INECC
INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO

GREEN CLIMATE FUND

FONDO MEXICANO PARA LA CONSERVACIÓN DE LA NATURALEZA, A.C.
FMCN INSTITUCIÓN PRIVADA

River Restoration for Climate Change Adaptation (RIOS)

Pre-feasibility study

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Abbreviations and acronyms

AFD	French Development Agency
ANVCC	National Atlas of Vulnerability to Climate Change
CSO	Civil Society Organization
C6	Coastal Watersheds Conservation in the Context of Climate Change project
ES	Ecosystem Services
FGM	Gulf of Mexico Fund (*Fondo Golfo de México, A.C.*)
FIRA	National Trust for Rural Development (*Fideicomisos Instituidos en Relación con la Agricultura*)
FMCN	Mexican Fund for the Conservation of Nature (*Fondo Mexicano para la Conservación de la Naturaleza, A.C.*)
FONNOR	Northwest Fund (*FONNOR, A.C.*)
GAP	Gender Action Plan
GCF	Green Climate Fund
GCM	Global Circulation Models
GEF	Global Environment Facility
GHG	Greenhouse Gas
ISPS	Intensive Silvopastoral Systems
INECC	National Institute of Ecology and Climate Change (*Instituto Nacional de Ecología y Cambio Climático*)
IRR	Internal rate of return
Mm3	Million m3 per year
IWAP	Integrated Watershed Action Plan
NDCs	Nationally Determined Contributions
NLC	National Learning Community
NPV	Net present value
PLAT	Local Provider of Technical Assistance (*Proveedores Locales de Asistencia Técnica)*
PES	Payments for Ecosystem Services
PfP	Pay-for-Performance
tCO2e	Tons of CO2 equivalent
TA	Technical Assistance
TC	Technical Committee
UNFCCC	United Nations Framework Convention on Climate Change

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Executive summary

Mexico´s geographic characteristics make it a highly vulnerable country to the adverse impacts of climate change. Its location between two oceans, as well as its latitude and topography significantly increase its exposure to extreme hydro-meteorological events (NDC, 2015). Various models predict that hurricanes will intensify, and drought and forest fires will increase. Coastal communities will be more vulnerable to flooding, and communities in the mountains will suffer increasingly from landslides, drought, and wildfires. The impacts of climate change will be most evident in the coastal watersheds of the Gulf of Mexico and the Gulf of California-Pacific, where deforestation is driven by demographic growth, urban expansion, and lack of enforcement of environmental regulations. Forests are cleared or burned for ranching, sugar cane, and illegal extraction of natural resources. If no action is taken, studies show increasing soil erosion, landslides, loss of productivity, filling of rivers with sediments, floods, and drought.

The proposed Project RIOS contributes to Mexico's national green growth agenda according to its General Law on Climate Change Law of 2012 (GLCC). The GLCC was amended in 2018 to incorporate the Nationally Determined Contribution (NDC). Under the NDC adaptation component, Mexico committed to reducing vulnerability to both extreme hydro-meteorological phenomena and long-term environmental degradation processes. The component includes measures in three main areas: adaptation of the social sector, ecosystem-based adaptation, and adaptation of strategic infrastructure and productive sectors.

According to the NDC, ecosystem-based adaptation consists of the conservation of biodiversity and ecosystem services as part of an integrated strategy to assist human communities to adapt to the adverse effects of climate change. Within this area, Mexico has set to implement the following actions by 2030:

i. Reach a rate of 0% deforestation by the year 2030.

ii. Reforest high, medium, and low watersheds with special attention to riparian zones and considering native species in the area.

iii. Conserve and restore ecosystems to increase ecological connectivity of all protected areas and other conservation schemes, through biological corridors and sustainable productive activities. This approach will consider the equitable participation of the population and will have a territorial approach.

The territorial approach that RIOS has selected is watersheds. They are territories defined by a system of rivers. In coastal watersheds, vegetation that connects mountains to the sea provides important ecosystem services, which are key to address the impacts of climate change. Through a geo-hydrological perspective, RIOS will thus focus on increasing watershed connectivity through river restoration, which includes restoring soils and forests along rivers and in areas of hydrological importance. The resulting biological corridors will improve ecosystem services in highly sensitive landscapes. Increasing adaptive capacities of the communities will also be favored by this territorial approach. The focus on watershed management and territorial planning seeks the integration of stakeholders sharing common problems instead of addressing dispersed problems by sectors, and thus overcome the fragmented or sectorial vision of territorial intervention (Cotler, 2007).

Mexico has two mountain ranges that cross the country from north to south and a volcanic system that runs from east to west. It also has an extensive coastline that is exposed to extreme weather events. These mountain systems, valleys, and coastal plains form a set of 757 watersheds with particular characteristics depending on their geographical location (CONAGUA, 2017). Among all these basins the present proposal selected two, one that drains towards the Pacific, the Ameca-Mascota basin in the state of Jalisco, and the Jamapa basin that drains into the Gulf of Mexico in the state of Veracruz. In the lower part of these basins, there are important human settlements, seaports, and high productivity of the agricultural, industrial, tourism, and commercial sectors, which are all vulnerable to climate change.

The selected basins, like many others of similar characteristics in the country, possess a high vulnerability to landslides, floods, and droughts. In basins of this type, coastal and of rapid response, the processes of runoff and infiltration are very sensitive to the loss of plant cover, since the water, finding no barriers in its path, tends to drain faster and infiltrate less. This will be exacerbated in the context of climate change where precipitation concentration is projected to be higher in less time and with longer periods of low water (INECC, 2019).

The RIOS project builds on the experience and information generated in these basins over the past six years through the GEF-funded project, "Coastal Basin Conservation in the Context of Climate Change" (C6) implemented by INECC, FMCN and other government institutions. This initiative generated local capacity with the creation of two regional funds and a collaborative network that included CSOs, government, and key local stakeholders. In the framework of this project, Integrated Watershed Action Plans (IWAPs) were designed for the Ameca-Mascota and Jamapa basins, based on geo-hydrological models and proposing Ecosystem-based Adaptation (EbA) activities, which were widely consulted with local stakeholders.

The IWAPs characterize the relationship between supply of and demand for environmental services between sub-basins. The environmental services selected for their importance in the watersheds are soil retention and water supply. Their modeling made it possible to identify priority activities to conserve and recover tyde services as an adaptation response. In line with ecosystem-based adaptation, the IWAPs guide land use activities that favor the environmental services of the watershed.

According to the IWAPs, RIOS proposes to carry out activities that increase the vegetation cover in riparian systems and slopes, as well as in areas for spring protection or for infiltration and soil retention. The aim is to reduce the vulnerabilities observed in the climatic regions, mainly: vulnerability of human settlements to flooding, of human settlements to landslides, of extensive livestock farming to water stress and fodder production to water stress. The proposed activities will: (i) reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses; (ii) increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration; (iii) conserve soil for productive activities; (iv) moderate extreme temperature thanks to vegetation coverage. As a result of these activities, RIOS aims to reduce vulnerability to the impacts of climate change, mainly by decreasing exposure to landslides, floods, and drought. Likewise, the project seeks to augment the adaptive capacity of the population and ecosystem resilience as a key strategy in a country where two-thirds of the territory are mountains and therefore highly sensitive to climate change (World Bank, 2010). Alignment of investments in the basins will also contribute to the increase in people's adaptive capacity and ecosystem resilience. The lessons learned from these activities will feed into the development of a National Strategy for River Restoration, which will allow for scaling-up actions to reduce vulnerability to climate change throughout Mexico's watersheds. These will support to the livelihoods of watershed-dependent communities and will increase the provision of ecosystem services.

RIOS has three components: i) Component 1: Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices, ii) Component 2: Alignment of public and private investments through natural capital accounting for scaling-up activities for the restoration of rivers for adaptation to climate change, and iii) Component 3: Design of a National River Restoration Strategy (NRRS) for climate change adaptation.

This pre-feasibility study provides the technical, economic, social, and environmental elements that sustain the RIOS project. The first chapter presents the criteria used to select the basins; describes their baseline in terms of geography, hydrology, and land use; presents the expected climate change impacts, based on vulnerability studies, as well as additional barriers identified. From this starting point, the Integrated Watershed Action Plans (IWAP) are described, which served to define sub-watersheds were the project will concentrate on restoration activities. A description of present projects that are key to scale RIOS is followed by the environmental and social assessment that defines potential risks during project intervention. The policy and legal landscape are followed by a description of climate financing in Mexico.

The second chapter allows us to further explore the topics of river ecosystems and adaptation, comparing ecosystem-based adaptation with alternative options. The third chapter provides an in-depth description of the project components, their relationship to create synergies and address climate change, the sustainability of the project and exit strategy, as well as its logical framework and theory of change. Project monitoring, considerations regarding the COVID-19 pandemic, as well as complementarity with other projects are further described in this chapter. The fourth chapter addresses mitigation and adaptation benefits, as well as benefits and co-benefits and their economic valuation. The fifth chapter describes the implementation arrangements. It builds from the stakeholder analysis and consultation to the implementation arrangements to ensure proper governance of the project. This is followed by a capacity assessment of the executing entities and presentation of the grievance redress mechanisms of FMCN and the project itself.

Chapter 1. CONTEXT

1.1 General context of targeted watersheds

The Project will operate in two regions highly affected by climate change due to the particular geography of the country, which is found between two oceans and has mountain ranges along both coastal regions: the Gulf of Mexico and the Gulf of California-Pacific. The two watersheds within each region selected for RIOS are Jamapa in the state of Veracruz and Mascota-Ameca in the state of Jalisco. They are part of 16 basins selected in the C6 project by three federal institutions (the National Institute of Ecology and Climate Change, the National Forestry Commission, the National Protected Areas Commission) and FMCN in 2013. This universe of 16 watersheds was selected due to its biodiversity values, presence of protected areas, the importance for the implementing institutions, local capacities, matching fund potential, and inter-institutional collaboration, taking into account opportunities to leverage programs to address climate change, land degradation, and sustainable forest management (World Bank, Project Appraisal Document, 2013).

This section provides a summary of the selection process of the Ameca-Mascota and Jamapa watersheds for the project from within the 16 watersheds selected for the C6 project. It also presents a general description of their land use, geography, and hydrology (baseline scenario). Section 1.7 presents a detailed environmental and social assessment of both regions, and Chapter 4 a full description of ecosystem services that the river ecosystems provide. Figure 1.1 shows the geographic location of the Jamapa and Ameca-Mascota watersheds in the states of Jalisco and Veracruz, respectively.

Figure 1.1. Location of the target basins in RIOS, showing the geographical overlaps with the C6 and CONECTA projects. Source: Own elaboration.

Selection of the Ameca-Mascota and the Jamapa watersheds

Within the two highly vulnerable regions to climate change (the coastal regions of the Gulf of Mexico and the Gulf of Mexico-Pacific), INECC, FMCN, and the two regional funds selected two of the 16 watersheds of the C6 project. The Ameca-Mascota and Jamapa watersheds were selected through a multicriteria analysis based on the following criteria:

1. **High environmental sensitivity and exposure to extreme rain events**: these watersheds are characterized by a high altitudinal gradient (the Jamapa watershed contains the highest mountain in Mexico and reaches the ocean), which results in pronounced slopes and rapid response rivers. They are therefore highly sensitive to the loss of vegetation cover, which results in increased runoff, soil erosion and lack of infiltration.

2. **High actual and future vulnerability to the effects of climate change**: all the municipalities in the basin have at least one of the vulnerabilities evaluated in the National Atlas of Vulnerability to Climate Change (ANVCC [1] in very high or high classification and with one of the Global Circulation Models (GCMs) the vulnerability will increase in the future.

3. **High social reliance on ecosystem services**: these basins provide ecosystem services to large human settlements in the lower watershed, while supporting important productive activities in the agricultural, industrial, tourism and commercial sectors. Downstream cities are the one of the main touristic centers in Mexico (Puerto Vallarta in Jalisco) and the main commercial maritime area (Puerto Veracruz, in Veracruz);

4. **Existent knowledge and experience**: the two watersheds have Integrated Watershed Action Plans (IWAP) developed during the C6 project. They include models that identified areas and activities required to conserve and restore ecosystem services (soil retention and water yield) and were widely consulted with key stakeholders. The IWAPs will be updated under the co-financed project CONECTA;

5. **Local capacities**: the C6 Project supported the creation and strengthening of two regional funds by FMCN. They have been key in developing the social fabric of these watersheds through linking networks of civil society organizations with local governments and academia.

[1] For further information, please refer to https://atlasvulnerabilidad.inecc.gob.mx/page/fichas/ANVCC_LibroDigital.pdf

Geography, hydrology and land use

Ameca-Mascota watershed

The Ameca-Mascota watershed located on the slope of the tropical Pacific, within the physiographic province of the Sierra Madre del Sur, covers an area of about 274,229 hectares. The area is dominated by mountains with heights that vary between 0 and 2,700 meters above sea level, which results in high ecosystem diversity ranging from coastal environments with tropical forests to habitats of temperate forests. The annual average temperature is 19.7°C, with temperatures ranging between 9.1°C and 31.6°C.

The main riverbed in the basin extends 143 km, from the source of the Mascota River to its connection with the Ameca River on the border of the municipality of Puerto Vallarta, for its subsequent discharge into the sea. The main tributary of this riverbed is the Talpa River, whose source is about 60 km to the southeast in the municipality of the same name. The basin is divided into 34 interconnected sub-basins, of which 16 are emitting, 17 are receiving-emitting and one is drainage or outlet (IWAP Vallarta Region, 2018). This classification of the sub-basins makes it possible to identify the relationship between them.

The emitting basins are those located in the upper parts or headwaters of the basins, where the first mountain runoff is formed. The receptor-emitting basins are those that connect the headwater areas with the middle and lower parts of the basin, where the economic activities with the highest water demand are concentrated. The drainage or outlet is where the river meets the sea.

The average yearly rainfall in Ameca is 1,220 mm and the average annual natural runoff of this basin is 2,230 million m3 per year (Mm3/year). Approximately 66 % of the total precipitation runs off through the basin.

The basin has an annual volume of extraction of 385.2 Mm3, which is concessioned and registered in the public water rights registry (REPDA), an annual volume of recharge of 119.9 Mm3, and availability of 1,962.28 Mm3 per year. Around 67% of the volume of surface water in the concession is for agricultural use.

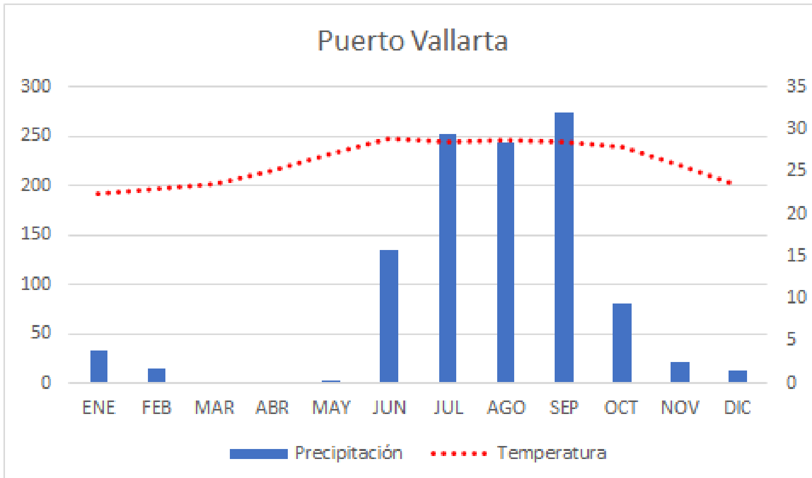


Figure 1.2. Example of climagram with the mean precipitation and temperature (1981-2010) for the weather station "La Desembocada", in Puerto Vallarta, Jalisco.

The climagrams show a very marked seasonality in precipitation throughout the year, with July, August, and September being the months that concentrate most of the year's precipitation (Figure 1.2). In the upper and middle part of the basin, the greatest precipitation is concentrated in July, while in the lower part of the basin (Puerto Vallarta) the greatest precipitation occurs in September (Figure 1.2).

The Ameca-Mascota River basin is part of a group of basins that provide water to one of the most important international tourist centers in the country, the Banderas Bay region (Puerto Vallarta and Riviera Nayarit). The watersheds that make up this mountainous landscape have been the substantial input for the success of its main economic activity, tourism, as well as for other activities: agriculture, livestock, forestry, among others, allowing regional development (IWAP Vallarta Region, 2018).

The basin coincides territorially with the Mascota and the Vallarta aquifers. The largest extraction of groundwater is centered on the latter. In the last groundwater update of the 653 aquifers in the country, the availability agreement published by the Official Journal of the Federation (DOF 04/01/2018) indicates that the Puerto Vallarta aquifer has a deficit of -1.24 Mm3 per year. The aquifer has a concession volume of 70.19 Mm3/year and extraction of 0.55 Mm3 pending registration and title of concession, a committed natural discharge of 17 Mm3/year and a total annual recharge of 86.5 Mm3/year. About 70% of the volume of groundwater granted in the concession is for public-urban use and approximately 21% is for agricultural use.

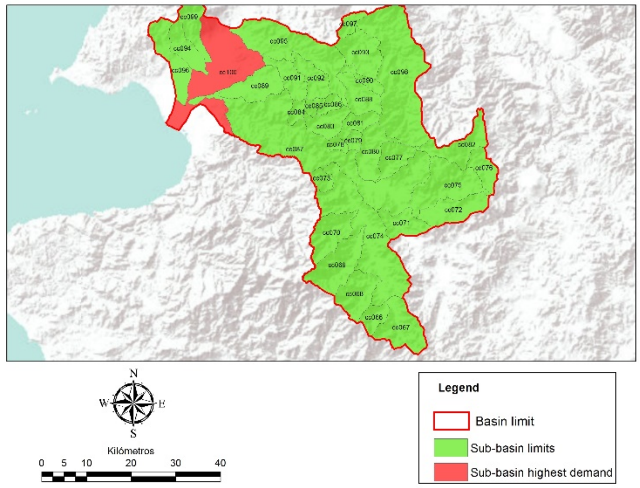


Figure 1.3. Water demand in the Ameca-Mascota basin shows the highest demand in the Puerto Vallarta Metropolitan Area.

The Ameca-Mascota river basin has three main valleys, where agricultural activity is concentrated. These valleys are located, one in the upper part of the basin around the town of Talpa de Allende, another in the middle part, in the municipalities of Mascota and San Sebastian del Oeste, and the other in the coastal plain that forms the delta of the Ameca river, where the national irrigation district 043 (DNR 043) is located. This district serves 42,000 hectares and about 7,000 users (Téllez and Delgado, 2011) and demands about 69% of the volume of surface water under concession and about 21% of the volume of groundwater under concession.

In the upper part of the basin in the mountain areas, forestry activities predominate, while in the middle part of the basin there is significant extensive livestock farming. This livestock activity is characterized by using the forests as a fodder system, rotating the livestock throughout the year. This livestock system, although it is not a trigger for land-use change, does have effects on forest degradation mainly through soil compaction, affecting hydrological processes such as infiltration.

In the lower part of the basin lies the city of Puerto Vallarta, whose water supply is provided by the drinking water operator (SEAPAL) and whose demand is 61 Mm3/yr (REPDA, 2014), of which 74% comes from underground sources and 26% from surface sources. Puerto Vallarta is the second most important tourist destination in Mexico, receiving more than 4 million tourists a year (SECTUR, 2015) with an average consumption of approximately 500 liters/day/tourist. The total population in the Ameca-Mascota watershed is only 10,851 inhabitants. 39% of the population is considered economically active, mainly in the primary sector (INEGI, 2010).

Although the population in the basin is small, the watershed is a key for the provision of ecosystem services of downstream. Traditional beach tourism is high in coastal areas; however, in some towns such as Mascota, Talpa de Allende, and San Sebastián del Oeste rural, nature, or religious tourism is found. This tourism activity with limited planning is a source of important pressure on ecosystems. In addition to tourism, both agriculture and livestock are developed through all the territory, mainly through extensive ranching. Main agriculture products include corn, beans, sugarcane, sorghum, tobacco, rice, tomatoes, and other vegetables (IWAP Region Vallarta, 2018).

According to Series VI of the INEGI, the region's ecosystems (Figure 1.4) are represented by coniferous forest (about 35%), broadleaf forest (24%), medium and low forest (22%), agricultural areas (17%) and urban areas (2%) (INEGI, 2018). The annual rate of land-use change recorded between 1993 and 2011 is 0.28%. In addition to deforestation, ecosystem degradation, especially in soils, is an important factor in this region.

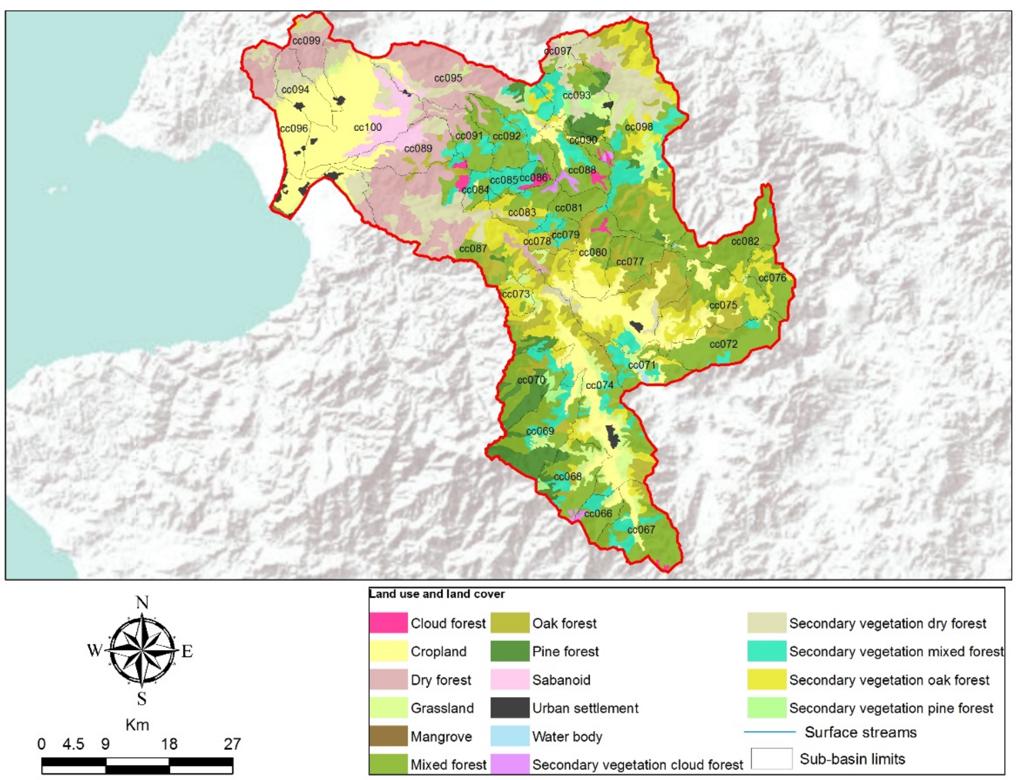


Figure 1.4. Spatial distribution of land-use and vegetation in the Ameca-Mascota watershed (INEGI, 2014).

Jamapa watershed

The Jamapa River basin occupies an area of 3,918 km2 and is made up of 31 municipalities in the state of Veracruz. The highest recorded elevation is 5,670 meters above sea level and the lowest is 0 meters above sea level, with an average elevation of 626 meters above sea level. The basin consists of two main watercourses, the Jamapa River in the northern section of the basin and the Cotaxtla River in the southern section. Both rivers are fed by meltwater from the highest mountain in Mexico, the Pico de Orizaba, and join 20 km before their mouth in the Gulf of Mexico. The main channel extends up to 206 km and the entire basin is divided into 38 sub-basins. The average annual precipitation is 1,541 mm and the average annual temperature is 22.9 ^{o}C (CONAGUA, 2014). The highest rainfall occurs in the summer, from June to September, with the latter being the month with the highest rainfall record, above 350 mm (Figure 1.5).

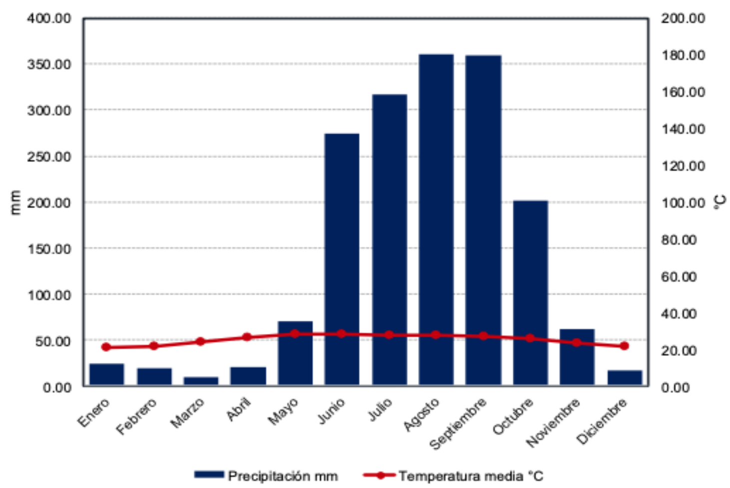


Figure 1.5. Example of climagram in a climatological station located in the lower part of the Jamapa basin 2005-2015, E.C. Tejar, municipality of Medellín (Source: SEMARNAT,2020).

The Jamapa River Basin coincides territorially with six aquifers. The main aquifer by the surface is the Cotaxtla aquifer, which represents 80% of the territory of the hydrological basin, followed by the coastal aquifer of Veracruz, which represents 14% (IWAP Jamapa, 2018).

Most of the water that runs through the Jamapa watershed is superficial. Natural surface runoff in the Jamapa basin is 2,136 Mm3/year (D.O.F. July 7, 2016) while infiltration into its main aquifer, the Cotaxtla, is 356 Mm3/year. From the surface runoff, 880 Mm3/year are extracted and some 594 Mm3/year return. This means that the basin is considered as having water availability since it is estimated that 1,849 Mm3/year reaches the sea. Of the 356 Mm3/year that infiltrate into the Cotaxtla aquifer, 170 Mm3 are considered to be a committed natural discharge and 185 Mm3 are extracted. Although the basin has water availability due to its runoff, the Cotaxtla aquifer is considered unavailable, with a deficit of 14.41 Mm3/year (CONAGUA,2018).

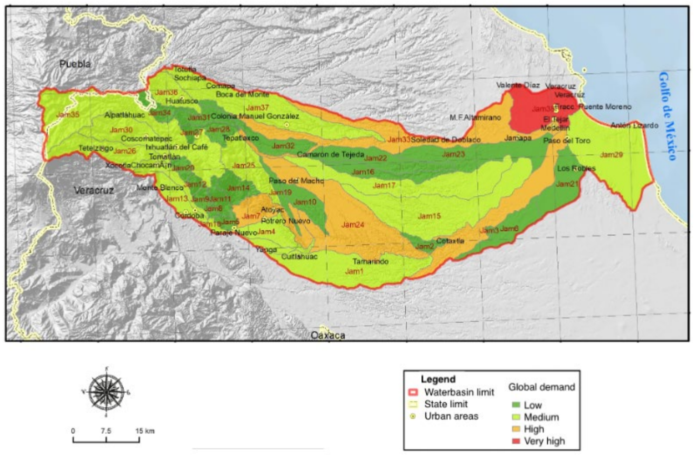


Figure 1.6. The Jamapa watershed indicating the highest (red) to the lowest (green) demand in surface water by sub-basins. The red sub-basin feeds the port of Veracruz.

The upper basin of the Jamapa River is characterized by its natural vegetation in good state of conservation and is the area where environmental hydrological services are generated (see IWAP below). In the middle basin, productive activities are carried out, mainly associated with rainfed agriculture and extensive cattle ranching, while in the lower part of the basin it is distinguished by urban use, industrial, commercial, and tourist activities. It is here that the metropolitan area of Veracruz is located, including its port, which has the greatest maritime commercial activity in the country and where land use has been modified to urban and commercial use (IWAP Jamapa, 2018).

The total population in the Jamapa watershed includes 521,661 inhabitants, 44.9% are urban and 55.1% rural. 48% of the population is considered economically active, mainly in the primary sector (IWAP Jamapa, 2018).

The natural vegetation of the basin covers approximately 14.5% of the territory and is composed of 19 different kinds of plant associations (Figure 1.7). The most widespread vegetation is the secondary vegetation of low deciduous forest, pine forest, and secondary tree vegetation of mountain cloud forest (61 km2). The most widespread land use is agricultural (57% of the total area of the basin), followed by livestock (25%); urban areas, and human settlements (1.2%) (INEGI, 2011). The main agricultural products in the region include bean, chayote coffee, and avocado (IWAP, 2018).

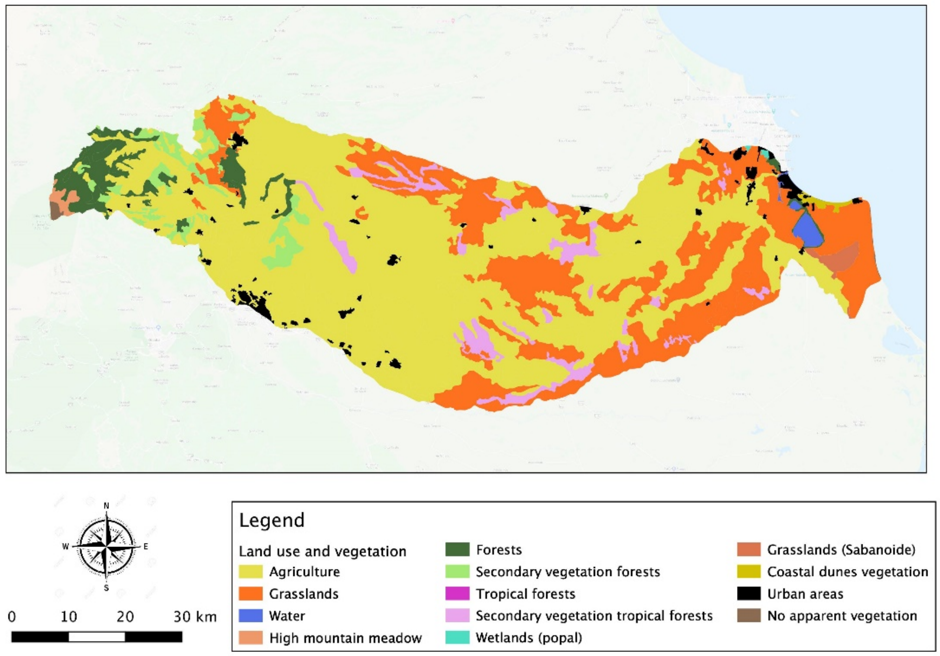


Figure 1.7. Spatial distribution of land-use and vegetation in the Jamapa watershed (INEGI, 2014).

The watershed provides essential ecosystem services to 29 urban settlements and more than 1,600 rural communities (IWAP Jamapa, 2018). The main ecosystem services identified in the watershed are protection against storms, rainwater flow regulator to reduce the effect of floods, natural protection against coastal erosion, contribution to the reduction of global warming, a refuge for numerous species of animals and plants (biodiversity reservoir), carbon reservoirs and reduction of the impact of winds produced by hurricanes (INECC, 2019a) (for a full list of ecosystem services, see Chapter 4).

1.2 Analysis of climate change risks, impacts, and vulnerability

Analysis of climate change risks, impacts, and vulnerability in Mexico[2]

Due to its geographical position in the southern part of the northern hemisphere, between two oceans, Mexico is particularly affected by the impacts of climate change. Climate change scenarios for the 2015-2039 period project higher annual temperatures range between 1 and 1.5 °C in most of the territory. In the case of precipitation, a decrease between 10 and 20% is

[2] This section is based on Mexico´s Sixth National Communication to UNFCCC (SEMARNAT and INECC, 2018) except when cited differently.

generally projected. All this could have very important economic, social, and environmental consequences.

Mexico is fully engaged with the international community to address climate change. It has implemented a pragmatic approach to reduce emissions and implement adaptation measures to reduce the vulnerability of its population, ecosystems, and infrastructure while ensuring national development and job creation. Sections 1.8 and 1.9 shows Mexico´s policy, legal, and regulatory landscape.

Greenhouse Gases Emissions

The National Inventory Report (INEGYCEI for its Spanish acronym) contained in the 6th National Communication to UNFCCC was updated in 2015 using 2006 IPCC methodologies. According to the INEGYCEI of 2015, direct GHG emissions in the country, without considering absorptions, reached 700 million tons of CO2 equivalent (MtCO2e), of which vehicle transportation contributes the most (22.8%), followed by electricity generation (20.3%), livestock (10.1%), and waste emissions (6.6%). Between 1990 and 2015, total GHG emissions increased by 57% at an average annual growth rate (AAGR) of 1.8%. However, deceleration has been observed in recent years: from 2010 to 2015 emissions increased by 5% and the AAGR was 0.9%, whereas from 2005 to 2010 emissions grew 12.9% with an AAGR of 2.5%. Emissions per capita were 3.7 metric tons of CO2e in 2015, which is below the world average of 4.4 metric tons of CO2e.

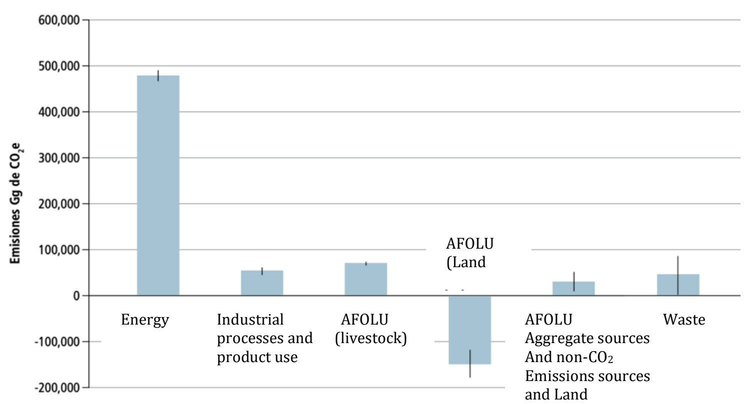


Figure 1.8. Mexico´s 2015 net emissions by sector (uncertainty depicted as a vertical line in each bar). Source: SEMARNAT and INECC, 2018.

Mexico has 162.1 million hectares of forest covering 82.3% of the country. Over the last decade, an estimated 3.5 to 5.5 million hectares have been lost, contributing to habitat fragmentation, loss of ecosystem services, and forest livelihoods, as well as climate change (Goldstein et al., 2016). The major drivers of deforestation are land-use change for agriculture and livestock

(82%), illegal logging (8%), forest fire and disease (6%), and other causes as hurricanes and natural disasters (2%). In 2015, the Agriculture, Forestry, and Other Land Use (AFOLU) sector presented a balance of -46,286.57 Gg of CO_2eq. From these emissions, aggregate sources and non-carbon emission sources corresponded to 31,491.90 Gg of CO_2eq (63.19%), followed by livestock with 70,567.60 Gg of CO_2eq (4.78%), and Land by -148,346.07 Gg of CO_2e (19.46%) (SEMARNAT-INECC, 2018).

Land use and land-use change and forestry (LULUCF) is a priority for climate strategies and actions in Mexico. Halting land-use change and promoting reforestation/restoration have both mitigation and adaptation impacts. Increasing vegetation cover acts as a carbon sink and reduces vulnerability to hydrometeorological phenomena in locations with steep terrain.

Rivers act as a natural source of GHG that can be released from the metabolisms of aquatic organisms. It is estimated that the CO_2 emissions from global streams and rivers are 1.8 ± 0.25 Pg C yr^{-1}, while the size of inland water CH_4 and N_2O evasions were 26.8 Tg C yr^{-1} and 1.26 Tg N yr^{-1}, respectively (Ho et al., 2020). Anthropogenic activities can largely alter the chemical composition and microbial communities of rivers, consequently affecting their GHG emissions. Ho et al. (2020) observed in Ecuador a clear pattern between water quality and GHG emissions in which the more polluted the sites were, the higher were their emissions. When river water quality deteriorated from acceptable to very heavily polluted, their global warming potential (GWP) increased by ten times. Compared to the average estimated emissions from global streams, rivers with polluted water released almost double the estimated GWP while the proportion increased to ten times for very heavily polluted rivers. Conversely, the GWP of good-water-quality rivers was half of the estimated GWP. Furthermore, surrounding land-use types (i.e., agriculture) significantly affected river emissions. The GWP of the sites close to urban areas was four-time higher than the GWP of the nature sites, while this proportion for the sites close to agricultural areas was double. Dissolved oxygen, ammonium, and flow characteristics were the main important factors on GHG emissions identified. These results highlight the impacts of land-use types on river emissions via water contamination by sewage discharges and surface runoff. Hence, to estimate the emissions from streams, both their quantity and water quality should be included.

In Mexico, over half of the watersheds have degraded rivers, and 68% of riparian corridors in Mexico present a medium, high or very high degradation state (Garrido et al. 2010). This is related to the pressures of land use change caused by the deterioration in territorial suitability for agricultural and livestock activities, caused by climate change; this leads to deterioration of the hydrological cycle and soils. Arévalo-Mejía et al. (2020) used the index of hydrological alteration in rivers (IAHRIS) to identify modifications in the components of their hydrological regimes. They identified 232 undisturbed basins (18% of the country's surface area), 554 altered basins (49% of the country's surface area) and 364 with lack of data (33% of the country's surface area). Furthermore, 70% of rivers suffer from some degree of pollution, especially from sewage discharges from large cities and industries. Of the 14,290 million m3 per year (453 m3/s) of wastewater produced, only 48.4% is treated (6,920 million m3/year, 219.3 m3/s) (CONAGUA, 2018). The largest flows of municipal wastewater were generated by the State of Mexico, Mexico City, Jalisco, Veracruz, and Nuevo Leon, which together contributed around 40% of the national volume generated. It is estimated that in 2015 the economic cost of pollution caused by untreated wastewater was 57,403 million pesos, equivalent to 0.3% of the gross domestic product (FCEA, 2017). Analysis of CH4 emissions in 2010 resulted in 68.5% of emissions being contributed by untreated water and its discharge to receiving bodies (Ramírez and Vázquez, 2010).

River restoration has the potential to support ecosystems and communities to better cope with climatic events. River restoration refers to ecological, physical, and management measures and practices aimed at enhancing and rehabilitating the functioning of the river system in support of ecosystem services. Many successful river restoration measures have been reported, which support improvements to ecosystem services (Lago, 2014). Some common goals of river restoration are to improve water quality, re-establish river type-specific habitats and ecosystem functioning, aid in species recoveries, and maintain the provision of ecosystem services (Lago, 2014). Riparian vegetation corridors regulate processes that result in valuable ecosystem services such as uptake, infiltration, and retention of sediments and contaminants from human activities (González et al., 2013). In the face of climate change, riparian ecosystems will be subject to an increase in air and surface water temperatures, alterations in the magnitude and seasonality of precipitation and run-off, and shifts in reproductive phenology and distribution of plants and animals (Seavy et al., 2009).

Policies and Mitigation Measures

The Government of Mexico (GoM) introduced a General Climate Change Law in 2012 to (i) support the transition to a competitive, sustainable and low-carbon economy; (ii) reduce climate vulnerability of the population and ecosystems; and (iii) assign the relevant federal competences. Other cross-sectoral instruments include the National Climate Change Strategy, National Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy, a 2015 Law on Energy Transition, and Mexico’s National Strategy on Biodiversity. These represent innovative environmental policies and have shown highly positive results in curbing deforestation and reducing poverty; an example for other countries globally. The GoM has committed to a reduction of 22% GHG and a reduction of 51% of Black Carbon. This commitment implies reducing unconditionally 25 percent of its greenhouse gas (GHG) and short-lived climate pollutant emissions and reaching zero deforestation by 2030 in its Nationally Determined Contributions (NDCs).

The cost of Climate Change in Mexico

Mexico is one of five countries in the world that is projected to experience the highest increases in poverty due to climate-induced extreme events (52% increase in rural households, 95.4% in urban households, change in poverty due to once-in-30-year-climate extreme) (Ahmed et al., 2009). In Mexico, there have been losses of human life and high economic and social costs associated with climate change impacts. Only between 2001 and 2013, around 2.5 million people were affected by hydrometeorological phenomena. This generates high levels of vulnerability in many regions (Romero-Lankao et al., 2014).

Based on historical information, and in a scenario of inaction both in Mexico and in the world, it is estimated that an increase in the average temperature by 1.0 °C could reduce the growth of national GDP per capita between 0.77 and 1.76 percent. The costs of inaction for 2014-2030 have been estimated to be around 143 billion dollars. However, the implementation of 30 NDC mitigation measures in 8 sectors of the economy is estimated at around 126 billion dollars. This means that 17 billion dollars could be saved with the implementation of appropriate mitigation actions. Climate change costs of inaction in the agricultural sector are comparable to the loss of a value close to two years of the 2010 agricultural production in Mexico. As an example, in the state of Veracruz, the accumulated losses of inaction may be equivalent to almost 10 times the value of the state's agricultural production in 2012.

Vulnerability to Climate Change

Due to the country's geographical location, topography, and socio-economic characteristics, Mexico is particularly vulnerable to the adverse impacts of climate change. In just over 100 years, both land and sea surface temperatures have increased across the country. This observed warming trend has been accompanied by an increased number of extremely warm days and the decrease of extremely cold days and freeze-overs. An increasing number of extreme hydrometeorological phenomena should be noted, such as tropical cyclones and hurricanes (Romero-Lankao, 2014).

Climate. The geographical location of Mexico and its topography (one of the most mountainous countries in the world) explain, to a large extent, the variety of climates that occur throughout the national territory, ranging from the warm humid to the cold Alpine, through the sub-humid, temperate and dry in arid areas. In the last 50 years, average temperatures in Mexico have increased by 0.85 °C. Additionally, there is an increase in the number of extreme hot days and a decrease in the number of extreme icy days and frosts (SEMARNAT, 2016). Moreover, precipitation also shows a wide range of values. For example, during 2013 and 2015, there was a 24 and 15% increase in precipitation, respectively, in relation to the average 740 mm annual rainfall calculated for the period 1981-2010. One of the main effects of climate change could be an alteration of the regional thermo-hydrological cycle, accompanied by changes in runoff, as well as in water availability and storage (Mendoza et al., 1997). Núñez-González (2020) found that precipitation in Mexico in the period 1960-2010 has decreased in most of the territory, showing a seasonal distribution, concerning the annual total, of 7.1% in spring, 54% in summer, 29.3% in autumn, and 8.8% in winter. The central and coastal regions of the Gulf of Mexico (rainy areas) have shown a significant decrease of 1% of total annual precipitation. INECC studies report, based on the results of the regionalized climate change scenarios for Mexico, that a reduction in the average natural availability of water would be expected, which would be affected by greater evapotranspiration, as well as by the decrease of its quality

Extreme weather events. Among the effects of climate change is the variation in the frequency and intensity of extreme hydrometeorological phenomena, such as tropical storms, floods, and droughts. Mexico, due to its geographical location, climatic condition, and socioeconomic characteristics, is highly vulnerable to these phenomena. Between 2000 and 2018, climate-related disasters caused 86.8% of the total damage recorded in the country resulting in an average annual cost of USD$2,110 million (CENAPRED, 2018). Between 1970 and 2013, 22 cyclones of category 3 or higher on the Saffir-Simpson scale affected both the Pacific and Atlantic Mexican coasts (GOM, 2015). In the case of droughts, there have been five significant events so far in this century. In 2010–2011, Mexico experienced one of its worst droughts in seven decades. It affected 90% of the territory (19 of the 32 federal entities), causing over US$100 million losses on bean yields alone (Altamirano et al., 2016), more than 1.7 million cattle died of starvation or thirst, and almost 2.2 million acres of crops withered across at least five states. The sea level has risen in many coastal zones of Mexico during the period 1901-2010, going from 17 to 21 centimeters (GOM, 2015).

Tropical Cyclones. The great extension of Mexico´s coasts and its location between mid and tropical latitudes favors the influence of the intertropical convergence zone during the hurricane season. This means that the country is constantly impacted by hydrometeorological phenomena, such as tropical cyclones, which affect more than 60% of the national territory. From 2000 to 2017, a total of 101 tropical cyclones accounted for damages over MX$226 billion (CONAGUA, 2018), 30% more hurricanes than occurred within 1980-1999. These phenomena usually detonate torrential rains and heavy rainfall, which in turn cause river and coastal floods and landslides, affecting daily activities and resulting in loss of human life, damage to property and infrastructure, destruction of crops, and loss of livestock (Brito and Pedrozo, 2015). The National Disaster Prevention Center (CENAPRED) estimates that over the next 100 years, the number of cyclones affecting Mexico will double.

Scarce water resources. Mexico has 757 hydrological basins, organized in 37 hydrological regions that are grouped into 13 Hydrological-Administrative Regions (RHA). The basins of the main rivers cover 65% of the national territory and 87% of the surface runoff flows through them. In 2016, 649 basins had water availability and 108 were in deficit. Surface sources provide 61% of the water for consumptive uses. According to current estimates, renewable water per capita will reach, in 2030, levels close to or lower than 1,000 m3/inhabitant/year. This is considered scarcity (CONAGUA, 2017[i]). Water quality is also a concern with 10% to 30% of the surface monitoring sites in Mexico showing being polluted (CONAGUA, 2010).

Climate context in the regions: historic and projected climate change and vulnerabilities

Mexico's geographic characteristics make it a highly vulnerable country to the adverse impacts of climate change. Its location between two oceans, as well as its latitude and topography significantly increase its exposure to extreme hydro-meteorological events (NDC, 2015). Mexico has two mountain ranges that cross the country from north to south and a volcanic system that runs from east to west. It also has an extensive coastline that is exposed to extreme weather events. These mountain systems, valleys, and coastal plains form a set of 757 watersheds with particular characteristics depending on their geographical location (CONAGUA, 2017). Among all these basins the present proposal selected two, one that drains towards the Pacific, the Ameca-Mascota basin in the state of Jalisco, and the Jamapa basin that drains into the Gulf of Mexico in the state of Veracruz. In the lower part of these basins, there are important human settlements, seaports, and high productivity of the agricultural, industrial, tourism, and commercial sectors, which are all vulnerable to climate change.

