insurance premium for construction part of business building, equipment and stocks, and the amount of expected insured sum (amount of expected compensation for the damage for the business building, equipment and stocks).

Despite majority of negative attitudes of respondents to obligation of insurance for businesses by lower price compared to the commercial one, there is relatively significant percentage of businesses with positive attitude towards these features of insurance products, for mandatory insurance from floods (34.8%), landslides (32.3%) and earthquake (34%). In the structure of responses, the percentage of indifferent attitudes is high (about 23%), which is probably the result of insecurity or unwillingness of management of businesses to respond.

There is a connection between mandatory insurance of business buildings and other covered variables, such as:

- Willingness to insure business buildings and equipment/stocks in building from all three assessed natural disasters;
- Experience with flood damages, while for other damages the test conditions have not been met.
- Exposure to landslide and earthquake risks, while for flood risk the test condition has not been met.
- Inclination to risk retention for all three natural disasters.
- Inclination to insurance of business building and equipment/stocks from all three natural disasters.
- Mandatory inclusion of flood risk into insurance policy for business building and equipment/stocks with increase of insurance policy price.

Fixed and variable annual insurance premium and insured sum were estimated in the context of assessed natural disasters for business buildings, equipment and stocks.

Businesses are ready to pay for insurance of business building from at least one of three natural disasters the insurance premium in the amount of 20368 KM (st. dev. = 200910). For the same natural disasters, median value of insurance premium they are ready to pay is 500 KM. The average annual insurance premium for equipment in business building from at least one of three natural disasters totals 27278 KM (st. dev. = 261748), while median value is 500 KM. For insurance of stocks in business building from the assessed natural disasters, the average annual insurance premium totals 5015 KM, and median value 500 KM.

Anticipated compensation from insurer for the damage on business building caused by at least one of three natural disasters totals 3528062 KM (st. dev. = 32970513), while median value is 50000 KM. Regarding the equipment, the maximum anticipated compensation totals 2308865 KM (st. dev. = 24100863). Median value in this case totals 30000 KM. Anticipated compensation for the damage on stocks caused by natural disasters totals 388555 KM (st. dev. = 1684793), and median value is 30000 KM. Those findings may be used as a basis for future determining of the average insurance premium and insured amount for the insurance products package related to the assessed natural disasters.

Using variable annual premium, the average variable compensation was determined, for both damages from assessed natural disasters on business building and damages on equipment and stock, as presented in the following tables.

Table 21-3: Anticipated premium and insured sum for the damages on business building caused by natural disasters

Description	Amount (in KM)			
Annual insurance premium for construction part of building	<=200	201-500	501-2000	2001+
Anticipated compensation for insured construction part of building	53718	130156	244893	15464242

Note: N = 157

Table 21-4: Anticipated premium and insured sum for the damages on equipment in building caused by natural disasters

Description	Amount (in KM)			
Annual insurance premium for equipment in building	<= 200	201-500	501-2000	2001+
Anticipated compensation for insured equipment in building	29321	130566	187280	9404355

Note: N = 149

Table 21-5: Anticipated premium and insured sum for the damages on equipment in building caused by natural disasters

Description	Amount (in KM)			
Annual insurance premium for stocks in building	<= 150	151 - 500	501 - 1200	1201+
Anticipated compensation for insured stocks in building	19369	357537	236050	996400

Note: N = 121

Presented data indicate that with increase of maximum amount of annual premium, the anticipated compensation for insurance of business building and equipment in building also increases. This does not apply to stocks, which means that respondents did not understand very well the problems related to insurance of stocks. In the last interval of the expected annual insurance premium for all three types of the subject of insurance, anticipated compensations have drastically increased compared to the previous intervals. That is the consequence of inclusion of large enterprises in the sample, whose expectations regarding the insurance premium and insured amount exceed significantly other business subjects.

21.7 WILLINGNESS OF AGRICULTURAL PRODUCERS TO PAY THE INSURANCE FROM NATURAL DISASTERS

The fourth chapter of the report presents the key study results on willingness of agricultural producers to pay the insurance for crops, products and/or cattle from natural disasters, such as floods, drought, hail and other hazards (frost, storm, etc.). The needs of agricultural producers for insurance from the mentioned disasters have been identified, financial aspects of damages from those disasters have been evaluated and the concept of insurance product for crops, products and/or cattle in farms has been proposed.

The sample includes 504 farms, 60.7% being in the FB&H, and 39.3% in the RS. They are located within the following river basins: Bosna (40.9%), Korana/Glina (3.4%), Neretva (12.5%), Sava/Drina (5.4%), Trebišnjica (2.4%), Ukrina (3.2%), Una (12.9%) and Vrbas (19.4%).

The farms are located in rural (84.5%) and suburban area (15.5%). Agriculture is the main activity of 45.8% respondents, while annual income from specific agricultural activity is to 3000 KM (22.3%), 3001-5000 KM (25.5%), 5001-8000 KM (26.9%) and 8001 KM and more (25.3%), but 64.1% of them said that they had additional sources of income as well. When it comes to the size of the assessed farms, 78.9% respondents owned 10 dunum of land or less. Dominant agricultural crops are grains, fruits and/or vegetables. The biggest percentage of farms keeps cattle (42.3%) and poultry (42.1%).

Farm owners are dominantly male (91.1%), with high school degree (81.7%). The average age of the farm owner is 58 years (median value is 60, and standard deviation is 11.5), where the youngest farm owner is 26, and the eldest 85.

21.7.1 Identification of agricultural producers needs for insurance from natural disasters

Results of this part of the study lead to a general conclusion that agricultural producers do not demonstrate clearly the need for insurance from natural disasters, although they are aware of the exposure to those risks. When it comes to the experience with the damages caused by natural disasters, majority of respondents, 52.4%, suffered the damage from flood. The second most frequent natural disaster they suffered the damages from is the hail (22.6% respondents). The agricultural producers suffered the least the damages from drought and other natural disasters (13.3% respondents). Besides, based on the analysis of the awareness on exposure to flood risk, it was concluded that 54.8% respondents are aware of the exposure to this type of risk. At the same time, the time aspect of the hazards from natural disasters so far has been clarified. Most of the flood damages (227 of 246) happened in 2014, while most of the drought, hail and other natural disasters damages happened in 2017 (more precisely, 20 of 53, 32 of 97 and 17 of 45, respectively).

When it comes to willingness to pay the insurance from natural disasters, there is relatively small percentage of those ready to pay the insurance from floods (8.7% respondents), drought (10.5%), hail (10.7%) and other natural disasters (8.4%). Majority of respondents (about ¾) did not show any interest to pay the insurance from natural disasters, while 14-15% (depending on disaster) was indifferent towards the insurance. However, there is a significant relationship between the experiences with damage and willingness to pay the insurance for crops, products and cattle from all assessed natural disasters.

There is a significant relationship between the willingness to pay the insurance from drought and hail, on one side, and location of the farm, on the other side.

Of total respondents, only three of them (0.6%) have insurance policy for crops, products or cattle, and the policy of two those respondents includes the flood risk. However, regarding the inclination to the risk retention from natural disasters, it was determined that 24.4% respondents were not inclined, and 22.7% were inclined to the risk retention under their own coverage. Surprisingly high is the percentage of respondents, 52.9%, who are indifferent towards the risk, in fact has no attitude towards the (in)significance of the insurance. Exceptionally high percentage of respondents indifferent and not inclined towards the risk retention may represent a potential for change of their attitude and behaviour towards the insurance from natural disasters. Regarding the assessment of reliability of the insurance system when it comes to compensation for the damage from natural disasters, 7.8% respondents believe in the insurance system, 45.9% do not believe in it, while 46.3% do not have emphasised attitude on reliability of the insurance system. In leads to a conclusion that biggest percentage of respondents (about 92%) does not know the insurance system nor has not confidence in it, and consequently, the need of the insurers to work on awareness raising of agricultural producers on benefits of the insurance and gaining the higher confidence rate. There is a significant relationship between perception of reliability of the insurance system and willingness to pay the insurance for crops, products and/or cattle from all natural disasters.

Furthermore, there is a significant relationship between inclination to the risk retention and willingness to insure the crops, products and/or cattle from all assessed disasters. In other words, it was determined that the respondents who were not inclined to the risk retention, on one side were ready to insure the crops, products and/or cattle from floods, drought, hail and other natural disaster, on the other side.

21.7.2 Financial aspects of damages caused by natural disasters to agricultural producers

The average value of the expected damage on crops in case of eventual damages caused by flood, drought, hail and other natural disaster totals 9900 KM (median value is 4000 KM, and standard deviation is 66767 KM), while for cattle the average value of expected damage is 3546 KM (standard deviation is 3284 KM). The average value of total expected damage is 13446 KM.