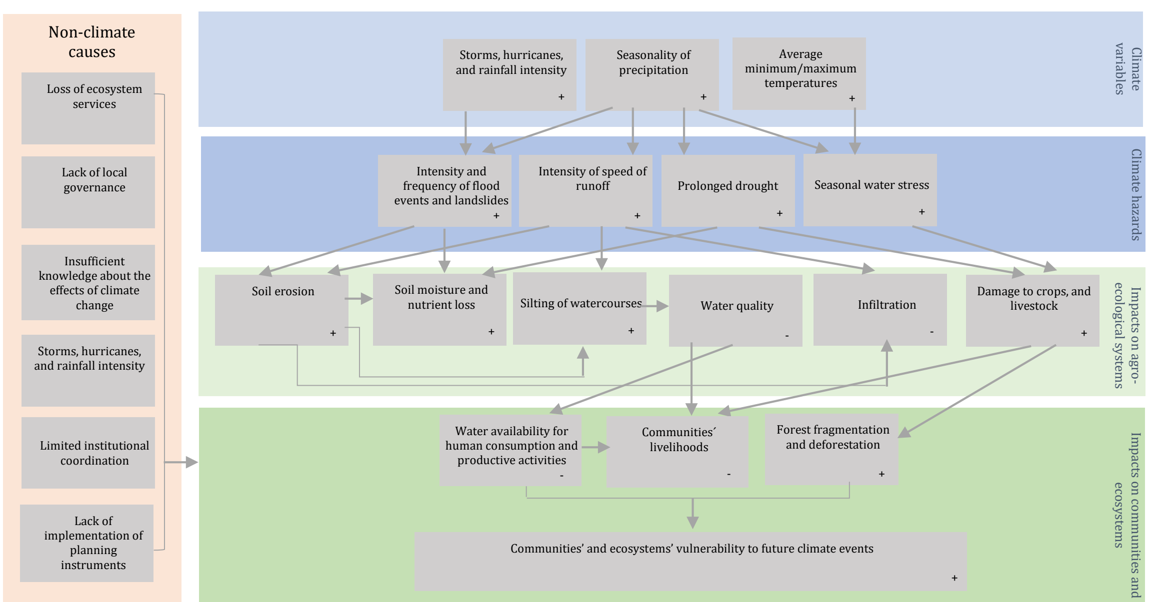


Figure 1.9.1. Climate change impact chain for RIOS.

This section details the expected climate change impact chain for RIOS (see Figure 1.9.1), starting with an analysis of observational date, following with a validation of models, and with a projection based on those models. This section also described the expected impacts due to climate change in RIOS regions and systems, as well as how the project will address those climatic impacts.

Observational stations in Ameca-Mascota and Jamapa

The National Meteorological System (SMN) in Mexico daily climatological network is composed of 5,238 stations distributed throughout the country. These stations record daily values of maximum and minimum temperature and precipitation. According to the Digital Climate Data of Mexico (http://uniatmos.atmosfera.unam.mx), 1,900 stations ae considered to have reliable and continuous data. We identified twenty stations in the area of influence of the project basins, ten in each region. Of these, the three stations with best continuous data were selected for each region.

Ameca-Mascota

Of the total network of SMN weather stations, only ten are located in the municipalities with influence in the Ameca-Mascota River watershed. Of the ten stations, six are in operation and four have suspended operations. Below is a summary table with the status of the stations and number of years with data.

Table 1.1. Summary of weather stations near the Ameca-Mascota subwatershed.

Key	Station	Status	Years with data
14035	Corrinchis II	Operating	27
14096	Mascota (SMN)	Operating	30
14044	El Bramador	Operating	29
14140	Talpa de Allende	Operating	17
14133	San Sebastian del Oeste	Suspended	13
14339	El Cuale	Operating	29
14081	La Desembocada	Operating	28
14116	Puerto Vallarta	Suspended	18
14271	Cumbre de Guadalupe	Suspended	11
14178	Mascota (DGE)	Suspended	18

The stations with best data series and quality are Mascota (14096) and El Bramador (14044), which are located at a distance of 11 and 25 km, respectively, from the intervention subwatershed. In the lower part of the watershed, station 14081 La Desembocada with 28 years of data was selected. There is one station in operation in the intervention subwatershed, 14140 Talpa de Allende, however, it only has 17 years of data.

Table 1.2. Stations selected for detailed analysis for the Ameca-Mascota watershed.

Station	Location	Altitude (masl)
14096 Mascota (SMN)	20.50° Lat. -104.78 Lon.	1230
14044 El Bramador	20.31° Lat. -105.04 Lon.	1074
14081 La Desembocada	20.72° Lat. -105.20 Lon.	19

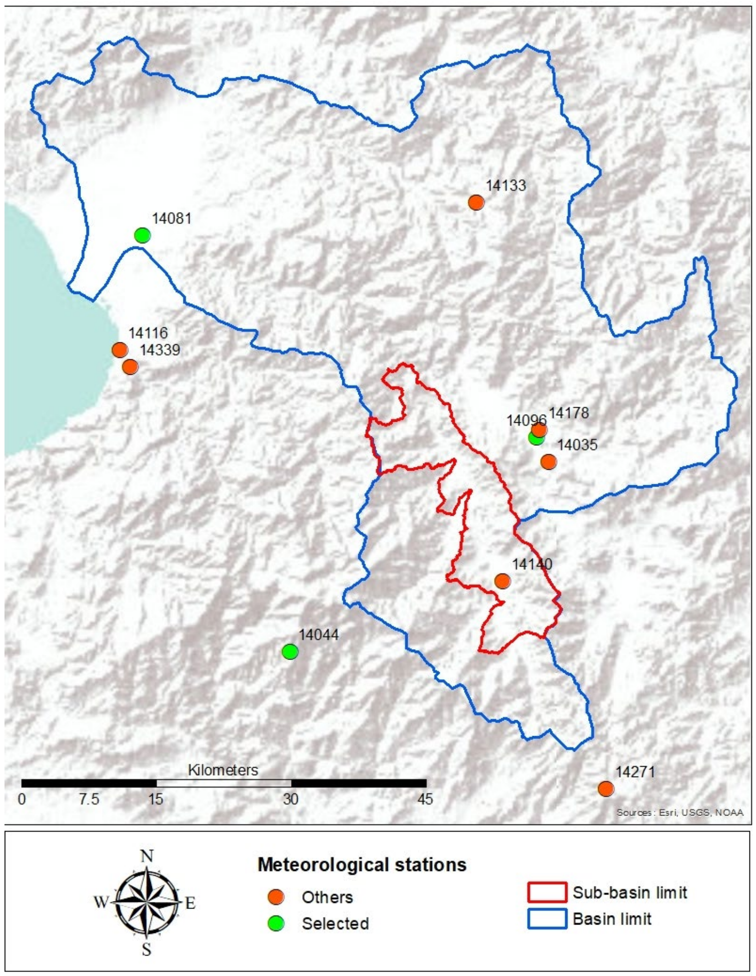


Figure 1.9.2. Distribution of meteorological stations in the municipalities with influence in the Ameca-Mascota watershed.

Jamapa

Ten meteorological stations were identified near the intervention watershed, three are suspended and seven are operating. These stations have 25 to 30 years of data. Table 3 summarizes the status of the stations and number of years with data.

Table 1.3. Summary of meteorological stations near the intervention subwatershed.

Key	Station	Status	Years with data
30364	Camarón de Tejeda	Operating	25
30047	Coyol	Suspended	27
30032	Coscomatepec	Suspended	26
30019	Cotaxtla	Operating	27
30094	Cotaxtla	Suspended	26
30342	Huatusco	Operating	30
30072	Ixhuatlán del Café	Operating	30
30048	Medellín	Operating	27
30056	Medellín	Operating	30
30163	Soledad de Doblado	Operating	26

Table 1.4. Selected stations for the Jamapa watershed.

Station	Location	Altitude (masl)
30342 Huatusco	19.14° Lat. -96.95 Lon.	1186
30047 Coyol	19.72° Lat. -96.69 Lon.	545
30163 Soledad	19.04° Lat. -96.42 Lon.	94

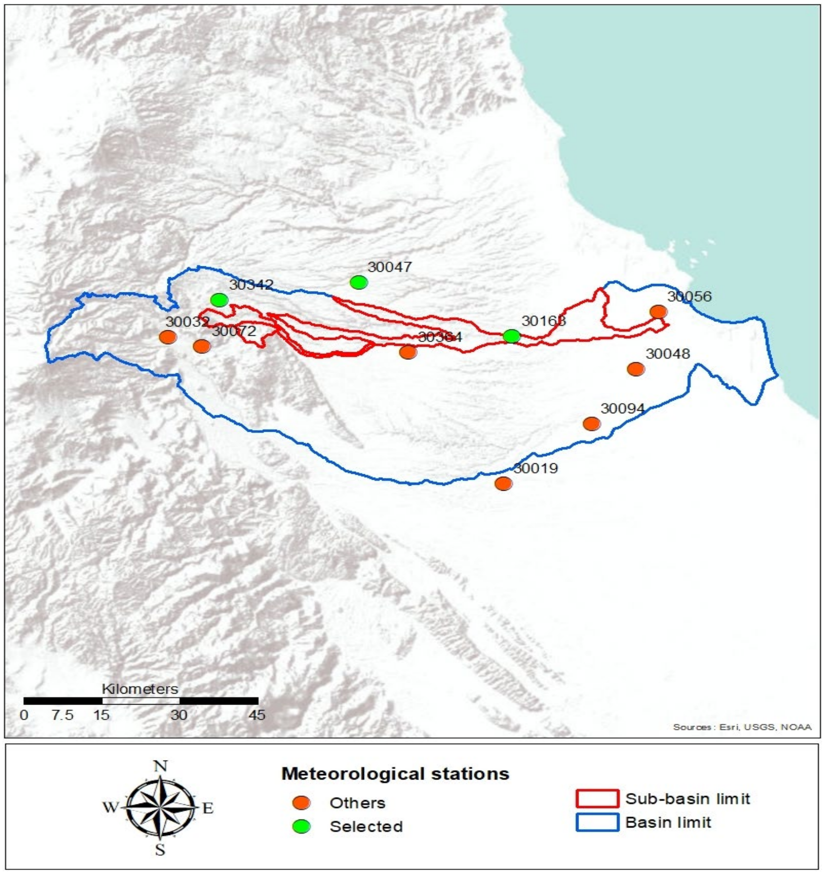


Figure 1.9.3. Distribution of meteorological stations in the municipalities with influence in the Jamapa watershed.

The Soledad de Doblado (30163) station is located in the intervention subwatershed, which is in operation and has 27 years of data. The stations with the best data series are the Huatusco (30342), Ixhuatlán del Café (30072) and Medellín (30056) stations with 30 years of data each, which are located at a distance of 31, 58 and 24 km from the intervention subwatershed, respectively.

Climatic parameters being assessed and relationship to climate logic

The main parameters that are being assessed with historic observational data to support the climate logic are:

Average temperature. The average temperature is one of the most-cited indicators of global climate. The global surface temperature is based on air temperature data over land and sea-surface temperatures. An increase in seasonal temperature increases seasonal water stress. The water demand also increases during periods of hot weather, causing a reduced water supply and pressure in many areas. This stress damages crops and livestock which reduces the livelihoods of local communities.

High and low temperatures. One-way climate changes can be assessed is by measuring the frequency of events considered "extreme" (among the minimum and maximum of temperature). Many extreme temperature conditions are becoming more common. The rise in water temperature during heat waves also contributes to the degradation of water quality and negatively impacts water ecosystems. The extreme temperatures (both high and low) damages crops and livestock which reduces the livelihoods of local communities.

Average precipitation. A decrease in rainfall augments the risk of more frequent, intense, and prolonged droughts under climate change. In this scenario, evaporation exceeds water absorption and soil moisture reduces, affecting areas dependent on rain-fed agriculture and causing decreased crop production and livestock to perish. Thus, a reduction in food supply or income and water quantity and quality is expected to occur. An increase in precipitation mainly upstream affects the speed of runoff, increasing soil erosion, loosing soil nutrients and generating flooding downstream.

Extreme precipitation. In recent years, a higher percentage of precipitation has come in the form of intense single-day events. The prevalence of extreme single-day precipitation events upstream could generate landslides, affect water quality with sediments and generating flooding, loosing nutrients crucial for local livelihoods.
Hurricanes. Hurricanes are a natural part of our climate system. However, an increase in hurricane activity and intensity may have catastrophic human and ecosystem outcomes. Hurricanes increases the magnitude of flood events and landslides, increasing the speed of runoff; this affects water quality and floods.

Extreme precipitation. Extreme precipitation is expected to intensify with global warming over large parts of the globe as the concentration of atmospheric water vapor that supplies the water for precipitation increases in proportion to the saturation concentrations at a rate of about 6–7% per degree rise in temperature. The most immediate impact of heavy precipitation is the prospect of flooding. Heavy rainfall also increases the risk of landslides, when above-normal rain raises the water table and saturates the ground, causing slopes to lose their stability. Excessive rainfall can also degrade water quality, dragging the soil, sediments, and pollutants like pesticides, nitrogen, and phosphorus, which end up in lakes and streams, damaging aquatic ecosystems and lowering water quality for human uses.

Historic analysis of observational station data

This section shows the main temperature and precipitation trends from the stations in each region or watershed.

In summary, this section finds from observational data that:

- Extreme temperatures in both basins have increased, which is less marked in the upper part of the wetter basin, which is Jamapa.
- Mean temperatures have increased in both watersheds in the spring-summer (SS) season in the middle and lower parts of the watersheds. There are differences between basins, since the drier watershed (Ameca) shows an increase also in the autumn-winter (AW) season in the middle and lower watershed, while the more humid Jamapa watershed shows a decrease in the AW season, most probably due to more extreme precipitation events due to storms and hurricanes. In both basins the upper watershed behaves different than downstream, since it shows a decrease in temperature, except for the SS season in Ameca, where there is a marginal increase. In both watersheds in the upper parts precipitation has shown an increase. In the drier Ameca basin precipitation shows an increase in the SS season and a decrease in the AW season. In the wetter Jamapa, precipitation has diminished in the upper and lower basin in both seasons.

Basin/part of the basin	**Mean temperature SS and AW**		**Max temperature (SS) Min temperature (AW)**		**Mean precipitation SS and AW**	
Ameca						
Higher - Mascota	**0 (+)**	**-**	**+**	**-**	**+**	**+**
Middle – Bramador	**+**	**+**	**+**	**-**	**+**	**-**
Lower – Desembocada	**+**	**+**	**+**	**-**	**+**	**-**
Jamapa						
Higher – Huatusco	**-**	**-**	**0 (+)**	**-**	**+**	**+**
Middle – Coyol	**+**	**-**	**+**	**-**	**-**	**-**
Lower - Soledad	**+**	**-**	**+**	**-**	**-**	**-**

Temperature change

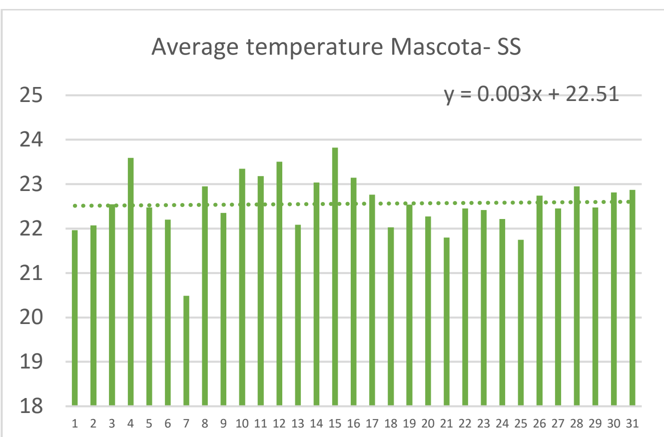
The seasonal observed temperature shows different trends in the stations and seasons. We divided data in two seasons distinctive seasons: Spring-Summer -SS- (May-October) and Autumn-Winter -AW- (November-April). For each station we included approximately 30 years of data (Mascota 1984-2014, el Bramador 1980-2014, Desembocada 1980 - 2014 in Jalisco; Huatusco 1980-2015, El Coyol 1979-2009, and Soledad de Doblado 1980-2010 in Veracruz).

Temperature change in Ameca-Mascota

In the three stations in Ameca-Mascota region, mean temperature has a positive trend in SS and AW, except for the Mascota station in the upper watershed in the AW, which shows a negative trend. Except for the upper watershed, the warm season is tending to be warmer, and cold season colder. This can also be observed in the maximum temperature figures for the stations, which show a positive trend in SS, while minimum temperature show a negative trend in AW in the three stations. The annual average has increased in the stations between ~ 0.075-0.003 °C annually.

This increase in average and maximum temperature in SS could have an impact on the increase in evapotranspiration of crops and an increase in water consumption in agriculture.

Historical mean seasonal temperature in stations in Ameca-Mascota



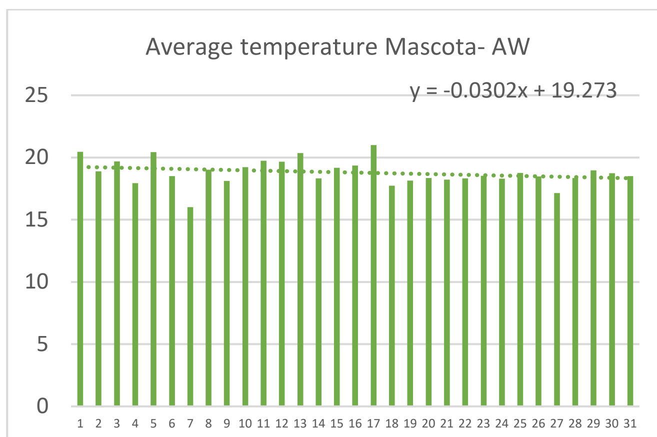


Figure 1.9.4. Historical mean seasonal temperature in stations in Ameca-Mascota (Mascota).

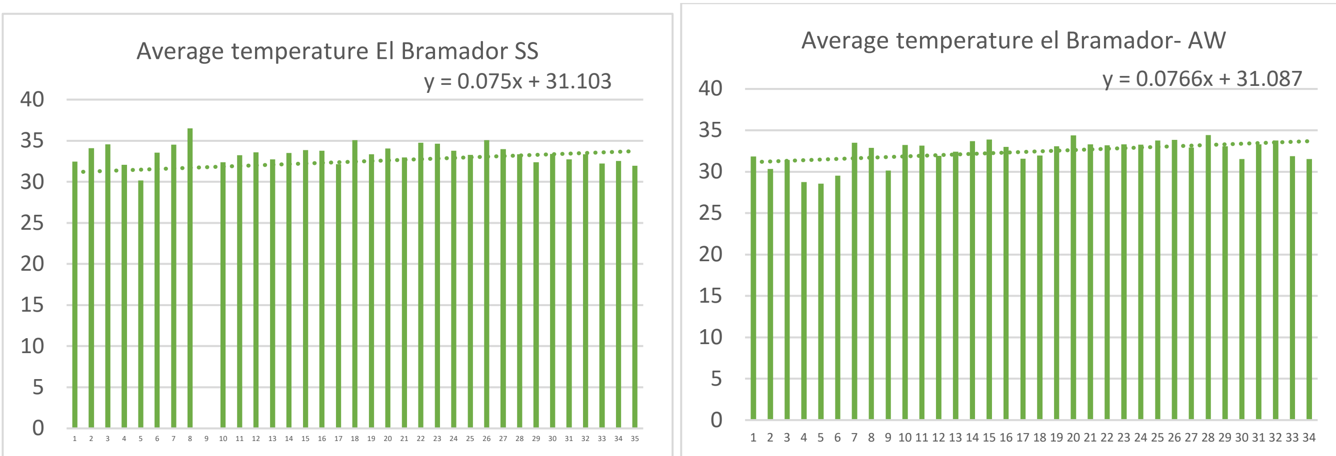


Figure 1.9.5. Historical mean seasonal temperature in stations in Ameca-Mascota (El Bramador).

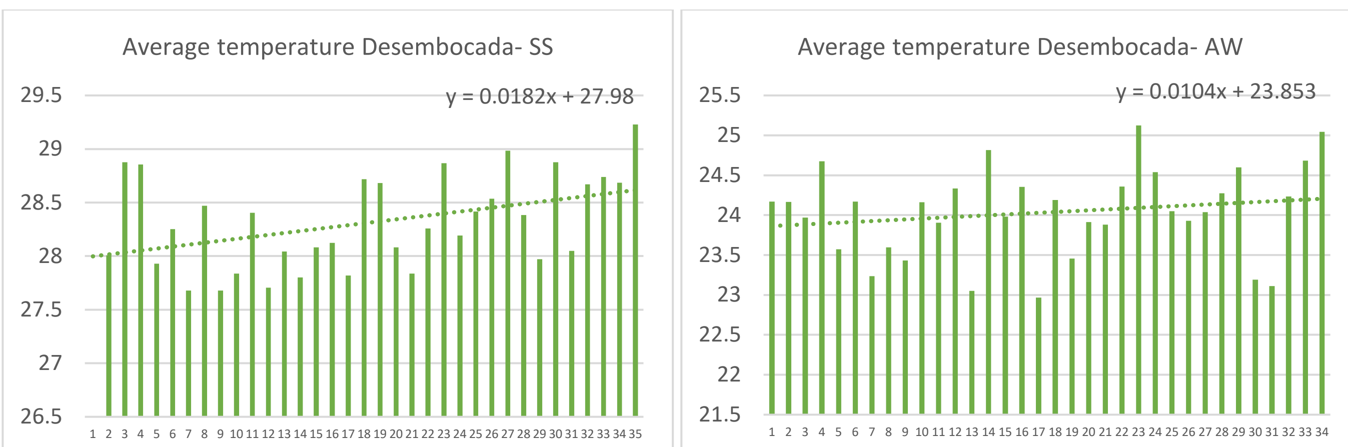


Figure 1.9.6. Historical mean seasonal temperature in stations in Ameca-Mascota (La Desembocada).

Between 1980 and 2014, the maximum temperature has increased between ~0.075-0.0315 °C annually in the three stations of the region in the warmest season (SS). On the other hand, in the cold season the temperature has decreased in all the stations mainly in Mascota, which is the station with the highest altitude.

Historical maximum and minimum seasonal temperature in stations in Ameca-Mascota

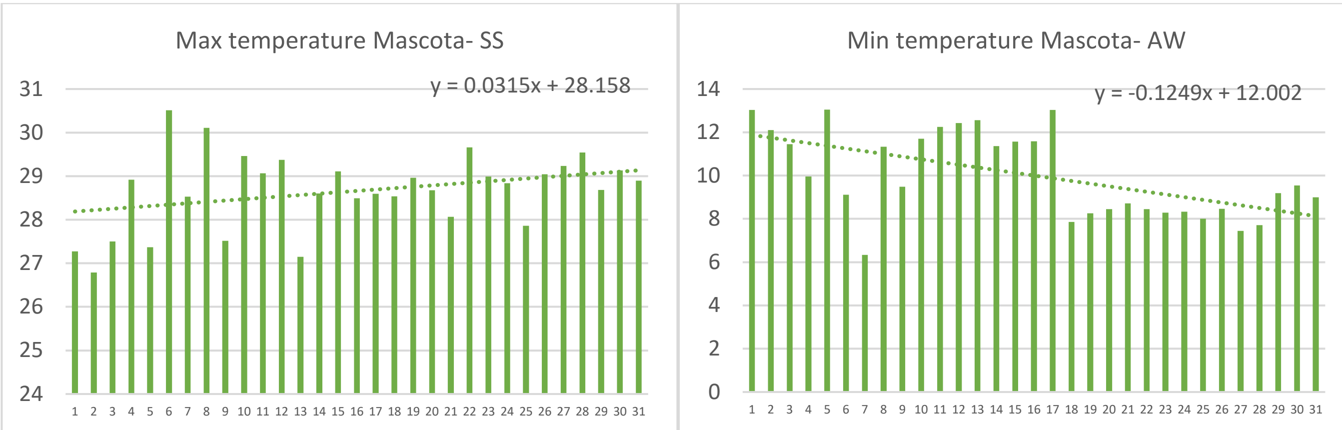


Figure 1.9.7. Historical maximum and minimum seasonal temperature in stations in Ameca-Mascota (Mascota).

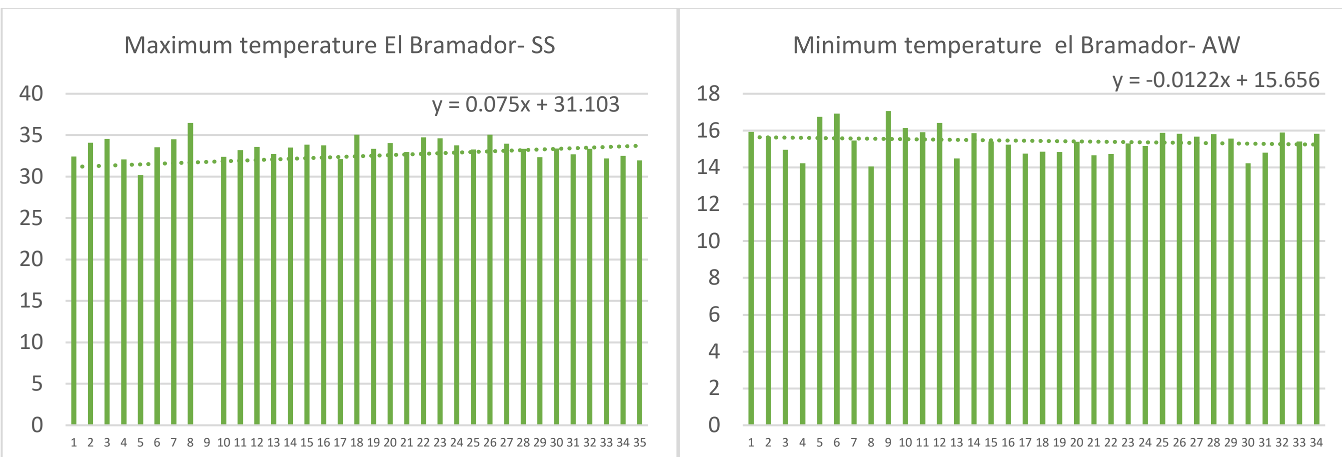


Figure 1.9.8. Historical maximum and minimum seasonal temperature in stations in Ameca-Mascota (El Bramador).

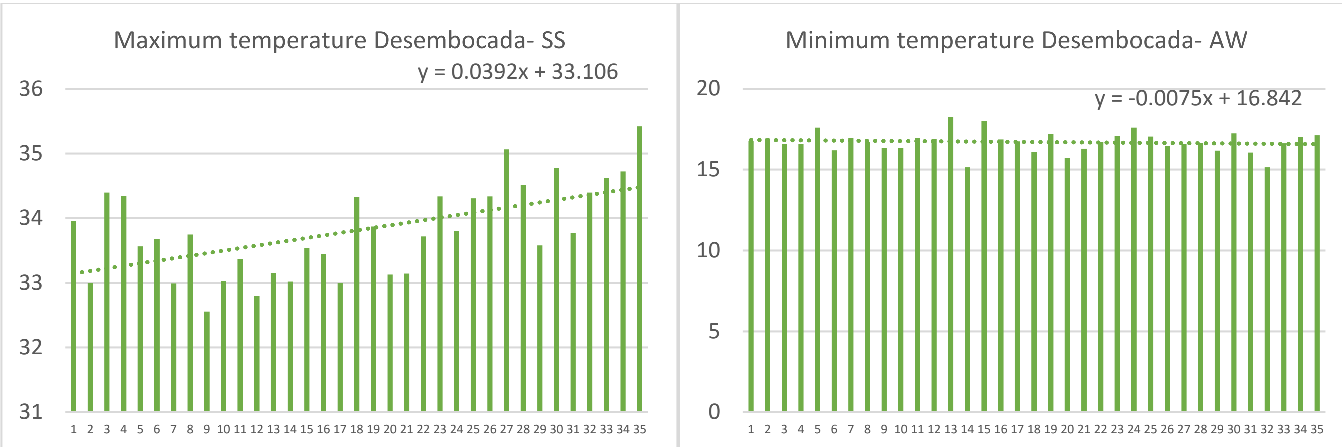


Figure 1.9.9. Historical maximum and minimum seasonal temperature in stations in Ameca-Mascota (Desembocada).

Temperature change in Jamapa

In Jamapa the mean temperature has increased in Coyol (the middle basin) and Soledad stations (downstream) close to ~0.025°C annually. In the highest part of the basin, temperature has slightly decreased. In all the stations, the temperature has decreased in AW.

The historical mean temperature in Huatusco presents minimal seasonal variations (Figure 1.9.10), which is in the upper part of the basin, where the coverage of cloud forest and shade coffee plantations is high. Studies in the region indicate that whilst fog frequency increased at medium and higher altitudes, it generally decreased at lower altitudes. This behavior suggests that it is very likely that the altitude of the lifting condensation level (LCL) has increased by 200–400 m (Barradas et al. 2010). Increase in peak precipitation events may also related to lower decrease in temperature in the upper watershed.

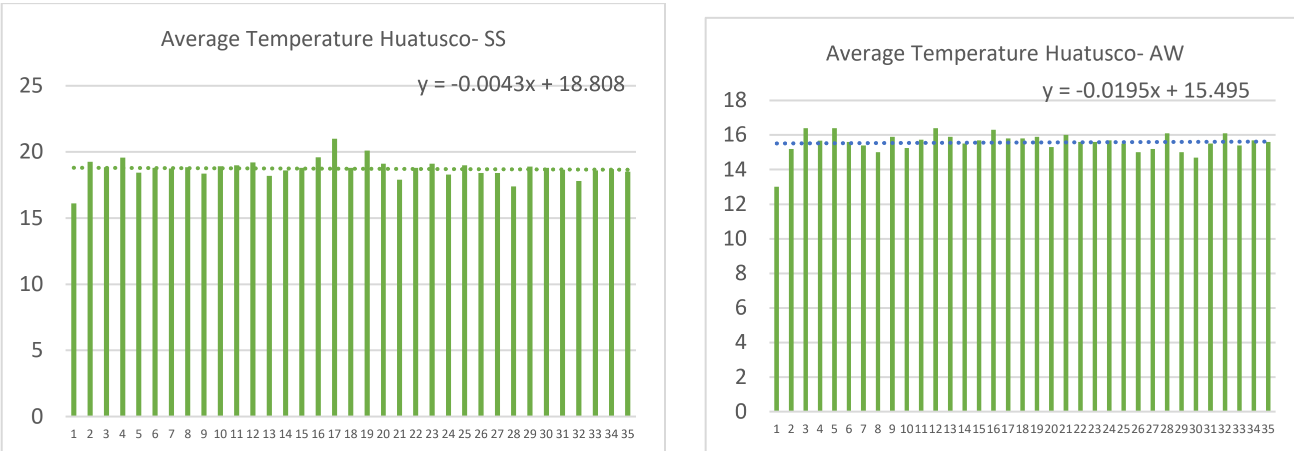


Figure 1.9.10. Historical mean seasonal temperature in stations in Jamapa (Huatusco).

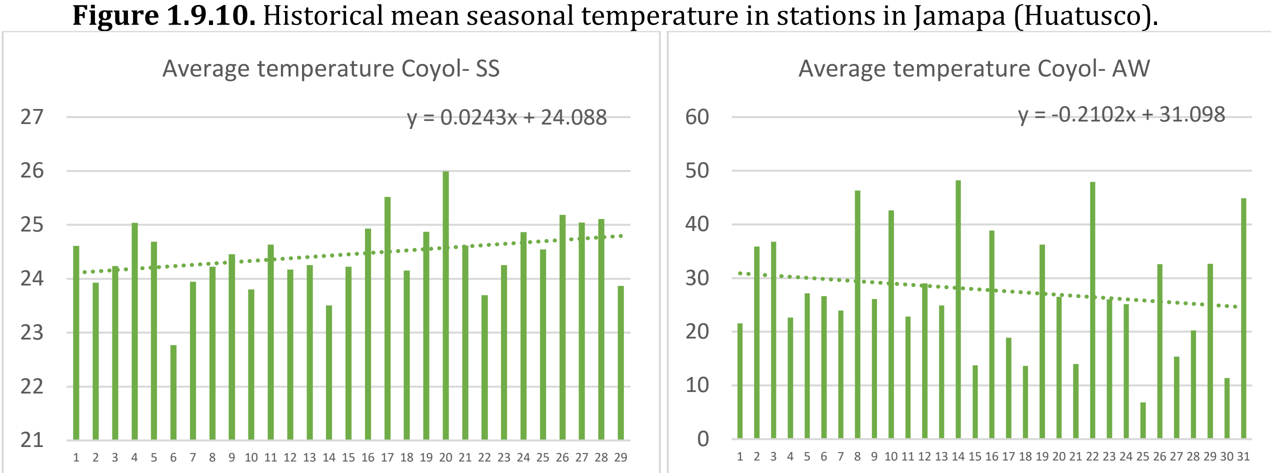


Figure 1.9.11. Historical mean seasonal temperature in stations in Jamapa (El Coyol).

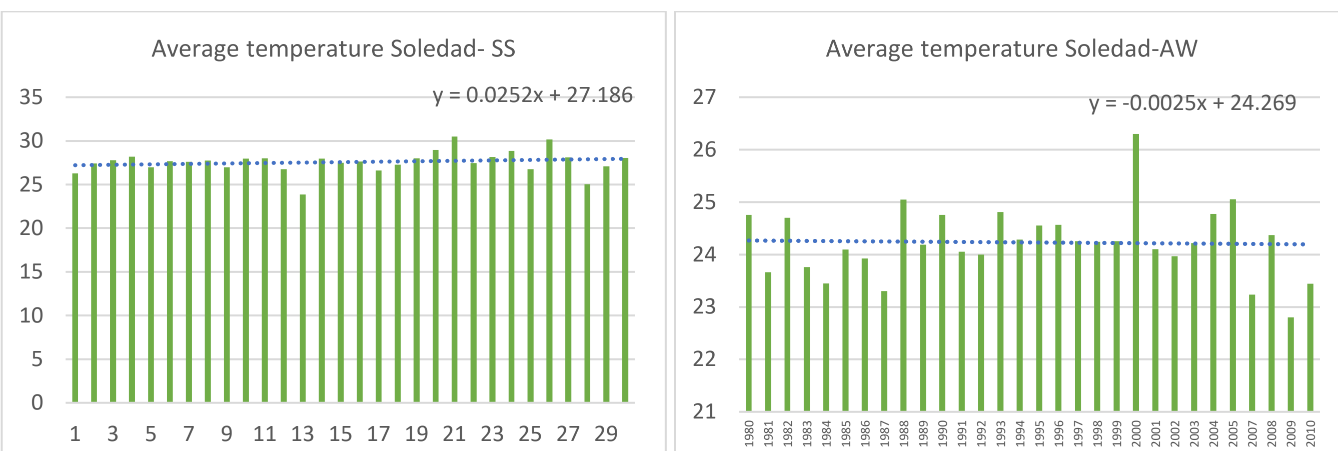


Figure 1.9.12. Historical mean seasonal temperature in stations in Jamapa (Soledad de Doblado).

Historical maximum and minimum seasonal temperature in stations in Jamapa

The maximum and minimum temperatures according to the seasonality of the upper Jamapa basin show that there is a slight historical increase in the last 30 years in SS while, for the AW, the decrease in temperatures is more noticeable (Figure 1.9.13).

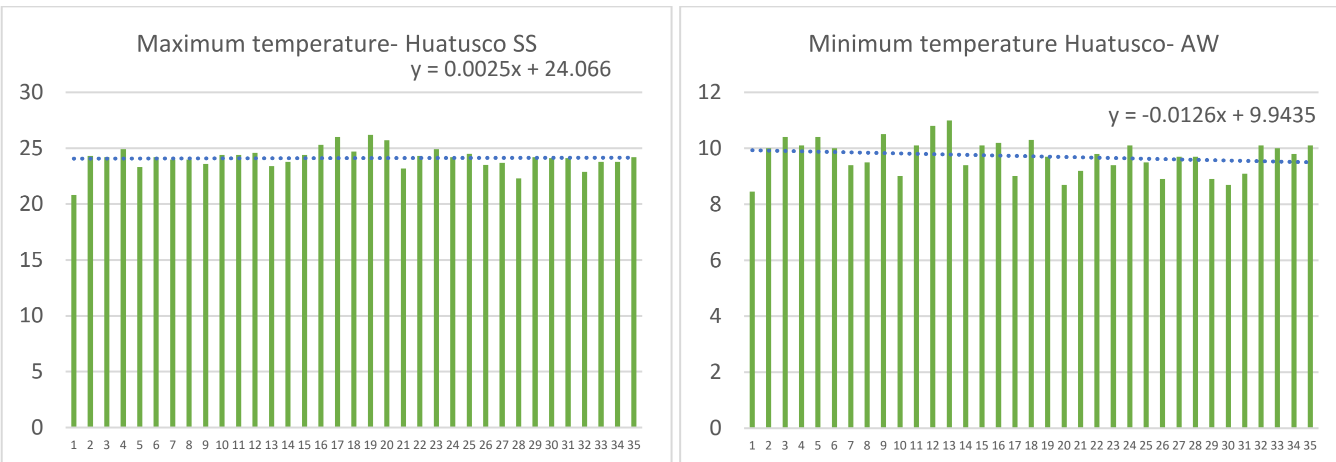


Figure 1.9.13. Historical maximum and minimum seasonal temperature in stations in Jamapa (Huatusco).

Contrary to the upper basin, in the middle part of the Jamapa basin (El Coyol), the maximum and minimum temperature values present extreme records with values above 30ºC (Figure 1.9.14). For the lower basin, the dry season is the one that registers conditions of decrease in the historical temperature (Figure 1.9.15).

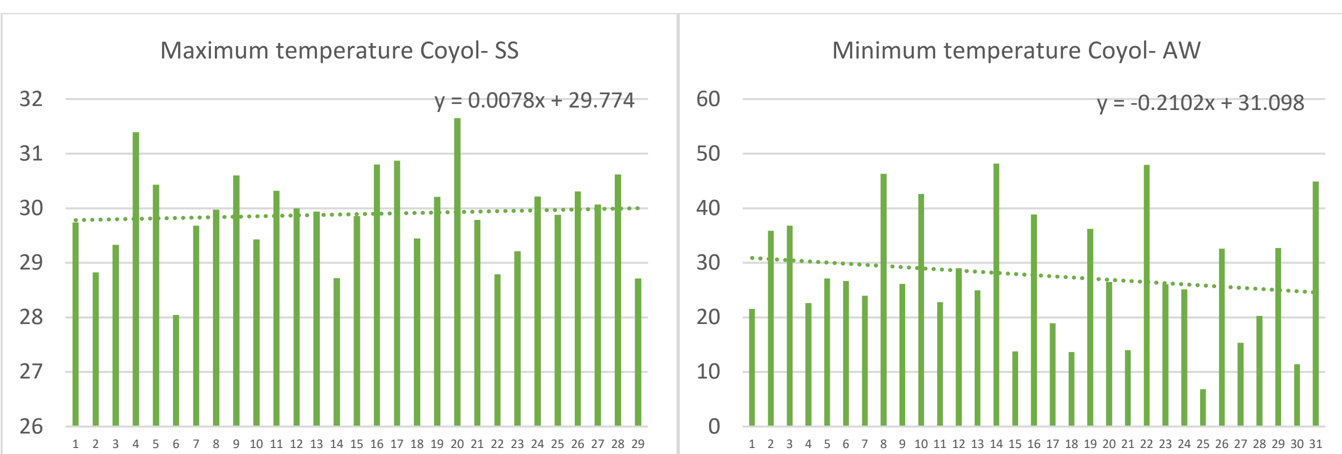


Figure 1.9.14. Historical maximum and minimum seasonal temperature in stations in Jamapa (El Coyol).

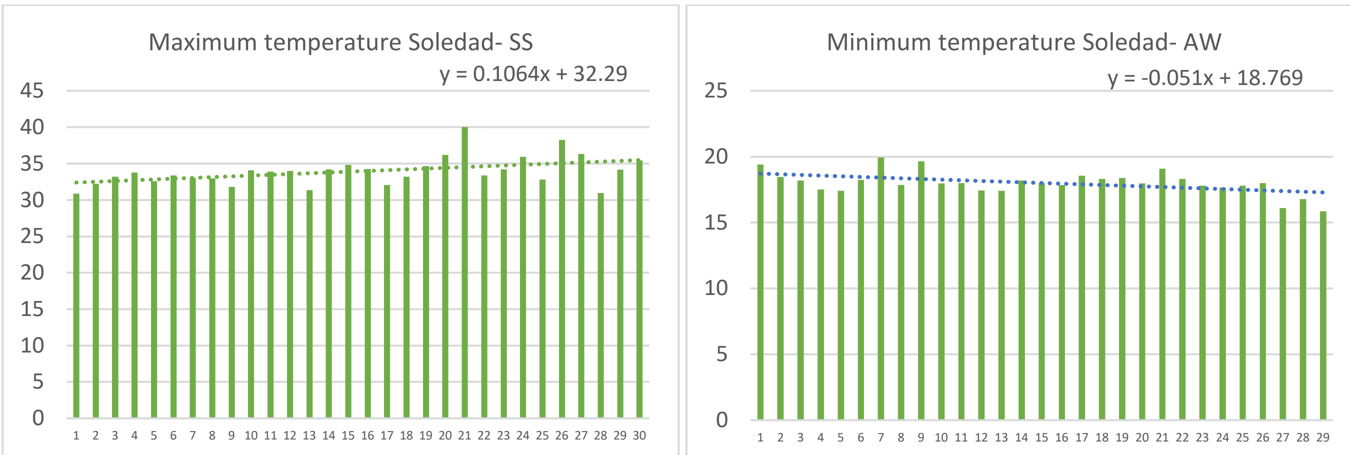


Figure 1.9.15. Historical maximum and minimum seasonal temperature in stations in Jamapa (Soldedad de Doblado).

Similar to Ameca-Mascota, SS had an increase in the maximum temperature in all the stations; the largest historical trend has been in Soledad (the downstream region) with a yearly increase of ~ 0.106°C annually. Minimum temperature has decreased in AW in AW.

Precipitation change

Precipitation change in Ameca-Mascota

Average precipitation has increased in the historic period in the three stations of the region during SS around ~1.5 mm and ~0.7 mm in one of them. Average precipitation in the AW shows that historically there is a decrease in the middle and lower parts of the watersheds. This could suggest that rainfall is moving away even more from the dry to the rainy season, except for the upper watershed, where the historical trends shows an increase throughout the year. Here, maximum precipitation is concentrated in the month of July, however, there are also peaks during the winter, representing an increase in the risk of landslides in the upper watershed due to water saturation in the soil.

A decrease in mean precipitation in AW in the middle and lower parts of the watershed results in the decrease in the natural recharge of the aquifer, due to less precipitation and greater extraction of water for agricultural activities during the dry season. And, on the other hand, a higher concentration (more volume in less time) of precipitation, which could increase the erosion factor of rain, increasing landslides, in addition to increasing the magnitude of surface runoff (including flash floods) and reducing infiltration capacity.

Historical mean seasonal precipitation in stations in Ameca-Mascota

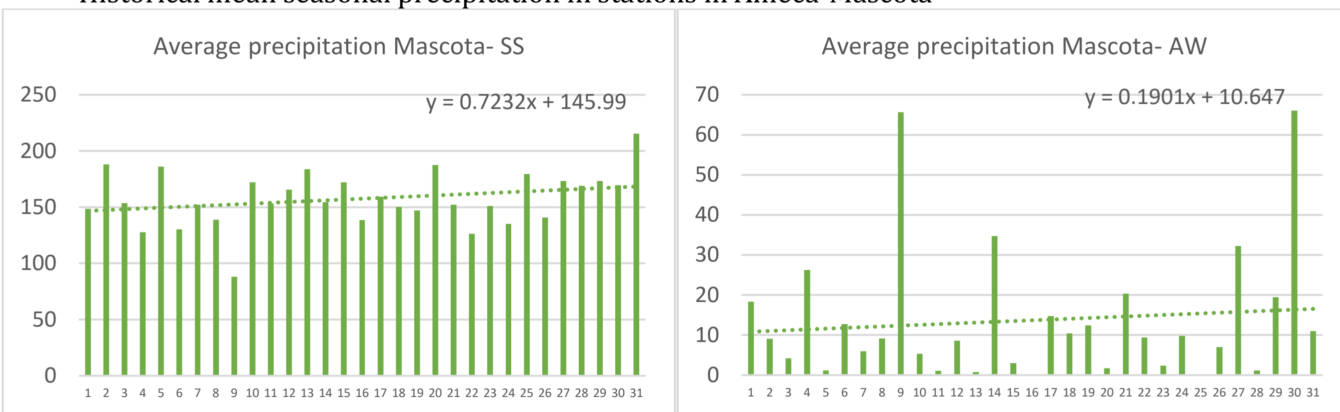


Figure 1.9.16. Historical mean seasonal precipitation in stations in Ameca-Mascota (Mascota).

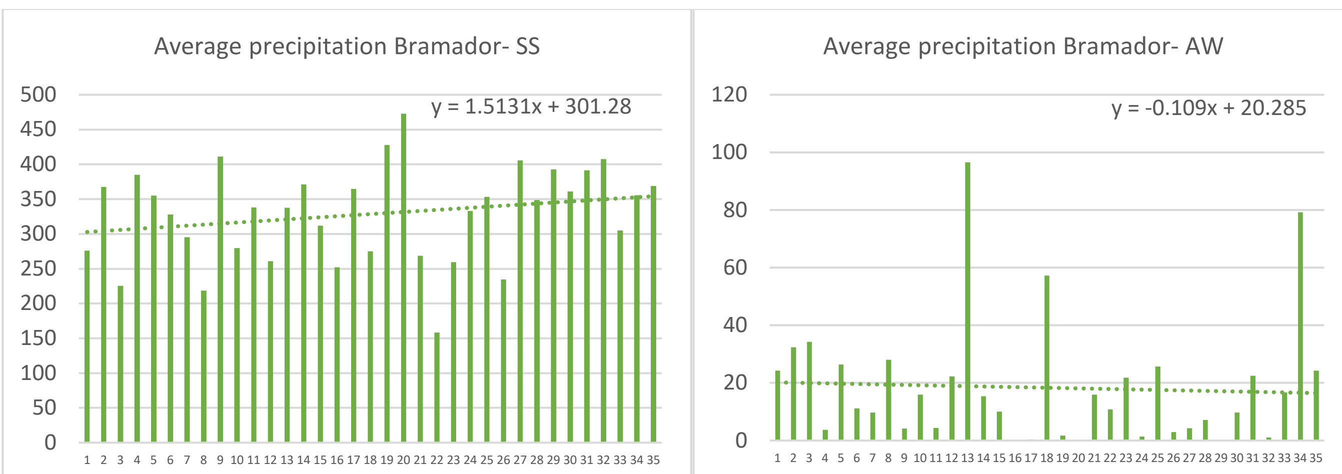


Figure 1.9.17. Historical mean seasonal precipitation in stations in Ameca-Mascota (Bramador).

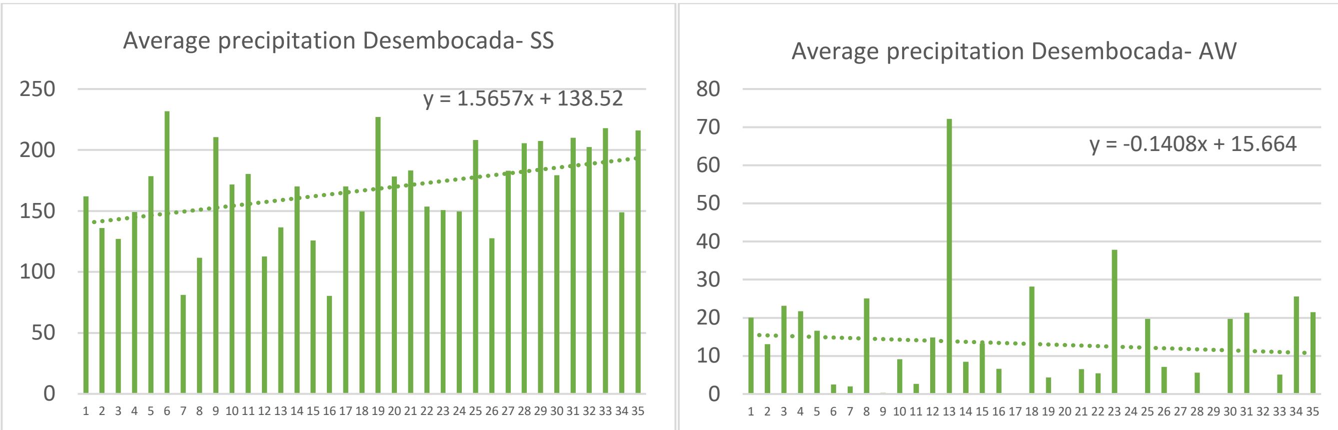


Figure 1.9.18. Historical mean seasonal precipitation in stations in Ameca-Mascota (Desembocada).

Historical mean seasonal precipitation in stations in Jamapa

Precipitation, in general, behaves with high records in the rainy season for the upper basin, however, in the dry season (AW) there have been years with extreme data in this region, which are recorded as out of the ordinary (Figure 1.9.19)

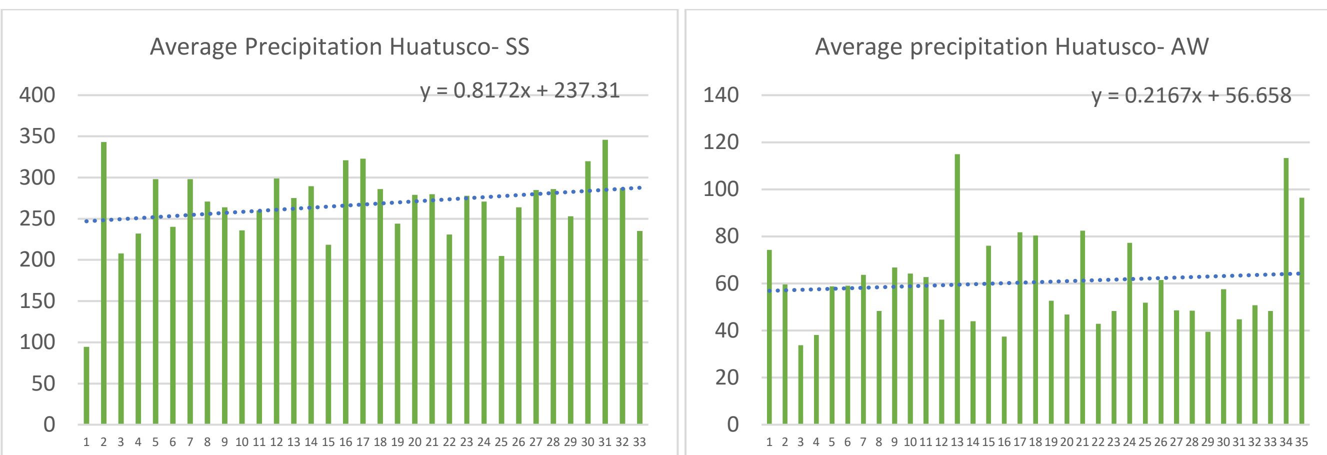


Figure 1.9.19. Historical mean seasonal precipitation in stations in Jamapa (Huatusco).

In the middle part of the basin, rainfall has shown a decrease especially in the dry season, and maintains a similar negative trend in the wet season (Figure 1.9.20). Mean precipitation shows a historical decrease in the middle and lower parts of the watershed, while the upper watershed has a historical increase.

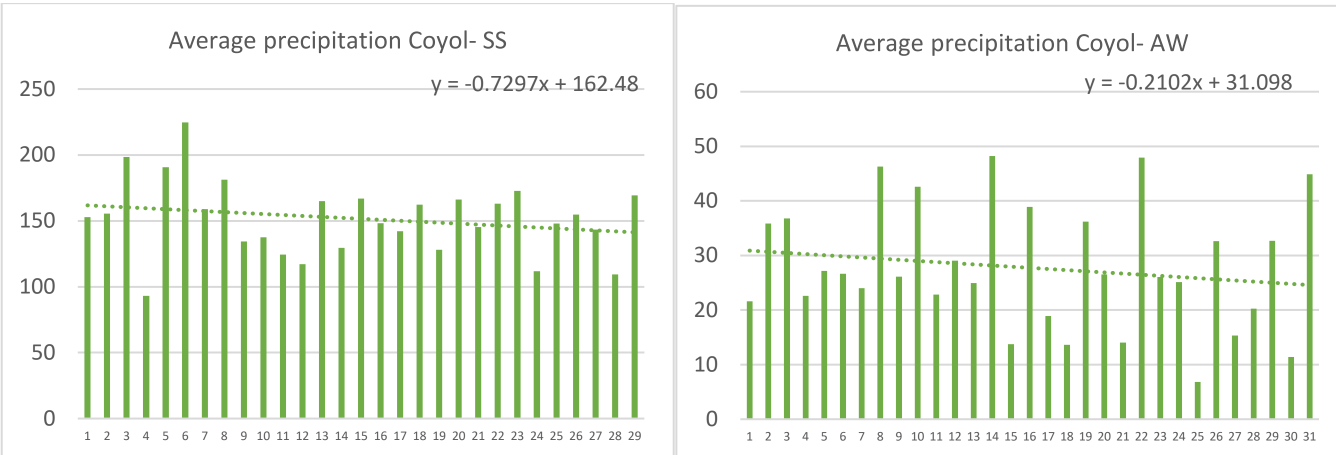


Figure 1.9.20. Historical mean seasonal precipitation in stations in Jamapa (El Coyol).

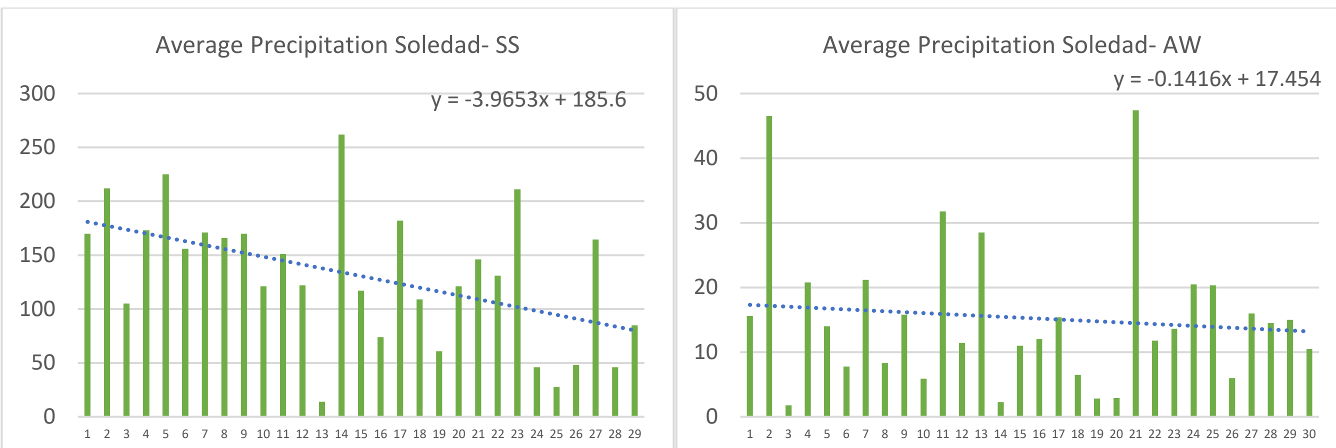


Figure 1.9.21. Historical mean seasonal precipitation in stations in Jamapa (Soledad de Doblado).

The area of Soledad de Doblado in the lowest part of the watershed floods with water from the Jamapa and Cotaxtla rivers, these shallow areas play an important role and respond to temporary variations mainly in the June and September months with the highest rainfall (Figure 1.9.21). Also, in these months, there are average rises in the water table in the order of three meters, which indicates a relationship between rainfall in the upper watershed, fluctuations in the water table and floods in the area (Neri-Flores et al., 2014).

Extreme daily (95th percentile) precipitation in Ameca and Jamapa

Extreme daily precipitation was analyzed in both regions with data from the station in the upper watershed in Mascota and the station in the middle part of the watershed in Jamapa. Both show a clear increase in extreme precipitation events.

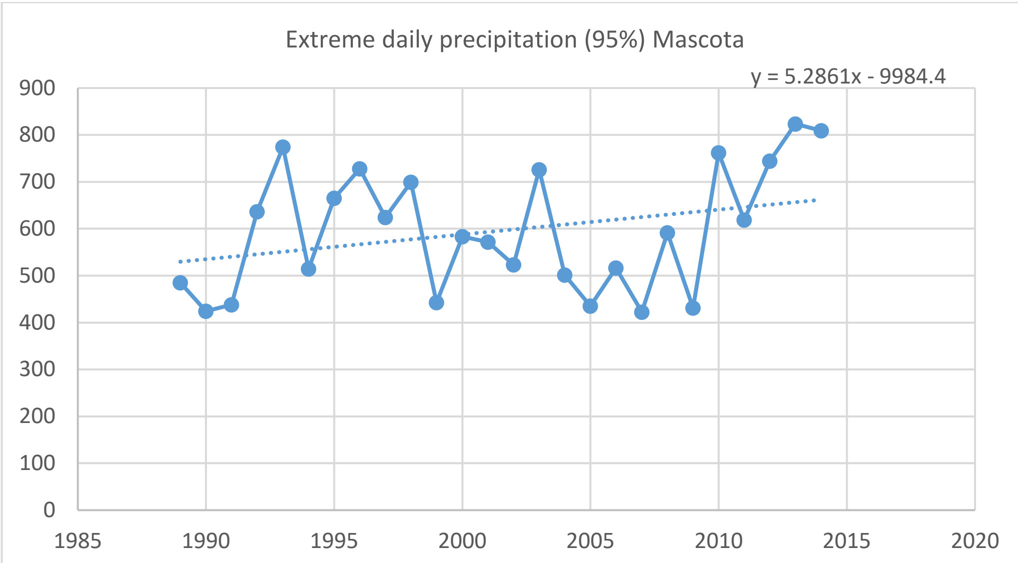


Figure 1.9.22. Extreme daily precipitation of 95th percentile in the upper part of the Ameca watershed per year.

Extreme daily (95th percentile) precipitation in Jamapa

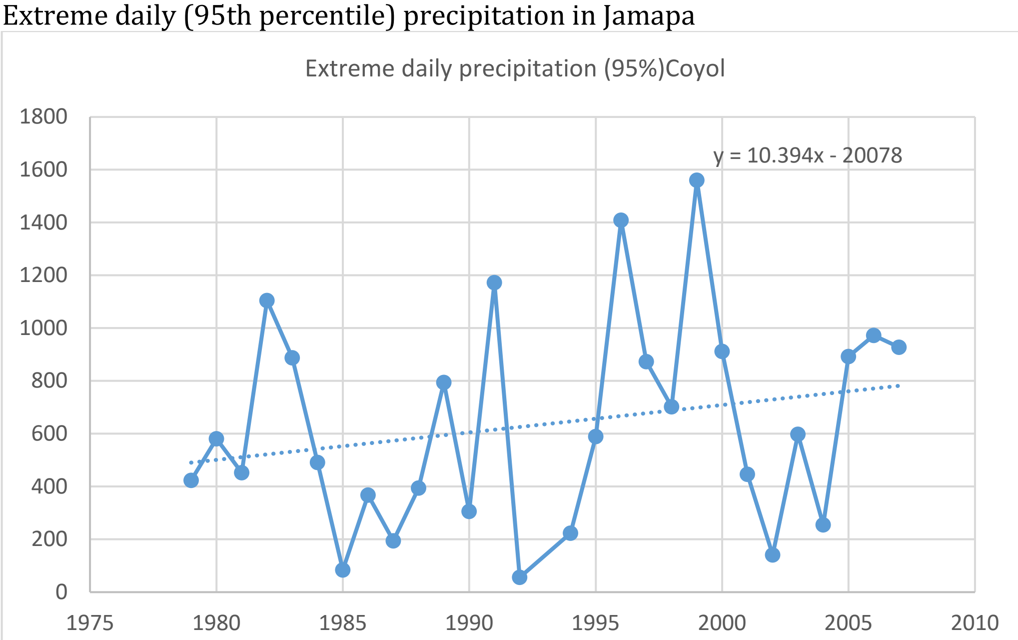


Figure 1.9.23. Extreme daily precipitation of 95th percentile in the middle part of the Jamapa watershed per year.

Extreme weather events

Extreme weather events in Ameca

The extreme weather events in the Ameca-Mascota basin have been increasing in the last 70 years both in frequency and intensity (Figure 1.9.24). In the last years, category 1, 2, 3, 4, and 5 hurricanes have occurred more frequently, generating losses and direct effects on more than 150 thousand people in the region according to the National Infrastructure Fund (FONADIN). In the period 1950-1979, 18 events occurred, over 70 percent of them classified as Tropical Depression or Tropical Storms, and only 5.5% were category 3 or above. However, during 1990-2019, 20 events occurred and more than 30% were category 3 or above.

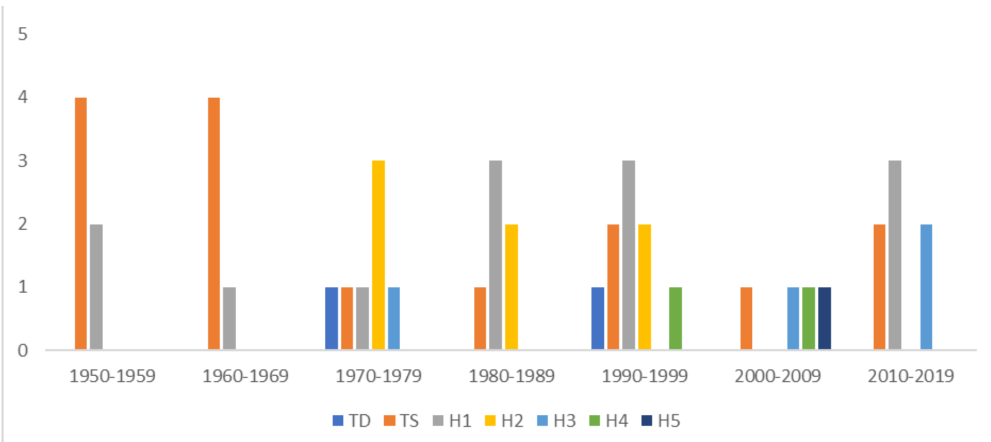


Figure 1.9.24. Frequency of tropical cyclones by decade and category in Ameca-Mascota Basin. (TD. Tropical Depression; TS. Tropical Storm; H1. Category 1; H2. Category 2; H3. Category 3; H4. Category 4 and H5. Category 5. Source: Own elaboration with data from Historical Hurricanes Tracks, NOAA, 2021.

Extreme weather events in Jamapa

Peaks in precipitation intensity are magnified with the presence of extreme weather events. In the Jamapa basin, the frequency of weather-related events has increased dramatically, mainly recently. Figure 1.9.25 shows that the number of events in the last decade (2010-2019) is 3.5 higher than the previous decade with more events (1930-1939). In the first 50 years with data (1920-1969) there were 15 events compared to 25 in the last 50 years (1970-2019), 13 of them in the last decade.

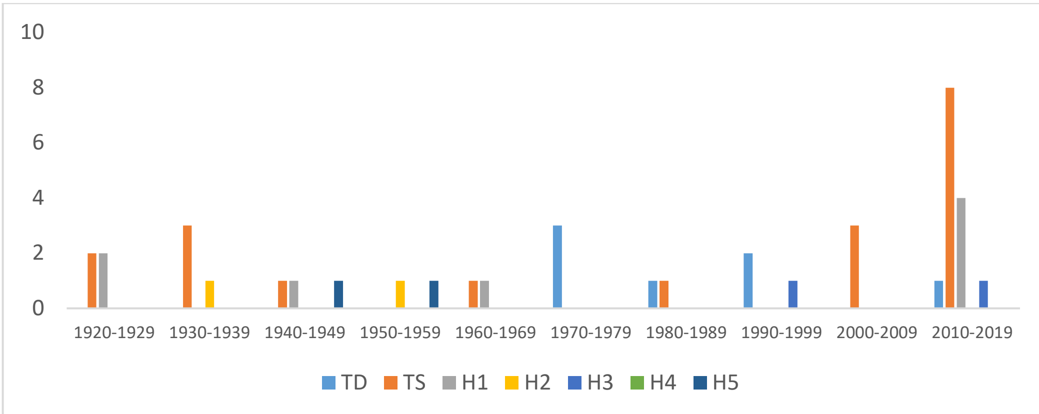


Figure 1.9.25. Frequency of tropical cyclones by decade and category in Jamapa Basin. TD. Tropical Depression; TS. Tropical Storm; H1. Category 1; H2. Category 2; H3. Category 3; H4. Category 4 and H5. Category 5. Source: Own elaboration with data from Historical Hurricanes Tracks, NOAA, 2021.

Climate-related disasters

Climate-related disasters in Ameca-Mascota

In the Ameca-Mascota watershed, from 1999 to 2018 most of the 46 disasters declared in the watershed municipalities were weather-related disasters (95%) (Figure 1.9.26). The national disaster fund (FONDEN) invested 383 million pesos (around USD$19 million) in these municipalities. The hydrometeorological phenomena in the Ameca-Mascota watershed from 2000 to 2015 have caused the following damages: 291,357 affected inhabitants, 21,216.6 ha of ruined crops and pastures, 3,350 damaged homes, 227 destroyed schools, 24 lost hospitals, and 186 km of broken trails (SEGOB, 2019).

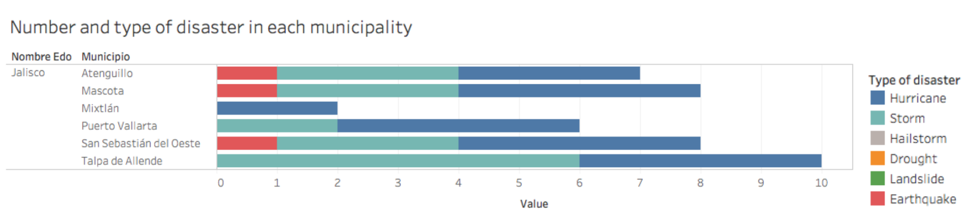


Figure 1.9.26. Disaster declarations to FONDEN (number) by the municipalities in the Ameca-Mascota Region Watersheds (red depicts earthquakes). Source: INECC, 2018.

Climate-related disasters in Jamapa

The main disasters in the region are weather-related, as shown in Figure 1.9.27. From a total of 374 disasters, only two are related to geological disasters (earthquake, marked in red). The majority (over 99%) of official disaster declarations are due to tropical cyclones and storms. The national disaster fund (FONDEN) has invested 3,981 million pesos (US$199 million) in these municipalities from 1999 to 2018.

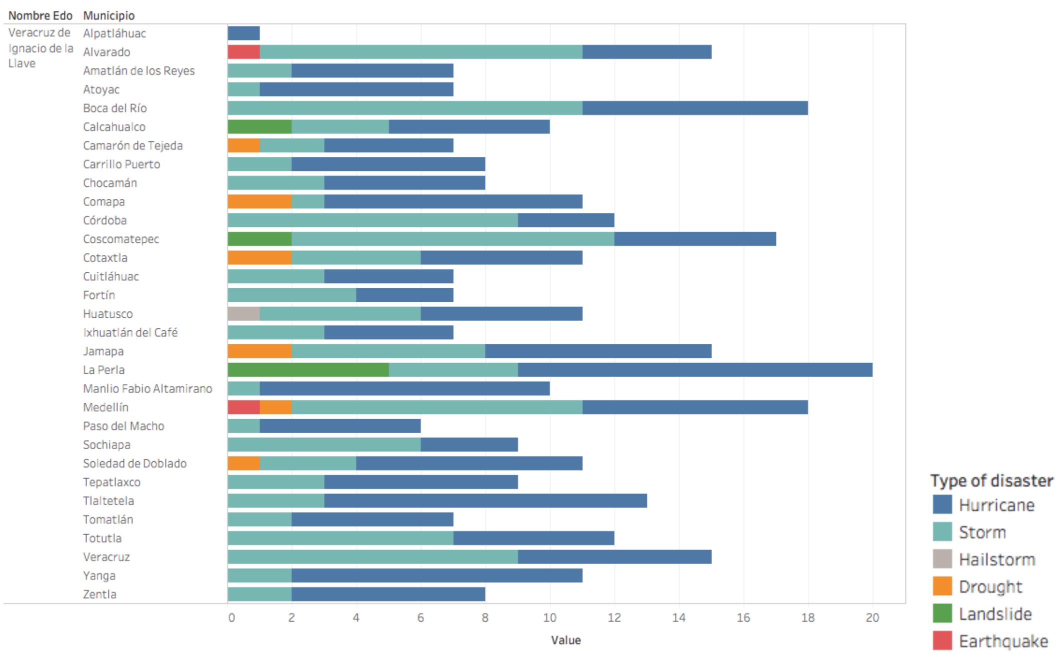


Figure 1.9.27. Disaster declarations by the National Disaster Fund Trust (FONDEN) (number) for the municipalities in the Jamapa Watershed. Source: INECC, 2018.

Climate model validation against observational data

Climate change information at the regional-to-local scale is one of the central issues within the global change debate, not only to assess the impacts of climate change on human and natural systems but also to develop suitable adaptation and mitigation strategies. Empirical statistical downscaling or dynamical regional climate models (RCMs) have been used to downscale potential climate changes at finer scales (Cavazos et al., 2019).

The Coordinated Regional Downscaling Experiment (CORDEX: http://www.cordex.org/) is a diagnostic model intercomparing project (MIP) to provide a common framework for regional climate downscaling (RCD) activities around the world (Gutowski et al., 2016). CORDEX main goals are to (Giorgi, 2019): 1) better understand relevant regional to local climate phenomena, along with their variability and changes, through downscaling; 2) evaluate and improve RCD models and techniques (e.g., RCM, ESD, VAR-AGCM, HIR-AGCM); 3) generate large coordinated and consistent ensembles of downscaled projections over regions worldwide, and, 4) foster communication and knowledge exchange with users of regional climate information.

This is achieved through the design and implementation of a common simulation and analysis protocol for domains[3] covering all land regions of the world at a grid spacing of 12 to 50 km (and larger for some regions), which involves the completion of ensembles of experiments for multiple scenarios, multiple driving GCMs, and multiple RCMs (along with perfect lateral boundary condition runs to validate the models) (Figure 1.9.28). An important component of the CORDEX program is also to devise model evaluation metrics both common across domains and related to phenomena specific for the different regions (Gutowski et al., 2016). Also, data storage and distribution protocol has been implemented, including a common data format for easy access to the data, taking advantage of the Earth System grid federation (ESGF) platform developed for global model intercomparison projects (Giorgi, 2019).

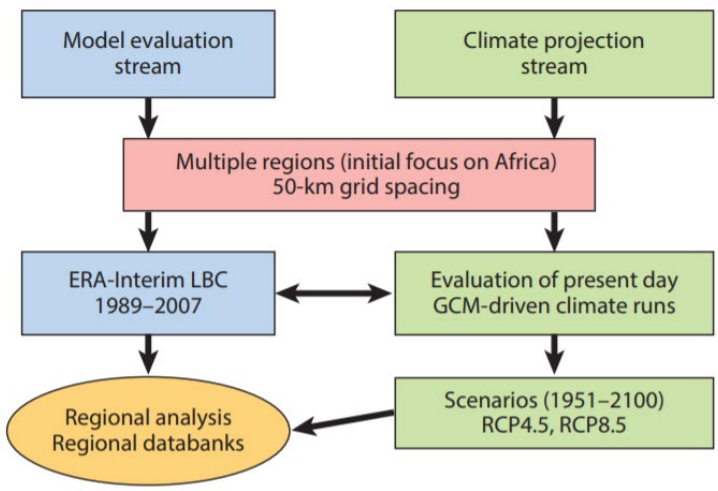


Figure 1.9.28. Schematic depiction of the model experiment protocol envisaged in CORDEX framework (Phase I), showing, in particular, the evaluation and projection experiment streams. Abbreviations: CORDEX, Coordinated Regional Downscaling Experiment; GCM, global climate model; LBC, lateral boundary condition; RCP4.5 and RCP8.5, representative concentration pathways in watts/square meter. Source: Giorgi and Gutowski, 2015.

CORDEX has become an important tool in regions where there is less certainty about observed gridded trends due to the lack of temporally continuous long-term climate station data and sparse spatial coverage,. In Mexico, only few studies have focused on temperature and precipitation trends using station data in some regions of the country (Cavazos et al., 2019). In consequence, the Universidad Nacional Autónoma de México (UNAM), the Universidad Veracruzana (UV) and the Universidad Autónoma de Zacatecas (UAZ) documented temperature and precipitation linear trends in the CORDEX-CAM domain during 1980–2010 using observed gridded climate data sets and three RCMs currently available for CORDEX-CAM. (Central

[3] A domain is a region for which the regional downscaling is taking place. For example, the African domain covers the whole of the African continent.

American). The first objective was to evaluate and intercompare the RCMs (PRECIS-HadRM3P[4], RCA4[5], and RegCM4[6]) using several climatic metrics of temperature and precipitation.

Following this example, the Accredited Entity´s staff and partners used CORDEX databases downloaded from the GCF-funded project https://climateinformation.org/. Historic maximum temperature, minimum temperature, average temperature, and rainfall data from thirty years (1980-2010) was taken from the meteorological stations located at Jamapa watershed in Veracruz and Ameca-Mascota watershed in Jalisco (review Tables 1.1 to 1.4), which include a diverse topographic setting that can result in much more variability than differences in temperature and precipitation values. For future climate, CORDEX provided climate data (temperature and rainfall) with a spatial resolution of 50 km for the four RCMs available for CORDEX (PRECIS, RCA4, RegCM4.0-Grell, and RegCM4.0-Tiedtke). For the RIOS coordinates, only North American CORDEX is available. This can have some additional bias due to topographic and environmental conditions.

A selected number of global climate models (GCMs) from the fifth Coupled Model Intercomparison Project (CMIP5) view also elected for comparison, as they some of these models are the basis of public policy design by the institution that coordinates climate change research and policy in Mexico (INECC) and that acts as technical leader of this project.

Table 1.5. Use of models in key institutional adaptation instruments in Mexico

Model	Ensemble	Use in key institutional adaptation instruments in Mexico
CCCma-CanESM2 SMHI-RCA4-v1	CORDEX-NA	
CCCma-CanESM2 UQAM-CRCM5-v1	CORDEX-NA	
ICHEC-EC-EARTH SMHI-RCA4-v1	CORDEX-NA	
MPI-M-MPI-ESM-LR UQAM-CRCM5-v1	CORDEX-NA	
BNU-BNU-ESM	CMIP5	

4 PRECIS (Providing Regional Climates for Impacts Studies) (http://www.metoffice.gov.uk/precis) was developed by the UK Met Office Hadley Centre; its objective is to facilitate the generation of climate change scenarios for developing countries. The low computational requirement of this model allows the user to perform numerical simulations on a laptop computer from a simple graphical interface.

5 RCA4 is a hydrostatic regional climate model from the Swedish Meteorological and Hydrological Institute (SMHI), based on the numerical weather prediction model HIRLAM. The output at 50-km grid resolution of the Swedish SMHI-RCA4 model forced with ERA-Interim was obtained from the CORDEX database of the Earth System Grid Federation (ESGF) hub (https://www.cordex.org/output/esgf-menu.html) for the 1979–2010 period.

6 The regional model RegCM4 (http://gforge.ictp.it/gf/project/regcm/frs/) was initially developed by the National Center for Atmospheric Research (NCAR). It is now constantly improved by the Earth System Physics department of the International Center for Theoretical Physics (ICTP). In this study, the hydrostatic core of RegCM4.5 was used for comparison with RegCM4.0 and the hydrostatic models PRECIS and RCA4. The Grell (1993) convective (G) parameterization over the continent was chosen in one experiment (RegCM4.0-G), which was performed at the ICTP. The other simulation (performed at the Universidad Veracruzana, Mexico) used Tiedtke (T) over the continent (hereafter RegCM4.5-T), as Tiedtke has shown good results in the Caribbean region (Martinez-Castro et al., 2017).

CNRM-CERFACS-CNRM-CM5	CMIP5	National Atlas of Vulnerability to Climate Change (ANVCC) (INECC 2019)
CSIRO-BOM-ACCESS1-0	CMIP5	
CSIRO-BOM-ACCESS1-3	CMIP5	
ICHEC-EC-EARTH	CMIP5	
IPSL-IPSL-CM5A-LR	CMIP5	
IPSL-IPSL-CM5A-MR	CMIP5	
IPSL-IPSL-CM5B-LR	CMIP5	
MOHC-HadGEM2-CC	CMIP5	ANVCC (INECC 2019)
MOHC-HadGEM2-ES	CMIP5	ANVCC (INECC 2019)
MPI-M-MPI-ESM-LR	CMIP5	ANVCC (INECC 2019)
MPI-M-MPI-ESM-MR	CMIP5	ANVCC (INECC 2019)
NCC-NorESM1-M	CMIP5	
NOAA-GFDL-GFDL-CM3	CMIP5	ANVCC (INECC 2019)
NOAA-GFDL-GFDL-ESM2G	CMIP5	ANVCC (INECC 2019)
NOAA-GFDL-GFDL-ESM2M	CMIP5	ANVCC (INECC 2019)
bcc-bcc-csm1-1-m	CMIP5	
bcc-bcc-csm1-1	CMIP5	

One station was selected on each region to validate models against observational data. The two selected stations have fewer extreme values according to the analyzed observational data, and are located in the middle basin. In Ameca- Mascota we selected the Mascota station, and in Jamapa the Coyol station.

Temperature

Comparison between models and observed temperature in Ameca-Mascota

The highest temperatures are recorded during spring and summer, being May and June the warmest months.

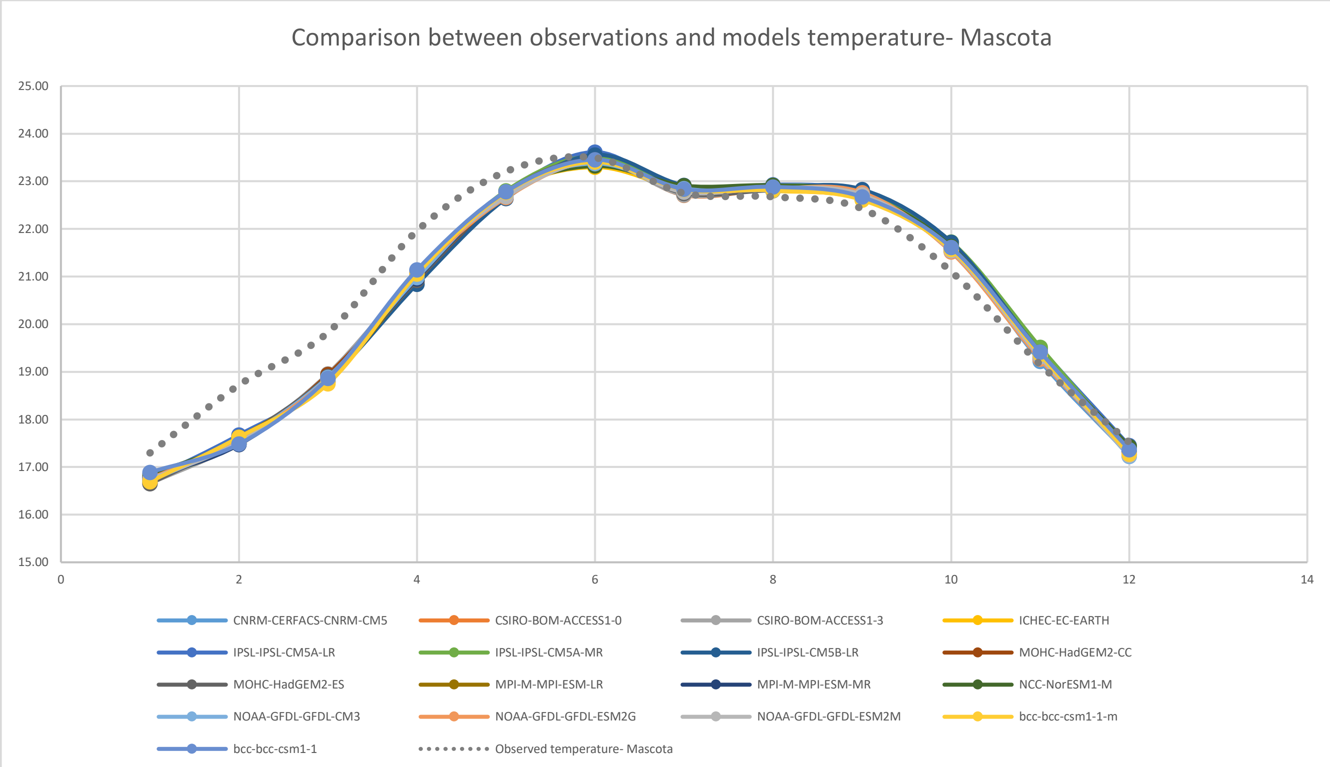


Figure 1.9.29. Comparison between observations and models- Mascota

All models underestimate temperature in SS, and overestimate in AW. The largest magnitude difference is in February.

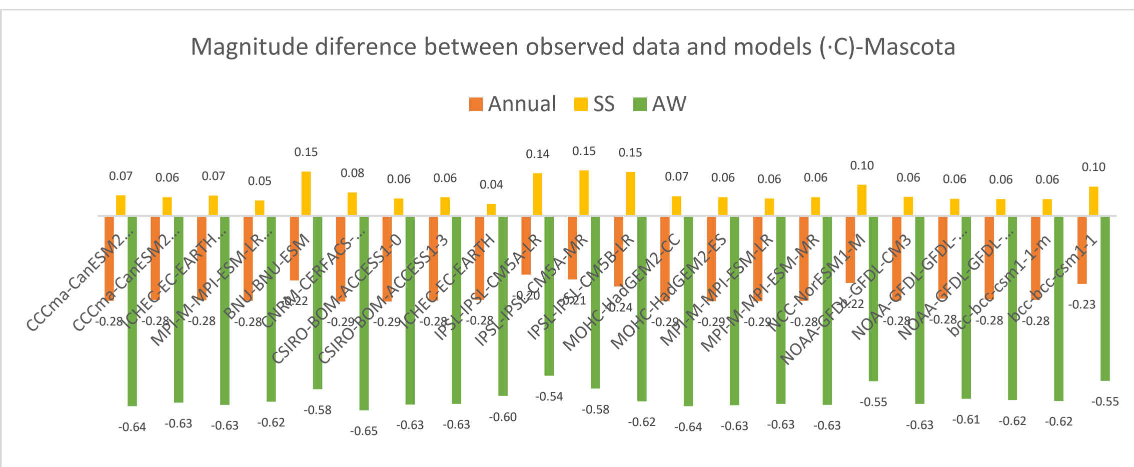


Figure 1.9.30. Magnitude of the difference between observational data

We used to measure to assess the degree of variability of the models compared to the observed data. One, the standard deviation of the difference, which measures dispersion of a data. The other, root mean square ot-mean-square error (RMSE) which is a frequently used measure of the differences between values (sample or population values) predicted by a model or an estimator and the values observed. Both are measured in the unit of analysis.

Table 1.6. Standard deviation an Root mean square of observed data and models Mascota

Models	Standard deviation of the difference (·C)			Root mean square error (·C)		
	Annual	SS	AW	Annual	SS	AW
CCCma-CanESM2 SMHI-RCA4-v1	0.55	0.32	-0.64	0.60	0.30	0.80
CCCma-CanESM2 UQAM-CRCM5-v1	0.54	0.29	-0.63	0.59	0.27	0.79
ICHEC-EC-EARTH SMHI-RCA4-v1	0.55	0.33	-0.63	0.59	0.31	0.78
MPI-M-MPI-ESM-LR UQAM-CRCM5-v1	0.53	0.31	-0.62	0.58	0.29	0.77
BNU-BNU-ESM	0.60	0.36	-0.58	0.61	0.36	0.79
CNRM-CERFACS-CNRM-CM5	0.55	0.32	-0.65	0.60	0.30	0.80
CSIRO-BOM-ACCESS1-0	0.55	0.32	-0.63	0.60	0.30	0.79
CSIRO-BOM-ACCESS1-3	0.54	0.34	-0.63	0.59	0.31	0.77
ICHEC-EC-EARTH	0.53	0.32	-0.60	0.58	0.29	0.77
IPSL-IPSL-CM5A-LR	0.57	0.35	-0.54	0.58	0.35	0.74
IPSL-IPSL-CM5A-MR	0.60	0.34	-0.58	0.61	0.35	0.79
IPSL-IPSL-CM5B-LR	0.63	0.40	-0.62	0.64	0.40	0.82
MOHC-HadGEM2-CC	0.55	0.33	-0.64	0.60	0.30	0.79
MOHC-HadGEM2-ES	0.54	0.31	-0.63	0.59	0.29	0.79
MPI-M-MPI-ESM-LR	0.54	0.31	-0.63	0.59	0.29	0.78
MPI-M-MPI-ESM-MR	0.55	0.30	-0.63	0.60	0.28	0.80
NCC-NorESM1-M	0.56	0.35	-0.55	0.58	0.33	0.75
NOAA-GFDL-GFDL-CM3	0.54	0.30	-0.63	0.59	0.28	0.78
NOAA-GFDL-GFDL-ESM2G	0.53	0.35	-0.61	0.58	0.32	0.76
NOAA-GFDL-GFDL-ESM2M	0.54	0.34	-0.62	0.59	0.32	0.77
bcc-bcc-csm1-1-m	0.54	0.30	-0.62	0.59	0.28	0.78
bcc-bcc-csm1-1	0.55	0.31	-0.55	0.57	0.30	0.75

Comparison between models and observed temperature in Jamapa

The highest temperatures are recorded during the spring and summer period, being May the warmest month. All models underestimate the observed data, mainly in the warmest and coldest months.

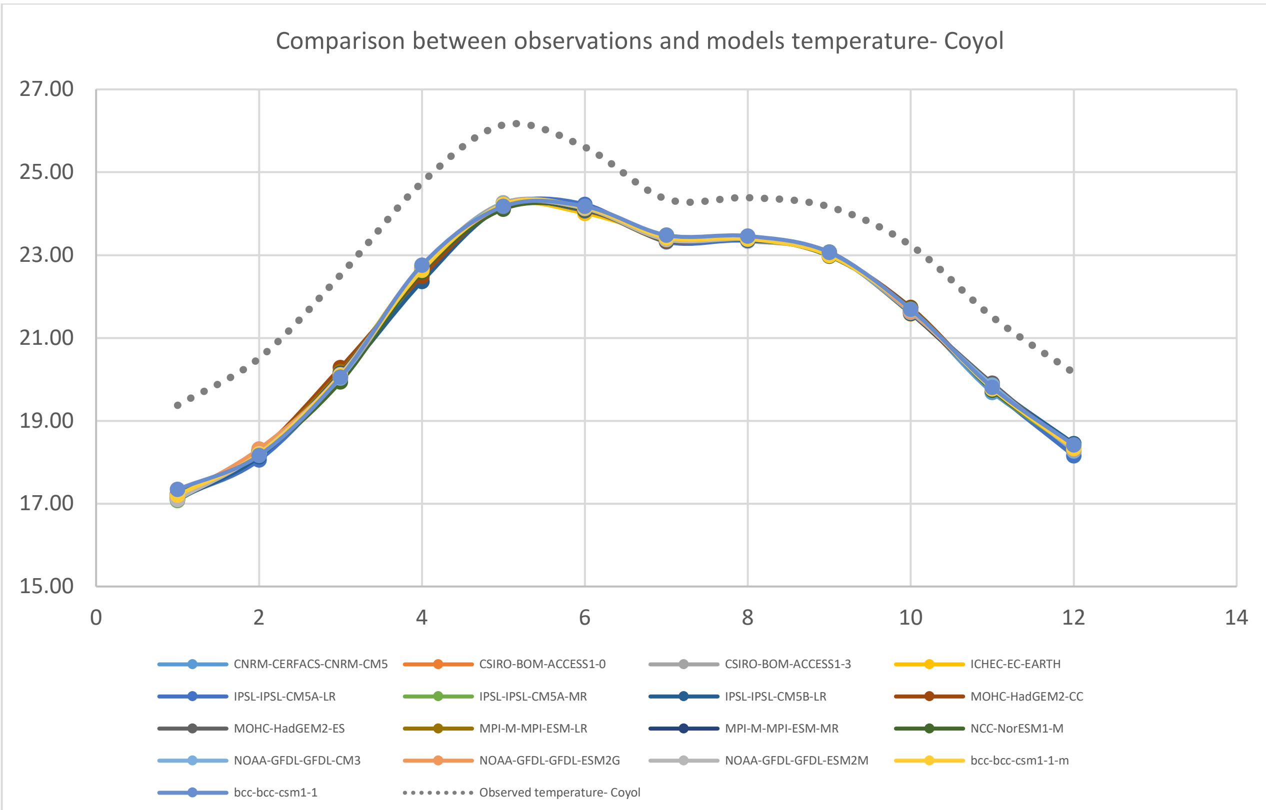


Figure 1.9.31. Comparison between models and observed temperature in Coyol

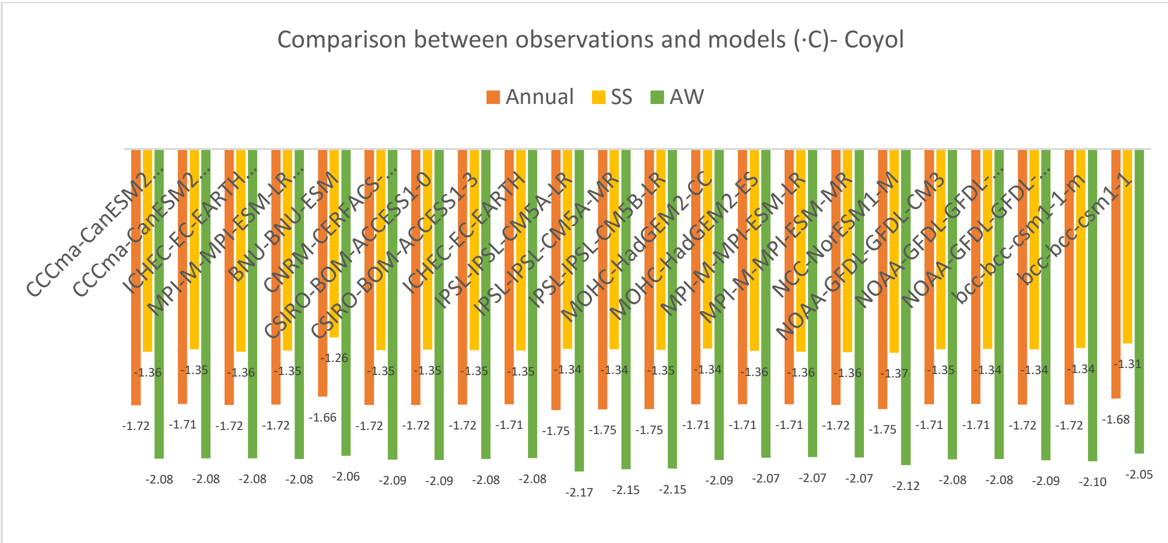


Figure 1.9.32. Magnitude difference. Temperature Coyol

Table 1.7. Standard deviation and Root mean square of observed data and models Coyol

Models	Standard deviation of the difference (mm)			Root mean square error (mm)		
	Annual	SS	AW	Annual	SS	AW
CCCma-CanESM2 SMHI-RCA4-v1	0.48	0.37	-2.08	1.78	1.40	2.09
CCCma-CanESM2 UQAM-CRCM5-v1	0.50	0.40	-2.08	1.78	1.39	2.09
ICHEC-EC-EARTH SMHI-RCA4-v1	0.51	0.41	-2.08	1.79	1.41	2.09
MPI-M-MPI-ESM-LR UQAM-CRCM5-v1	0.50	0.40	-2.08	1.78	1.40	2.10
BNU-BNU-ESM	0.54	0.40	-2.06	1.74	1.32	2.08
CNRM-CERFACS-CNRM-CM5	0.50	0.40	-2.09	1.78	1.40	2.10
CSIRO-BOM-ACCESS1-0	0.50	0.37	-2.09	1.78	1.39	2.10
CSIRO-BOM-ACCESS1-3	0.49	0.35	-2.08	1.78	1.39	2.10
ICHEC-EC-EARTH	0.51	0.41	-2.08	1.78	1.40	2.09
IPSL-IPSL-CM5A-LR	0.53	0.36	-2.17	1.82	1.38	2.18
IPSL-IPSL-CM5A-MR	0.53	0.37	-2.15	1.82	1.39	2.17
IPSL-IPSL-CM5B-LR	0.56	0.42	-2.15	1.83	1.40	2.17
MOHC-HadGEM2-CC	0.49	0.37	-2.09	1.78	1.38	2.10
MOHC-HadGEM2-ES	0.49	0.38	-2.07	1.78	1.40	2.09
MPI-M-MPI-ESM-LR	0.50	0.41	-2.07	1.78	1.41	2.08
MPI-M-MPI-ESM-MR	0.50	0.42	-2.07	1.78	1.42	2.09
NCC-NorESM1-M	0.52	0.40	-2.12	1.82	1.42	2.14

NOAA-GFDL-GFDL-CM3	0.51	0.39	-2.08	1.78	1.39	2.10
NOAA-GFDL-GFDL-ESM2G	0.50	0.40	-2.08	1.78	1.39	2.10
NOAA-GFDL-GFDL-ESM2M	0.50	0.38	-2.09	1.78	1.39	2.11
bcc-bcc-csm1-1-m	0.50	0.37	-2.10	1.78	1.38	2.11
bcc-bcc-csm1-1	0.52	0.42	-2.05	1.75	1.36	2.07

Precipitation

Comparison between models and observed precipitation in Ameca-Mascota

The greatest amount of precipitation in the Jamapa watershed is recorded during the summer period, in months July-September. The models are close to the observed data in AW, but overestimate in SS.