It was determined that the respondents may cover from their own sources about 21.02% of damage from natural disasters, and more than half of them may not compensate for the damage from their own resources (median value is 0). With the bank loans or loans from microcredit organisations they would be able to cover about 7.2% of total damage, and more than half of them (median value 0) cannot cover the damage by taking the loan. In case of the damage caused by natural disasters, 37.3% respondents expect to the donation (from international and local institutions, and similar), while 36.3% of them do not expect to get the support, and 26.5% is indifferent.

Only 23.8% respondents receive subsidies and state support or support from local self-governance unit for agricultural businesses, and even 97.2% are not satisfied with the work of the state and its institutions on protection from natural disaster risks.

21.7.3 Concept of insurance products from natural disasters for agricultural producers

Study results indicate that about 50% respondents are indifferent to obligation of insurance for crops, products and/or cattle (by lower price compared to the commercial one), which may be explained by their lack of knowledge and unwillingness to respond. While 18.1% of respondents have positive attitude to obligation to pay the insurance for crops, products and/or animals from floods and drought, 31.7% have negative attitude; 17.9% respondents have positive attitude towards insurance for crops, products and/or cattle from hail, and 31.9% have negative attitude. Regarding the insurance from other natural disasters (e.g. frost, storm and similar) 14% have positive attitude, and 33.7% negative attitude.

When it comes to the amount of annual insurance premium for crops and products, as well as cattle, majority of respondents (55%) are ready to pay the annual premium of 100 KM or less.

Majority of respondents, 62.5 and 60%, expects the amount of 1000 KM or less as compensation for the damage on crops and products, as well as cattle. This may be used as the basis for future determining of average premium and insured amount.Furthermore, there is a significant relationship between the attitude to obligation to insure crops, products and cattle from flood and drought and annual income of agricultural farm, as well as the attitude to obligation to insure the crops, products and cattle from flood and the age of farm owner. There is a significant relationship between the attitude to obligation to pay insurance from natural disasters and the entity of the farm, except for the case of insurance from hail.

It should be noted here that significant relationship is determined between the attitude to obligation to insure crops, products and cattle and willingness to pay insurance from drought only. At the same time, there is a significant relationship between the attitude to obligation to insure crops, products and cattle and experience with the damage from all natural disasters.

There is a significant relationship between the attitude to obligation to pay insurance and inclination to the risk retention, as well as the attitude to the obligation and perception of insurance system security.

21.8 CONCLUSIONS AND RECOMMENDATIONS

Generally, the conclusion is that all assessed segments (households, public institutions, business subjects, agricultural producers) have relatively high needs for insurance from natural disasters considering the situation and level of development of insurance market in B&H. There is a significant potential for development of insurance package from natural disasters for all four assessed segments. High percentage of respondents is not inclined to the risk retention in all assessed segments represent a potential for change of their attitude and behaviour towards the insurance from natural disasters. The respondents have positive attitude to obligation to insure from assessed disasters by lower price compared to the commercial one. For households, public institutions and business subjects, the fixed anticipated premium and insured amount for construction part of building and assets is determined (and stocks for businesses) for insurance from floods, landslides and earthquakes. For households and businesses, the variable premium and insured amount is estimated as well. Fixed expected premium and insured amount is determined for agricultural producers for insurance from floods, drought, hail and other disasters.

Therefore, the most important implications of this study pertain to identification of potential product packages for insurance from natural disasters for the assessed segments. However, there are certain challenges in concept generation regarding its clarity, estimated desired benefit, interests, possible development, and similar, that could have a potential for diversification of insurance risks for the assessed segments aimed at their protection. In that sense, recommendations have been determined enabling development of knowledge and awareness on importance of insurance from natural disasters and generation of new concept of insurance products package from natural disasters adjusted to the needs of the assessed segments and insurers which would require comprehensive surveys.

21.8.1 Recommendations for introduction of new insurance products from natural disasters for households

Key recommendations for introduction of new insurance product from natural disasters for households would be:

Organise the awareness campaign for citizens on importance of insurance from natural disasters, taking into consideration the entity, experience with damages, awareness on exposure to risks of natural disasters, willingness to insure residential buildings/houses from natural disasters, inclination to purchasing commercial assets insurance products, inclination to the risk retention, etc.

Design and introduce the insurance product from natural disasters including unified risks from floods, landslides and earthquakes. Particularly should be considered the possibility of mandatory insurance of this kind. The concept of the specific product should be assessed among insurers as well as among the citizens. It is necessary to assess the models available in some developed countries or some countries at the similar level of development (such as Romania), particularly in the segment of normative, organisational and distributive solutions. Models of new products could be with fixed and variable premium, as well as insured sum, on which the brokers at international reinsurance market should be consulted.