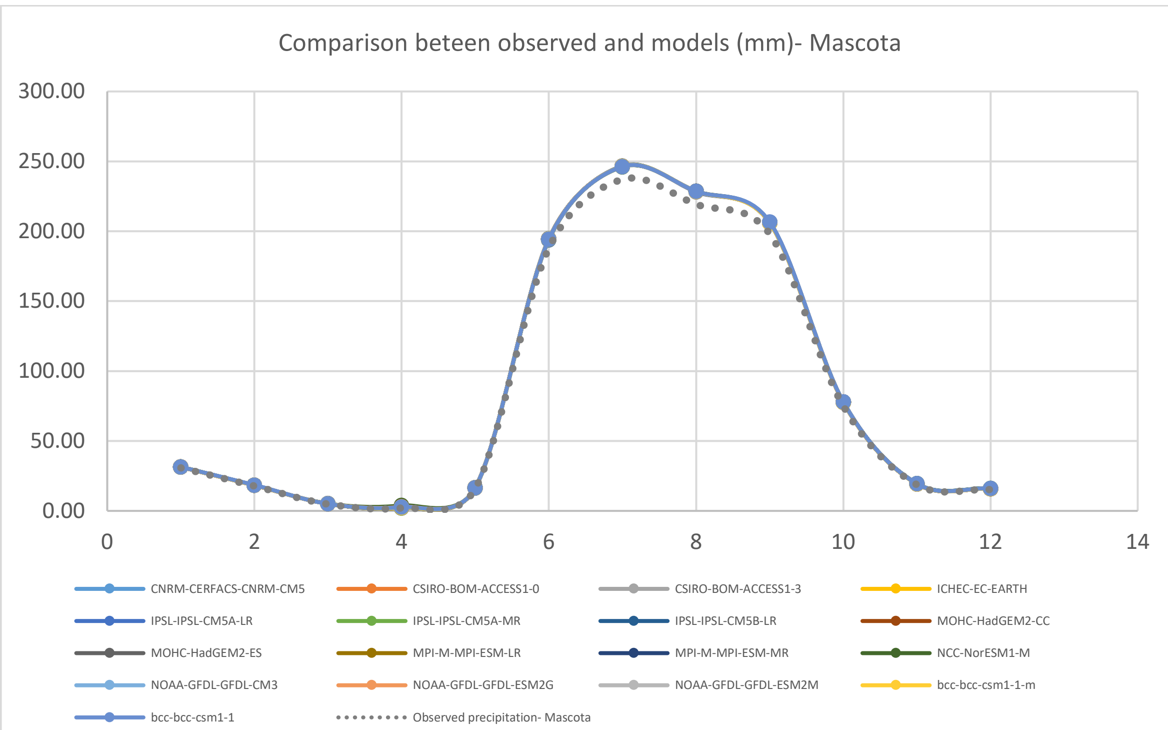


Figure 1.9.33. Comparison beteen observed and models (mm)- Mascota

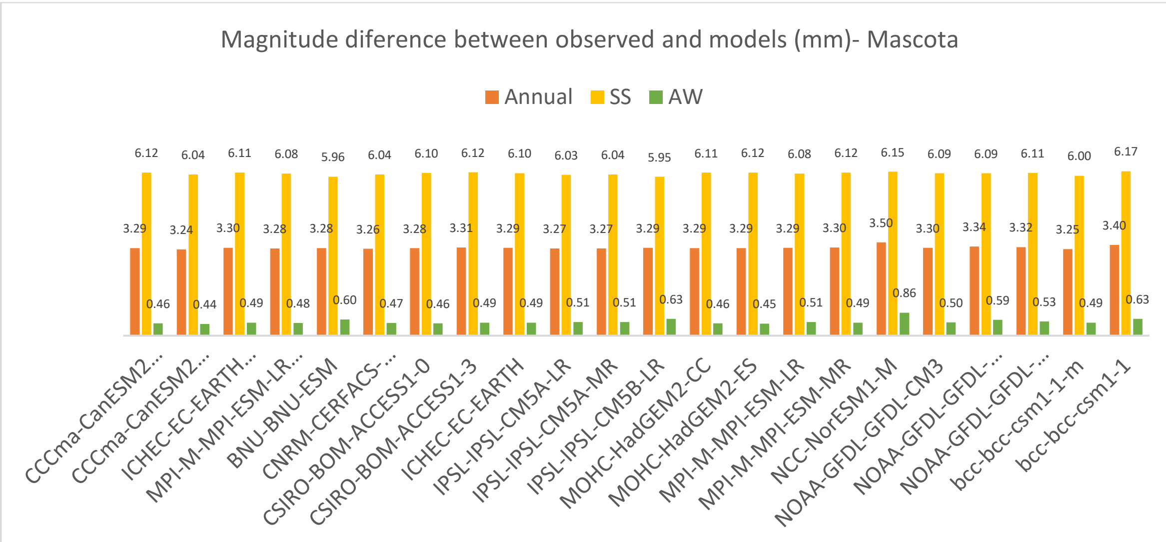


Figure 1.9.34. Magnitude diference between observed and models (mm)- Mascota

Table 1.8. Standard deviation and Root mean square of observed data and models Mascota

Models	Standard deviation of the difference (mm)			Root mean square error (mm)		
CCCma-CanESM2 SMHI-RCA4-v1	3.79	3.56	0.44	4.86	6.86	0.49
CCCma-CanESM2 UQAM-CRCM5-v1	3.81	3.60	0.49	4.92	6.94	0.52
ICHEC-EC-EARTH SMHI-RCA4-v1	3.80	3.59	0.48	4.89	6.90	0.51
MPI-M-MPI-ESM-LR UQAM-CRCM5-v1	3.66	3.48	0.60	4.80	6.76	0.62
BNU-BNU-ESM	3.78	3.58	0.47	4.87	6.87	0.50
CNRM-CERFACS-CNRM-CM5	3.81	3.57	0.46	4.90	6.91	0.50
CSIRO-BOM-ACCESS1-0	3.81	3.59	0.49	4.92	6.95	0.51
CSIRO-BOM-ACCESS1-3	3.81	3.61	0.49	4.92	6.93	0.51
ICHEC-EC-EARTH	3.77	3.59	0.51	4.87	6.87	0.55
IPSL-IPSL-CM5A-LR	3.78	3.61	0.51	4.88	6.88	0.57
IPSL-IPSL-CM5A-MR	3.66	3.54	0.63	4.81	6.77	0.65
IPSL-IPSL-CM5B-LR	3.82	3.58	0.46	4.91	6.93	0.49
MOHC-HadGEM2-CC	3.83	3.61	0.45	4.93	6.95	0.49
MOHC-HadGEM2-ES	3.78	3.59	0.51	4.90	6.90	0.53
MPI-M-MPI-ESM-LR	3.81	3.59	0.49	4.92	6.94	0.51
MPI-M-MPI-ESM-MR	3.67	3.56	0.86	4.96	6.95	0.98
NCC-NorESM1-M	3.78	3.56	0.50	4.90	6.91	0.52
NOAA-GFDL-GFDL-CM3	3.76	3.60	0.59	4.91	6.92	0.62

NOAA-GFDL-GFDL-ESM2G	3.78	3.58	0.53	4.91	6.93	0.55
NOAA-GFDL-GFDL-ESM2M	3.76	3.58	0.49	4.84	6.83	0.51
bcc-bcc-csm1-1-m	3.77	3.59	0.63	4.96	6.98	0.66
bcc-bcc-csm1-1	3.82	3.59	0.46	4.92	6.94	0.51

Comparison between models and observed precipitation in Jamapa

The largest amount of precipitation in the Jamapa River watershed is recorded during the summer period, with peaks in July and September. All models slightly overestimate precipitation, mainly in SS.

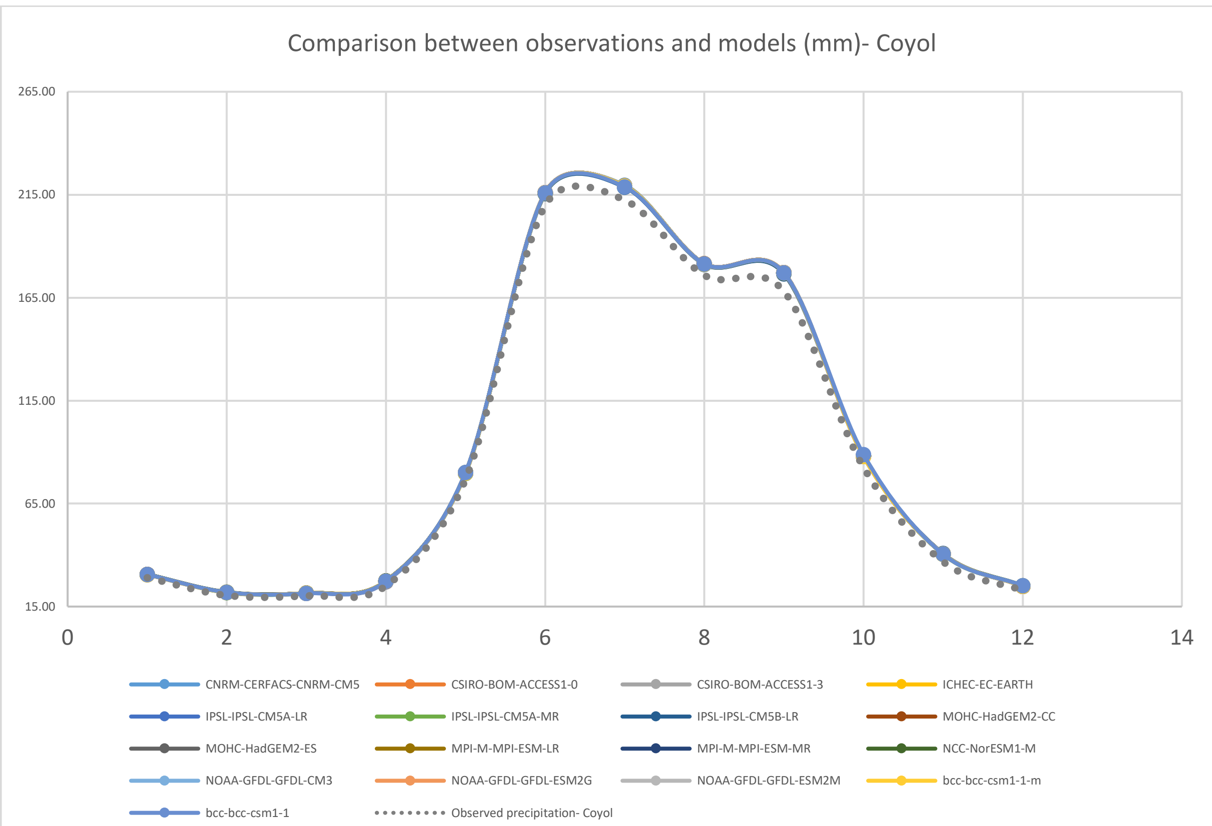


Figure 1.9.35. Comparison between observations and models (mm)- Coyol

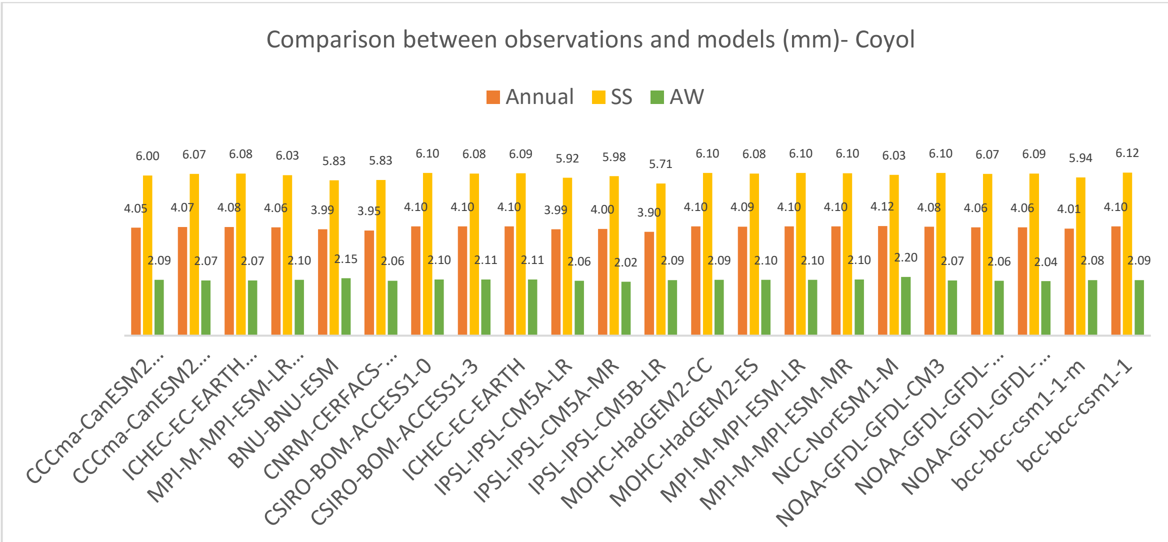


Figure 1.9.36. **Comparison between observations and models (mm)- Coyol**

Table 1.9. Standard deviation and Root mean square of observed data and models Coyol

Models	Standard deviation of the difference (mm)			Root mean square error (mm)		
CCCma-CanESM2 SMHI-RCA4-v1	2.54	1.93	2.07	4.74	6.32	2.24
CCCma-CanESM2 UQAM-CRCM5-v1	2.54	1.92	2.07	4.74	6.33	2.24
ICHEC-EC-EARTH SMHI-RCA4-v1	2.50	1.91	2.10	4.71	6.27	2.26
MPI-M-MPI-ESM-LR UQAM-CRCM5-v1	2.40	1.90	2.15	4.61	6.08	2.33
BNU-BNU-ESM	2.41	1.86	2.06	4.58	6.08	2.22
CNRM-CERFACS-CNRM-CM5	2.55	1.95	2.10	4.77	6.36	2.26
CSIRO-BOM-ACCESS1-0	2.53	1.92	2.11	4.76	6.33	2.27
CSIRO-BOM-ACCESS1-3	2.54	1.95	2.11	4.76	6.34	2.27
ICHEC-EC-EARTH	2.50	1.95	2.06	4.65	6.18	2.25
IPSL-IPSL-CM5A-LR	2.53	1.98	2.02	4.68	6.25	2.18
IPSL-IPSL-CM5A-MR	2.31	1.76	2.09	4.48	5.93	2.24
IPSL-IPSL-CM5B-LR	2.55	1.95	2.09	4.77	6.36	2.26
MOHC-HadGEM2-CC	2.53	1.93	2.10	4.75	6.33	2.26
MOHC-HadGEM2-ES	2.55	1.96	2.10	4.77	6.36	2.25
MPI-M-MPI-ESM-LR	2.54	1.94	2.10	4.77	6.35	2.27
MPI-M-MPI-ESM-MR	2.43	1.81	2.20	4.73	6.26	2.36
NCC-NorESM1-M	2.57	1.97	2.07	4.77	6.36	2.23
NOAA-GFDL-GFDL-CM3	2.56	1.98	2.06	4.75	6.34	2.23

NOAA-GFDL-GFDL-ESM2G	2.56	1.93	2.04	4.75	6.34	2.21
NOAA-GFDL-GFDL-ESM2M	2.49	1.95	2.08	4.67	6.20	2.25
bcc-bcc-csm1-1-m	2.51	1.80	2.09	4.75	6.34	2.24
bcc-bcc-csm1-1	2.50	1.93	2.09	4.70	6.26	2.26

Selection of models based on comparison with observational data

Model was selected based on four criteria: 1) magnitude of difference with observational data, 2) general variability, 3) seasonal variability, and 4) trend (sign). Based on these criteria, two models perform better; one CORDEX model (CCCma-CanESM2 UQAM-CRCM5-v1) and a CMIP5 model (NOAA-GFDL-GFDL-ESM2G).

Main current and expected of climate change impacts related to RIOS

Selection of models based on comparison with observational data

Model was selected based on four criteria: 1) magnitude of difference with observational data, 2) general variability, 3) seasonal variability, and 4) trend (sign). Based on these criteria, two models perform better; one CORDEX model (CCCma-CanESM2 UQAM-CRCM5-v1) and a CMIP5 model (NOAA-GFDL-GFDL-ESM2G).

Main current and expected of climate change impacts related to RIOS

CORDEX model

We used a Representative Concentration Pathways (RCP) scenario of 4.5[7] CP 4.5. RCP 4.5 is described by the IPCC as an intermediate scenario. According to the IPCC, RCP 4.5 requires that carbon dioxide (CO2) emissions start declining by approximately 2045 to reach roughly half of the levels of 2050 by 2100. It also requires that methane emissions (CH4) stop increasing by 2050 and decline somewhat to about 75% of the CH4 levels of 2040, and that Sulphur dioxide (SO2) emissions decline to approximately 20% of those of 1980–1990. Like all the other RCPs, RCP 4.5 requires negative CO2 emissions (such as CO2 absorption by trees).

Expected scenarios using CORDEX

[7] The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) is due for publication in 2013-14. Its findings will be based on a new set of scenarios that replace the Special Report on Emissions Scenarios (SRES) standards employed in two previous reports. The new scenarios are called Representative Concentration Pathways (RCPs). There are four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6 - the last is also referred to as RCP3-PD. (The numbers refer to forcings for each RCP; PD stands for Peak and Decline).

Future temperature in Mascota is expected to increase in the period 2011-2040 of 1.10·C, 2041-2070 at RCP4.5. The month with a larger expected change (delta) are June and July (1.3). In the period 2041-2070, 6 months have an increase superior to 2·C at RCP4.5.

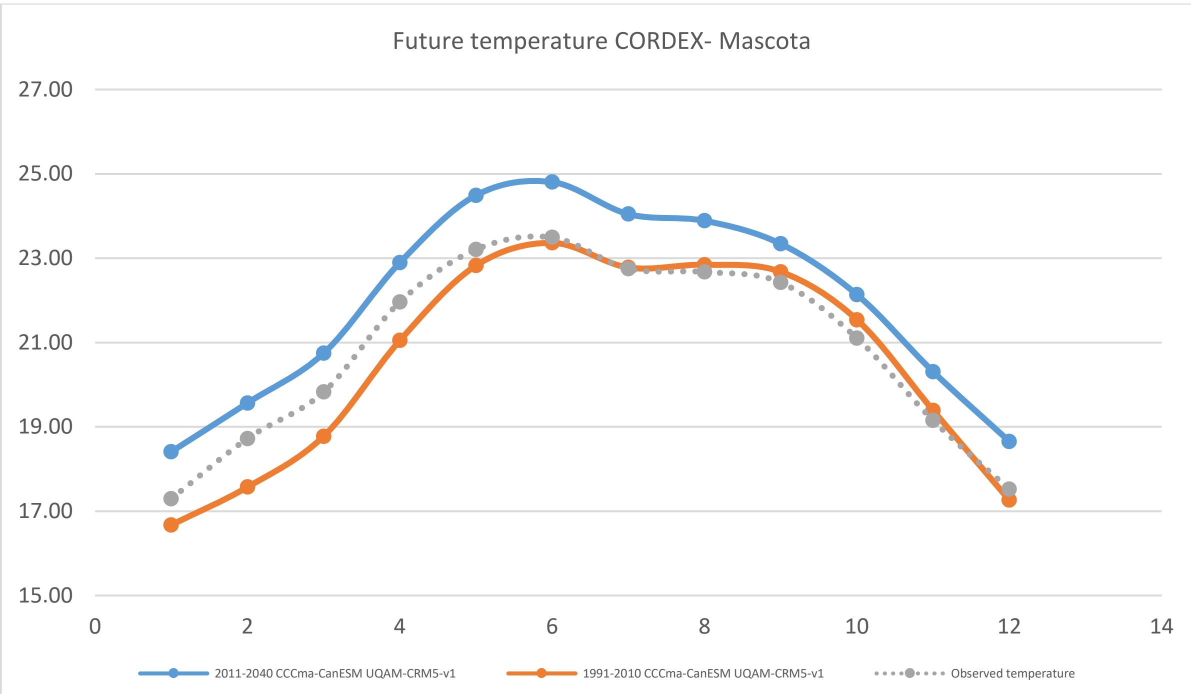


Figure 1.9.37. Predicted temperature using CORDEX and observed data

In terms of precipitation, the model does not predict the historical observed trend in the region. This may be because the lack of an appropriate fit of regional and global models in mountainous areas.

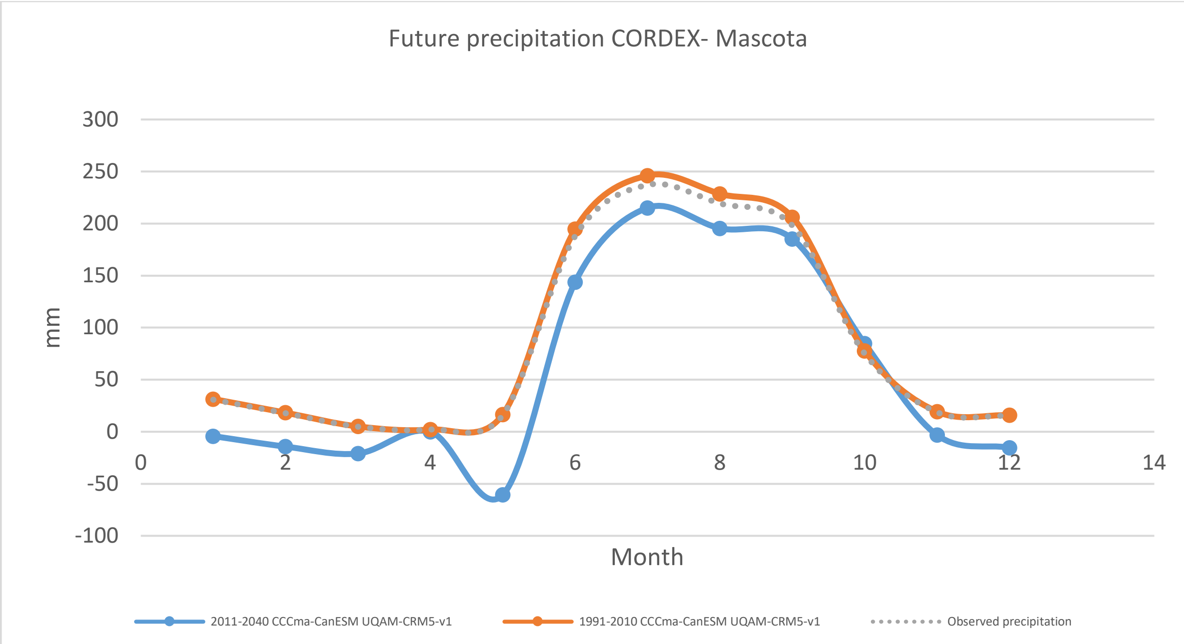


Figure 1.9.38. Predicted temperature using CORDEX and observed data

In the case of Coyol station in Jamapa temperature will increase in most months. In 2041-2070, four months will increase more than 2·C at RCP4.5. and will continue increasing in the future.

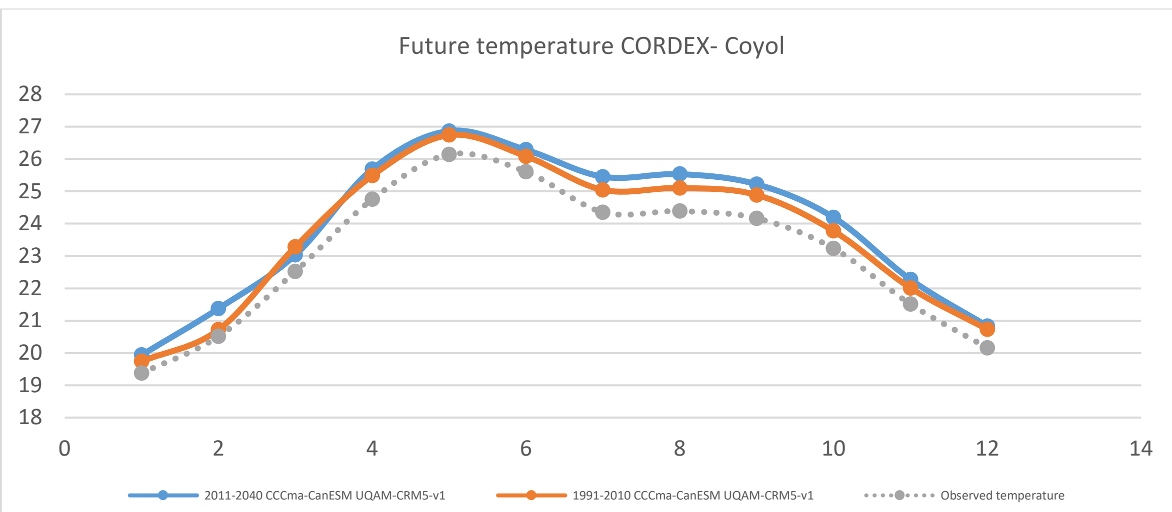


Figure 1.9.39. Predicted temperature using CORDEX and observed data

Precipitation in Coyol will have more intense peaks in the future, mainly in April, June and September.

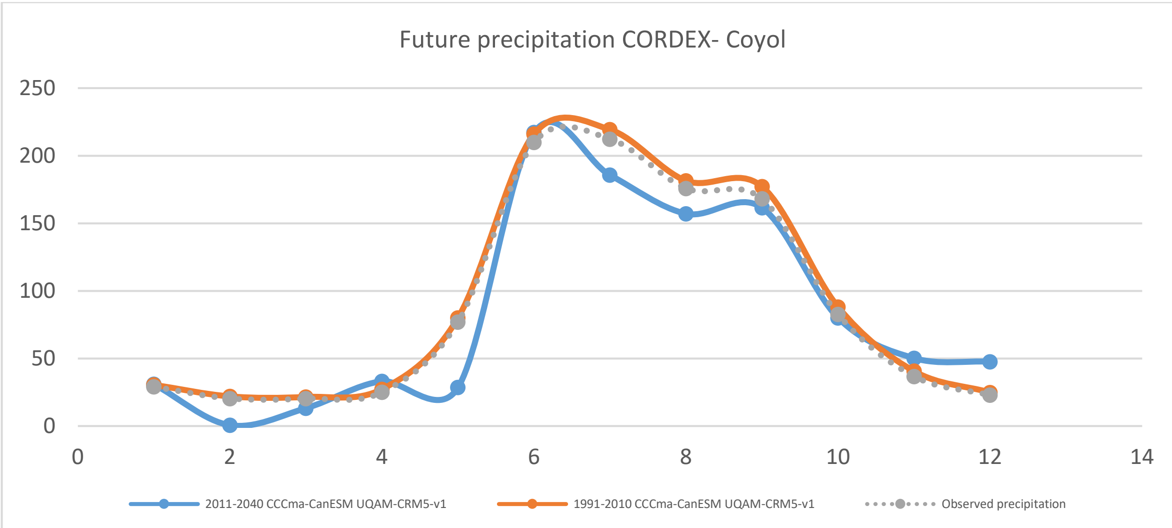


Figure 1.9.40. Predicted precipitation in Coyol

Other models

Other studies had used different strategies to model potential future scenarios. The balance between ETo, mean annual precipitation and the evapotranspiration coefficients associated with vegetation, carried out by INVEST's Water Yield module, allows estimating the current mean annual evapotranspiration for each sub-basin. Figure 1.9.40 represents the current annual evapotranspiration percentage for each sub-basin, the highest evapotranspiration percentages correspond to sub-basins with a high percentage of primary vegetation, while the lowest percentages correspond to sub-basins with high urban density and agricultural crops, mean values correspond to areas where tropical deciduous and sub deciduous forests predominate.

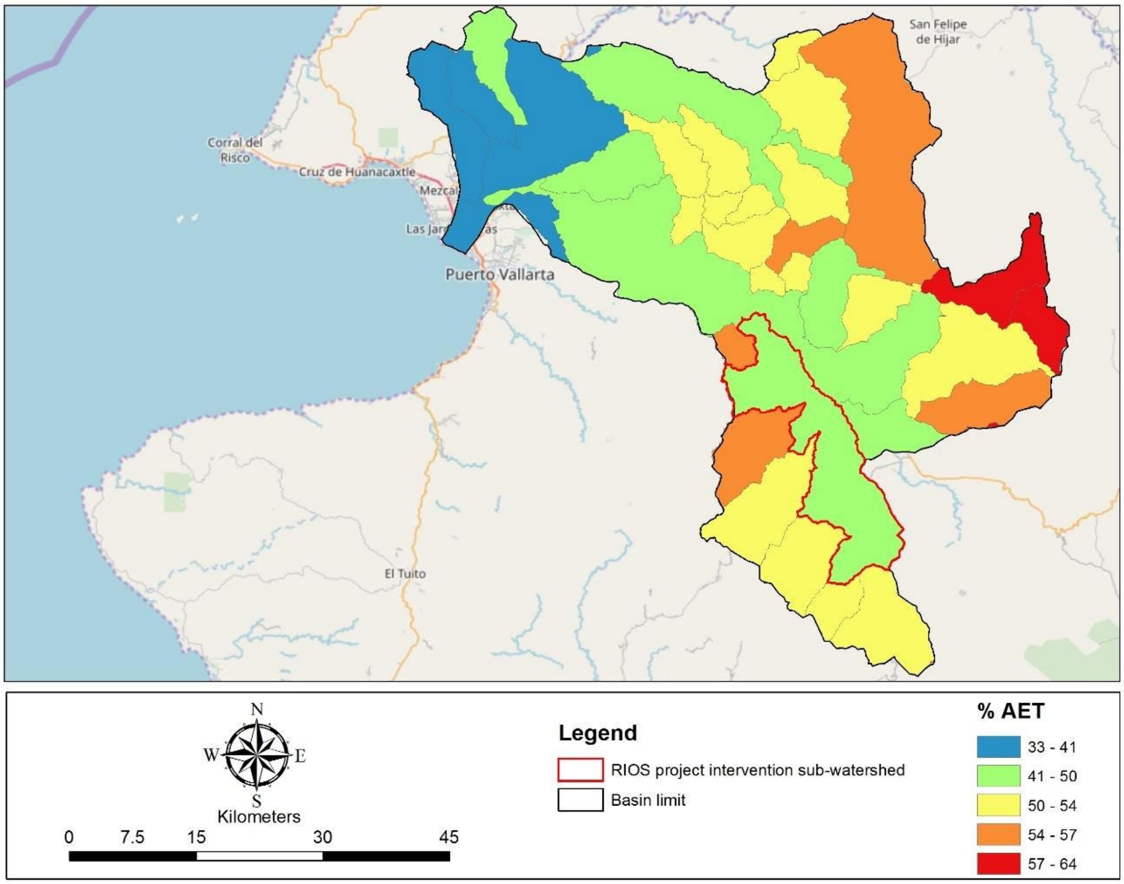


Figure 1.9.40. Average annual evapotranspiration percentage in the Ameca-Mascota river basin including the intervention sub-basins.

Regarding the changes in evapotranspiration under climate change scenarios, Martínez and Patiño (2012) point out that the effects of climate change on hydrological systems will depend on the conditions in rain catchment areas, on the morphology and topology of the main river. In terms of forest hydrology, one of the hydrological functions attributed to forests is the "sponge effect" which consists of reducing runoff from precipitation and maintaining both the flow rates and the recharge of the aquifers during periods of rain (Martínez and Navarro, 2007). In a study carried out in the ANP La Primavera and its influence area, whose climatic and vegetation conditions are similar to those of the intervention sub-basin with pine, oak and tropical deciduous forests, it was observed that in the entire study area (ANP + influence area), by mid-century (2050) evapotranspiration will increase in a range of 1.7% (RCP 4.5 w / m2) and 2.5% (RCP 8.5 w / m2) with respect to the current evapotranspiration 33% of the 904.3 mm that it rains on average annually (Table 1.11). These changes in evapotranspiration will have a negative effect on infiltration. It is important to mention that this study indicates that infiltration is up to 28.1% higher within the ANP, in areas with more than 75% forest coverage (Pérez A., et al., 2020).

Table 1.1.1. Percentages of runoff, evapotranspiration, infiltration and current and projected average annual precipitation under climate change scenarios in the ANP La Primavera and its area of influence.

Parameter	**Current**	**RCP 4.5**	**RCP 8.5**
Mean annual rainfall (mm)	904.3	871	820
Runoff (%)	4.6%	10.6%	10.1%
Evapotranspiration (%)	62.1%	63.8%	64.6%
Infiltration (%)	33.3%	25.6%	25.3%

In the study "Impacts of climate change on Mexican soils" published by INECC-UNDP (2016), the Potential Evapotranspiration (PET) was estimated using the Penman's method modified by Monteith (Sys et al., 1991). Databases of average monthly temperature, cloudiness to estimate hours of sunshine, relative humidity, and wind speed, which define the PET, were generated in each Area of Climate Influence (AIC). To define the average annual isotherms, the method described by Gómez et al. (2008) was used, generating simple linear regression models for the different areas of thermal variation in the country, based on the analysis of temperature behavior related to the height of the terrain, as temperature variation and altitudinal range are influenced by the geographic position and humidity conditions of the different regions of the country. The results of this evaluation showed that in the Ameca-Mascota watershed, an increase in potential evapotranspiration is expected in the future (Figure 1.9.41)

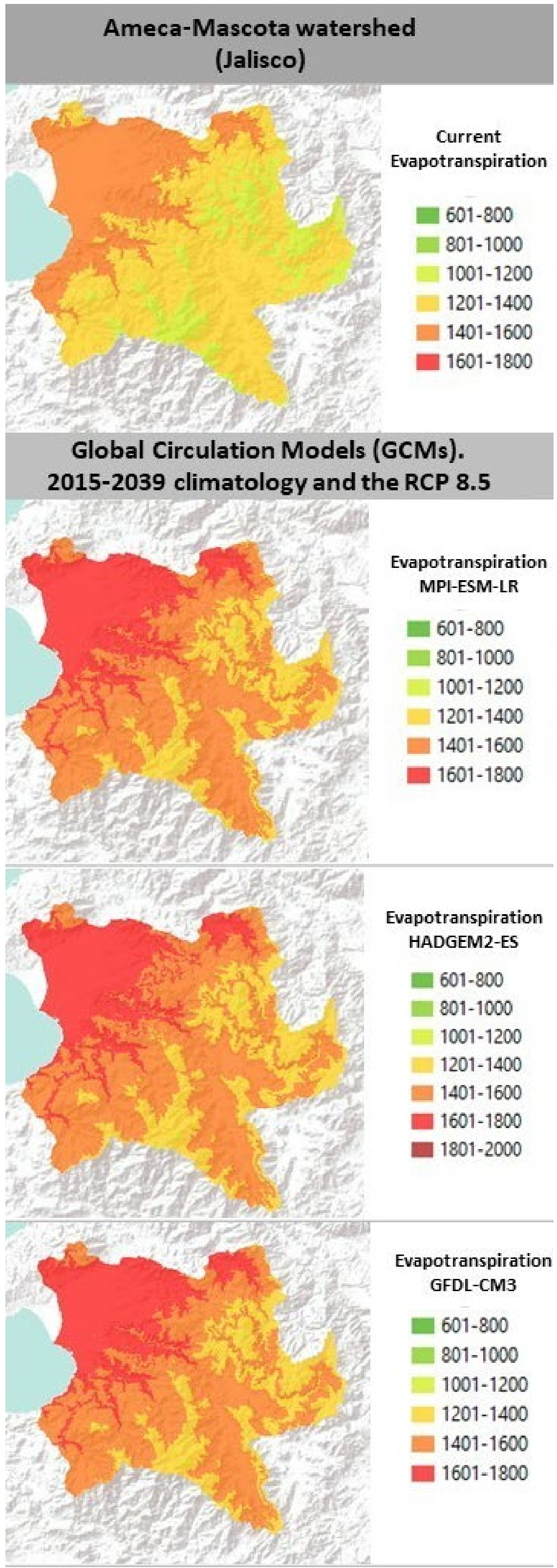
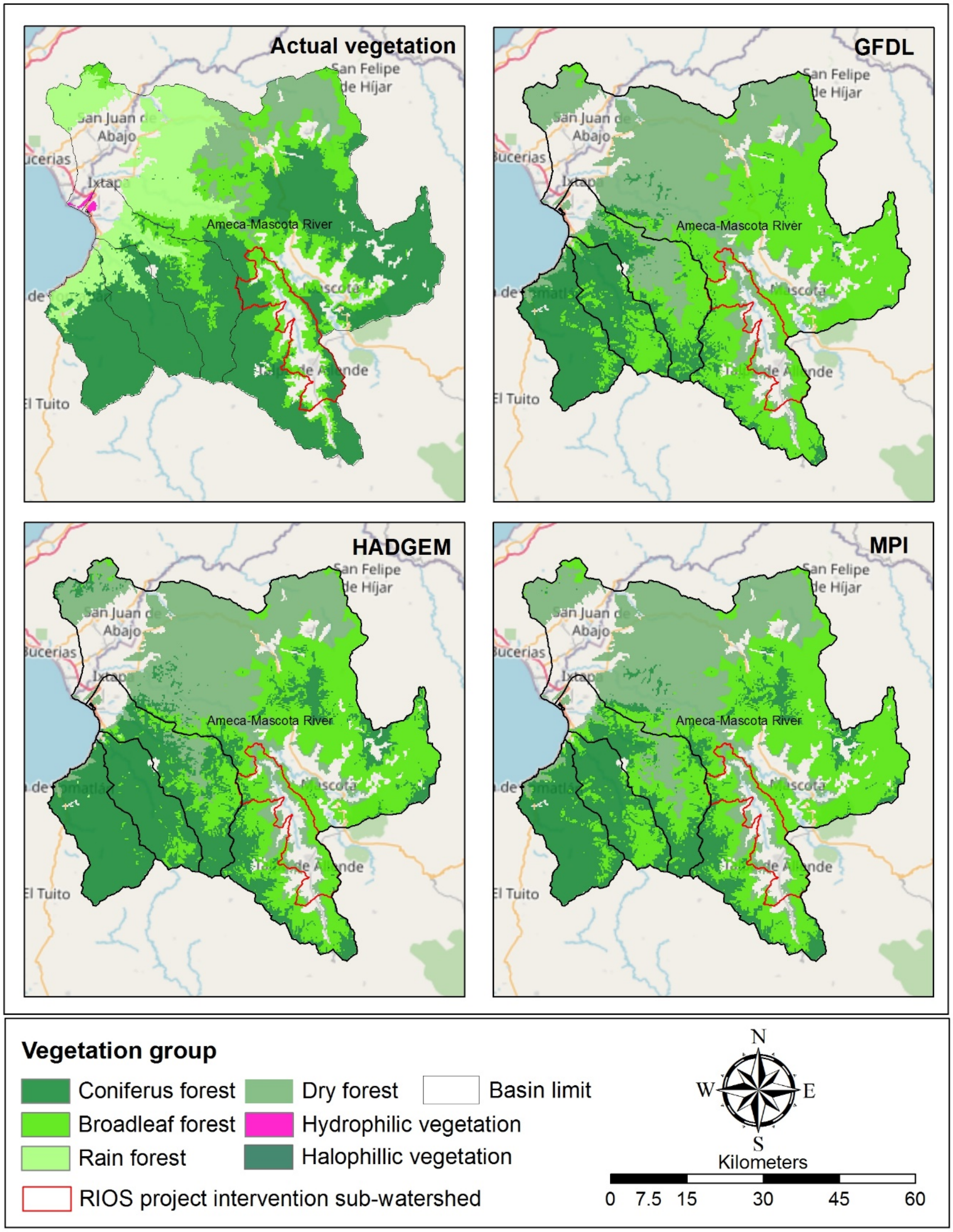

Ameca-Mascota watershed
(Jalisco)
Current
Evapotranspiration
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800
Global Circulation Models (GCMs).
2015-2039 climatology and the RCP 8.5
Evapotranspiration
MPI-ESM-LR
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800
Evapotranspiration
HADGEM2-ES
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800
1801-2000
Evapotranspiration
GFDL-CM3
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800

Figure 1.9.41. Behavior of potential soil evapotranspiration for the Ameca-Mascota basin under the global circulation models. Source: UNDP-INECC, 2016.

Taking these possible scenarios into account, the project seeks, on the one hand, to reduce the pressure on primary forests and increase forest coverage in riparian systems and areas of agricultural use, this in order to increase the “sponge effect” of the Talpa-Mascota sub-basin.

Regarding vegetation and climate change, the Institute of Geography of the National Autonomous University of Mexico (UNAM) and the National Institute of Ecology and Climate Change (INECC), carried out a study of the impact of climate change in bioclimatic zones from Mexico. This study is based on the sampling points of the National Forest Inventory, soil profiles and 19 bioclimatic variables, to model the current distribution of the main vegetation groups in Mexico, to model distribution under climate change scenarios.

For the Ameca-Mascota basin, it is projected that the bioclimatic conditions at the end of the century will favor the development of dry forests and broadleaf forests. In other words, the conditions for the development of coniferous forests and rainforests will be affected in the future (Figure 1.9.42).



Actual vegetation
GFDL
HADGEM
MPI
San Felipe de Híjar
San Juan de Abajo
Bucerías
Ixtapa
Ameca-Mascota River
Mascota
El Tuito
Vegetation group
Coniferus forest
Dry forest
Basin limit
Broadleaf forest
Hydrophilic vegetation
Rain forest
Halophillic vegetation
RIOS project intervention sub-watershed
N
W
E
S
Kilometers
0 7.5 15 30 45 60

Figure 1.9.42. Changes in bioclimatic conditions and distribution of vegetation under climate change scenarios.

Climate change scenarios project that only between 33 and 44% of the current area of coniferous forests will conserve the bioclimatic conditions for their development, while between 51 and 60% of the current area of broadleaf forests will change their bioclimatic conditions, favoring the development of dry forests.

Model	Current / Change to	Coniferus forest (CF)	Broadleaf forest (BF)	Rain forest (RF)	Dry forest (DF)	Hydrophilic vegetation (HV)
GFDL	CF	32%	1%	23%		
	BF	65%	39%	3%		
	RF			*		
	DF	3%	60%	74%	100%	100%
	HV					
MPI	CF	44%	1%	23%		
	BF		48%	6%	100%	
	RF			*		
	DF	55%	51%	71%		100%
	HV	1%				
HADGEM	CF		3%	28%		
	BF	55%	46%	2%		
	RF			*		
	DF	45%	51%	70%	100%	100%
	HV					*

% Change % Permanence * Loss of bioclimatic conditions for these kind vegetation

Table 1.1.2. Percentages of change and permanence of climatic conditions for the different types of vegetation in the intervention basins.

Jamapa watershed

Current situation of evapotranspiration and projections

The balance between ETo, mean annual precipitation and the evapotranspiration coefficients associated with vegetation, carried out by INVEST's Water Yield module, allows estimating the current mean annual evapotranspiration for each sub-basin. Figure 1.9.42 shows the results for the sub-basins of the Jamapa basin, showing the percentage of precipitated water that is evapotranspired. The areas with a higher percentage of evapotranspiration are found in the sub-basins of the middle zone of the basin (red and orange colors). In these areas, more than 53% and up to 62% of the water that precipitates evaporates. The sub-basins with the lowest percentage of evapotranspiration are found in the cloud forest area and shade coffee cultivation as well as in the lower part of the basin (blue and green colors). In the RIO project intervention sub-basins, evapotranspiration with respect to precipitation is medium or high, with mean values greater than 50%.

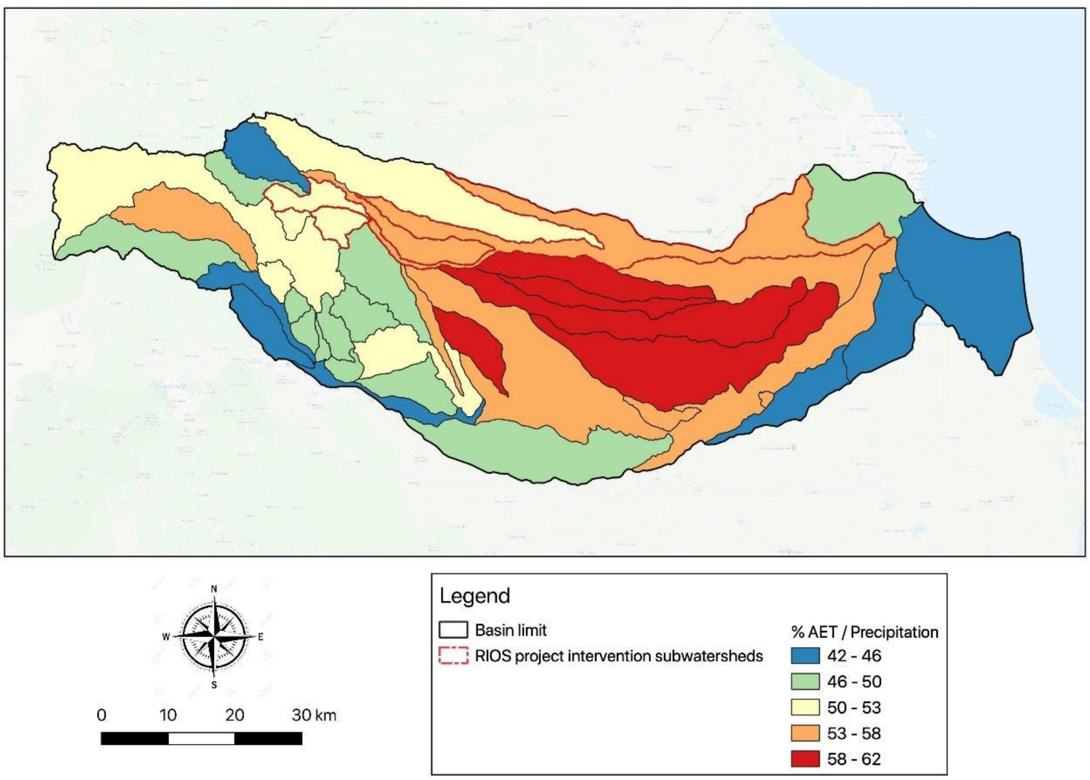


Figure 1.9.43. Percentage of evapotranspiration with respect to precipitation in the Jamapa sub-basins, including the RIOS project intervention sub-basins.

Concerning projections of evapotranspiration change in Mexico, a recent reference publication "Veracruz a decade in the face of climate change", refers that for Mexico analyzes have been carried out on the impacts on water resources, specifically on evapotranspiration. Raynal and Rodríguez (2007) in the study "Possible impact scenarios of climate change on potential evapotranspiration (ET) in the Conchos river basin, Mexico", identified that with an increase in temperature of 1 ° C, evapotranspiration will increase between 3 and 3.5% compared to the current value, generating a soil moisture deficit between 9 and 40%; while for an increase of 3 ° C the ET will rise between 8.8 and 10%, increasing the soil moisture deficit from 27.5 to 116%.

Regarding Veracruz, in a study for the central zone, they found that the Climate Change scenarios suggest decreases in rainfall, with ranges ranging from 10 to 20% with respect to the observed values, and that the temperature will rise from 1 ° C in 2020, up to 4 ° C by 2050, on average, which will affect the infiltration capacity of water available for crops in the region and will cause greater vulnerability for agricultural production. Pereyra et al. (2008), when establishing the water balance for the four hydrological regions of the entity, emphasized that in order to know the state of the water resources it is necessary to speak of the hydrological cycle, including the evaporation processes from the ground, sea or continental water, condensation of humidity in clouds, precipitation, soil and water bodies accumulation and evaporation.

Pereyra et al. (2011) affirm that an increase in real evapotranspiration will cause a deficit in soil moisture, which, together with the decrease in precipitation, will increase water demand, a process that is already critical during dry months (from March to May). A good water management by CONAGUA will be required, as well as planning the storage of excess runoff during the rainy season.

There are some evapotranspiration projections in the literature for the central region of the state of Veracruz. A study for the Antigua basin shows that, given the increase in temperature projected by global models for the 1920s and 1950s, the actual evapotranspiration will increase throughout La Antigua river basin, with maximum values in the lower part and the minimum values in the mountain areas (Pereyra et al., 2011).