21.8.2 Recommendations for introduction of new insurance products from natural disasters for public institutions

For public institutions, the following recommendations for design of insurance product from natural disasters are given:

The biggest willingness of public institutions was demonstrated regarding the insurance from floods and earthquakes, while they were the most aware of the exposure to risk from floods. Consequently, at about half of the insured respondents, the insurance policy includes the flood risk. Significant percentage of the respondents who are not inclined to the risk retention under their own coverage or those with indifferent attitude to the insurance system may mean for the insurers the potentially new market segment (because the institutions believe that about 43% of total damage from natural disasters may be covered from the budget). Intensive marketing campaign should be conducted here, including not only awareness on importance of insurance, but confidence building in insurance industry, with emphasis on coverage of the flood damages. Determined parameters in terms of median value of annual insurance premium for construction part of public building(s) or equipment from natural disasters in the amount of 500 and 300 KM as well as median value of anticipated compensations for the damages caused by natural disasters in the amount of 50000 and 40000 KM may be used by the insurers as the starting point while determining the price and scope of coverage for insurance products.

Important conclusion is that even 2/3 to 3/4 of interviewed public institutions (education, public administration, health and culture) demonstrated positive attitude towards the obligation to pay insurance from all assessed natural disasters. Particular question of interest was to the need to make comprehensive assessment of further acceptable model(s) of implementation of mandatory insurance.

21.8.3 Recommendations for introduction of new insurance product from natural disasters for business subjects

Key recommendations for introduction of new insurance product from natural disasters for businesses are:

Study results indicate the need for organisation of the awareness campaign for management of business subjects on importance of insurance from natural disasters and building the confidence in the insurance system. In that sense, it would be necessary to consider the variables pertaining to the need for insurance from natural disasters, such as experience with damages, awareness on exposure to risks, inclination to insurance of assets, inclination to the risk retention, etc.

The campaign should be organised for big enterprises as well but focusing on the early warning system about future floods and/or torrents, as well as other natural disasters threatening the performance of activities by those businesses.

Design and introduce the insurance products package from natural disasters for business subjects including unified risks from floods, landslides and earthquakes. The model of new products package should include the aspects of mandatory/voluntary insurance, fixed and/or variable premium and fixed and/or variable insured sum. At the same time, the concept of new product should comply with the activity, size of business, value of business buildings/equipment/stocks, etc. Specific products package should be defined through comprehensive assessment of businesses, insurers, capital market stakeholders, state institutions, etc.

21.8.4 Recommendations for introduction of new insurance products from natural disasters for agricultural producers

For agricultural producers, the following recommendations for design of insurance product from natural disasters are given:

Although aware of the exposure to risks from natural disasters, agricultural producers are not ready to purchase commercial (private) insurance. However, since the significant relationship between the experience with damages and willingness to insure the crops, products and cattle from all assessed natural disasters is determined, the work should be done on the awareness on natural disasters, their hazardous effects, and the agricultural producers should be educated about benefits and opportunities for purchase of insurance (through brochures, training programmes, counselling, etc.). At the same time, exceptionally high percentage of respondents indifferent and not inclined to the risk retention under their own coverage may represent a new market segment for insurers. More active role of state and/or local self-governance units may, through certain public-private partnership, go towards the farmers, aimed at provision of insurance policies by subsidized prices. Gaining the higher confidence of agricultural producers in insurance industry is also a question of particular interest.

Considering that in case of damages caused by natural disasters, majority of the damage (about 80%) the agricultural producers would not be able to cover from their own resources, and are not ready to pay for commercial insurance from flood, and are mainly indifferent to the mandatory insurance (except for drought), one should consider in this case the possible models of mandatory insurance from floods, and, at the same time, acceptable ways to implement the selected model, previously communicated to agricultural producers. Solutions of this issue should be related to the policy of the government when it comes to the subsidies, in fact incentives to agricultural producers.

Finally, this study may be the basis for development of the insurance package model for natural disasters, which would ensure with its performances the diversification of insurance risk for different market segments (households, public institutions, business subjects and agricultural producers) aimed at their protection. Model of insurance package from different natural disasters could be adjusted to different market segments, possible scenarios and assessment of risks, as well as estimated damage and insured losses. Development of insurance package model for natural disasters could be implemented through synchronization and engagement of relevant state institutions, insurers and reinsurers, financial institutions, capital market institutions, etc.