In the study "Impacts of climate change on Mexican soils" published by INECC-UNDP (2016), the Potential Evapotranspiration (PET) was estimated using the Penman's method modified by Monteith (Sys et al., 1991). Databases of average monthly temperature, cloudiness to estimate hours of sunshine, relative humidity, and wind speed, which define the PET, were generated in each Area of Climate Influence (AIC). To define the average annual isotherms, the method described by Gómez et al. (2008) was used, generating simple linear regression models for the different areas of thermal variation in the country, based on the analysis of temperature behavior related to the height of the terrain, as temperature variation and altitudinal range are influenced by the geographic position and humidity conditions of the different regions of the country. The results of this evaluation showed that in the Jamapa watershed, an increase in potential evapotranspiration is expected in the future (Figure 1.9.44).

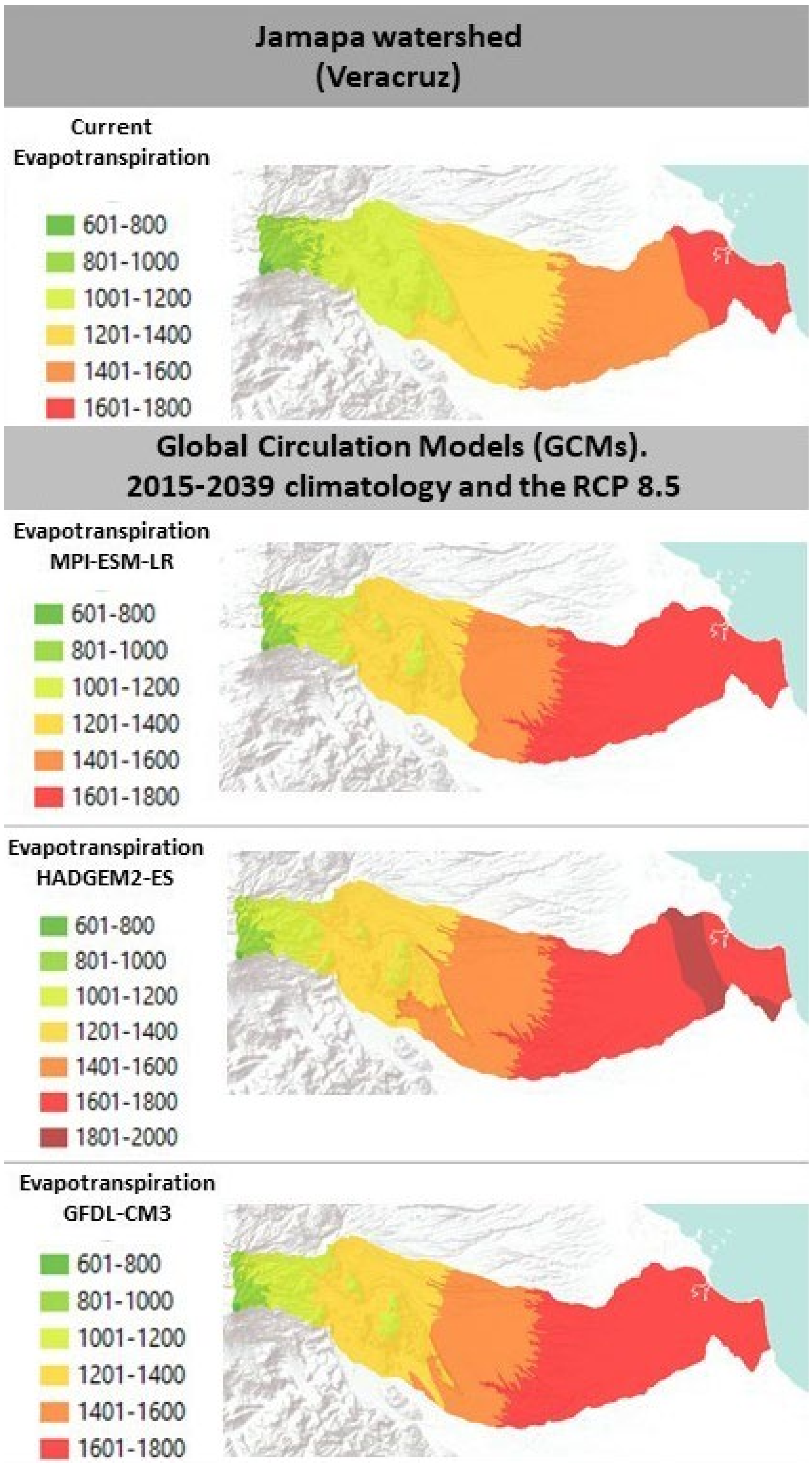
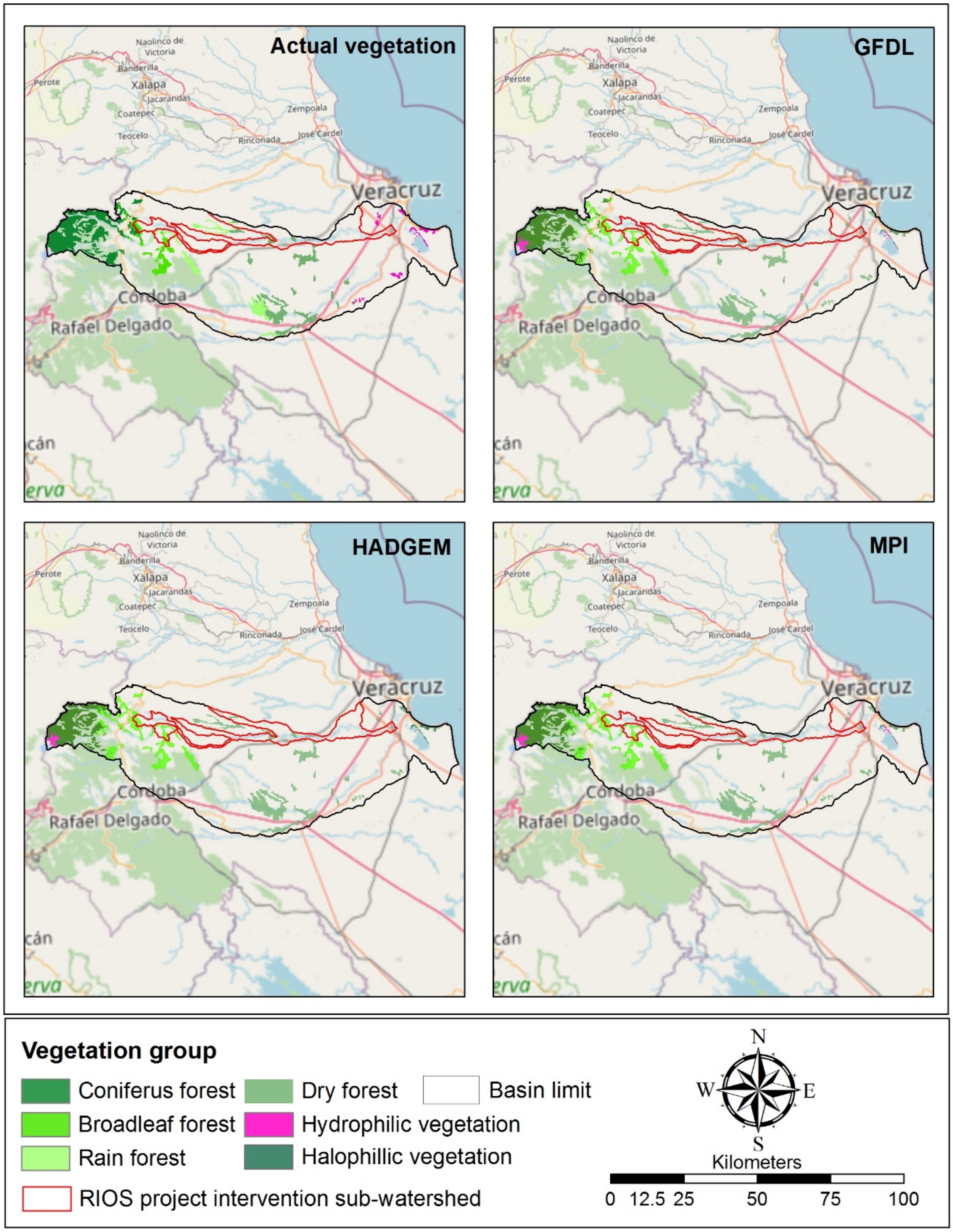

Jamapa watershed
(Veracruz)
Current
Evapotranspiration
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800
Global Circulation Models (GCMs).
2015-2039 climatology and the RCP 8.5
Evapotranspiration
MPI-ESM-LR
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800
Evapotranspiration
HADGEM2-ES
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800
1801-2000
Evapotranspiration
GFDL-CM3
601-800
801-1000
1001-1200
1201-1400
1401-1600
1601-1800

Figure 1.9.44. Behavior of potential soil evapotranspiration for the Jamapa basin under the global circulation models. Source: UNDP-INECC, 2016.

Climate change is causing variations in the patterns of temperature and precipitation in the Jamapa river basin, these variables need balanced conditions for ecosystems to maintain and develop, if these changes, it is likely that the vegetation will also change. The potential change of natural vegetation in the Jamapa River basin under climate change scenarios shows these potential changes. In Figure 1.9.45 it is possible to observe the prediction of changes in vegetation or land use in the plant groups that will suffer them in their distribution, according to the projections of climate change in the bioclimatic zones of Mexico.

- For the upper part of the basin, the coniferous forest will decrease between 16 and 26% concerning the current surface (see Table 1.2.1).
- In the middle basin, the humid forests will disappear, benefiting the conditions in this area for the development of dry forests. In this strip, we find the sub-basins of the intervention of the RIOS project.
- The lower area of the basin will present conditions for the development of halophilic vegetation, partially replacing hydrophilic vegetation.



Actual vegetation
GFDL
HADGEM
MPI
Naolinco de Victoria
Banderilla
Perote
Xalapa
Jacarandas
Coatepec
Teocelo
Zempoala
Rinconada
José Cardel
Veracruz
Córdoba
Rafael Delgado
Vegetation group
Coniferus forest
Dry forest
Basin limit
Broadleaf forest
Hydrophilic vegetation
Rain forest
Halophillic vegetation
RIOS project intervention sub-watershed
N
W
E
S
Kilometers
0 12.5 25 50 75 100

Figure 1.9.45. Coverage of current natural vegetation and in the context of climate change in the Jamapa river basin under various scenarios.

Table 1.2.1 Changes in current natural vegetation compared to three climate change projections for the horizon 2075-2099 for the Jamapa river basin.

		Current vegetal structures				
General Circulation Model	Change to	Coniferous forest (27450 ha)	Broadleaf forest (5725 ha)	Humid forest (7118 ha)	Dry forest (10993 ha)	Hydrophilic vegetation (2475 ha)
GFDL	Coniferous forest	84				
HADGEM		72				
MPI_ESM		74				
GFDL	Broadleaf forest	12	100	34.5		
HADGEM		24	100	33.5		
MPI_ESM		22	100	33.7		
GFDL	Humid forest					
HADGEM						
MPI_ESM						
GFDL	Dry forest			65.5	100	58.3
HADGEM				66.5	100	48
MPI_ESM				66.3	100	56
GFDL	Hydrophilic vegetation	4.5				10.6
HADGEM		4.5				0.8
MPI_ESM		4.5				13.6
GFDL	Halophilic vegetation					31
HADGEM						51
MPI_ESM						30

The greatest impacts for the agricultural areas will occur in the middle and lower part of the basin where they are concentrated. Although we do not have specific projections for the uses of agricultural land and pastures indirectly, we can infer that in the middle zone where these systems currently coexist with humid forest ecosystems, there will be conditions for the development of ecosystems adapted to drier conditions, like dry forests. In the lower zone, where we currently find agricultural activities adapted to conditions similar to hydrophilic vegetation, they will change favoring more halophilic systems.

Scenarios in National Atlas of Vulnerability to Climate Change

The National Atlas of Vulnerability to Climate Change (ANVCC) considers the territorial dynamics where the climate problem develops and focuses on institutional efforts to reduce the risks. It provides relevant information on climate change adaptation to strengthen processes and to reduce the vulnerability of the population and ecosystems in the face of present and future climate hazards. The ANVCC used the climate change scenarios to integrate future conditions projected by four general circulation models: MPI-ESM-LR (Germany), GFDL-CM3 (United States), HADGEM2-ES (England), and CNRM (France), with a time horizon from 2015 to 2039 and the RCP 8.5. For the selection of the four MGC models, the spatial resolution of 30" x 30" (approximately 926 m x 926m) was restructured, for which the effect of topography was incorporated. Three of the scenarios used were assessed and compared against observed data (se previous sections). The three of them were ranked above the medium and one of them was the second-best performing indicator. This instrument uses the four scenarios selected by the Mexican government to report to IPCCC. Moreover, the methodology and results have been validated by stakeholders. Therefore, it is a key tool to inform public policy in Mexico.

The National Atlas of Vulnerability to Climate Change (ANVCC) (INECC 2019) evaluates the vulnerability of all municipalities in the country with the following equation (IPCC, 2007):

$$Vulnerability\ = (exposure + sensibility) - (adaptive\ capacity)$$

The vulnerabilities evaluated in the ANVCC are six, of which the RIOS project will focus on five that are most relevant for the project watersheds:

- Vulnerability of human settlements to flooding (VPI)
- Vulnerability of human settlements to landslides (VPDes)
- Vulnerability of extensive livestock farming to flooding (VGI)
- Vulnerability of extensive livestock farming to water stress (VGEH)
- Vulnerability of fodder production to water stress (VFEH)

According to the ANVCC, all municipalities in the watersheds have at least one of the vulnerabilities evaluated, classified as very high or high, and under the Global Circulation Models (GCMs) the vulnerability will increase in the future.

In terms of the variables that define vulnerability, exposure is the character, magnitude, and speed of change and variation of the climate that affects a system under current conditions and with climate change. Exposure of each of the watersheds was described in the previous two sections.

Sensitivity is the degree to which a system is affected by climate change and variability due to its defining characteristics. In terms of sensitivity, since high altitudinal gradients characterize the two basins (Mexico is one of the most mountainous countries in the world), RIOS will focus on riparian and hillside restoration, as well as promoting adequate practices on slopes and key areas next to the rivers.

Adaptive capacity focuses on describing the institutional capacities available to reduce potential climate-related impacts. RIOS will work on increasing the area with payment for environmental services, increase the land under natural resources management through the protection and restoration of ecosystems to prevent flooding, landslides or water stress. It will also provide information on floods, landslides, or water stress to help develop tools for risk management, and it will strengthen producer organizations to improve livestock productivity under sustainable practices.

Perception surveys in local communities developed in Ameca-Mascota and Jamapa during project preparation indicate that producers identify regional changes in the climate, specifically less rainfall in dry seasons, more heat and drought, and more intense rains. They highlighted that they have suffered natural disasters such as fires and especially landslides, which affect their pastures by causing loss of pasture and causing the death of cattle. They also reported the loss of infrastructure and assets due to these landslides.

Vulnerability in the Ameca-Mascota watershed

According to the National Atlas of Vulnerability to Climate Change (ANVCC) (INECC, 2019), climate change scenarios in the near future project a temperature increase that ranges from 0.5 to 4.5°C, and precipitation around +20mm change. Under this scenario, the Ameca-Mascota watershed presents VPDes, VGI, VGEH, and VFEH (INECC, 2018) (Figure 1.10). Climate change projections show that VGI, VGEH, and VFEH will increase for 2030.

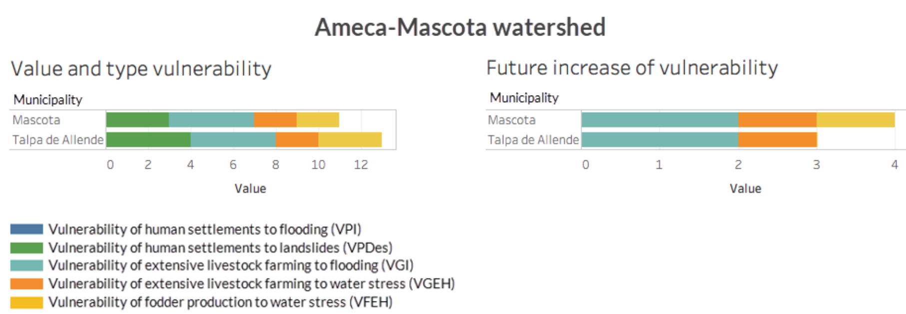


Figure 1.10. Number (value) and variety (type) of current vulnerabilities identified in the Ameca-Mascota´s municipalities (left) and their future projection (right) according to the four global circulation models (GCM: CNRMC-M5, GFDL-CM3, HADGEM2-ES, and MPI-ESM-LR, RCP 8.5) for the period 2015-2039, measured according to INECC´s vulnerability index. Source: INECC, 2018.

Vulnerability in the Jamapa watershed

The Jamapa watershed is considered highly vulnerable to climate change. According to the National Atlas of Vulnerability to Climate Change (ANVCC) (INECC, 2019), climate change scenarios in the near future project an increase between 1 and 2°C in temperature and precipitation up to +20mm change. Under this scenario, the Jamapa watershed presents VPI, VPDes, VGI, VGEH, and VFEH (INECC, 2018) (Figure 1.11). Climate change projections show that VGEH and VFEH will increase by 2030.

Figure 1.11. Number (value) and variety (type) of current vulnerabilities (left) identified in the Jamapa´s municipalities and their future projection (right) according to the four global circulation models for the period 2015-2039, measured according to INECC´s vulnerability index. Source: INNEC, 2018.

Main current and expected of climate change impacts related to RIOS

Most ecosystems are vulnerable to climate change even under low and medium-range scenarios of global warming (Scholes and Settele, 2014). They are likely to be affected through changes in mean conditions (temperature or precipitation), exacerbating climate variability (wet rainy season), and the intensity and frequency of extreme weather events (storms, floods) (Malhi et al., 2020). Moreover, climate extremes interact synergistically with local human-related threats or stressors, such as land-use change, pollution, and overexploitation of resources (Franca et al., 2020). All these disturbances affect ecosystem structure and function, the ecological interactions among species, and their geographical ranges, which will result in changes in biodiversity and ecosystem services with direct implications for agriculture and food security, land use and forestry, human health and sanitation, settlements and infrastructure (Locatelli et al., 2008; Shaw et al., 2011).

Ecosystems play a significant role in adaptation to climate variability and change. They regulate temperature and influence the amount of water available and the timing of water delivery through rain interception and infiltration, creating buffers against climate-related hazards, reducing damage from floods, storms, landslides, and droughts.

Both basins have mountains close to the coast. Precipitation is increasing in the upper part, while extremes in temperature are increasing downstream. In the drier watershed (Ameca) averages temperatures are increasing downstream, while they are showing increased seasonality in the wetter basin (Jamapa). These historical trends, if they continue, as supported in general by the models, are already having the following impacts:

Table 1.10. Main impacts

RIOS Systems		Impacts of climate change in RIOS regions
Key ecosystems	Rivers	In upper watersheds, more rain will fall during the rainy season, producing soil erosion and landslides. Increase of suspended solids and their accumulation in rivers leads to lower water quality, siltation and increasing floods in the middle and lower parts of the basins.
	Forests	The increase in maximum and extreme temperatures and the decrease of precipitation in the dry season will intensify evapotranspiration, augmenting water stress, which in turn is predicted to produce changes in the floristic composition and affect ecosystem functions. Changes in temperature and precipitation are predicted to be excessive for the physiological tolerance of many species, causing them to change their distribution and diminish their area of occupancy, which will be especially evident in cloud forest and tropical evergreen forests in the project basins. The predicted result includes habitat fragmentation, loss of ecosystem services, and of biodiversity, particularly amphibians and reptiles.
Productive practices	Agroforestry	Rising temperatures, especially in the middle and lower parts of the watersheds, will increase evapotranspiration and diminish water availability, as well as infiltration, causing a deficit in soil humidity. Thus, irrigation may increase in response to rising temperature extremes and drought, further depleting water supplies. A reduction in agricultural productivity with increased risks of wildfires is predicted to occur. Reductions in agricultural productivity or sudden losses of crops will have ripple effects, including increased food prices and food insecurity. The increased frequency (in the Jamapa basin) and intensity (in the Mascota watershed) of extreme storms and tropical cyclones leads to siltation and floods that devastate crops, accelerate soil erosion, and decrease water quality.
	Sustainable livestock management	The increase in extreme temperatures and decrease of precipitation in the AW season in the middle and lower watersheds will impact cattle through heat stress, climate-related diseases, and shortages in drinking water, augmenting morbidity and mortality. Quality, availability, and even the composition of pasture and forage species will also be affected. Sudden losses of livestock will likely have ripple effects, including increased food prices and food insecurity. Increased frequency or intensity of extreme storms, tropical cyclones,

		and floods will harm livestock, accelerate soil erosion, and pollute water.
	Human settlements and infrastructure	Increased frequency of extreme storms, landslides and floods will affect populations, damaging people, homes, livelihoods, schools, hospitals, as well as tourism, energy, communication, and transport infrastructure. A decrease in water quality and availability will also occur.

Activities under RIOS to decrease vulnerability to climate change and maintain/increase the provision of ecosystem services

RIOS proposes to carry out activities that increase the vegetation cover in riparian systems and slopes, as well as in areas for the protection of springs, or important for infiltration or soil retention. In particular, it will seek to increase vegetation cover, through forest restoration and support to silvopastoral and agroecological systems. The increase in vegetation cover reduces the impact of rain on the ground, dampens the erosion of the rain, reducing the risks of erosion and soil detachment. On the other hand, restoration increases the density of roots, retaining soil, maintaining humidity, and facilitating the infiltration process. The project will contribute increasing time of water spent in the basin, improving the infiltration processes and water quality.

Through actions in ecosystem-based adaptation (EbA), such as forest restoration and support to silvopastoral and agroecological systems, the project seeks to: (i) reduce soil erosion, improve water quality and diminish silting of watercourses; (ii) increase the time that water remains within the watershed, decreasing the force and speed of runoff, as well as increasing infiltration; (iii) conserve soil for productive activities; (iv) moderate extreme temperature due to the increase in vegetation cover. As a result of these activities, RIOS aims to reduce vulnerability to the expected impacts of climate change, mainly by decreasing exposure to landslides, floods, and drought.

As climate change adaptation is multidisciplinary in nature and requires the collective effort of a broad range of stakeholders at distinct levels, RIOS seeks to augment the adaptive capacity of the population and ecosystems as a key strategy in a country where two-thirds of the territory are mountains and therefore highly sensitive to climate change (World Bank, 2010). The increase in the adaptive capacity will enable the alignment of public and private investments in the basins. The lessons learned from these exercises will feed into the development of a National Strategy for River Restoration, which will allow for scaling up actions to reduce vulnerability to climate change throughout Mexico.

Table 1.11. Activities under RIOS to decrease vulnerability to climate change and maintain/increase the provision of ecosystem services

Systems		Examples of eligible activities	Main ecosystem services provided/improved by those practices	Expected climate change adaptation impact	Vulnerability addressed	Sources
River restoration	**Riparian restoration**	Community work on reforestation/ restoration of riverbanks (for example, watershed committees)	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities • Moderate extreme temperature thanks to vegetation coverage	Increased capacity building and re-appropriation of traditional knowledge in the communities where the project is implemented to promote riverbank reforestation/restoration for flood risk reduction.	VPI, VGI	Meli, 2011 Mushamuka, 2011 Chazdon, 2008 Riis et al., 2020
		Restoring riverbanks with native vegetation		Increased hillside stability and reduced sediment deposits that limit water flow and increase floods downstream. Improved capacity of riparian ecosystems to provide soil retention and water provision services.		Tillery and Renges, forthcoming Addy, 2016 Dixon et al., 2016
	Restoration	Restore forests with native species	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Moderate extreme temperature thanks to vegetation coverage	Maintained biodiversity of ecosystems to improve the provision of ecosystem services and the capacity to respond to possible impacts of climate change.	VFEH, VGEH	Ministerio Medio Ambiente Chile, 2014 Chazdon, 2008
		Restore patches to increase connectivity		Increased connectivity and habitat corridors of species of ecological relevance and to improve the provision of ecosystem services and the capacity to respond to possible impacts of climate change.		Fundación Biodiversidad, 2016 Useche, 2006 Riis et al., 2020
		Recover and restore soils	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Conserve soil for productive activities	Promoted the recovery of soil ecosystems to contribute to the storage of carbon in the roots of plants and soil, to mitigate greenhouse gas emissions to the atmosphere. Improved soil retention to reduce flood risk and drought. Restoration not only gives quick results but also is economical, generates jobs, and ensures food security.		UNFCCC, 2019 Ortiz, 2007 Riis et al., 2020
Forest protection and conservation	**Agroecological practices**	Conserve soils with agroecological practices (living fences, stubble, cover crops,	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Conserve soil for productive activities	Increased implementation of sustainable production practices to reduce potential sources of diffuse pollution to water bodies, improve diets, and adapt practices to climatic events.	VFEH, VGEH, VGI VPI, VPDes	Martínez-Rodríguez et al. 2017 Keenan, 2015 Garbach et al., 2014

		organic fertilizing, productive diversification)				
		Train and acquire equipment for fire prevention, control, and management	● Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration ● Moderate extreme temperature thanks to vegetation coverage	Decreased risk of fires and reduced impact from fires as a potential impact of climate change. Incorporate fire spread prevention measures that compromise the maintenance of biodiversity and environmental services.		UNDP, 2017 Giannakopoulos et al., 2012 Garbach et al., 2014
		Build capacities in communities for extraction and sustainable use of plants of interest (seed banks, nurseries, cover crops, organic fertilizing, productive diversification)	● Moderate extreme temperature thanks to vegetation coverage	Increased use of biodiversity in a sustainable manner to minimize the potential effects of climate change on biodiversity.		Cach, 2016 Garbach et al., 2014
		Develop green business	● Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses ● Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration ● Conserve soil for productive activities Moderate extreme temperature thanks to vegetation coverage	Improved systems that promote the provision of ecosystem services and increase the commercial value of products.		Ochoa, 2018 Garbach et al., 2014
Productive practices	**Sustainable livestock management**	Improve livestock practices in transition to sustainable livestock management including silvopastoral systems.	● Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses ● Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration ● Conserve soil for productive activities	Reduced sources of diffuse contamination to water bodies. Restored the water flow to contribute to the connectivity of the basin to reduce the risks of landslides in the upper basin and floods downstream.	VFEH, VGEH, VGI	FAO, 2011 Gaccio, 2011 SEMARNAT, 2011 FAO, 2000 Hoffmann et al., 2014 Riis et al., 2020

		Living fences (fruit and fodder trees)	• Moderate extreme temperature thanks to vegetation coverage			
		Improvement of pastures (grass enrichment, rotations, legumes, fodder)	• Moderate extreme temperature thanks to vegetation coverage			
		Reforest/restore riparian corridors along streams and rivers, excluding cattle or limiting access points	• Moderate extreme temperature thanks to vegetation coverage • Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities			
	Agroforestry	Enrich fallow areas	• Moderate extreme temperature thanks to vegetation coverage • Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities	Increased productivity and reduced losses due to climate impacts by implementing practices resilient to climate change.	VFEH, VGEH, VGI, VPDes	Torres et al., 2008 Armelinda, 2013 Jose, 2009
		Develop sustainable management programs (diversified systems, shade coffee)		Improved systems that promote the provision of ecosystem services and increase the commercial value of products.		Schaller et al., 2017 Jose, 2009
		Develop business plans for shade systems like coffee or diversified systems.		Improved systems that promote the provision of ecosystem services and increase the commercial value of products.		Bunn et al., 2018 Baker and Haggar, 2007 Jose, 2009

1.3 Other causes and barriers that affect targeted watersheds

Although the origin of the potential impacts identified in target watershed is in the physical-geographic and climatic domain, these impacts are exacerbated by inadequate land-use planning, resulting in the expansion of human settlements, environmental deterioration, deforestation in the upper parts of the basins, as well as the inappropriate management of dams (INECC, 2019). Six main non-climate causes and barriers have been identified in the two watersheds: (i) loss of ecosystem services, (ii) lack of local governance, (iii) insufficient information and knowledge about the effects of climate change, (iv) limited institutional coordination, (v) limited alignment of public and private investments, and (vi) lack of implementation of planning instruments.

Loss of ecosystem services in watersheds

One of the main problems identified in the Ameca-Mascota basin in Jalisco is forest degradation and forest loss due to changes in land use. This is associated with a series of activities such as agriculture, extensive livestock, and extractive activities such as small-scale mining, expansion of urban and tourist areas. Likewise, the Ameca-Mascota presents impacts related to water quality due to cattle access near the rivers, and lack of wastewater management in rural communities that lack sewer and treatment systems.

Ameca-Mascota presents areas with steep slopes, so during peak events in terms of precipitation, the magnitude and speed of runoff are significant. Therefore, the degradation of ecosystems in medium and high areas of the basin has modified the patterns in the rainfall-runoff regimes, negatively impacting the infiltration and recharge processes. In a climate change context, deforestation and degradation of ecosystems become a highly relevant problem, both for water management and for landscape management in terms of water security and protection against natural disasters.

In the case of the Jamapa basin in Veracruz, the loss of the glacier in the Pico de Orizaba has been identified. Various authors have mentioned that it will significantly affect the contribution of water to the Jamapa basin (Welsh., et al. 2010; Soto and Delgado, 2020). Soto (2014) estimated 14,538,860 m^3, the entire potential volume of water that the glacier holds, could be lost by 2030. The soil erosion and related effects (landslides, floods) that this water will have in its journey down the watershed remains to be quantified.

The upper basin of the Jamapa has lost forest cover due to agricultural use, which occupies almost 50% of this area. In the middle watershed, agriculture along, grasslands for cattle and urban areas are the dominant land uses, while 70% of the lower part of the basin is dominated by agricultural use and 20% by grasslands (Ortiz, 2013). Vegetation, such as coniferous forests, cloud forests, medium, and low forests, mangroves, and tule ponds have thus been drastically reduced in the basin. Ecosystem services provided by still conserved areas with vegetation include water yield, sediment retention, regulation of temperature, and reduction of flash floods during heavy rains, which benefit urban, productive, industrial, and tourist activities (Neri-Flores, et al., 2019).

Unplanned human development in both Ameca-Mascota and Jamapa basins damages local ecosystems and reduces their capacity to provide essential services to sustain people's livelihoods. For a full list of ecosystems services identified in target watersheds see Chapter 4.

Lack of local governance

An adequate watershed-scale governance scheme is conceived under a multi-scale principle, from the basic unit (the property) to the landscape unit or economic unit (forest supply chain, livestock region, among other examples) interacting effectively with each other and with other territorial scales (state, region, nation, global) (CONAFOR, 2017). In the case of the RIOS project, watershed-level governance requires the involvement of a variety of local stakeholders (see Chapter 5.1, Stakeholder Engagement Plan).

In the Ameca-Mascota region, there is a lack of both institutional and technical administrative capacities of the municipalities. The Junta Intermunicipal Sierra Occidental y Costa (JISOC) is an inter-municipality initiative that aims at improving local governance. To make the change effective, it is necessary to continue strengthening local stakeholders, including communities, producers, small landholders, and others.

In the Jamapa basin, there is low community organization for landscape management. Successful community governance in Jamapa is limited to a few local figures promoting water management through a user assembly. In addition, some civil associations generate spaces of governance for the sustainable management of the basin (Domínguez and Castillo, 2018). In the upper area of the Jamapa basin, there are various civil society organizations that seek to promote sustainable practices, including integrated watershed management, conservation of water recharge areas, shaded coffee production, sustainable livestock management, and restoration of wetlands. However, in the middle and lower parts of the basin local governance is low.

Insufficient information and knowledge about the effects of climate change

According to the interviews implemented in January 2020 within the framework of the co-financed Project CONECTA, farmers in the region have very limited information about the effects of climate change and most of the information they do receive is via television from national news sources or through their cell phone. Planning in their productive activities lacks the component of climate change because they ignore potential effects or how to address them. The Municipal Ecology Directorates, the JISOC, the State Livestock Union, and local coffee organizations are platforms that provide technical support and could promote climate change awareness in their training.

There are various studies that seek to measure the effects of climate change and the climate vulnerability of the population, as well as of productive activities through modeled scenarios of changes in temperature and precipitation (Welsh, et al., 2018; Soto, 2014; Zarecero-Salazar, 2015; Maldonado, et. Al., 2017; INECC-FGM, 2018; Moreno, et al., 2019). However, there are still significant gaps regarding the direct effects on activities such as shade coffee production, seasonal agriculture or livestock (which depend on rain cycles for pasture production, cattle fattening, and milk production). Similarly, there is limited knowledge of the effects on ecosystems and the modifications of ecosystem services that they provide to the productive sectors and the population. Little information is available on the value of ecosystem services in the region, and therefore users (and potential buyers) of ecosystem services are not aware of their value.

Limited institutional coordination

Despite the existence of a legal framework at both at the federal and state levels that provide the enabling conditions for mainstreaming public policies and coordination between sectors towards rural development and climate change action, the execution of public programs and resources is disjointed and poorly coordinated. This is especially the case in forest areas where agricultural and forestry activities converge. This is related to intersectoral coordination platforms that operate poorly at the local level, while there are no planning instruments that trigger coordination in public investments.

Limited alignment of public and private investments

It is essential to coordinate investments of public and private institutions that make decisions on natural resources at the federal, state, and municipal levels. However, in both basins, there is a lack of communication and understanding between the public and private sectors, which has made it difficult to visualize common interests and coordinate activities. Some limitations that have been identified are insufficient ownership of issues related to the comprehensive management of the basin, insufficient investment to stop the destructive processes in the basin, and lack of information on how to invest in ecosystem services (Fuentes and Paré, 2012).

Lack of implementation of planning instruments

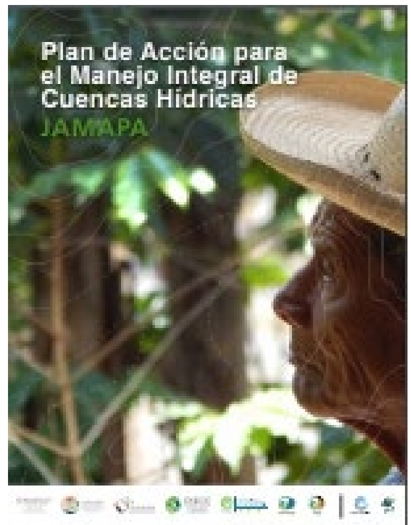
A national planning instrument related to river restoration with a climate change vision is currently lacking. Some regions in the country have relevant planning instruments. For example, in Jalisco, the Vallarta region has worked on the development of instruments with a functional vision on climate change perspectives, such as the Puerto Vallarta Municipal Climate Change Program, which proposes a series of adaptation and mitigation measures. Some of the adaptation measures for the population in the Vallarta Region were designed with a territorial vision of the basin. They include actions in the middle and upper parts of the Ameca-Mascota basin in order to provide protection to the population downstream. Coordinated investments for the implementation of this planning instrument is lacking, while adequate and practical monitoring protocols that incorporate indicators on the provision of ecosystem services and reduction to vulnerability to climate change have been developed.

In the case of the Jamapa basin, there are no local territorial planning instruments that guide land use. Advances have been made only at the state level. This has led to land use change in the basin being mainly driven by agricultural activities as mentioned in previous paragraphs. However, it is possible to find community plans for shade coffee at the community level.

1.4 The IWAPs: Tools to know the hydrological dynamics and to select priority sub-basins

The main analytical instrument that guides the RIOS Project is the Integrated Watershed Action Plans (IWAPs). The IWAPs are plans that identify the areas to implement activities required to conserve critical environmental services to reduce vulnerability to climate change. Through the project, the IWAPs will guide the selection of priority areas for 1) conservation, 2) restoration, and 3) adaptation of productive practices. Ecosystem based adaptation (EbA) will be informed by the IWAPs and support an integrated management of the watersheds to face the challenges of climate change.

IWAPs for Ameca and Jamapa basins were developed in 2016 as part of the implementation of the C6 project (Figures 1.17 and 1.18). The model and approach taken for these watersheds was presented at the 2016 Natural Capital Symposium at Stanford University and was well received by academia and practitioners, highlighting the innovative incorporation of climate change and wide stakeholder consultations. This approach was also presented during the training *Introduction to the Natural Capital Approach* and *InVEST Software Suite* that took place at Stanford University on 23-25 October, 2016.



Figures 1.17 and 1.18. Cover of the publication of the IWAPs of the two selected watersheds.

IWAPs use InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) models. InVEST is an open-source software developed by Stanford University (https://naturalcapitalproject.stanford.edu/software/invest). It consists of a suite of models used to map and value the goods and services from nature that sustain and fulfill human life. It helps explore how changes in ecosystems can lead to changes in the flows of many different benefits to people. The InVEST models are spatially-explicit. Basin maps were used as information sources. InVEST models are based on production functions that define how changes in an ecosystem's structure and function are likely to affect the flows and values of ecosystem services across a landscape. The models account for both service supply and the location and activities of people who benefit from such services.

In the watersheds selected for the C6 project, two processes were modeled using InVEST: water yield and soil retention. Given the topography of the watersheds, experts concurred that these are the two most important variables to consider for the recovery of the main hydrological ecosystem services (HES) provided by the basins. These services are key to reduce the four vulnerabilities to climate change addressed by RIOS in the two watersheds. As explained earlier, the four vulnerabilities that will be addressed by RIOS and defied by the ANVCC are of human settlements to flooding (VPI) and landslides (VPDes), of extensive livestock farming to water stress (VGEH) and of fodder production to water stress (VFEH).

As explained earlier, the watersheds selected for RIOS, as many watersheds in the country, are expected to receive higher precipitation events as a result of climate change. However, while water quantity at an annual level may not seem a problem, the risk comes from its distribution through the year. In both watersheds, the impact comes from higher extremes, since flood and drought cycles are becoming more acute. Base flow is already diminishing in the dry season, while peak flow is increasing in the rainy season (see Figures 1.2 and 1.5).

Mapping water yield through surface runoff can detect areas where conservation, restoration or adaptation practices can lead water to infiltrate, diminish its speed and reduce erosion, while increasing soil humidity in the dry season. Also, soil retention avoids erosion. In these watersheds, erosion not only leads to loss of productivity and of stored carbon, it also causes landslides in the upper watersheds, sedimentation and increase in suspended solids in rivers, which decreases water quality, and floods downstream.

Both variables, water yield and soil retention, are linked. Modeling their interaction for the watershed can strategically determine where and what activities can modify the dynamics of water and soil in the watershed to increase HES and thus reduce vulnerabilities to climate change. Hence, to determine the degree of provision of HES, IWAPs used as inputs the two key processes: 1) surface runoff, and 2) potential soil loss due to water erosion. To analyze this, we used InVEST Water Yield, and Sediment Delivery Ratio Models. The next sections summarize the applications of these two models and the results for each of the two watersheds selected for RIOS.

The IWAPs have a basin vision that considers the territorial dynamics between their units of analysis (sub-basins). They reflect the hydrographic relations between them, differentiating the sub-basins that provide hydrological ecosystem services (HES), which drain towards other sub-basins, and those that receive them. The results of the application of the models are also presented by sub-basins, thus reflecting the connection between them.

Water Yield Models for the IWAPs

The Water Yield Model estimates the annual average quantity of water produced by a watershed. Spatially-explicit outputs of relative water yields can identify areas contributing the most to water quantity and inform how changes in the landscape will alter such contribution. For the Water Yield Model, the results represent the surface runoff in annual millimeters per pixel. The model takes the Budyko curve as a basis to make a balance between; 1) climatic variables (precipitation and evaporation) and 2) biophysical variables (root depth, water contained in the soil, and transpiration of plants). This way, the model gives a geographical interpretation of where the best interactions occur among the variables for the runoff process to occur. However, a greater runoff may represent a risk to erosion processes. For this reason, the Sediment Delivery Ratio Model (SDR) was also implemented, to identify those sites with the greatest potential for soil loss due to water erosion.

The water yield model performs a balance with the inputs from Table 1.5, where runoff is the difference between the average annual precipitation, minus the volume of water lost to evapotranspiration by the specific vegetation, and the water retained in the soil.

Table 1.5. Main inputs and data sources for the Water Yield Model.

Input	Description	Source of Information
Average annual precipitation	Average annual precipitation was estimated, based on average monthly rainfall, for a period of 1950-2000.	Centro de ciencias de la atmósfera UNAM https://atlasclimatico.unam.mx/atlas/kml/index.html#ModelosGlobales5ta
Vegetation and land use (VYUS)	A raster layer of the types of vegetation and land use in the basin was elaborated, this layer is associated with a table with the evapotranspiration coefficients. The layer was obtained from reclassification and rasterization of the INEGI V Series vegetation and land use chart.	INEGI Conjunto de datos vectoriales de la carta de vegetación y uso de suelo serie V (2014)
Annual average of potential evapotranspiration or reference (ETo).	This layer is generated from the temperature and precipitation variables with monthly average data from 1950-2000. The interaction between the average annual ETo obtained the VYUS and the evapotranspiration coefficients determines the volume of water evaporated by the plants on average per year.	Centro de Ciencias de la Atmósfera, UNAM https://atlasclimatico.unam.mx/atlas/kml/index.html#ModelosGlobales5ta
Water contained in the soil available to plants	This layer represents the fraction of the precipitation that remains stored in the soil, available for plant growth. This layer is obtained from the texture, gravel content, compaction, and organic matter contained in the soil. With this layer, the model determines the saturation and the volume of water retained by the soil.	USDA, Agricultural Research Service https://www.ars.usda.gov/research/software/download/?softwareid=492
Root growth restriction depth	This layer represents the depth in the soil, how far the roots can grow, either because of a chemical or physical limitation. This layer was obtained from the soil profiles, from the vectorial data set of the INEGI Series II soil chart, adding the depth of the different soil horizons in each profile.	World soil information https://www.isric.org/index.php/explore/soilgrids
Biophysical table	In this table, the types of vegetation and soil use are associated by means of an identifier, with the evapotranspiration and root depth coefficients for each type of vegetation and crop present in the basin.	FAO http://www.fao.org/3/X0490E/x0490e0b.htm#crop%20coefficients

The application of these model results in: (a) a raster layer (.tif) in which each pixel has an associated value representing surface runoff in annual millimeters per pixel; (b) a shapefile (.shp) where each sub-basin has an associated value representing sub-basin surface runoff in annual millimeters. The results for both basins are presented below:

Water Yield Model in the Ameca-Mascota watershed

Figure 1.19 shows the raster layer (.tif) resulting from the Water Yield model for the Ameca-Mascota basin. The pixels in green are the areas of the basin with higher surface runoff. Most of them are located in the lower and medium parts of the basin. These are areas of farming and dry forests in the surroundings of the cities of Puerto Vallarta and Bahía Banderas.

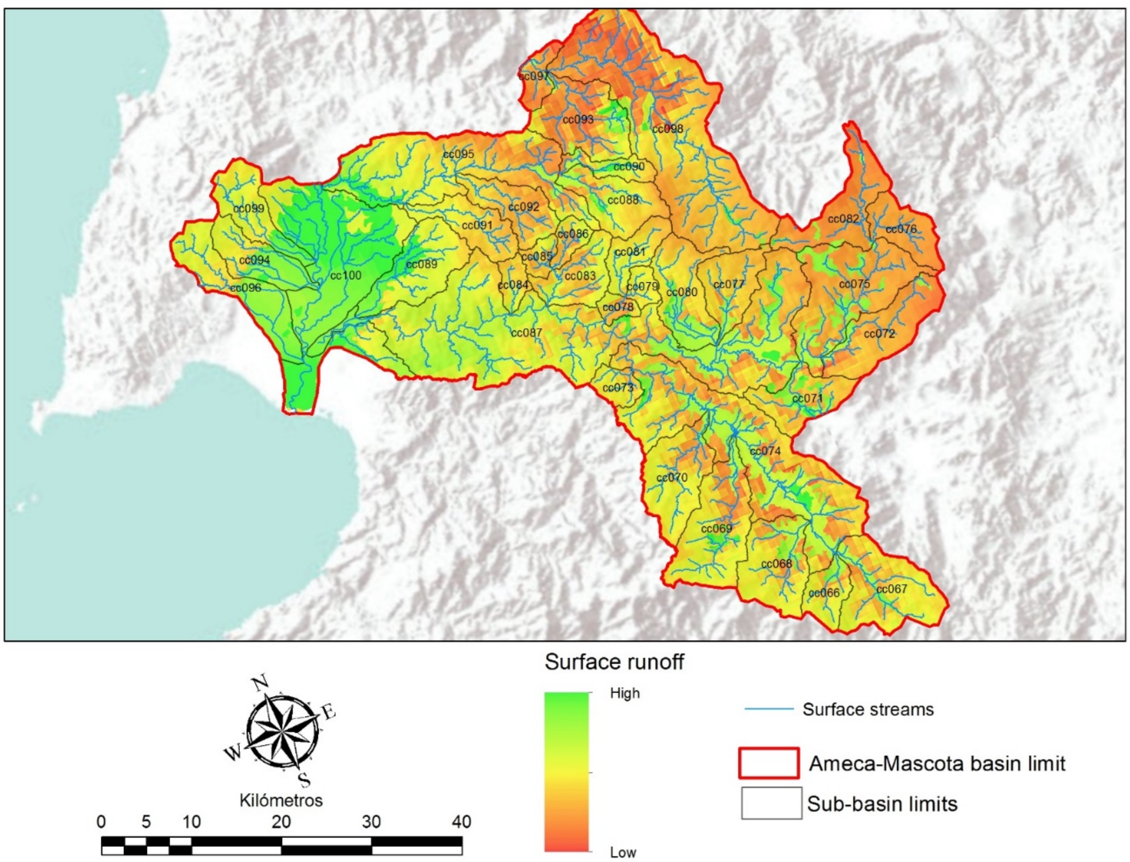


Figure 1.19. Water runoff in Ameca-Mascota basin, illustrating site-specific water runoff.

Water runoff at a sub-basin level for the Ameca-Mascota basin is presented in Figure 1.20. The figure shows 5 categories (very low, low, medium, high and very high).

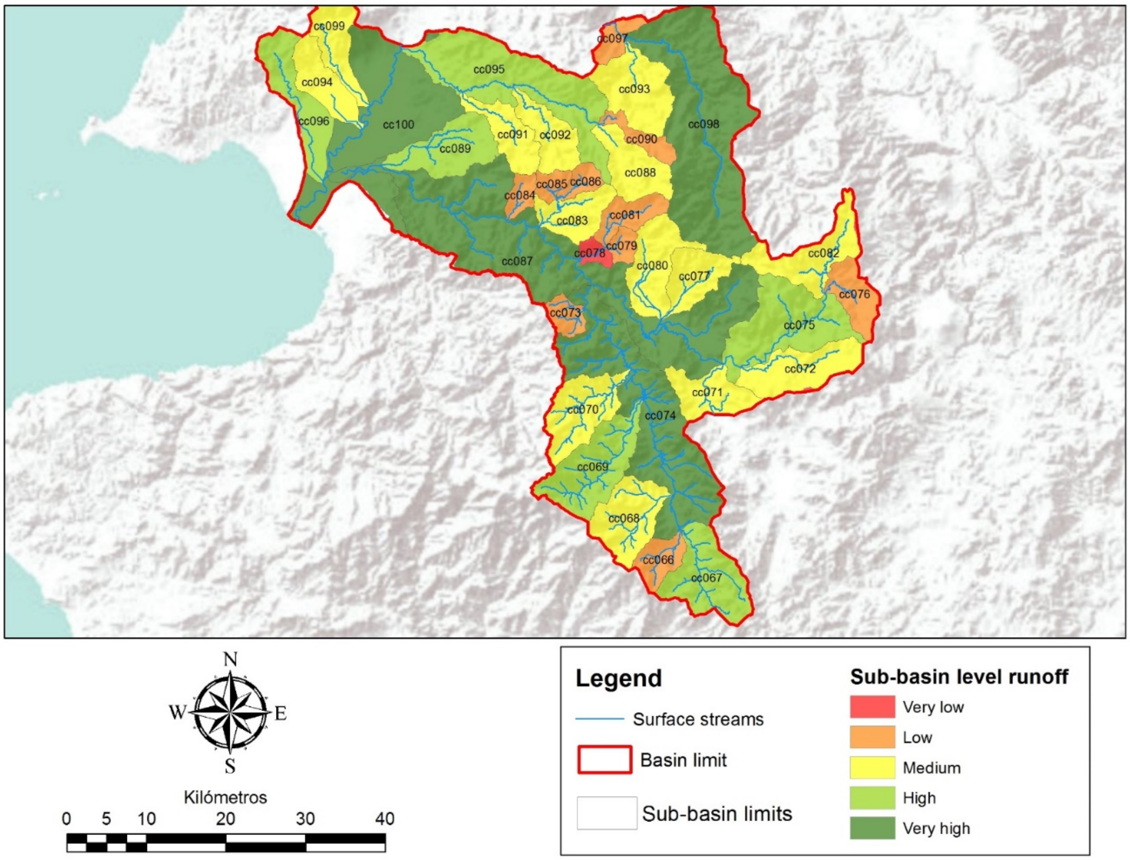


Figure 1.20. Water runoff in Ameca-Mascota sub-basins.

Water Yield Model in the Jamapa watershed

Figure 1.21 shows the raster layer (.tif) resulting from the Water Yield model for the Jamapa basin. The pixels in dark green are the areas of the basin with higher surface runoff. Most of them are located in the upper part of the basin. These are areas of cloud forests and shaded coffee lands in the surroundings of the city of Huatusco and Cordoba.

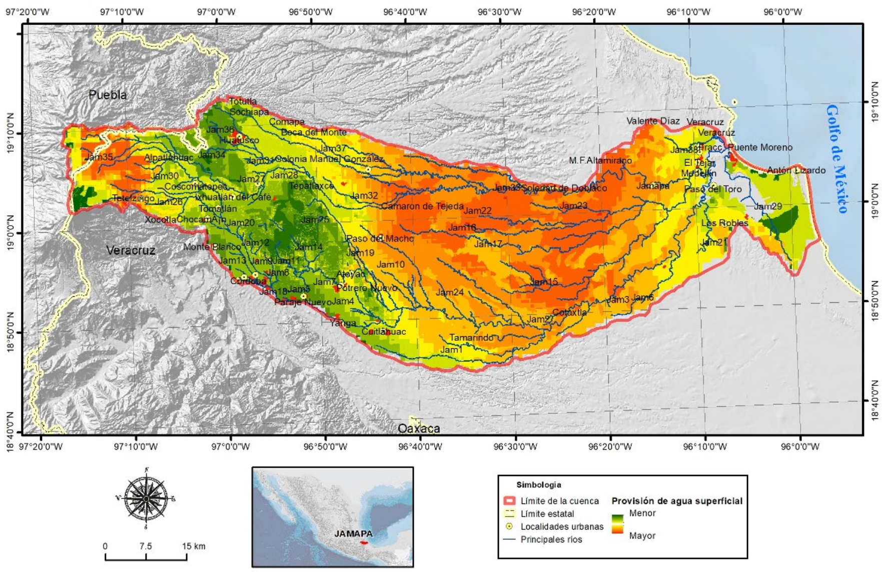


Figure 1.21. Water runoff in Jamapa basin, illustrating site-specific water runoff.

Water runoff at a sub-basin level for the Jamapa basin is presented in Figure 1.22. The figure shows 5 categories (very low, low, medium, high and very high).

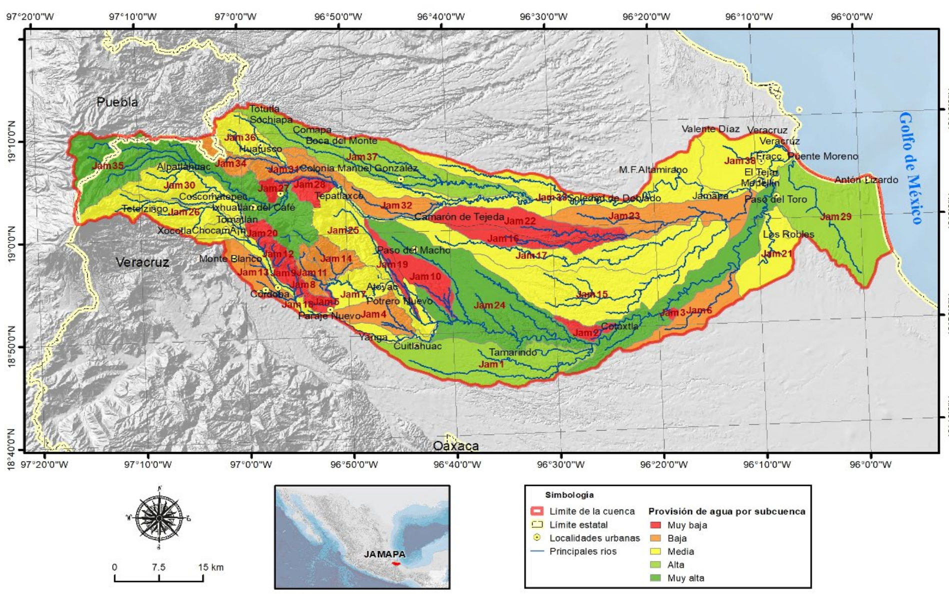


Figure 1.22. Water runoff in Jamapa sub-basins.

The Sediment Delivery Ratio Model

The Sediment Delivery Ratio (SDR) Model estimates the capacity of a land parcel to retain sediment by using the information on geomorphology, climate, vegetative coverage, and management practices. A land parcel's estimated soil loss and sediment transport inform the service step of the InVEST model, which produces outputs in terms of avoided sedimentation. The model can also value the landscape in terms of water quality maintenance or avoided reservoir sedimentation and determines how land-use changes may impact the cost of sediment removal. The model used is based on the Universal Equation of Potential Soil Loss (USLE) which uses the variables (Table 6): 1) rainfall erosivity, 2) soil erodability, 3) length and 4) the magnitude of the slope to estimate the potential loss of soil in tons per hectare per year (ton/ha*year). The main inputs used for the SDR Model for the two watersheds are described in Table 1.6.

Table 1.6. Main inputs and data sources for the Sediment Delivery Ratio model.

Input	Description	Source of information
Rain erosivity	This layer represents the kinetic energy associated with the intensity of the rain, and its ability to shed and fragment the soil. R= EI30 It was built for each region, using the average annual rainfall from 1950-2000 (from a monthly basis), and the intensity of rain during the first 30 minutes.	Atmospheric Sciences Research Center, UNAMhttps://atlasclimatico.unam.mx/atlas/kml/index.html#ModelosGlobales5ta Maximum intensities: Campos-Aranda, 2009. Intensidades Máximas de lluvia para diseño hidrológico urbano de la república Mexicana.
Soil erodability	This layer represents the susceptibility of the soil to be fragmented and swept away by rainfall. In interaction with rain erosivity, the model determines the amount of soil that can be detached.	International Institute for Applied Systems Analysis (IIASA). Harmonized World Soil Database http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/
Digital Elevation Model (DEM)	Using the altitude data from the DEM, the InVEST model estimates the length and magnitude of the slope in the basins. These factors determine the ability of the terrain to drag the detached soil.	National Institute of Statistics and Geography (INEGI) https://www.inegi.org.mx/app/geo2/elevacionesmex/
Land-use and vegetation	A raster layer for vegetation types and land-uses located in the basin was developed and associated with USLE factors C and P. The layer was obtained from reclassification and rasterization of INEGIS´s vegetation and land-use chart (Series V).	INEGI, Series V, Vector data set of vegetation and land-use chart (2011)

Biophysical information	This table associates the types of vegetation and land-use with factors C and P. The C-factor or cover is an indicator of the protective effect of vegetation coverage on the surface of the soil. The P-factor represents support activities for erosion control and management (terrace or contour crops, for example).	FAO http://www.fao.org/docrep/T1765E/t1765e0c.htm

The Sediment Delivery Ratio Model in the Ameca-Mascota watershed

Areas located in the upper-medium part of the basin, with high slopes and canyons, are the most susceptible to erosion in the Ameca-Mascota watershed. Figure 1.23 shows the raster layer (.tif) resulting from the SDR model in which each pixel has an associated value representing the potential volume of soil loss expressed in tons per year. Areas colored in red, orange and yellow present the highest susceptibility of erosion in the basin in decreasing order. The hotspots for potential soil erosion are located in the Talpa farming valley and its associated hillsides.

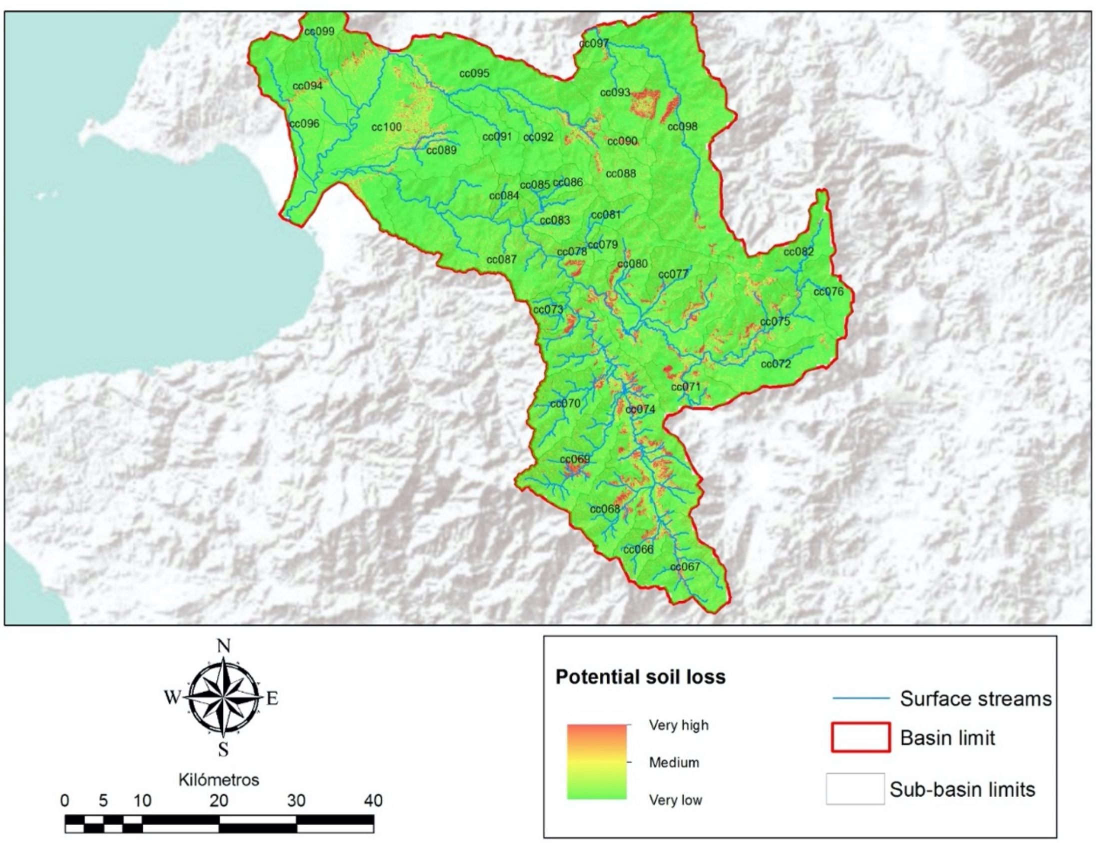


Figure 1.23. Model in Ameca-Mascota basin illustrating site-specific susceptibility to erosion.

Figure 1.24 presents the susceptibility to soil erosion in the sub-basins that form the Ameca-Mascota watershed. The highest potential for soil loss is sub-basin cc074. The figure shows five categories (very low, low, medium, high and very high).

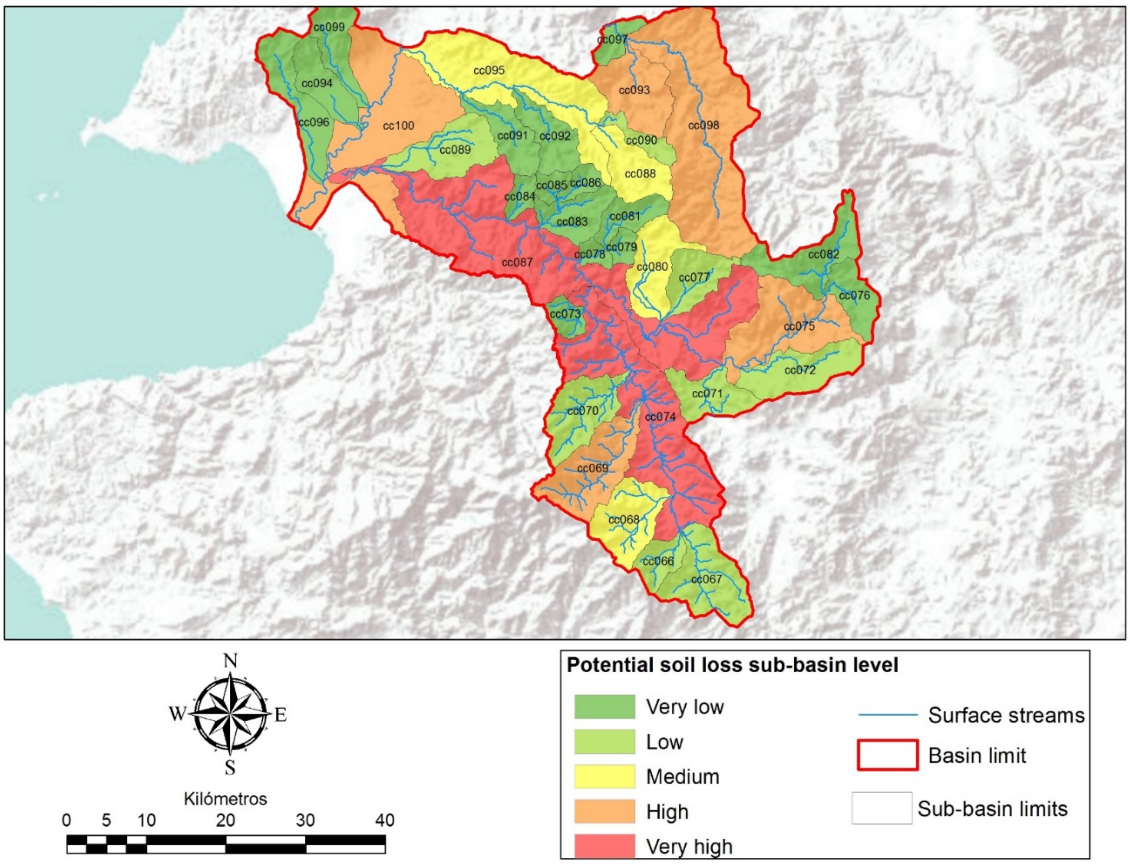


Figure 1.24. Model in Ameca-Mascota basin illustrating sub-basin susceptibility to erosion.

The Sediment Delivery Ratio Model in the Jamapa watershed

In the Jamapa watershed, areas located in the upper-medium part of the basin, with high slopes and canyons, are the most susceptible to erosion. Figure 1.25 shows the raster layer (.tif) resulting from the SDR model in which each pixel has an associated value representing the potential volume of soil loss expressed in tons per year. Areas colored in red, orange and yellow present the highest susceptibility of erosion in the basin. The hotspots for potential soil erosion are located in the cloud forest and coffee lands around the city of Cordoba and the village of Ixhuatlán del café.

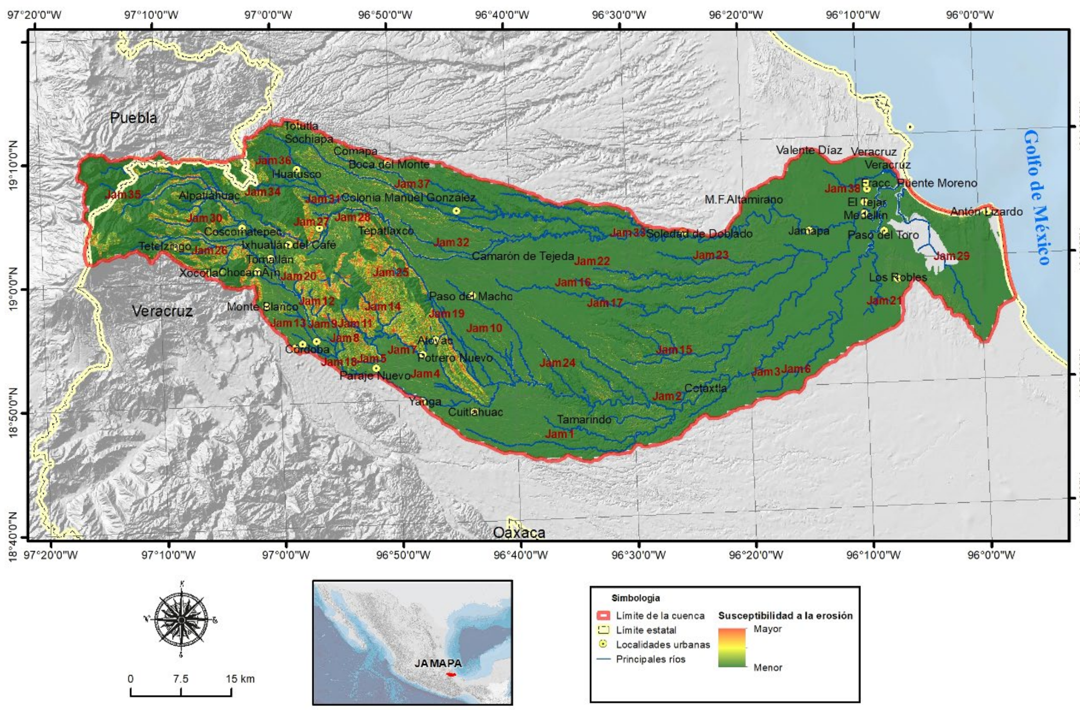


Figure 1.25. Model in Jamapa basin illustrating site-specific susceptibility to erosion.

Figure 1.26 presents the potential soil loss at a sub-basin level within the Jamapa watershed. The figure shows five categories (very low, low, medium, high and very high).

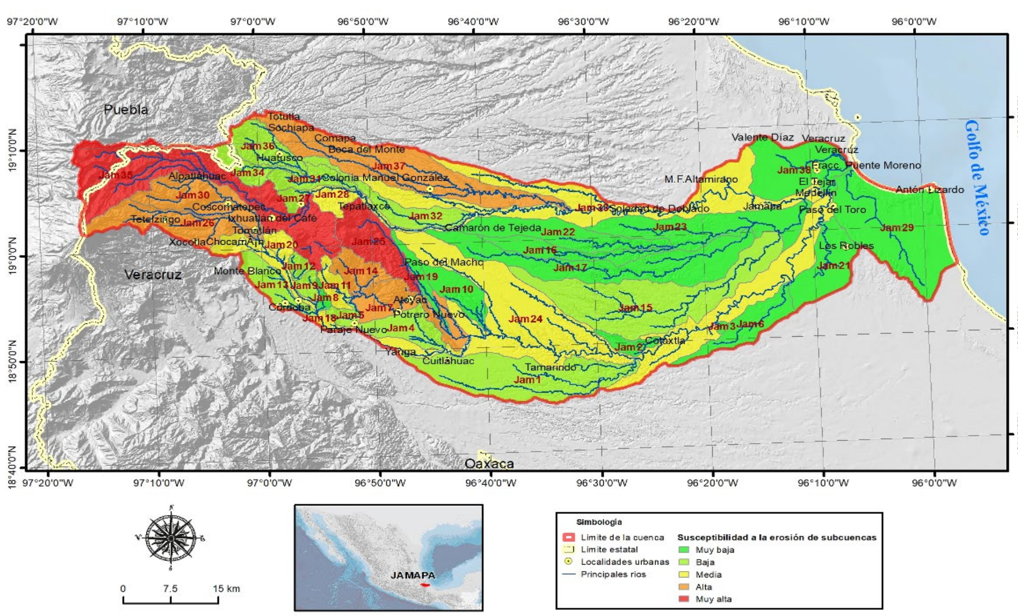


Figure 1.26. Model in Jamapa basin illustrating sub-basin susceptibility to erosion.

Combining both models to map ecosystem services

Using the results from the models explained in the previous section and their interaction, areas within the watersheds were categorized for their provision of HES (very high, high, medium and low) (Figure 1.27). For example:

i. high provision: indicate a high surface runoff (water yield model) and low potential for soil loss,

ii. low provision: low surface runoff and a high potential for soil loss.

The sites identified in the IWAPs with a very high potential for HES provision means that they provide these services both in quantity and quality. In order to increase HES, it is important to design restoration, conservation or adaptation activities. For example, since erosion is a major cause of sediment export, conserving the vegetation at sites with low erosion potential and high runoff leads to higher infiltration and less water stress during the dry season.

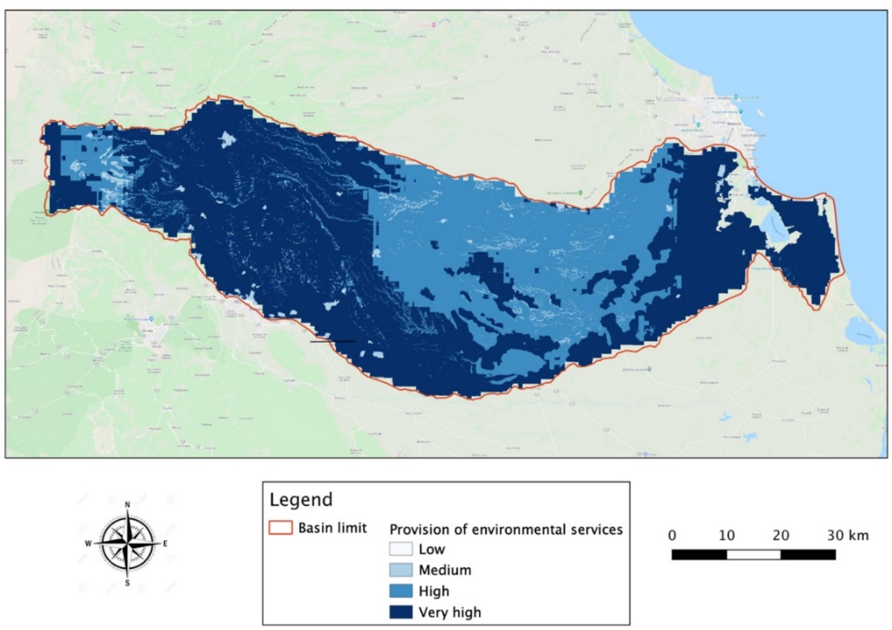


Figure 1.27. Provision of hydrological environmental services in the Jamapa river basin.

Projecting changes in selected watersheds

Considering the degree of provision of HES, as well as the connection between areas of high supply and areas of high demand, the change in bioclimatic conditions under climate change scenarios was modelled based on the studies by INECC and UNAM´s Institute of Geography (Trejo and Sanchez Colon, 2015). These studies model the potential distribution of the main vegetation cover in Mexico under climate change scenarios, using probabilistic models made for 19 bioclimatic variables, described by Busby in 1991, and physical variables such as slope exposure, soils, and geology. Bioclimatic variables were developed using climatology data from 1950 to 2000, then temperature and precipitation projections (2075-2099) were incorporated, and finally, the future distribution of bioclimatic conditions was modeled. In this way, the vegetation cover for four climate change scenarios was obtained. With these inputs as a basis, layers were superimposed to identify sites where at least three models indicate future changes in bioclimatic conditions. This layer of coincidence between models was used to detect areas that will experience change and where adaptation practices within the watershed should focus to ensure HES provision (Figure 1.28).

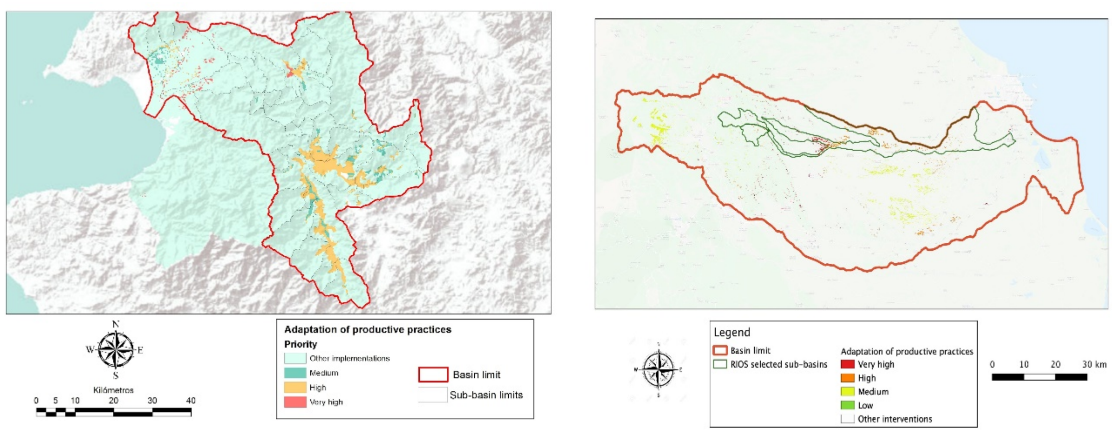
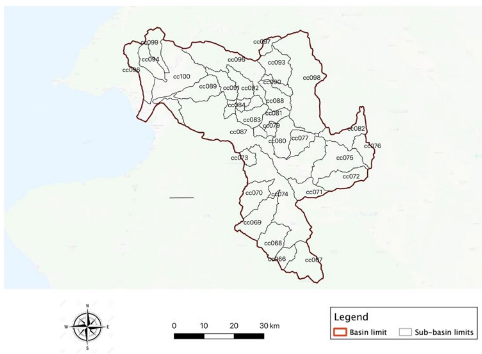
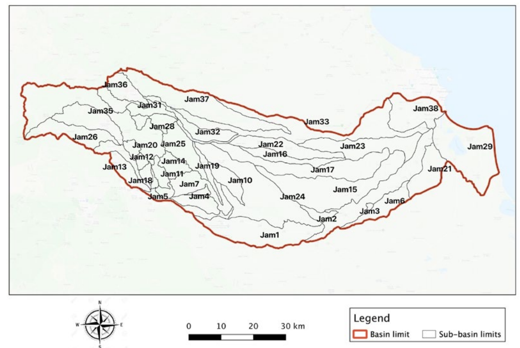


Figure 1.28. Maps resulting from models on future bioclimatic conditions in the Ameca-Mascota (left) and Jamapa (right) watersheds.

Priority sub-basins within the watersheds

IWAPs have a basin vision that considers the territorial dynamics between their units of analysis, (its sub-basins). They reflect the hydrographic relations between them, differentiating sub-basins that provide HES, which drain towards other sub-basins, and those that receive them. Figures 1.29 and 1.30 show the 35 sub-basins of the Ameca-Mascota watershed and the 38 sub-basins of the Jamapa watershed.





Figures 1.29 and 1.30. The Ameca-Mascota and the Jamapa river basins with their sub-basins.

One of the advantages of using a watershed perspective is that the connections between the areas that provide HES with those that demand them can be mapped. For the Ameca-Mascota watershed, four sub-basins show a clear connection between the areas of highest HES supply and demand (Figure 1.31). One of those four sub-basins is key to connect the areas of supply and demand (sub-basin in green). RIOS will therefore aim at focusing activities in this priority sub-basin to best serve the areas of highest HES demand, which is found in the city of Puerto Vallarta.

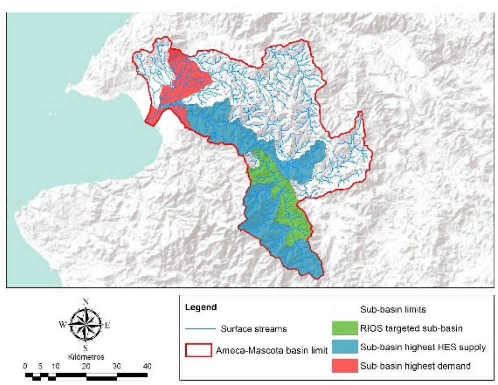


Figure 1.31. Map showing the sub-basin that connect (green) the areas of highest supply of HES (blue) with sub-basins with highest HES demand (red) in the Ameca-Mascota watershed.

In the case of Jamapa (Figure 1.32) three sub-basins (green) connect the sub-basins with highest HES supply (blue) with the sub-basin of highest HES demand (red). The city of Veracruz is in the sub-basin of highest HES demand. RIOS will therefore aim at focusing activities in the three connecting sub-basins to ensure provision of HES to the sub-basin of highest HES demand.

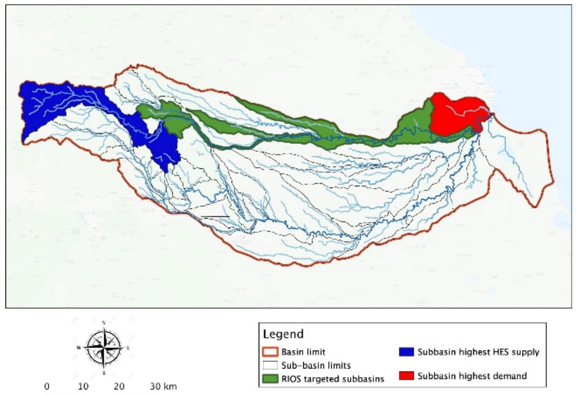


Figure 1.32. Map showing the sub-basin that connect (green) the areas of highest supply of HES (blue) with sub-basins with highest HES demand (red) in the Jamapa watershed.

1.5 RIOS: Intervention sites, and expected results

As a targeting exercise, adaptation activities and respective areas were projected for the four sub-basins of intervention of the RIOS project (one sub-basin in the Ameca-Mascota basin and one in the Jamapa basin). The activities in the RIOS proposal focus on the restoration of vegetation cover in riparian systems and slopes, as well as the adaptation of productive practices in the livestock sector. We focus on livestock areas because it is one of the main activities associated with the management of riparian zones in these sub-basins and because there will be co-financing for it.

The selection criteria for interventions sites within the sub-basins were:

1. Relevance of grasslands within the sub-basins.

2. Relevance of perennial and intermittent rivers within the grasslands. Rivers were classified according to Strahler orders of streams.

3. The sites that met the above criteria were selected for their potential for riparian vegetation restoration. A buffer of 15 m on both sides of the rivers was then used to calculate the potential riparian area for intervention. The riparian area was then associated with the adjacent livestock plots considering that cattle exclusion from riparian areas is one of the adaptation practices in a farm/ community. The potential areas to support sustainable ranching practices was then calculated.

Sub-basin in the Ameca-Mascota watershed

"Talpa-Mascota" sub-basin has a total surface area of 22,702 ha and is located in the municipalities of Mascota (33%) and Talpa de Allende (67%). Natural vegetation mainly covers the sub-basin with 7,872 ha of forests and 5,798 ha of secondary vegetation (Figure 1.33). These land uses are followed by agriculture (5,702 ha) and grasslands (2,938 ha).

In this sub-basin the main form of livestock ranching is extensive and free grazing in degraded forest areas. The Talpa-Mascota sub-basin contains 35.7 ha with a potential for riparian restoration associated with ranching zones (Figure 1.33). Considering an average of 48.3 ha per ranch, there is a potential intervention site of 1,724.3 ha along riparian areas for the activities of sustainable ranching practices.

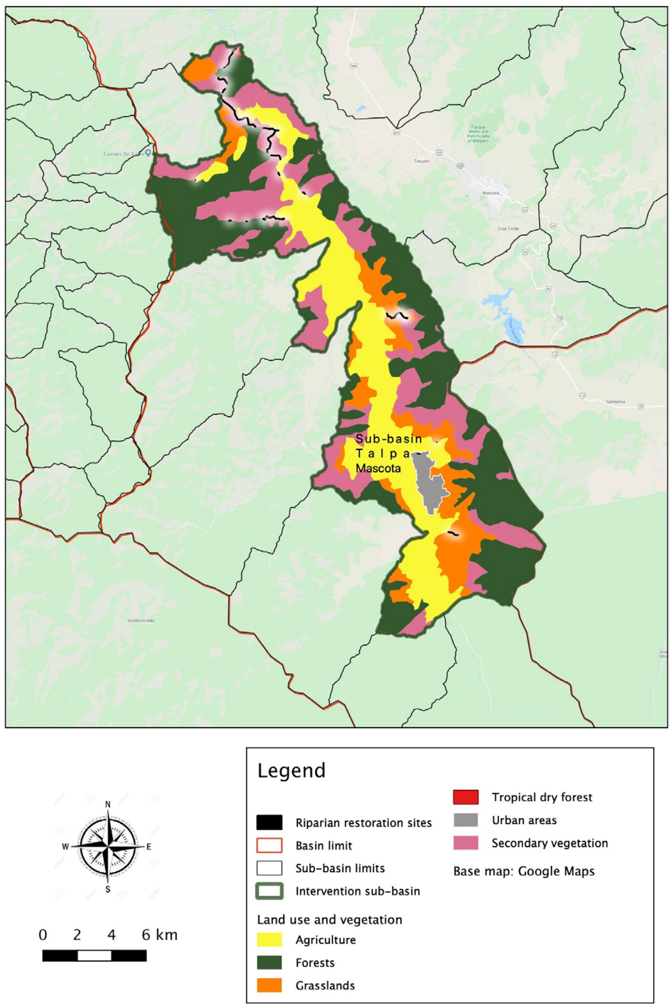


Figure 1.33. Riparian restoration sites (lines in black) and associated productive areas in the Talpa-Mascota sub-basin in the Ameca-Mascota watershed.

Sub-basin in the Jamapa watershed

The total target area in Jamapa, comprising three sub-basins, is 36,309 ha. Agricultural land use covers 66% of the three sub-basins, that is 24,156 ha (Figure 1.34). As for natural vegetation, the sub-basins have small patches of cloud forest (252 ha) and oak-pine forests in the two upper sub-basins (sub-basins Jam28 and Jam31), and 790 ha of secondary rainforest vegetation in sub-basin Jam33. Grasslands are represented by 9,179 ha, all of which are included in Jam33 sub-basin.

Riparian restoration will focus in Jam 33 sub-basin grasslands including approximately 366 ha for the potential restoration of riparian vegetation adjacent to grasslands. Considering an average of 15.3 ha per property, there is a potential intervention site of 5,599.8 ha along riparian areas for the activities of sustainable ranching practices.

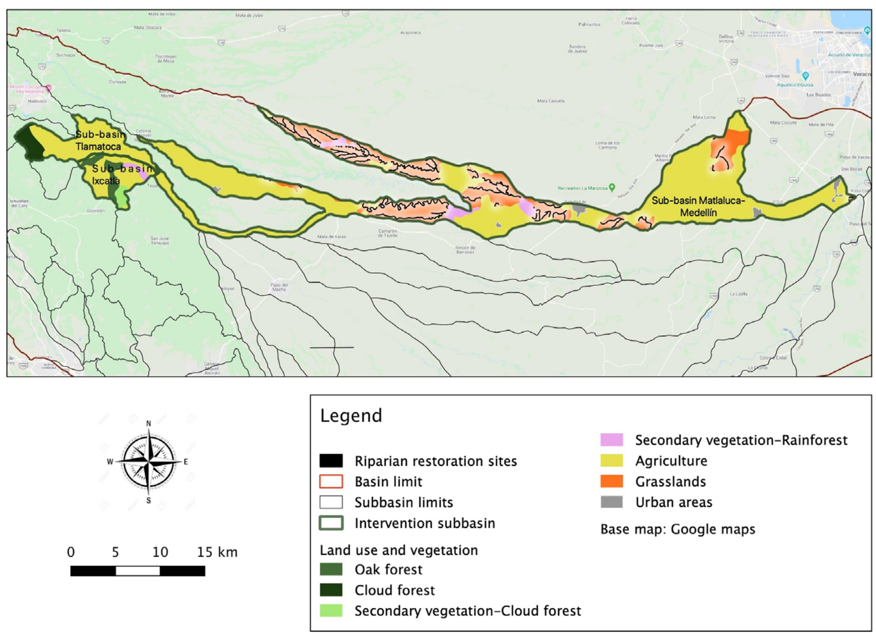


Figure 1.34. Riparian restoration sites (lines in black) and associated productive areas in the three priority sub-basins (Jam28-Ixcatla, Jam31-Tlamatoca and Jam 33-Matlaluca-Medellín) in the Jamapa watershed.

Table 1.7 summarizes the main characteristics of the four priority sub-basins for the RIOS project, emphasizing the distribution of potential areas for riparian restoration, as well as areas with the potential for the adaptation of ranching practices. The table also includes the expected beneficiaries within each sub-basin as well as the benefitted population downstream.

Table 1.7. Characteristics of the four priority sub-basins within the watersheds.

River basin	Sub-basin	Hydrographic configuration	Sub-basin area (ha)	Area with potential for practices (ha)	Riparian area (ha)	Beneficiaries	Vegetation (ha)
Mascota -Ameca	Talpa-Mascota	Receiving-Emitting	22,702	1,724.3	35.7	**Basin** 5,513 F; 5,259 M; 10,772 T **Downstream** 127,008 F; 128,479 M 255,487 T and 4,057,875 tourists	Forests: 7,872 Rainforests: 29 Agriculture: 5,702 Grasslands: 2,938 Secondary vegetation: 5,798
Jamapa	Jam 33 or Sub-basin Matlaluca-Medellín	Receiving-Emitting	29,652	5,599.8	366	**Basin** 20,731 F; 21,534 M; 42,754 T **Downstream** 323,303 F; 286,844 M 610,147 T and 2,475,694 tourists	Grasslands: 9,179 Agriculture: 19,195 Secondary vegetation: 790 (Rainforest)
	Jam 28 or Sub-basin Ixcatla	Receiving-Emitting	2,756	-	-	**Basin** 1,489 F; 1,495 M; 2,984 T **Downstream** *(idem Sub-basin Matlaluca-Medellín)*	Agriculture: 3,248 Cloud forest: 640 Oak forest: 14
	Jam 31 or Sub-basin Tlamatoca	Receiving-Emitting	3,901	-	-	**Basin** 3,431 F; 3,353 M; 6,784 T **Downstream** *(idem Sub-basin Matlaluca-Medellín)*	Agriculture: 1,713 Oak-pine forest: 612 Secondary vegetation: 178 (rainforest) and 253 (cloud forest)
Total			**59,011**	**7,324.1**	**401.7**	**Basin 31,146 F; 31,641 M; 63,294T Downstream 450,311 F; 415,323 M 865,634 T and 6,533,569 tourists per year**	

According to the IWAPs, RIOS proposes to carry out activities that increase the vegetation cover in riparian systems and slopes, as well as in areas for protection of springs, or important for infiltration or soil retention. The aim is to: (i) reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses; (ii) increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration; (iii) conserve soil for productive activities; (iv) moderate extreme temperature thanks to vegetation coverage. As a result of these activities, RIOS aims to reduce vulnerability to the impacts of climate change, mainly by decreasing exposure to landslides, floods, and drought. Likewise, the project seeks to augment the adaptive capacity of the population and ecosystems as a key strategy in a country where two-thirds of the territory are mountains and therefore highly sensitive to climate change (World Bank, 2010). The increase in the adaptive capacity will enable the alignment of investments in the basins. The lessons learned from these exercises will feed into the development of a National Strategy for River Restoration, which will allow for scaling up actions to reduce vulnerability to climate change throughout Mexico.

Expected result: reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses and Conserve soil for productive activities

The increase of soil loss is a consequence of unsustainable activities in BAU scenario (Keesstra et al., 2015), and they can have negative consequences in the ecosystem and people. On the other hand, healthy river ecosystems and riparian vegetation, are an effective sink for sediment (Ricker et al, 2012). In this way, the quantification of sediments is a suitable proxy of the state of rivers and the quality of hydrological ecosystem services that the RIOS project provides. This Chapter complements Chapter 4.3 that evaluates the economic costs and benefits of the Project.

Table 1.8 shows some previous studies that calculate soil erosion empirically or through modeling. As table 1.8 shows, reduced soil loss through restoration is between 14-88.4%, with an average of 41.42%. For productive practices, reduced soil loss was between 14-85 with an average of 47.8%. The years measured varied between 6-21 years.

Table 1.8. Previous studies that evaluate soil retention in activities similar to RIOS

Study	Method	Practice Ratio of reduced soil loss Years
Assessing the soil erosion control service of ecosystems change in the Loess Plateau of China	USLE	Restoration 63.3% 8 years
Quantifying the Effect of Ecological Restoration on Soil Erosion in China's Loess Plateau Region: An Application of the MMF Approach	MMF (Morgan, Morgan and Finney) model	Restoration 88.4% 21 years

Effectiveness of exclosures to control soil erosion and local community perception on soil erosion in Tigray, Ethiopia	USLE Survey of community perception Interview	Sustainable livestock 49% 10 years
La jolla, una estrategia campesina basada en el manejo del arrastre hídrico de sedimentos y la diversidad vegetal	Emprirical measurment Volume (m3)= Thickness (m) Area (m2)	Sustainable agriculture 51% n.d.
The assessment of regulatory ecosystem services: the sediment retention service in a mountain landscape in the Southern Romanian Carpathians	USLE INVEST	Restoration and Sustainable livestock 14% n.a.
Before and after riparian management: sediment and nutrient exports from a small agricultural catchment, Western Australia., 270(3-4), 253-272.	Empirical, using a monitoring station	Sustainable Livestock 40-85% 6 years

Source: Own elaboration

We apply a sediment connectivity approach using the InVEST model. InVest is an open-source model developed by Stanford University, used to map and value goods and services from nature that sustain and fulfill human life. The use of InVest for this objective has excellent potential to quantify the sediment retention service (Hamel et al., 2015).

We calculated the Universal Soil Loss Equation (USLE) for each of the territorial prioritization categories to implement practices related to: 1) restoration and conservation, 2) adaptation, and 3) riparian restoration. We used the layers:

1) Sub-basin limits
2) Layers of prioritization for the adaptation of productive practices
3) Prioritization layers for restoration
4) PPS Potential Soil Loss Layer (USLE)

The methodology used is based on calculating the potential soil loss PPS (USLE) values within each restoration and adaptation of practices categories. The minimum, maximum, average, and accumulated values for each zone were calculated. To calculate the statistics by area, we followed these steps:

1) Pixel size standardization for layers: USLE, prioritization for adaptation of practices, and prioritization for restoration. All layers were adjusted to 30m x pixels.
2) Layer cutting at the sub-basin level: USLE values, adequacy of practices and restoration for the intervention sub-basins were extracted.
3) Calculation of statistics by zone: the statistics of the values of USLE contained in the

categories of adaptation of practices and restoration were calculated.

Assumptions:

1) In order to estimate the sediment retention potential, by obtaining statistics by zone, a 100 m buffer (due to the resolution of the USLE capacity) was applied to the hydrographic network (1: 50,000) with all requests for the stream.
2) In order to apply zonal statistics, we considered the condition of the stream (virtual, perennial, and intermittent stream).
3) In average, the ha per type of practice that is supported by the project will have similar characteristics to the average pixel per type of practice.
4) The type of practice will have a similar soil retention behavior than the average in previous studies shown in Table 1.8.

The Table 1.9 shows the results for each sub-basin. The columns show the number of pixels for each priority category, the area in hectares and the minimum, maximum, average and total values for each of the categories of prioritization of adaptation of practices and restoration.

Table 1.9. Potential soil loss without project

Region	Areas with potential for:		Potential soil loss (ton/ha *year)
			Without Project (average, range between medium-high priority)
Ameca-Mascota	Riparian restoration	Perennial	27.79
		Intermittent	25.46
	Adaptation of productive practices		59.50 – 66.34
Jamapa	Riparian restoration	Perennial	13.12
		Intermittent	7.18
	Adaptation of productive practices		21.68- 263.84

Because the activities in Component 1 are voluntary and demand-based, we cannot control for the number of hectares of each practice. In all cases, we used the average soil retention ratio from the literature review:41.42% for restoration, and 47.8% for the adaptation of productive practices. We also assumed that half of the area will be in each region. For this reason, we conducted a sensitivity analysis by assuming three scenarios:

- Scenario 0: BAU. The BAU scenario assumes that practices will remain as they are in the baseline. This is a conservative BAU, as it does not assume that the trend of land-use change will continue and may exacerbate soil loss.

- Scenario 1: Conservative scenario. This scenario assumes that: i) most activities will have less impact in soil loss, and iii) soil loss will be similar than the average in previous studies (see Table 1.8) per practice.

- Scenario 2: Realistic scenario. This scenario assumes that i) the proportion of ha per practice will be similar to previous projects, and ii) the proportion of hectares in priority category (medium, high and very high) will be proportionally distributed iii) soil loss will be similar than the average in previous studies (see Table 1.8 per practice.

- Scenario 3: Positive scenario. This scenario assumes that i) most activities will be geared towards the practice with more impact in soil loss, and ii) the proportion of hectares in priority category (medium, high and very high) will be proportionally distributed, iii) soil loss will be similar than the average in previous studies (see Table 1.10) per practice.

Table 1.10. Potential soil retention with project

Region	Areas with potential for		Potential soil loss (ton*ha /year)	Potential soil retention (ton/ha*yr)						
			Scenario 0 Without project (average, range between medium-high priority)	Rate of retention	Scenario 1 With Project (conservative)		Scenario 2 With Project (realistic)		Scenario 3 With Project (positive)	
					Number of ha	Potential soil retention (ton*ha /year)	Number of ha	Potential soil retention (ton*ha /year)	Number of ha	Potential soil retention (ton*ha /year)
Ameca-Mascota	Riparian restoration	Perennial	28	41.4%	200	2,302	100	1,151	50	576
		Intermittent	25	41.4%	200	2,109	100	1,055	50	527
	Adaptation of productive practices		59.50 – 66.34	47.8%	2,700	81,205	3,500	105,265	4,000	120,303
Jamapa	Riparian restoration	Perennial	13	41.4%	200	1,087	100	543	50	272
		Intermittent	7	41.4%	200	595	100	297	50	149
	Adaptation of productive practices		21.68-263.84	47.8%	2,700	184,246	3,500	441,404	4,000	504,462
			TOTAL		6,200	271,543	7,400	549,716	8,200	626,288

Table 1.11. Soil loss in intervention areas under BAU and scenarios

Soil loss (ton/ha*yr)

Scenario 0 Without Project	Scenario 1 With Project (conservative)	Scenario 2 With Project (realistic)	Scenario 3 With Project (positive)
8,624,500	8,352,957	8,074,784.08	7,998,211.66

The realistic scenario shows a reduction of 549,716 tons of soil loss into the rivers. This reduction also increases the water quality and reduces the risks of landslides and floods (Table 1.11). By intervening an area equivalent to 3.78% of the basin, the project can realistically reduce 6.37% of the soil loss, which shows that the proposed interventions are effective. This soil will be conserved for the implementation of productive practices in 7,000 ha, which will maintain income streams for producers, mainly the most vulnerable ones.

Additionally, to the expected reductions in soil loss, the project will improve water quality. The experience in C6 when monitoring suspended solids in a body of water showed that with the presence of a forest the solids present in the water is 19.4 mg / L, a level that is in normal values, however when this forest disappears (in this case due to forest use) the levels of solids rise to 27.1 mg / L, a value above normal levels, the loss of the forest causes sediment levels to increase by erosion, putting at risk the infrastructure for water collection and storage that provide the population of small towns and medium and large cities. Moreover, according to the participatory water system implemented in C6, after 4 years of project implementation, the fecal coliforms decreased 49% after 2km of the area where riparian restoration was implemented and suspended solids were reduced 25-65%.

Expected result: Moderate extreme temperature through vegetation cover

Most global climate models indicate that river temperature will increase by ~1.0–3.0 °C by 2070–2100 (van Vliet et al., 2013), resulting in severe consequences both for stream ecosystems and for communities who benefit from freshwater.

Among the varied ecosystem services and functions provided by riparian vegetation, these ecotones play a significant role in moderating temperature extremes in river environments, especially during summer, when river flows are lowest and water temperature highest. Riparian forests provide shade, reducing solar radiation inputs from being received at the stream surface; limiting the amount of energy received at the air-water interface; reducing wind speed and augmenting humidity, thus limiting turbulent heat exchange (Dugdale et al., 2018; Garner et al., 2017).

The degree to which a river responds to radiative and climatic forcing is heavily dependent on patterns of land use and topography within the basin and is thus complex and multi-faceted (Fernandez et al., 2016; Hannah and Garner, 2015). Likewise, moderating water temperature through forest shade is a combination of factors including forest type, species, stand density, and canopy architecture (Dugdale et al., 2018).

Expected result: Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration

When rain falls on the earth´s surface, some of it infiltrates into the soil, some stagnates on the surface, while some flows over as runoff. The volume and speed of runoff depend on the size of the storm (how much rain falls in an amount of time), as well as the size of the contributing drainage area, the slope, and the soil and vegetation conditions.

Changes from natural land cover to agricultural and urban land uses often have adverse effects on water quantity and quality in heavy thunderstorms, such as increased surface runoff volume and rates, decreased runoff lag time, less water storage and infiltration, decreased groundwater recharge, and impaired water quality (Liu et al., 2017).

Riparian vegetation increases the river roughness, resulting in more turbulent flow, in slower runoff and flow velocities, more time for infiltration, and in a broader flood wave with lower peak discharges. Riparian buffers (including buffer strips, riparian wetlands, and floodplains) have proved to be effective in reducing runoff volume by 0 to 100% (average 45%) (Arora et al., 2010).

The slope of a basin and soil compaction and erosion also affect the amount and the timing of runoff. As the ground becomes increasingly steep, water will move faster and will have less time in contact with the ground surface, reducing the time during which it could infiltrate. With higher amounts of sediment in the water, the surface pores in the soil which the water might otherwise enter can become plugged, reducing infiltration and increasing surface runoff. Thus, the way the vegetation is spatially distributed along the slopes is an important factor for decreasing runoff and its speed.

Monitoring these effects during project implementation

The RIOS project will optimize riparian restoration strategies to maximize summer stream temperature reductions, decrease surface runoff volume and rates, modify sediment erosion/deposition regimes, and influence stream water quality.

Water quality monitoring, including air and water temperature, total suspended solids, hardness, alkalinity, dissolved oxygen, and turbidity will be fundamental to screen changes and document the benefits of riparian vegetation throughout the project.

Monitoring site climate-linked parameters will also be key to record the number and duration of rainfall events and relate them to the characteristics of the watershed and the effects of the riparian buffers established (e.g., dimensions, vegetation, percent slope, soil type).

1.6 FMCN´s projects for scaling-up

In 25 years, FMCN has funded 2,163 conservation projects, investing more than US$177 millon and protecting 229 species. The following projects are the basis for the scaling-up strategy of RIOS, built on their last five years of operation, and regarding their on-the-ground outcomes, the co-financing reached, the stakeholder participation achieved, and the experiences and lessons learned that will be incorporated into RIOS. It also includes a brief description of the CONECTA project, which will provide investment alignment and parallel financing for RIOS.

Integrated Coastal Watershed Conservation in the Context of Climate Change Project (C6)

The Coastal Watersheds Conservation in the Context of Climate Change project (C6) promotes integrated management of coastal watersheds to conserve biodiversity, contributes to climate change mitigation, and enhances sustainable land use in the Gulf of Mexico and Gulf of California. The National Commission for Protected Areas (CONANP), the National Forestry Commission (CONAFOR), the National Institute of Ecology and Climate Change (INECC), and FMCN are the implementing partners. The World Bank, through a Global Environment Facility (GEF) grant, provided the financing in the amount of US$ 39.52 million. The project was implemented in 2014-2019. The complete World Bank Implementation Completion and Results (ICR) Report rated all the outcomes as Satisfactory and the Monitoring and Evaluation Quality as Substantial. The project has been highlighted by the World Bank as one of the most successful projects in the 2020 Spring Meetings and by GEF as a Best Practice Project (official ICR report available at:

http://documents1.worldbank.org/curated/en/681991578327809888/pdf/Mexico-Coastal-Watersheds-Conservation-in-the-Context-of-Climate-Change-Project.pdf).

While administrative World Bank supervision of the project has ended, C6 has a long-term vision, since most of its funding is in the form of endowment funds whose interest will sustain activities in its five components: (1) Consolidation of protected areas by strengthening management effectiveness through the financing of biodiversity conservation activities included in annual operating plans; (2) Promoting sustainability within watersheds through the Biodiversity Fund that generates income to finance the provision of Payment for Environmental Services (PES); (3) Enabling adaptive management by strengthening monitoring capacities and systems in selected basins including the development of Integrated

Watershed Actions Plans (IWAPs); and (4) Innovative mechanisms for inter-institutional collaboration and promotion of social participation at the regional and local levels, involving state and municipal governments, civil society, and academia, to improve cross-sectoral coordination for IWAPs; (5) Support the Technical Project Committee, the Fund for the Gulf of Mexico, and the Fund for the Northwest in the implementation and supervision of the Project, including administration and provision of technical assistance and training.

C6 achieved several fundamental outcomes between December 2013 and June 2019:

- It pioneered a landscape approach for watershed ecosystem management to help build resilience to climate change and curb ecosystem degradation. The landscape approach comprised a holistic view of watersheds, from the mountains where they originate to the coasts where they meet the sea; it also involved the communities and institutions that call these watersheds home and the diverse ways in which they use the territory. This landscape approach became visible in the Integrated Watershed Action Plans (IWAPs), which include specific actions to be implemented with the participation of public, private, and local stakeholders in priority watersheds to recover their functionality and improve ecosystem service provision.
- It strengthened the management of 1,748,204.73 hectares of protected areas across the watersheds in the Gulf of California and the Gulf of Mexico, through community environmental monitoring and surveillance, fire prevention and control, environmental education, coral reef restoration, as well as the management of invasive species and pests.
- Two mutually supporting endowment funds— one within FMCN and one within CONAFOR —were established, the accruing interest from which will finance conservation and livelihood activities in the long term.
- It helped raise US$28.6 million for project activities. This matching finance included contributions from CONAFOR (US$9.09 million); the Packard Foundation (US$ 4.71 million); the Helmsley Foundation (US$ 1.086 million); the German Development Bank (US$ 12.601 million); the Hydraulic Infrastructure Fund of Sinaloa (US$ 486,000); the Resources Legacy Fund (US$ 100,000); and a few private sector donors, including US$ 189,000 from Braskem-Ides and US$ 346,000 from Materias Primas de Monterrey (now COVIA); and others.
- C6 supported the sustainable management of 35,784 hectares within watersheds, through PES and agroecosystem and sustainable forest management and agroecosystem subprojects, following IWAPs.
- Of 32 sub-projects, 90% continued operations beyond the financial support committed by the project, which engaged in ventures such as honey production, shade-grown coffee production, and sustainable cattle ranching. The sub-projects provided socio-

economic benefits to local communities, who recognized the value of ecosystem services provided by the watersheds.

- The project supported the establishment one new Protected Area in the Gulf of California, totaling 354,849 hectares.
- Enhanced watershed management prevented a total of 5.53 metric tons of CO2 from entering the atmosphere and saved an estimated 11,743 hectares from deforestation.
- The Jaguar's Western Corridor along the Gulf of California was established, spanning 12,212 hectares of protected habitat.
- Training sessions between 2014 and 2019 enabled community members to monitor biodiversity via 104 sample points, using remote sensing imagery for flora and fauna identification. Community pride and ownership in the sustainable management of watersheds was a key outcome.
- The project delivered 171 water-quality training workshops, employing the Global Water Watch methodology, resulting in 106 certified monitors and 3,433 registries on physical, chemical, and biological variables related to water quality, including *E. coli* levels. Riparian restoration through sub-projects in two sites reduced suspended solids by 25-65% and fecal coliform colonies by 49-58%.
- In total, the project held 1,669 workshops, attended by 16,173 participants (6,585 women and 9,588 men), 22.2% of whom were indigenous peoples.
- The project achieved a management cost per hectare of US$ 279 over four years or US$ 69.75 annually, which remained relatively low compared to other agroforestry and sustainable forestry management projects, where studies estimated costs at US$ 230.77 per year for agroecosystem activities and US$ 446.15 per hectare yearly for sustainable forest management activities.

Watersheds and Cities

The Watersheds and Cities project, coordinated by FMCN, is a platform for technical and financial support to develop integrated watershed management initiatives linked to the water supply in more than 20 watersheds and 15 cities in Mexico. Since its creation in 2001, it has operated with the financial support from the William and Flora Hewlett Foundation, the Gonzalo Río Arronte Foundation (FGRA), and FEMSA Foundation[8], among others.

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[8] FEMSA Foundation participates in the beverage industry operating Coca-Cola FEMSA, a public bottler of Coca-Cola products. In the beer sector, they are shareholders of HEINEKEN, a company with presence in more than 70 countries.

The project is based on the principle that integrated watershed management is the most equitable, sustainable, and cost-effective way to ensure the provision of water and other ecosystem services. Therefore, it contributes to building resilience by improving community governance to face water-related situations, such as droughts and floods. Restoring the health of the watershed through natural solutions and local participation reduces rural communities´ vulnerability to climate change and the impact on their livelihoods.

In each selected watershed, the project has established a strategic alliance with a local partner that guides an integrated watershed management process based on planning, resource investment, and institutional collaboration. The project has five components: (1) Raising awareness among the population about the relationships between cities and their water recharge areas; (2) Establishing discussion platforms for watershed management and decision-making; (3) Establishing financial arrangements to improve watershed management and economic compensation for providers of hydrological environmental services; (4) Conducting land-based activities to improve the health and recharge capacity of watersheds and livelihoods and well-being of communities; (5) Exchanging knowledge among stakeholders through a Learning Community.

The articulation of the components enables the development of local initiatives with increased participation of social and governmental actors resulting in the convergence of institutional, technical, and financial resources. The activities developed have leveraged arrangements between the government, NGOs, communities, and Water Utilities to increase investments in green infrastructure and sustainable community livelihoods.

From 2010 to 2019, the local initiatives of the Watersheds and Cities project contributed into keeping more than 350,000 hectares under conservation and sustainable use schemes –around 25,000 of these received compensations from the Payment for Environmental Services Program from CONAFOR; and have promoted land-use planning and management instruments in more than one million hectares.

Over the last ten years, around 7,300 families have benefited from eco-technologies and productive activities implemented by local partners, which has translated into more than 32,000 persons adopting, directly or indirectly, best practices in transition to sustainability.

Also, local partners have mobilized almost US$ 28.9 million of additional funds from local governments, the private sector, and other foundations, which are applied to complement conservation and community development actions in the different regions, achieving a leverage ratio of nearly 4:1 (FMCN invested US$7.4 million).

In this same period, Watershed and Cities project has undergone two external evaluations, in 2014 and 2018. Both agree that the project has:

- Improved communication and awareness on the importance of integrated watershed management and the relationship between natural resources and water. Local initiatives have ventured into communication practices aimed at key stakeholders in the different regions, both in rural and urban areas of the watershed, to achieve a better understanding of water issues and land management with a watershed approach.

- Led to the creation of diversified fundraising and investment strategies for watershed conservation and water management. With this variety of investment options, local partners implement pilot projects to reduce environmental degradation, use best practices for water management, and ensure the active participation of communities in the sustainable management of their natural resources.
- Enhanced articulation between environmental factors and social background. Watersheds and Cities link environmental and social factors in the construction of adequate solutions for the conservation and recovery of the eco-hydrological functions of watersheds, maintenance and provision of environmental services, interagency cooperation, and improvement of quality of life in rural areas.
- Strengthened organizations and teams that are influencing decision making related to how to use and safeguard water and how to manage water-related hazards, such as floods and droughts, in the face of the climate change crisis.

Local initiatives have been able to change the mindset of key actors, from inertia to action, to find new ways of working; create alliances; change laws or policies, and mobilize others to collaborate. Examples of this are: (a) A voluntary contribution scheme through the water bill in Saltillo, Coahuila, in which more than 62,000 households make a monthly contribution for the conservation of a natural protected area and the water protection services it offers; (b) Three local partners have been able to get on the boards of Water Operating Agencies, influencing decisions to increase investment for watershed management and make drinking water distribution services more transparent; (c) In the State of Colima, the Watersheds and Cities local initiative contributed to the modification of three State Laws to enable municipalities to create compensation schemes for hydrological services to forest owners; (d) In Baja California, the project's sustained monitoring of water quality, along with the dissemination of results and strengthening of social fabric led to the construction of a water purification plant for marginalized communities.

Development, Financing Community Forest Enterprises (EmFoCo)

Nearly 70% of Mexico´s forests are located in collective properties (ejidos and communities) with high rates of poverty. In these rural areas, more than 12 million people depend on forest resources for their income. However, the technological and entrepreneurial skills of forestry businesses are limited, threatening biodiversity and increasing greenhouse gas emissions.

The project "Support for Micro, Small, and Medium Enterprises operating in forest environments -Implementation of the Forest Investment Program in Mexico" under the Climate

Investment Funds (CIF), known as EmFoCo aimed to strengthen the financial inclusion of community forest enterprises (EFC) in REDD+ forest landscapes of Campeche, Jalisco, Oaxaca, Quintana Roo, and Yucatán. The project was implemented during 2013 - 2019.

Its strategy was the creation of financial products suitable to the needs of each EFC and the development of primary skills of administration and business knowledge to grow business opportunities in an environmentally sustainable, financially viable, and socially feasible manner. The community-based multi-purpose financial intermediary Financiando el Desarrollo del Campo (FINDECA), the National Forestry Commission (CONAFOR), and FMCN were the implementing partners, and the Inter-American Development Bank (IDB-MIF) provided financial support of US$ 3 million.

EmFoCo achieved several important outcomes between 2013 and 2019:

- The project was the first experience for private participation in the Forest Investment Program worldwide.
- It founded a tailored credit and technical assistance model to increase the EFC´s competitiveness and profitability.
- It designed and applied innovative credit products from the private sector to finance forestry projects in five states in Mexico.
- The project developed a set of management standards following the economic and cultural conditions of the EFC.
- The initiative created an application for evaluating the business effectiveness of the EFC.
- The project strengthened 82 EFC through its different assistance models and benefited 5,974 people (38% women and 62% men).
- It supported the sustainable management of 595,135 hectares.
- CONAFOR, IDB, and FINDECA delivered more than US$5 million in loans to 28 community forest enterprises and created more than 237 jobs. Of all the credits granted, the overdue portfolio always remained at 0%.
- The 80% of credit was used for the production of organic shade coffee and the legal harvest of forest products (timber and non-timber). The remaining 20% was for the production of gum and honey.

The project encouraged that 82% of the EFC continued with a certification on forest management, such as the Mexican Certification of Sustainable Forest Management or the Forest Stewardship Council.

Connecting Watershed Health with Sustainable Livestock and Agroforestry Production (CONECTA)

The proposed Connecting Watershed Health with Sustainable Livestock and Agroforestry Production (CONECTA) project aims to integrate land use planning and the use of natural resources with sustainable livestock and agroforestry production. It comprises four key areas of intervention or components: (1) Development and Promotion of Integrated Landscape Management in targeted priority watersheds; (2) Strengthening Business Skills for Sustainable Rural Production to build business and organizational capacity of livestock and/or agroforestry producer groups; (3) Conservation, Restoration, and Implementation of Sustainable Productive Practices in Cattle and Agroforestry Landscapes to increase connectivity in the watersheds; and (4) Monitoring and Project and Knowledge Management. INECC and FMCN are the implementing partners. The World Bank, through a GEF grant, will be providing the financing in the amount of US$ 13.76 million. The project will be implemented in 2021-2025.

RIOS Scaling-Up Strategy

C6, EmFoCo, and the Watersheds and Cities initiatives accomplished significant results and revealed substantial lessons that will serve to increase the impact of upcoming projects, as to benefit more people and foster policy and program development on a lasting basis. In this regard, RIOS will be built on an informed-scaling-up strategy based on C6 vast amount of local background information and its successfully tested landscape conservation model; in the Watersheds and Cities experiences for strengthening collaborative spaces and networks and the development of long-term financing mechanisms, and on EmFoCo´s appropriate approach for accompaniment, technical assistance, and tailored-made access to credit, particularly:

- **Manage at the landscape level.** To best manage watersheds from adjacent threats, such as upstream water contamination and spillover effects of land degradation, work should proceed at the landscape level. In C6, this approach facilitated the creation of the IWAPs and the effective coordination among implementing partners and across areas that were previously disconnected from a management perspective. The advantage is that the basins where RIOS will operate already have an IWAP, which will be used to better target the eligible areas for funding under the sub-projects of *Component 1: Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices.* RIOS will also scale up this experience to strengthen the national capacities and policies driven by conservation and production objectives, through improving the existing methodologies to evaluate the vulnerability of the project basins (Output 1.2) and support the development of the National River Restoration Strategy with a climate focus (Outputs 3.1 and 3.2) to ensure their long-term sustainability and impact.

- **Leverage private and public financing focusing on green solutions.** The experience of C6, EmFoCo, and the Watersheds and Cities projects on building financial mechanisms and strategies to leverage additional resources will contribute to RIOS´ *Component 2: Alignment of public and private investments through natural capital accounting for scaling-up activities for the restoration of rivers for adaptation to climate change*. In particular**,** C6 successfully created innovative private-public partnerships for pooling resources and achieving a maximum impact from the secured funding to conservation activities. The Watersheds and Cities´ local initiatives pursued innovative approaches to leverage resources, particularly in partnership with the private sector, and learned that green infrastructure must be made attractive for investments as business cases to ensure its long-term sustainability. Regarding enabling environment and capacities for producers to access dedicated credit lines, EmFoCo experience proved that producers can successfully apply for, execute, and repay credits and can invest remarkably well to make foundational improvements on their sustainable businesses, as long as they are given technical support and their capacities are strengthened accordingly to specific needs. Based on these lessons learned, RIOS will align and catalyze public and private investments for watershed connectivity by operating with innovative mechanisms (e.g. credits and PES or pay-for-performance schemes) (Outputs 2.1 and 2.2), funding bankable project pipelines, and supporting the development of institutions and organizations that can broker projects and financial mechanisms for climate-smart investments (Output 2.3).
- **Work with civil society organizations (CSO) and community networks**. Working closely with CSO and regional networks facilitates the flow of knowledge, strengthens the bonds of communities across regions, and bolsters community enterprises to support economies of scale, collective marketing, and integration into the local economy. In the case of C6, Watersheds and Cities, and EmFoCo, these bonds often turned into networks or coalitions to continue the work after the project closed. RIOS will promote and facilitate the involvement of key stakeholders, that have already changed their perspectives and mind-sets towards sustainable development. Through the learning community platform (Output 1.3), RIOS will strengthen civil society organizations and community networks, some of which were formed during the implementation of C6 and the Watersheds and Cities projects, as they will be key to increasing forest and water connectivity through conservation, restoration and best management practices sub-projects, as well as monitoring vulnerability, enforcing continued action, supporting local capacity building, raising awareness, and promoting outreach. These same local networks will constitute an important partnership to provide successful factual examples and proposals for the design of the National River Restoration Strategy for climate change adaptation under *Component 3: Design of a National River Restoration Strategy for climate change adaptation.*
- **Regional Funds (RF) play an important role.** The investment and maintenance costs of conservation can be greatly reduced by an efficient organization and by building on

existing projects and intrinsic value. As FMCN´s local counterparts, RFs have multidisciplinary teams that work at different administrative levels (e.g. federal, state, municipality, and community). They also combine expertise stemming from the collective involvement on local conservation efforts with knowledge on institutional opportunities and barriers. The C6´s experience showed that transferring resources to these regional organizations can in itself be a cost-effective measure, not only because of their geographical proximity, but also because they have greater legitimacy, sustained interest, coordination and mediation competencies, and the ability to establish effective engagement, training, and technical assistance mechanisms more relevant to regional and local contexts. Thus, for RIOS, the RFs will have diverse opportunities to influence and stimulate the top-down and the bottom-up scaling-up process.

- **Strengthen institutional coordination**. Actions at a landscape level by communities, coupled with efforts of governmental agencies, the private sector, donors, and other key stakeholders, can lead to achieving results at a larger scale beyond the initial target area. To successfully manage inter-institutional relations and to ensure delivery of the array of interconnected outcomes, C6 and EmFoco projects established each a Technical Project Committee (TPC) with representatives from their implementing partners. The TPC was commissioned with reviewing and approving operational procedures, providing policy guidance, supervising and supporting the implementing agencies, and ensuring timely channeling of resources, and solutions in real-time. The deep involvement of the TPC fostered a shared sense of responsibility and accountability for success. This coordination became a significant strength for both projects, helping them ultimately exceed expectations in achieving outcomes. In the case of C6, the TPC has continued its activities upon closing, and it is currently operating more broadly in watershed ecosystem management across institutions and projects. An important lesson learned through these past projects is the importance of institutional capacity building and institutional memory for carrying forward subsequent projects and aligning to past ones. Thus, the TPC in place through the C6 project will be adapted for the RIOS project, thus mitigating the risk of complex institutional arrangements.

- **Aligning investments and parallel financing.** It is important to act on how the projects can best leverage and reorient capital from different financial institutions to scale up transformative contributions supporting long-term low-GHG and climate-resilient development. In this case, the GEF grant project CONECTA will be part of the parallel RIOS financing to support complementary management activities. CONECTA will strive to align public and private funding to accelerate sustainable beef, milk, and agroforestry production along with the principles of deforestation-free value chains. Further, public expenditures would need to be linked to land management practices and better environmental outcomes while delivering positive impacts on soil carbon sequestration and productivity. The project's co-benefits include mitigation of GHG emissions, increased climate resilience of production practices, improved livelihoods, and conservation of biodiversity. CONECTA is also well-aligned with the objectives of the UN decade on Ecosystem Restoration and the Global Landscape Forum that promotes restoration of degraded and destroyed ecosystems as a proven measure to fight the climate crisis and enhance food security, water supply, and biodiversity.

1.7 Environmental and Social Assessments

RIOS Environmental and Social Assessment (ESA) is part of the Simplified Approval Process submitted to Green Climate Fund (GCF). The GCF uses an interim Environmental and Social Policy based on the following eight Performance Standards (PS) of the International Finance Cooperation (IFC):

- PS1: Assessment and management of environmental and social risks and impacts
- PS2: Labor and working conditions
- PS3: Resource efficiency and pollution prevention
- PS4: Community health, safety, and security
- PS5: Land acquisition and involuntary resettlement
- PS6: Biodiversity conservation and sustainable management of living natural resources
- PS7: Indigenous Peoples
- PS8: Cultural heritage

The Mexican Fund for the Conservation of Nature (FMCN) also has its Environmental, Social, and Gender Safeguards (NSASG), described in its Conservation Operation Manual (MOAC), which are aligned to the Performance Standards of the GCF, consistent to the legal and regulatory framework in the country, and congruent with the IFC, the World Bank (WB), and the Inter-American Development Bank (IDB) standards (Table 1.5). All programs and projects financed by the FMCN are screened according to these NSASGs.

Table 1.12. FMCN NSASGs and their IFC, WB, and IDB equivalents by issue.

NSASG	Performance Standard Objectives[9]	Relation to other Institutions Standards
1. Environmental and social assessment and management	• To identify and evaluate environmental and social risks and impacts of the project. • To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.	IFC - PS1: Assessment and management of environmental and social risks and impacts WB - ESS1 Assessment and Management of Environmental and Social Risks and Impacts IDB – ESPS1: Assessment and Management of

[9] Taken from the IFC Performance Standards and the IDB Environmental and Social Policy Framework.

	• To promote improved environmental and social performance of clients through the effective use of management systems. • To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately. • To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.	Environmental and Social Risks and Impacts
2. Biodiversity and natural resources (habitat, forests, natural resource management, ecosystem services)	• To protect and conserve biodiversity. • To maintain the benefits of ecosystem services. • To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.	IFC - PS6: Biodiversity conservation and sustainable management of living natural resources WB - ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources IDB – ESPS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
3. Pollution control and prevention (chemicals management, pest control, environmental health)	• To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities. • To promote more sustainable use of resources, including energy and water. • To reduce project-related GHG emissions.	IFC – PS3: Resource efficiency and pollution prevention WB - ESS3: Resource Efficiency and Pollution Prevention and Management IDB – ESPS3: Resource Efficiency and Pollution Prevention
4. Climate change	• To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances. • To ensure that the safeguarding of personnel and property is carried out by relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.	IFC - PS4: Community health, safety, and security WB - ESS4: Community Health and Safety IDB – ESPS4: Community Health, Safety, and Security
5. Land acquisition and land tenure, compensation, and resettlements	• To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs. • To avoid forced eviction. • To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by providing compensation for loss of that resettlement activities are implemented, with	IFC – PS5: Land acquisition and involuntary resettlement WB - ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement IDB – ESPS5: Land Acquisition and Involuntary Resettlement

	appropriate disclosure of information, consultation, and the informed participation of those affected. • To improve, or restore, the livelihoods and standards of living of displaced persons. • To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.	
6. Indigenous Peoples	• To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples. • To anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts. • To promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner. • To establish and maintain an ongoing relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life-cycle. • To ensure the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples when the circumstances described in this Performance Standard are present. • To respect and preserve the culture, knowledge, and practices of Indigenous Peoples.	IFC – PS7: Indigenous Peoples WB - ESS7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities IDB – ESPS7: Indigenous Peoples
7. Gender	• To anticipate and prevent adverse risks and impacts based on gender, sexual orientation and gender identity, and when avoidance is not possible, to mitigate and compensate for such impacts. • To establish preventative actions to prevent or mitigate risks and impacts due to gender in projects, throughout the project cycle. • To achieve inclusion from project-derived benefits of people of all genders, sexual orientation and gender identities. • To prevent exacerbation of GBV, including sexual harassment, exploitation and abuse, and when incidents of GBV occur, to respond in a prompt manner. • To promote safe and equitable participation in consultation and stakeholder engagement processes regardless of gender, sexual orientation and/or gender identity. • To meet the requirements of applicable national legislation and international commitments	IDB – ESPS9: Gender Equality

	relating to gender equality, including actions to mitigate and prevent gender-related impacts.	
8. Physical cultural resources and cultural heritage	▪ To protect cultural heritage from the adverse impacts of project activities and support its preservation. ▪ To promote the equitable sharing of benefits from the use of cultural heritage.	IFC - PS8: Cultural heritage WB - ESS8: Cultural Heritage IDB – ESPS8: Cultural Heritage

During the process of designing and developing the RIOS proposal, FMCN´s staff screened for the environmental and social risks/impacts based on the available information and using an Environmental and Social Screening Checklist (ESSC). This ESSC intends to guide the staff in classifying the project as either Low, Moderate, or High risk based on the NSASGs. Table 1.12 presents the ESSC for RIOS, which was classified as low risk, since it has no or minimal potential negative environmental and/or social impacts, either upstream or downstream.

Table 1.14. Project Environmental and Social Screening Checklist.

Would the project,	Not Applicable	No	Yes	Unknown
1. Environmental and social assessment and management.				
1.1 Conserve, protect and enhance natural resources?			X	
1.2 Improve efficiency in the use of resources?			X	
1.3 Protect and improve rural livelihoods and social well-being?			X	
1.4 Respect access and benefit-sharing measures in force?			X	
1.5 Exclude any potentially affected stakeholders, in particular vulnerable groups, from fully participating in decisions that may affect them?		x		
1.6 Safeguard the relationships between biological and cultural diversity?			X	
2. Biodiversity and natural resources (habitat, forests, natural resource management, ecosystem services).				
2.1 Include practices that could have a negative impact on biodiversity, ecosystems, ecosystem services, or result in the conversion or degradation of natural habitat or critical habitat?		X		
2.2 Involve changes to the use of lands and resources that may have adverse impacts on habitats, ecosystems, and/or livelihoods?		X		
2.3 Pose risks of introducing invasive alien species or genetically modified organisms that may have an adverse effect on biodiversity?		X		
2.4 Involve the production or harvesting of livestock, aquatic species, natural forests, plantation development, or reforestation?			X	
2.5 Is within or adjacent to critical habitats and/or environmentally sensitive areas, including protected areas?		X		
3. Pollution control and prevention (chemicals management, pest control, environmental health).				

3.1 Result in the release of pollutants to the environment with the potential for adverse local, regional, or transboundary impacts?		X		
3.2 Result in the generation of waste that cannot be recovered, reused, or disposed of in an environmentally and socially sound manner (hazardous and non-hazardous)?		X		
3.3. Involve the procurement, provision, application, or disposal of pesticides that have a known negative effect on the environment or human health?		X		
3.4 Include activities that require significant consumption of raw materials, energy, or water?		X		
4. Climate change.				
4.1 Involve activities to reduce greenhouse gas emissions?			X	
4.2 Include measures to build resilience or decrease vulnerability to climate change of people, communities and ecosystems now or in the future?			X	
4.3 Avoid health risks to contagious diseases or transmission for project workers or communities in the project area?			X	
5. Land acquisition and land tenure, compensation, and resettlements.				
5.1 Affect the legitimate tenure rights of individuals, community-based property rights/customary rights to land, territories and /or resources?		X		
5.2 Involve the physical and economic displacement of people (e.g. loss of assets or access to resources due to land acquisition or access restrictions)?		X		
6. Indigenous Peoples.				
6.1 Are there any indigenous peoples present in the project area?		X		
6.2 Are project activities likely to have adverse effects on indigenous peoples' rights, lands, natural resources, territories, livelihoods, knowledge, social fabric, traditions, cultural heritage, or governance systems?		X		
6.3 Are indigenous communities outside the project area likely to be affected by the project?		X		
7. Gender.				
7.1 Potentially reproduce discriminations against women based on gender, especially regarding participation in design and implementation or access to opportunities and benefits?		X		
7.2 Promote women's and men's equitable access to and control over productive resources and services?			X	
7.3 Foster their equal participation in institutions and decision-making processes?			X	
8. Physical cultural resources and cultural heritage.				
8.1 Are project activities likely to have adverse effects on culture or heritage (tangible and intangible)?		X		

8.2 Constrain access to cultural sites for the communities?		X		

RIOS is considered by the GCF as Category C or minimum to no risk. Therefore, the project will have a positive impact on ecosystems, biodiversity, and the beneficiaries' livelihoods. Potential adverse environmental and social impacts will be small-scale, minimal, reversible, and readily addressed through mitigation measures.

Accordingly, the project operation will trigger the NSASGs detailed in Table 1.15.

Table 1.15. FMCN NSASGs trigger.

NSASG	Reasons for triggering
1. Environmental and social assessment and management	The project shall consider the potential environmental and social risks and impacts identified during the Environmental and Social Screening Process, including physical, biological, socio-economic, health, safety, cultural, and transboundary impacts and global impacts, such as greenhouse gas emissions and vulnerability to climate change effects.
2. Biodiversity and natural resources (habitat, forests, natural resource management, ecosystem services)	Positive impacts on biodiversity and ecosystems are expected due to the increase in restored and conserved surfaces, as well as from forest and water connectivity gained through best production practices in non-forest land. However, the project shall provide technical guidelines, assistance, and supervision for the correct application of conservation, restoration and best production practices.
3. Pollution control and prevention (chemicals management, pest control, environmental health)	RIOS will exclude the procurement and use of agrochemicals. Nevertheless, farmers may keep purchasing of other activities not related to the project of pesticides and other agricultural chemical products, posing potential risks for producers and their families, as well as for the environment.
4. Climate change	The project will implement activities to decrease vulnerability to climate change of people, communities and ecosystems. Sufficient training and accompaniment shall be provided for achieving reliable results.
5. Land acquisition and land tenure, compensation, and resettlements	Not applicable. No impacts are expected, as there are no plans for land acquisition, appropriation or resettlement. Participation is voluntary and based on the demand of beneficiaries in their own territories.
6. Indigenous Peoples	Not applicable. Indigenous populations are not present in target areas.
7. Gender	RIOS shall include specific measures to ensure an equal participation of males and females in the sub-projects, as well as in the capacity building, consultation, and decision-making processes.
8. Physical cultural resources and cultural heritage	The project will safeguard the intangible cultural heritage related to traditional knowledge on flora and fauna.

This ESA presents a broad overview of the legal framework and the socio-environmental context relevant to the intervention scope of RIOS. It identifies the main potential unintended environmental and social adverse risks expected from the project operation activities and proposes mitigation measures necessary to avoid, prevent, or minimize the impacts identified.

Legal and Regulatory Framework

RIOS shall comply with applicable national, state, and municipal laws and all their requirements. Table 1.16 summarizes the current principal environmental laws in Mexico on climate change and restoration relevant to the project.

Table 1.16. Principal environmental laws in Mexico.

NSASG	Legislation	General Description
1. Environmental and social assessment and management	Mexican Constitution	Includes economic, social, and cultural rights of the Mexican people and calls for a federal government that takes an active role in promoting those rights.
	General Law of Ecological Balance and Environmental Protection (LGEEPA)	Addresses a broad range of environmental matters including water, air and ground pollution, resource conservation and restoration, and environmental enforcement. Article 28 requires the Environmental Impact Assessment for forest harvests in tropical forests and species of difficult regeneration; land-use changes in woodlands and arid-areas; activities in wetlands, mangroves, lagoons, rivers, lakes, and estuaries connected to the sea, as well as on its federal coastlines; and activities at ANP, among others.
	National Water Law (LAN)	Regulates the exploitation, use, and management of all national waters, surface or groundwater, its distribution, and control, as well as the preservation of its quantity and quality to achieve its integrated and sustainable development.
	Law on Sustainable Rural Development	Promotes the sustainable rural development in the country, ensuring an adequate environment and the rectory of the State and its role in the promotion of equity, including planning and organization of agricultural production, industrialization and commercialization, and the other goods and services, and all those actions aimed at raising the quality of life of the rural population. Article 174 specifies that the Federal Government, in coordination with the governments of the states and municipalities, shall provide priority support to producers, especially those located in the upper parts of the watersheds, to carry out sustainable agricultural, livestock, and forestry practices for the optimal use of land and water, as well as the reduction of claims, the loss of human life and property by natural disasters. Article 175 establishes that ejidatarios, comuneros, indigenous peoples, owners or possessors of the property rights and other

		populations that inhabit a natural protected area in any of their categories shall have priority to obtain permits, authorizations, and concessions to develop activities following the LGEEPA, the General Law on Wildlife, and other official applicable ordinances.
2. Biodiversity and natural resources (habitat, forests, natural resource management, ecosystem services)	Mexican Constitution	Includes economic, social, and cultural rights of the Mexican people and calls for a federal government that takes an active role in promoting those rights.
	General Law of Ecological Balance and Environmental Protection (LGEEPA)	Addresses a broad range of environmental matters including water, air and ground pollution, resource conservation and restoration, and environmental enforcement.
	General Wildlife Law	Regulates the conservation of wildlife and its habitat, through the protection and maintaining of optimal levels for sustainable use, so as to simultaneously maintain and promote the restoration of its diversity and integrity, as well as to increase the well-being of the inhabitants of the country.
	NOM-060-SEMARNAT-1994	Establishes the specifications to mitigate the adverse effects caused to the soils and water bodies by forest exploitation. It does not use the concept of restoration but refers to one of its actions: reforestation. Specifies that the reforestation efforts must be made with native species as a preventive measure of erosion. Besides, it particularizes the reforestation of riparian vegetation when present signs of deterioration.
	NOM-022-SEMARNAT-2003	Establishes specifications governing the sustainable use in coastal wetlands to prevent their deterioration, encouraging their conservation and restoration. Recognizes the value of wetlands, as well as the implementation of actions for protection and restoration, considering the original forest structure to prevent its loss and that of its dynamic hydrology.
	NOM-152-SEMARNAT-2006	Regulates the contents of the forest management programs for the utilization of forest resources timber and non-timber, in forests and vegetation in arid zones.
3. Pollution control and prevention (chemicals management, pest control, environmental health)	General Law of Ecological Balance and Environmental Protection (LGEEPA)	Addresses a broad range of environmental matters including water, air and ground pollution, resource conservation and restoration, and environmental enforcement. Title 4th. Chapter II - Prevention and Control of Pollution govern various sources of pollution that may have relevance in some projects supported by FMCN. In its Article 117, it establishes the criteria for the prevention and control of water pollution, in which participation and co-responsibility of society is an indispensable condition for avoiding water pollution. Chapter III - Prevention and Control of Water Pollution and Aquatic Ecosystems regulate in its Article 120 the discharges derived from agricultural activities and the application of pesticides, fertilizers, and toxic substances.

		Chapter IV - Prevention and Control of Soil Pollution in its Article 134 dictates that the use of pesticides, fertilizers, and toxic substances should be compatible with ecosystems integrity and consider their effects on human health to prevent the harm that they could cause.
4. Climate change	General Law on Climate Change	Establishes significant elements to encourage adaptation of Mexico's natural and human systems to climate change. It lays the general foundations for regulating greenhouse gases emissions and compounds; regulating climate change mitigation and adaptation actions; reducing the vulnerability of the population and ecosystems to the adverse effects of climate change; conserving forest land uses and preventing its degradation and deforestation; promoting the efficient and sustainable use of energy resources; and in general, transitioning to a green economy. Federal, state and municipal authorities will all be responsible for meeting concrete goals, such as the development of risk maps, urban development programs that consider climate change, and a subprogram for the protection and sustainable management of biodiversity to face climate change. Article 71 provides for gender equity and participation of populations most vulnerable to climate change, as well as indigenous peoples, academics, and researchers in planning processes.
	Law for Climate Change Action for the state of Jalisco (LACCEJ)	Defines the principles, criteria, instruments, and bodies for the implementation of the State Policy on climate change and to establish the basis for developing state and municipal public policies with cross-cutting criteria in the prevention, adaptation, and mitigation of climate change. The actions of adaptation and mitigation shall contribute to biodiversity, ecosystems and their services, to protect and improve the livelihoods of the population, and to guide the institutions, the productive sector and civil society toward sustainable development. Under the adaptation component, the LACCEJ commits to improving resilience and reducing the vulnerability of society, watersheds, natural ecosystems, and urban and agricultural systems to both extreme hydro-meteorological phenomena and long-term environmental degradation processes.
	Veracruz State Law of Mitigation and Adaptation to the effects of Climate Change	Sets the concurrency of the State and municipalities in the formulation and implementation of public policies for climate change adaptation, mitigation of its adverse effects, to protect the population and contribute to sustainable development.
	Municipal Program of Climate Change of Puerto Vallarta, Jalisco, 2020-2030 (PMCC PV)	Identifies the priority actions to be carried out in the municipality to reduce emissions of greenhouse gases and its vulnerability to climate change with a 2030scope. To achieve its objective, the PMCC PV has 61 adaptation and mitigation measures grouped into the following strategic areas: 1. Sustainable Productive Activities, 2. Energy Transition, 3. Integral Waste Management, 4. Ecosystem

		conservation and management, 5. Integral Water Management, 6. Sustainable mobility, and 7. Enabling Conditions. The strategic area on Ecosystem Conservation and Management contemplates measures to promote the sustainable use of natural capital, and focuses on ecosystems that are natural and cultural milestones, carrying out their restoration, conservation, and protection of environmental services. Such ecosystems include natural reefs, beaches, forest areas, green areas, and wetlands.
5. Land acquisition and land tenure, compensation, and resettlements	General Law of Ecological Balance and Environmental Protection (LGEEPA)	Addresses a broad range of environmental matters including water, air and ground pollution, resource conservation and restoration, and environmental enforcement. It defines the objectives, categories, authorities, and procedures for the establishment, management, administration, and monitoring of NPAs.
6. Indigenous Peoples	Convention 169 of the International Labour Organization	Recognizes the aspirations of indigenous peoples to take control of their institutions and ways of life, their economic development, and to maintain and strengthen their identities, languages, and religions, within the framework of the states in which they live.
	United Nations Declaration on the Rights of Indigenous Peoples	Recognizes the urgent need to respect and promote the rights and intrinsic characteristics of indigenous peoples, especially the rights to their lands, territories, and resources, which derive from their political, economic and social structures and cultures, their spiritual traditions, history and conception of life.
	Mexican Constitution	Includes economic, social, and cultural rights of the Mexican people and calls for a federal government that takes an active role in promoting those rights. Articles 2 and 3 prohibit any discrimination based on ethnic or national origin, gender, age, different capacities, social status, health conditions, religion, opinions, preferences, marital status, or any other that threatens human dignity and intends to nullify or impair the rights and freedoms of individuals. Article 4 recognizes the multi-ethnic composition of Mexican society and acknowledges the fundamental rights and autonomy of indigenous peoples. Among these significant rights are their self-determination for social, economic, political, and cultural organization; their capacity to implement their proper regulatory system for the resolution of internal conflicts; respect for individual guarantees and human rights; equitable gender participation in domestic governance issues; the right to preserve the diversity of elements that constitute or form part of identity; access and respect for all forms of land ownership and tenure outlined in the Constitution. Article 27 places the legal status of the population nucleus of ejidos and communities, setting guidelines for land security, human settlement, and productive organizations. Likewise, it establishes the protection and integrity of the lands of indigenous groups and provides the ejidal assembly of power as the supreme organ for the organization within the ejido.

7. Gender	Mexican Constitution	Includes economic, social, and cultural rights of the Mexican people and calls for a federal government that takes an active role in promoting those rights. Articles 2 and 3 prohibit any discrimination motivated by ethnic or national origin, gender, age, different capacities, social status, health conditions, religion, opinions, preferences, marital status, or any other that threatens human dignity and is intended to nullify or impair the rights and freedoms of individuals.
	General Law on Equality between Women and Men	Institutes the obligation of the relevant authorities to ensure the principle of substantive equality between women and men for employment.
	General Law on Women's Access to a Life Free from Violence	Provides for the prohibition of labor violence constituted by the illegal refusal to hire the victim or to respect their permanence or general working conditions; disqualification of work carried out or, threats, intimidation, humiliation, exploitation, impediment to women from carrying out the breastfeeding period provided for in the law and all kinds of discrimination based on gender status, as well as sexual harassment.
	Federal Labour Law	Sets out guidelines for promoting inclusion and substantive equality in Mexico. In doing so, the Mexican State reaffirms its commitment to equity and balance in industrial relations, protects workers' rights, and promotes the creation of lawful jobs.
	Federal Law to Prevent and Eliminate Discrimination	Establishes that discrimination based on ethnic or national origin, gender, age, disability, social and health status, religion, opinions, sexual preferences, marital status, or any other that violates the dignity of individuals and intends to nullify or impair their rights and freedoms, is prohibited. It secures an obligation of federal public authorities to implement leveling, inclusion, and affirmative actions as a priority for groups based on discrimination or vulnerability.
	National Biodiversity Strategy and its 2016 - 2030 Action Plan	Includes the gender perspective in 19 lines of action and 50 actions. It establishes equal rights, opportunities, and circumstances between men and women for decision-making, inclusion, and non-discrimination to avoid any distinction, exclusion, or restriction that may prevent or nullify the recognition or exercise of rights and equal possibilities.
8. Physical cultural resources and cultural heritage	Mexican Constitution	Includes economic, social, and cultural rights of the Mexican people and calls for a federal government that takes an active role in promoting those rights. Article 4 guarantees the right to access to culture and enjoyment of the goods and services provided by the state. Article 27 provides for the regulation of territorial property for social benefit and exploitation. Article 73 empowers Congress to legislate on "... fossil remnants, and on archaeological, artistic, and historical monuments, whose preservation is of national interest". Article 124 provides that powers not expressly granted to the federation are understood to be reserved to the States.

	General Law on Human Settlements	Articles 5, 6, 7, 8, and 33 consider the protection of cultural heritage in population centers and the powers each level of government has in its sphere of competence.
	Convention on the Protection of World Cultural and Natural Heritage	Defines "cultural heritage" as monuments, ensembles, and places of exceptional universal value; as well as "natural heritage" such as natural monuments, geological and physiographic formations that constitute habitats, and strictly delimited natural places or areas of exceptional universal value for science, conservation or natural beauty (including Biosphere Reserves).
	Convention for the Safeguarding of Intangible Cultural Heritage	Defines "intangible cultural heritage" as the uses, representations, expressions, knowledge, and techniques - along with the instruments, objects, artifacts and cultural spaces that are inherent to them - that communities, groups and in some cases, individuals recognize as an integral part of their cultural heritage, including knowledge and uses related to nature and the universe.

Social and Environmental Context

Socio-economic conditions

The two sub-basins in which RIOS will operate are located within 14 municipalities of Jalisco and Veracruz states, with a total surface of 5,968 km^2 and an overall population of 850,604 inhabitants, with a ratio of 52% women and 48% men (INEGI, 2010).

In Jalisco, the Talpa-Mascota sub-basin is located in the municipalities of Mascota and Talpa de Allende. The total population comprises 28,655 inhabitants distributed in 3,120 km^2, about nine inhabitants/km^2 (INEGI, 2010).

In Veracruz, the Jamapa sub-basin is located in the municipalities of Camarón de Tejeda, Comapa, Huatusco, Ixhuatlán del Café, Jamapa, Manlio Fabio Altamirano, Medellín, Paso del Macho, Soledad de Doblado, Tepatlaxco, Veracruz, and Zentla. The total area of these municipalities is 2,848 km^2, slightly less than in Jalisco, yet the total population is over 28 times greater (821,949 inhabitants) and the population density reaches 289 inhabitants/km^2 (INEGI, 2010).

The socio-economic conditions in the 14 municipalities vary considerably. Nevertheless, poverty remains a feature of the social landscape of these watersheds. Around 42% of the population lives in poverty, and almost half has an income below the well-being threshold (CONEVAL, 2010). There are eight municipalities in Veracruz with high and very high marginalization and social deprivation, representing the population’s deficit and deprivation concerning the satisfaction of some basic needs and constitutional rights, such as access to decent housing (Constitutional Article 4), to elementary education (Constitutional Article 3) and to a wage sufficient to fulfill the average needs of a family (Constitutional Article 123).

Table 1.17. Sociodemographic data from the municipalities where RIOS will operate (CONAPO, 2010; CONEVAL, 2010; UNDP, 2010).

State	Municipality	Surface (km²)	Population			Poverty[10] 2010			Marginality Index[11] 2010		Social Deprivation Index[12] 2010		Migratory Intensity Index [13] 2010	
			Total	Men	Women	Population living in poverty	Population in extreme poverty	Population with income below the line of well-being						
Jalisco	Mascota	1,381	14,245	7,010	7,235	6,779	516	7,190	-1.16531	Low	-1.19272	Very Low	0.9681	High
	Talpa de Allende	1,739	14,410	7215.00	7,195	7,988	1,751	8,290	-0.54157	Medium	-0.65852	Very Low	0.1000	Medium
Veracruz	Camarón de Tejeda	125.78	6,224	3103.00	3,121	4,251	1,310	4,357	0.46749	High	0.26985	Medium	-0.119	Medium
	Comapa	311.78	18,713	9,527	9,186	17,255	7,770	17,311	0.76015	High	0.68359	High	1.0864	High
	Huatusco	202.47	54,561	26,216	28,345	35,697	11,441	37,121	-0.09112	Medium	0.00178	Low	0.1333	Medium
	Ixhuatlán del Café	129.49	21,407	10,541	10,866	17,970	7,850	18,155	0.59959	High	0.85957	High	0.4161	Medium
	Jamapa	132.4	10,376	5,085	5,291	5,623	1,301	5,813	-0.13222	Medium	-0.34896	Low	-0.626	Low
	Manlio Fabio Altamirano	246.75	22,585	11,171	11,414	13,991	3,208	14,889	-0.39997	Medium	-0.40192	Low	-0.660	Low
	Medellín	398.20	59,126	28,431	30,695	25,016	3,780	29,265	-1.14784	Low	-0.96328	Very Low	-0.993	Very Low

[10] Poverty applies when a person does not have sufficient income to purchase goods and services to meet his/her needs and lack of at least one of the following six indicators: access to education, health services, social security, as well as necessary services, spaces, and quality in housing (CONEVAL, 2010).
[11] The Marginality Index considers four structural dimensions: lack of access to education, residence in inadequate housing, perception of insufficient monetary income, and living in localities with fewer than five thousand inhabitants (CONAPO, 2010).
[12] The Index of Social Deprivation is a weighted measure that summarizes four indicators of social deprivation: education, health, primary services, and spaces in housing (CONEVAL, 2010).
[13] The Migratory Intensity Index is a measure that summarizes the migratory characteristics of Mexican households in terms of remittances, migrants living in the United States, circular migrants, and return migrants (CONAPO, 2010).

	Paso del Macho	398.97	29,165	14,390	14,775	17,438	4,586	19,010	0.06035	Medium	-0.15188	Low	0.0224	Medium
	Soledad de Doblado	416.30	27,008	13,339	13,669	20,036	5,214	21,110	-0.25507	Medium	-0.17185	Low	-0.608	Low
	Tepatlaxco	59.78	8,249	4,207	4,042	7,092	3,068	7,244	1.16303	Very High	1.00367	High	-0.330	Low
	Veracruz	247.90	552,156	261,537	290,619	167,245	24,095	211,826	-1.64171	Very Low	-1.39331	Very Low	-0.882	Very Low
	Zentla	178.66	12,379	6,205	6,174	11,353	2,999	11,549	0.39557	High	0.12991	Medium	0.8348	High
		5,968	**850,604**	**407,977**	**442,627**	**357,734**	**78,889**	**413,130**						

According to the Migratory Intensity Index (CONAPO, 2010), Jalisco has a high migratory degree (0.3688) and Veracruz a medium one (-0.3865). The migration process in the target area is related to social deprivations that force the population to travel to other municipalities, regions, and countries (particularly to the United States of America) looking for better living conditions (Table 1.17). Economically, 41.5% of the total population of the municipalities make up the Economically Active Population (PEA) (Table 1.18). Within the occupation of the population, the one dedicated to primary sector activities prevails, especially agricultural and livestock.

Table 1.18. Economically active population by occupation and economic activity within the municipalities where RIOS will operate (INEGI, 2010).

State	Municipality	Employment 2010					
		Economically Active Population[14]		Occupied Population		Non-occupied Population	
		Total	%	Total	%	Total	%
Jalisco	Mascota	5,346	37.5	5,111	95.6	235	4.4
	Talpa de Allende	5,464	37.9	5,273	96.5	191	3.5
Veracruz	Camarón de Tejeda	2,260	36.3	2,182	96.5	78	3.5
	Comapa	6,604	35.3	6,413	97.1	191	2.9
	Huatusco	21,591	39.6	20,966	97.1	625	2.9
	Ixhuatlán del Café	7,391	34.5	7,053	95.4	338	4.6
	Jamapa	4,094	39.5	3,940	96.2	154	3.8
	Manlio Fabio Altamirano	8,465	37.5	8,131	96.1	334	3.9
	Medellín	25,812	43.7	25,081	97.2	731	2.8
	Paso del Macho	11,209	38.4	10,896	97.2	313	2.8
	Soledad de Doblado	10,321	38.2	10,023	97.1	298	2.9
	Tepatlaxco	2,884	27.7	2,862	99.2	22	0.8
	Veracruz	236,884	42.9	227,432	96.0	9,452	4.0
	Zentla	4,647	37.5	4,576	98.5	71	1.5
		352,972	**41.5**	**339,939**	**96.3**	**13033**	**3.7**

[14] Economically Active Population. People of 12 years or more who had or performed an economic activity (occupied population) or actively sought to conduct one (non-occupied people).

In the target municipalities, there are 226 ejidos and agrarian communities[15], with 21,050 people collectively owning 251,026.38 hectares of land (INEGI, 2007; Table 1.19). The surface area of the social property in the Talpa-Mascota sub-basin (139,180 hectares) is slightly higher than in the Jamapa sub-basin (111,846 hectares). However, the total number of collective tenures as well as of ejidatarios, comuneros, and posesionarios is almost six times greater in the Jamapa watershed (193 ejidos/agrarian communities and 17,953 owners) than in the Talpa-Mascota sub-basin (33 ejidos/agrarian communities and 3,097 holders). Thus, the atomization and small landholdings in the social ownership deepens the dangers of land overexploitation, soil erosion, and unsustainable use.

Intra-municipal inequality and poverty gaps also affect particularly vulnerable groups, including women, people with denied access to land tenure, households with disabled persons, among others, which shall be considered within RIOS to guarantee equitable access to the project´s opportunities and benefits. The project target area does not contain indigenous territories.

Table 1.19. Ejidos and Agrarian Communities within the municipalities where RIOS will implement (INEGI, 2007).

State	Municipality	Ejidos and Agrarian Communities[16]				
		Total	Total Area (ha)	Total Population with social property rights	Ejidatarios[17] and Comuneros[18]	Posesionarios[19]
Jalisco	Mascota	16	50,673.83	1,163	894	269
	Talpa de Allende	17	88,506.20	1,934	1,745	189
Veracruz	Camarón de Tejeda	5	5,523.40	535	401	134
	Comapa	15	10,083.58	2,146	1,196	950
	Huatusco	10	1,524.50	623	623	0

[15] The Mexican Constitution establishes three different forms of land tenure in Mexico: private, public, and social. Social property is further subdivided into agrarian communities and ejidos. There are almost 32,000 ejidos and agrarian communities across the country, with more than 5.6 million ejidatarios and comuneros owning slightly over half of the lands in México (ejidos 84.5 million ha and communities 17.4 million ha; Morett-Sánchez and Cosío-Ruiz, 2017). The ejidos and agrarian communities constitute a modality of private property. Their lands do not belong to the nation. Ejido and communal goods are property of the population nucleus (the set of people benefited with land endowment: ejidatarios and comuneros), and the Agrarian Reform Federal Law (1971) and the agrarian law in force (1992) are clear about it. Therefore, in the case of public utility, the lands from ejidos or communities do not return automatically to the dominion of the nation but rather through an expropriator act with prior compensation. The maximum authority of ejidos and agrarian communities is the General Assembly. The direction organs are the commissary (whether ejidal or of communal goods), designated by direct vote from ejidatarios or comuneros, and made up of a president, a secretary, and a treasurer, which in turn are supervised by a vigilance council integrated by its president, secretary and vocal, and all having their respective substitutes. All matters related to the ejido or the agrarian community are discussed and solved by agreement of the majority of the members in the general assembly.

[16] Ejidos and Agrarian Communities. Social property of land that covers most of the surface in the Mexican countryside.

[17] Ejidatario/Ejidataria. Mexican man or a woman who forms part of the ejido and has a legal certificate of agrarian rights, parcel certificate or common rights, or the resolution of the agrarian tribunal.

[18] Comunero/Comunera. Holder of rights within an agrarian community, which allows him/her to use and enjoy his/her land and the transfer of its rights, as well as the use and benefit of the assets of common use.

[19] Posesionario. Adult Mexican who has resided for a year or more in the lands of the ejido, who is recognized by the General Assembly of the ejido or by the corresponding agrarian tribunal.

	Ixhuatlán del Café	13	5,193.46	1,311	1,311	0
	Jamapa	12	5,722.83	1,003	753	250
	Manlio Fabio Altamirano	28	16,927.92	2,607	1,981	626
	Medellín	33	19,244.00	3,292	2,150	1,142
	Paso del Macho	27	15,804.46	1,855	1,372	483
	Soledad de Doblado	26	17,155.50	2,565	1,464	1,101
	Tepatlaxco	5	1,001.20	270	249	21
	Veracruz	16	8,663.00	1,127	825	302
	Zentla	3	5,002.50	619	567	52
		226	**251,026.38**	**21,050**	**15,531**	**5,519**

A deeper level of detail can be achieved by analyzing the existing localities within the sub-basins for RIOS operation. In the Jamapa sub-basins, there are 129 rural towns and four urban localities. In these settlements live 52,522 people, with a ratio of 49% men and 51% women (INEGI,2010). 38% of them (19,916 inhabitants) represent the economically active population, of which 4,516 are women and 15,380 men (INEGI,2010). The un-occupied population comprises 584 people (3%), 73 women versus 503 men (INEGI,2010). In the Talpa-Mascota sub-basin, there are only 30 localities with a total population of 10,851 people (INEGI, 2010). Two of them belong to the municipality of Mascota, with a total of 154 residents; 96% of them are located in San José del Mosco. 28.3% (42 people) constitute the economically active population, all being occupied, with a ratio of 93% (39) males and 7% (3) women. The other 28 localities belong to the municipality of Talpa, with a total population of 10,697 inhabitants. Of them, 13 villages contain 99% of the residents. 39.47% (4,193 people) comprise the economically active population, with a ratio of 96% occupied and 4% un-occupied.

The main economic activities in the Ameca-Talpa watershed correspond to agricultural activities, located in the valleys, principally grains. In the mountains, forestry and cattle ranches dominate the landscape. Religious tourism in the municipality of Talpa is another significant business activity, with around 3,000,000 visitors per year arriving to the place (Pilgrim Route, 2019 http://www.guiatalpa.com/ruta-del-peregrino.html). In the Jamapa sub-basin, the main economic activities in the upper part of the basin include the cultivation of coffee and cornfields, as well as backyard livestock. In the middle and lower areas, there is extensive livestock ranching and farming of sugarcane and tropical fruit trees such as mango, banana, and citrus fruits.

Environmental context

a) Ameca-Mascota watershed

The Ameca-Mascota watershed is located on the slope of the tropical Pacific, within the physiographic province of the Sierra Madre del Sur. The area is dominated by mountains with heights that vary between 0 and 2,700 meters above sea level, which results in a varied ecosystem diversity ranging from coastal environments with tropical forests to habitats of temperate forests. The annual average temperature is 19.7°C, with temperatures ranging between 9.1°C and 31.6°C. The average yearly rainfall is 1,220 mm. The basin covers an area of about 274,228.71 hectares.

The National Commission for the Knowledge and Use of Biodiversity (CONABIO) and the National Commission for Protected Areas (CONANP) ponder this region as a priority for conservation, due to its extraordinary richness of species and the critical environmental services provided (Romero et al., 2013). The watershed has a total of six natural protected areas that preserve 73,406.50 hectares (Table 1.20), which represents almost 27% of the total basin surface. Conservation efforts beyond these protected areas include the Priority Terrestrial Region 62 - Sierra Vallejo - Ameca River and two priority areas under the Alliance for Zero Extension (AZE - Río Mascota and Oriente de Talpa de Allende).

Table 1.20. Federal and state protected areas and private areas voluntarily destined to conservation (ADVC) in the Ameca-Mascota watershed.

Protected area	Administration	Protected area total surface (ha)	Watershed area sheltered by the protected área (ha)	Biodiversity secured
Cuenca Alimentadora del Distrito Nacional de Riego 043 (Subcuenca Río Ameca)	Federal	354,849.52	61,480.64	**Flora:** Pino piñonero (*Pinus cembroides*), pino triste (*Pinus lumholtzii*), pino teocote (*Pinus teocote*), pino blanco (*Pinus durangensis*), pino de navidad (*Pinus ayacahuite*), cedro de San Juan (*Cupressus lusitanica*), encino jarrillo (*Quercus laurina*), encino rugoso (*Quercus rugosa*), biznaga cabeza de viejo (*Mammilaria senilis*), pino real (*Pinus engelmannii*), pino ocote chino (Pinus leiophylla), pino de chihuahua (*Pinus chihuahuana*), cedro (*Juniperus deppeana*), táscate (*Juniperus durangensis*), (*Quercus resinosa*), (*Quercus potosina*), (*Quercus eduardii*), (*Quercus grisea*), (*Quercus sideroxyla*), (*Quercus chihuahuensis*), (*Quercus aristata*), (*Quercus uxoris*), (*Quercus gentry*), (*Artostaphylos pungens*), encino chaparro (*Quercus microphylla*), Ejechí (*Mastichodendron capiri*), cedro (*Cedrela odorata*), lapacho rosado (*Handroanthus impetiginosus*), madroño (*Arbutus xalapensis*), pinabeto (*Pseudotsuga menziensii var. glauca*) y ciprés de Moctezuma (*Taxodium huegelii*). **Fauna:** Aves - guajolote (*Meleagris gallopavo*), águila real (*Aquila chrysaetos*), codorníz de moctezuma (*Cyrtonyx montezumae*), búho moteado (*Strix occidentalis*), trogón orejón (*Euptilotis*

				neoxenus), guacamaya verde *(Ara militaris*), pato friso (*Anas strepera*), cerceta ala azul, pato media luna (*Anas discors*), pato cucharón norteño (*Anas clypeata*), codorniz cotuí (*Colinus virginianus*), paloma ala blanca (*Zenaida asiatica*), paloma huilota (*Zenaida macroura*), tórtola cola larga *(Columbina inca*), tórtola coquita (*Columbina passerina*). Mamíferos - venado cola blanca (*Odocoileus virginianus*), pecarí de collar (*Pecari tajacu*), puma (*Puma concolor*), coyote (*Canis latrans*), conejo serrano (*Sylvilagus floridanus*), liebre cola negra (*Lepus californicus*), chichimoco (*Tamias bulleri*), murciélago negruzco (*Myotis nigricans*), jaguarundi (*Puma yagouaroundi*), nutria de río (*Lontra longicaudis*) y jaguar (*Panthera onca*), ocelote (*Leopardus pardalis*). Reptiles y Anfibios - serpiente de cascabel (*Crotalus lepidus*), culebra nocturna ojo de gato (*Hypsiglena torquata*), culebra ciempiés del Pacífico (*Tantilla calamarina*), culebra real coralillo (*Lampropeltis triangulum*) e iguana negra (*Ctenosaura pectinata*).
Reserva de la Biosfera Estatal Sierra de Vallejo	State	63,093.51	11,530.31	
ADVC Zona de Conservación Cañada Larga	Private (Common use land)	235	235	**Fauna:** Mamíferos - venado cola blanca (*Odocoileus virginianus*), jabalí (*Pecari tajacu*), puma (*Puma concolor*), zorra gris (*Urocyon cinereoargenteus*). Aves - conguita (*Columbina passerina*) y zopilote aura (*Cathartes aura*).
ADVC Peñas Blancas	Privada (Common use land)	29	29	**Fauna:** Reptiles - víbora de cascabel (*Crotalus basiliscus*). Aves - pava cojolita (*Penelope purpurascens*). Mamíferos - jaguar (*Panthera onca*) y ocelote (*Leopardus pardalis*).
ADVC Zona de Conservación Arroyo Texas	Privada (Common use land)	64	64	**Flora:** Capomo (*Brosimum alicastrum*), papelillo (*Bursera simaruba*) y guácima (*Guazuma ulmifolia*). **Fauna:** Aves - aguililla gris (*Buteo plagiatus*), perico (*Amazona sp.*), trogón (*Trogon sp.*), vaquero (*Piaya cayana*) y momotus (*Momotus sp.*).
ADVC Área de Conservación Vallejo	Privada (Common use land)	104	67.55	**Flora:** Papelillo (*Bursera simaruba*), capomo (*Brosimum alicastrum*), guácima (*Guazuma ulmifolia*), cuastecomate (*Crescentia alata*), hierba mula (*Achyranthes aspera*) y cocuixtles (*Bromelia karatas*).

Based on the VI series of use of soil and vegetation from INEGI (2014), the set of primary and secondary coniferous forests, broad-leaved forests, cloud forests, and deciduous and sub-deciduous forests embrace 78% of the total area. The cropland, pasture, and grassland areas cover 19%. The remaining 1% corresponds to urban areas and other vegetation types (Table 1.13 and Figure 2).

Table 1.21. Land-use and vegetation areas in the Ameca-Macota watershed (INEGI, 2014).

Land-use and vegetation	Ameca-Mascota Watershed	
	ha	%
Primary Vegetation	136,542	50
Secondary Vegetation	77,348	28
Grassland and Pastures	10,308	4
Cropland	42,673	15
Human Settlements	1,826	1
Other	5,531	2
Total	**274,229**	**100**

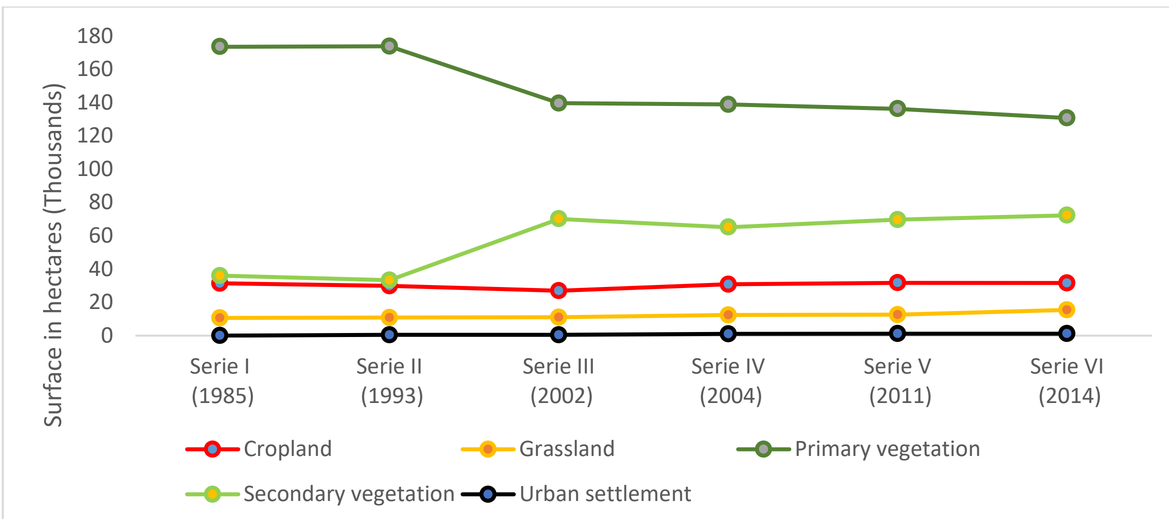
The Ameca-Mascota watershed has been historically affected by deforestation and forest degradation due to land-use change for agriculture. In the last 25 years, the traditional hillside agricultural systems have been transformed toward more extensive farming practices, reducing the fallow period, and increasing the use of agrochemicals and soil degradation. This activity is also one of the central causes of fires by inadequate crop burning practices (roza, tumba y quema).

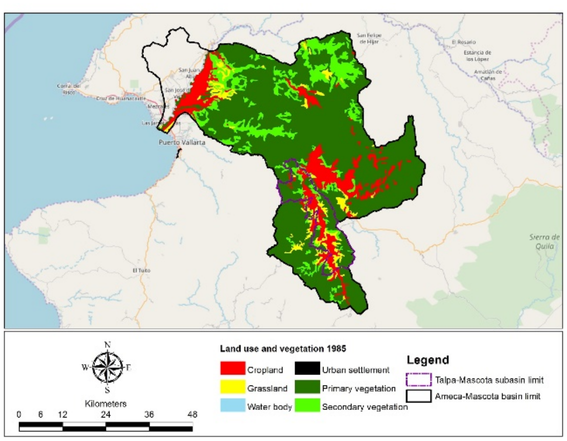
The expansion of livestock has also been a significant cause of land-use change and degradation of forests in the last 40 years. The bovine production system is extensive. During the rainy season, ranchers rely on fodder obtained from free grazing in the diverse ecosystems. During the dry season, an essential part of the forage used to cover the cattle nutritional deficiencies is obtained from food supplement and induced pastures established in the production units by removing tropical deciduous and broad-leaved forests. The inadequate management of rangelands and cattle, combined with a strong water deficit of more than six months, declines the productivity, produces soil degradation, and pushes the opening of new areas for grazing. Livestock also demands wood for the poles used in the enclosures, which has an impact on forest degradation rates. Bovine production continues to be a central economic activity in the region and is powerfully rooted in the local culture despite its low profitability.

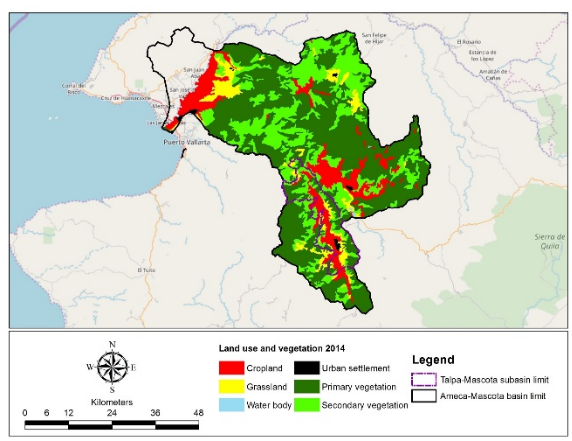
Land-use change due to urbanization and tourism development has occurred primarily on agricultural land, but some forest areas can be attractive for real estate speculation and residential developments.

Other factors that encourage deforestation and forest degradation in the area are the lack of competitiveness of sustainable forestry activities; illegal logging; deficiency of local technical accompaniment; insufficient planning instruments to align public and private investments; frequency and intensity of extreme hydrometeorological events; weakened territorial governance, among others.

In the Ameca River basin between 1985 and 2014, 35,715 ha of primary forest were lost, however, 87% of the loss of forests occurred between 1993 and 2002. Between 2004 and 2011, the primary vegetation coverage has remained stable, showing a slight decrease between 2011 and 2014. It is worth mentioning that the area of urban settlements in the basin has increased from 0 to 1150 ha from 1985 to 2014, there is also an increase in the area of grasslands from 10,630 ha in 1980 to 15, 460 in 2014, which represents an increase of 45%.







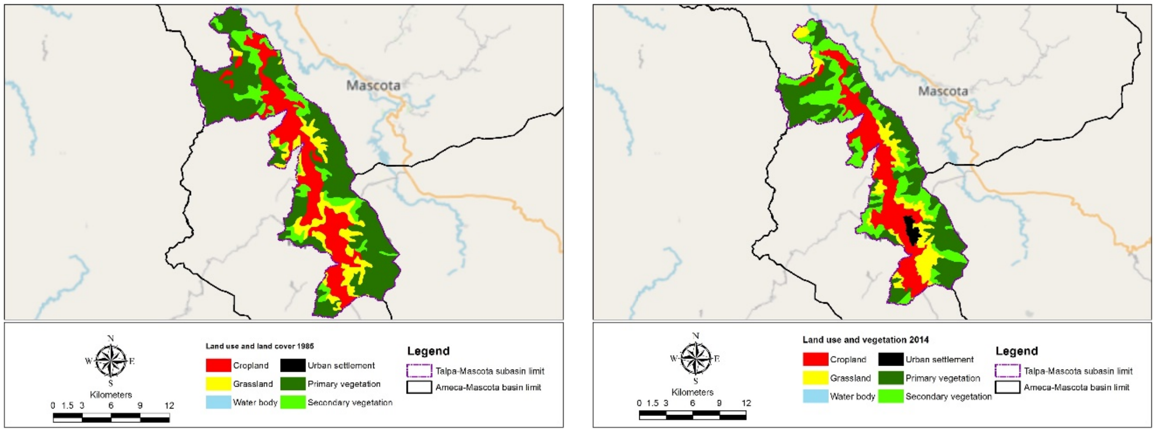


Figure 1.35 Changes in vegetation and land use in the Ameca-Mascota river basin, between 1985 and 2014.

The figures show the loss process of primary vegetation, the second figure represents the primary and secondary vegetation cover, as well as the different land uses in the Ameca-Mascota river basin during 1993, it can be observed a notable increase in secondary vegetation in the middle and upper part of the basin. In the Talpa-Mascota intervention sub-basin, the process of fragmentation of primary vegetation is notorious.
All these issues have an impact on the decline in the quality and quantity of water available throughout the year, as it favors soil compaction and erosion, amending the patterns of absorption and infiltration of water, in addition to climate change, which has impacts on the modification of precipitation regimes (refer to Appendix 1.3 - Analysis of climate change risks, impacts, and vulnerability analysis at national/regional level and location of the project).

The National Forestry Commission made a forest zoning where forest lands are identified and grouped within the hydrological basins, sub-basins and micro basins, considering biological, environmental, socioeconomic, recreational, protective and restorative functions and sub-functions, in order to promote better administration and contribute to sustainable forestry development.

National zoning identifies:

I) Conservation areas and restricted use,
II) II) Production areas and
III) III) Restoration areas.

Restoration zones are sub-zoned into 5 sub-zones, these sub-zones identify forest lands with different degrees of erosion and degradation:

III A. Forest land with high degradation and showing evidence of severe erosion, with the presence of gullies,

III B. Preferably forest lands, characterized by lacking forest vegetation and showing evidence of severe erosion, with the presence of gullies,

III C. Forest land or preferably forest land with medium degradation, characterized by having a canopy cover of less than twenty percent and showing evidence of severe erosion, with the presence of gutters,
III D. Forest or preferably forest land with low degradation, characterized by having a canopy cover of less than twenty percent and showing evidence of laminar erosion, and
III E. Forest lands or preferably degraded forest lands that are subject to recovery treatments, such as afforestation, reforestation or natural regeneration

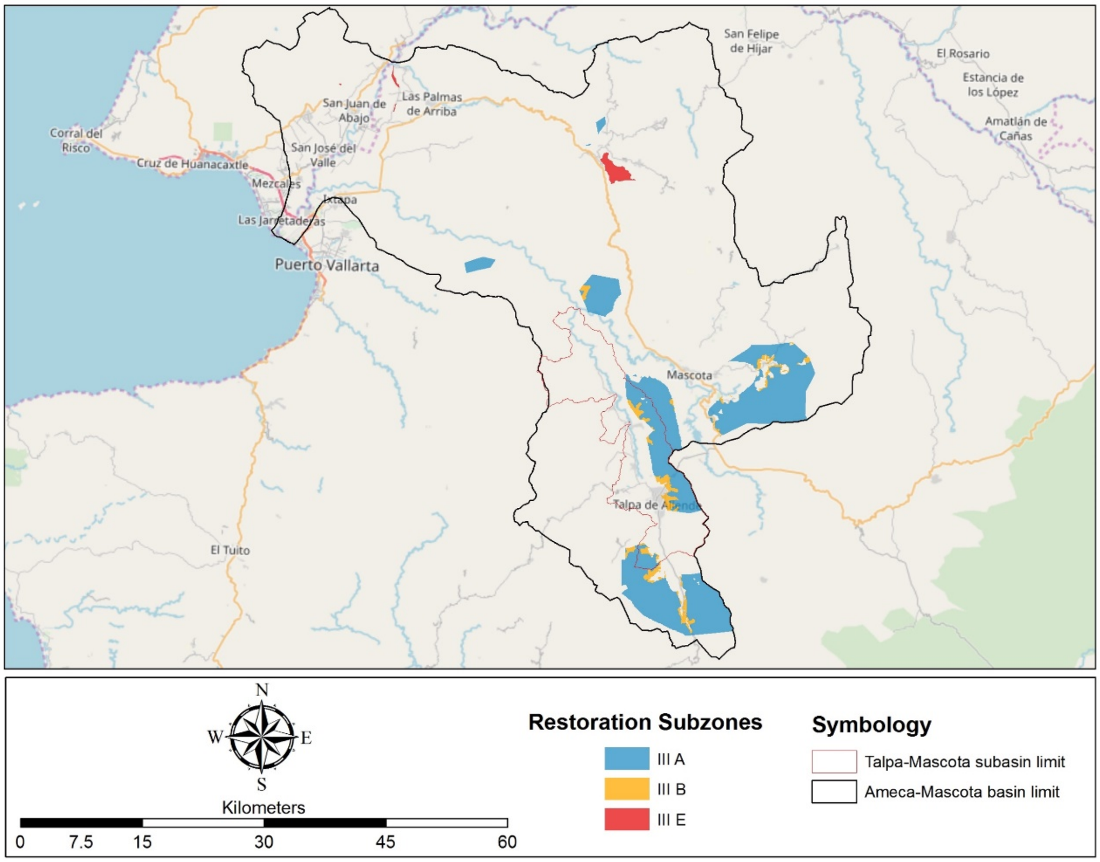


Figure 1.36. Distribution of the forest restoration subzones in the Ameca-Mascota River basin[20].

b) *Jamapa watershed*

The Jamapa River watershed is located in the mountains of the Sierra Madre Oriental and runs toward the Gulf of Mexico. Physiographically, the eastern part of the basin is situated in the Llanura Costera del Golfo Sur, while the western part is in the Neovolcanic Axis (Mexican Volcanic Belt). The area is dominated by mountains with heights that vary between 0 and 5,670 meters above sea level, which results in a varied ecosystem diversity ranging from coastal

[20] [20] Sistema nacional de Información y Gestión Forestal (SNIF): Zonificación Nacional Forestal https://snigf.cnf.gob.mx/zonificacion-forestal/

environments with tropical forests to habitats of temperate forests. The annual average temperature is 18.5°C, with temperatures ranging between 4.9°C and 26.4°C. The average yearly rainfall is 1,468 mm. The basin covers an area of about 384,984 hectares.

The watershed has a total of five natural protected areas that preserve 6,582.37 hectares (Table 1.22), which represents almost 2% of the total basin surface. Conservation efforts beyond these protected areas include the Priority Terrestrial Region 122 – Pico de Orizaba – Cofre de Perote, two Important Bird and Biodiversity Areas (IBA - Centro de Veracruz and Metlac River), and a RAMSAR site (Mandinga).

Table 1.22. Federal and state protected areas and areas voluntarily destined to conservation (ADVC) in the Jamapa watershed.

Protected area	Administration	Protected area total surface (ha)	Watershed area sheltered by the protected area (ha)	Biodiversity secured
PN Pico de Orizaba	Federal	19,750.00	5701.77	**Flora:** Pino negro (*Pinus hartwegii*), oyamel de Juárez (*Abies hickelii*), enebro (*Juniperus monticola*), rosa de las nieves (*Eryngium proteiflorum*), siempreviva (*Echeveria sp.*) y enebro azul (*Juniperus sabinoides monticola*). **Fauna:** Mamíferos – gato montés (*Lynx rufus*), coyote (*Canis latrans*). Reptiles - lagartija cornuda de montaña (*Phrynosoma orbiculare*). Aves - carpintero (*Picoides stricklandi*).
Reserva Ecológica Tembladeras - Laguna Olmeca	State	234.51	191.30	**Flora:** Palma real (*Acrocomia mexicana*), apachite (*Sabal mexicana*) cocotero (*Cocos nucifera*), almendro malabar (*Terminalia catappa*), espadaña (*Typha domingensis*), platanillo (*Thalia geniculata*), lechuguilla de agua (*Pistia stratiotes*), palo mulato o chaca (*Bursera simaruba)*, higuera (*Ficus sp.*), palma apachite (*Sabal sp.*), ceiba (*Ceiba pentandra*), apompo (*Pachira aquatica*), orejón (*Enterolobium cyclocarpum*), guazimo (*Guazuma ulmifolia*), higuerilla (*Ricinus communis*) y roble rosa (*Tabebuia rosea*). **Fauna:** Mamíferos - armadillo (*Dasypus novencinctus*), tlacuache (*Didelphis marsupialis*), mapache (*Procyon lotor*), zorra gris (*Urocyon cinereoargenteus*), cacomixtle (*Bassariscus astutus*), comadreja (*Mustela frenata*), ardilla gris (*Sciurus aureogaster*), conejo (*Sylvilagus floridanus*). Reptiles y Anfibios - iguana verde (*Iguana iguana*), iguana negra (*Ctenosaura similis*), lagartija común (*Sceloporus variabilis*), lagartija o perrillo (*Anolis sp.*), tlaconete (*Bolitoglossa platydactyla*), sapo marino (*Bufo marinus*), rana (*Rana berlandieri*), tilcampo (*Ctenosaura acanthura*), teterete (*Basiliscus vittatus*), boa mazacuata (*Boa constrictor*), culebra corredora (*Drymobius margaritiferus*), tortuga tres lomos

				(*Staurotypus triporcatus*), tortuga chopontil (*Claudius angustatus*) y tortuga casquito (*Kinosternom herrerai*). Aves - garza de zapatillas doradas (*Egretta thula*), garza ganadera (*Buculcus ibis*), martín pescador (*Ceryle torquata*), águila pescadora (*Pandion haliaetus*), gavilán caracolero (*Rostrhamus sociabilis*), zopilote común (*Coragyps atratus*), aura (*Cathartes aura*), zopilote sabanero (*Cathartes burrovianus*), gavilán pajarero (*Accipiter striatus*), aguililla caminera (*Buteo magnirostris*), halcón peregrino (F*alco peregrinus*), chachalaca (*Ortalis vetula*), tecolotito común (*Glaucidium brasilianum*), colibrí coroniazul (*Amazilia cyanocephala*) y cigüeña americana (*Mycteria americana*).
Reserva Ecológica Arroyo Moreno	State	248.06	239.36	**Flora:** Mangle rojo (Rhizophora mangle), mangle blanco (Laguncularia racemosa), mangle negro (Avicennia germinans), mangle botoncillo (Conocarpus erectus), zapote domingo (*Mammea americana*), chico zapote (*Manilkara zapota*) y helecho de manglares (*Acrostichum aureum*). **Fauna:** Reptiles - cocodrilo (*Crocodylus moreletti*). Aves - halcón peregrino *(Falco peregrinus*).
Zona Sujeta a Conservación Ecológica y de Valor Escénico Punta Canales o Isla del Amor	State	6.91	4.09	**Flora:** Haba del mar (*Canavalia rosea*), Campanita de la playa (*lpomoea imperati*), Bejuco de mar (*lpomoea pes-caprae*), mangle negro (*Avicennia nitida*) y *Chamaecrista chamaecristoides.*
ADVC Reserva Ecológica Natural en la Cuenca Alta del Río Atoyac 1 Z-1 P1/1	Private (Common land use)	445.85	445.85	**Flora:** Mona blanca (*Lycaste skinneri*). **Fauna:** Mamíferos - martucha (*Potos flavus*), jaguar (*Panthera onca*), ocelote (*Leopardus pardalis*), tigrillo (*Leoparuds wiedii*), epuercoespín (*Sphiggurus mexicanus*) oso hormiguero (*Tamandua mexicana*), nutria de río (Lontra longicaudis). Aves - oro corona azul (*Amazona farinosa*), perico frente naranja (*Eupsittula canicularis*), perico mexicano (*Psittacara holochlorus*). Reptiles- mazacuata (*Boa constrictor*).

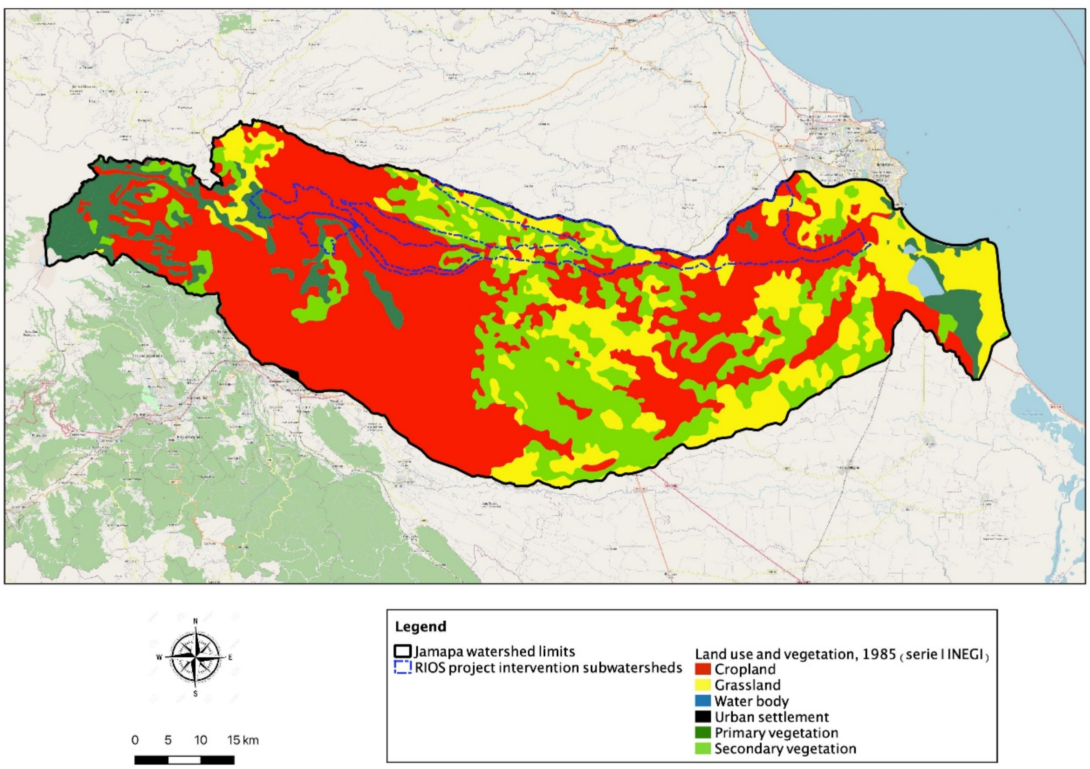
Based on the VI series of use of soil and vegetation from INEGI (2014), the set of primary and secondary coniferous forests, broad-leaved forests, cloud forests, evergreen, and sub-deciduous forests comprise 12% of the total area. Cropland, pasture, and grasslands cover 85% of total area. The remaining 2% corresponds to urban areas (Table 1.23 and Figure 3).

Table 1.23. Land-use and vegetation areas in the Jamapa watershed (INEGI, 2014).

Land-use and vegetation	Jamapa Watershed	
	ha	%
Primary Vegetation	19,426	5
Secondary Vegetation	26,160	7

Grassland and Pastures	101,925	26
Cropland	227,900	59
Human Settlements	6,947	2
Other	2,626	1
Total	**384,984**	**100**

The different land uses of the Jamapa basin allow us to visualize the productive, economic, and social dynamics of the territory over time. In the mid-1980s, agriculture dominated the landscape of the Jamapa river basin (Figure 1.37). According to the Series I of land use and vegetation carried out with the analysis of satellite images of 1985 (INEGI, 1997), agriculture was distributed in 49.8% in the basin (Table 2); primary and secondary vegetation with 30% of the surface, while the use of livestock land occupied almost 20% of the surface.



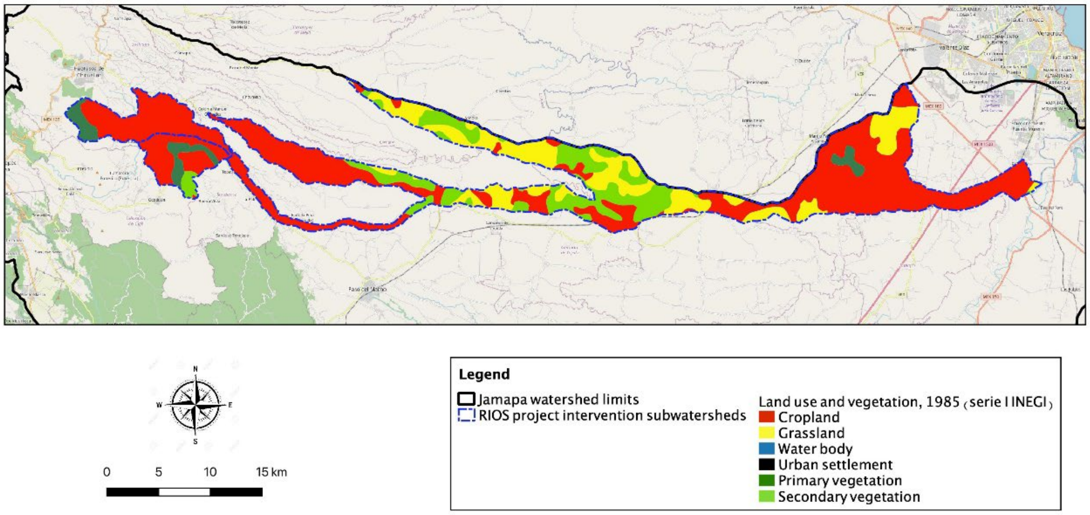


Figure 1.37. Land Use and vegetation in 1985in the Jamapa river basin and the sub-basins of the intervention of the RIOS project (source: FGM elaboration based on INEGI, 1997).

If we compare with data from 30 years later, in the period 2014 (Figure 1.38), it is possible to observe that the growth of the agricultural frontier has dominated the change in land use by increasing 36,207 ha (9.4%) followed by grasslands with 26,431 ha (6.9%). This increase was concentrated in the period 1985-2002. It should be noted that urban areas in 1985 covered 220 ha and, 35 years later, they covered 30 times more area (6,727 ha). This growth affected the primary and secondary natural vegetation, which contracted by 69,557 hectares (18%). 90% of the loss of vegetation occurred between 1985 and 2002 (Figure 1.39). Since 2002, the loss of primary and secondary vegetation has continued but at a slower rate than in the first period of analysis. In the sub-basins of the intervention of the RIOS project, the greatest change is observed in their middle part where secondary vegetation zones have been converted to agricultural zones and pastures. In general, the dynamics of changes in land use have been concentrated in the middle area of the basin.

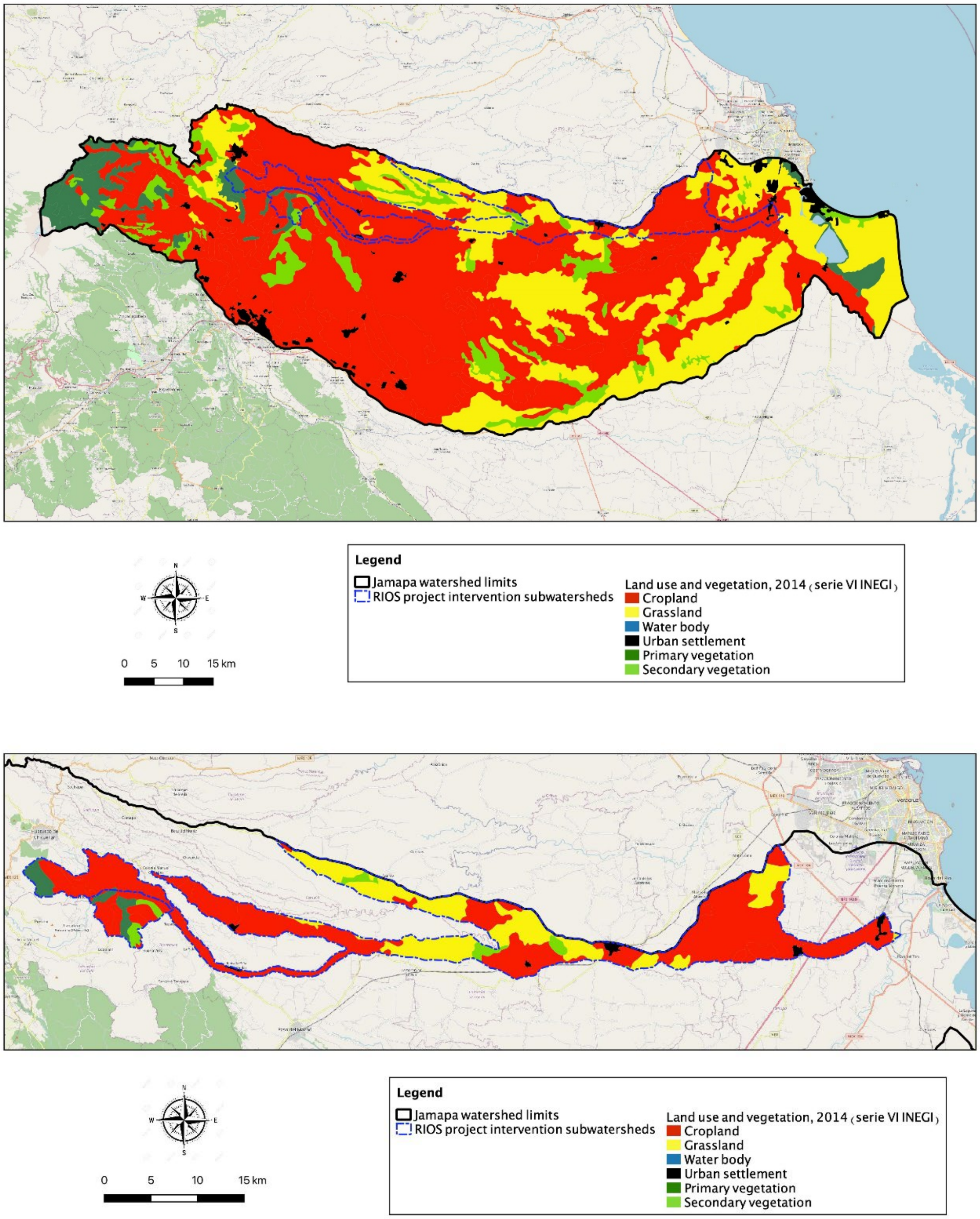


Figure 1.38. Land Use and vegetation in 2014 in the Jamapa river basin and the sub-basins of the intervention of the RIOS project (source: FGM elaboration based on INEGI, 1997).

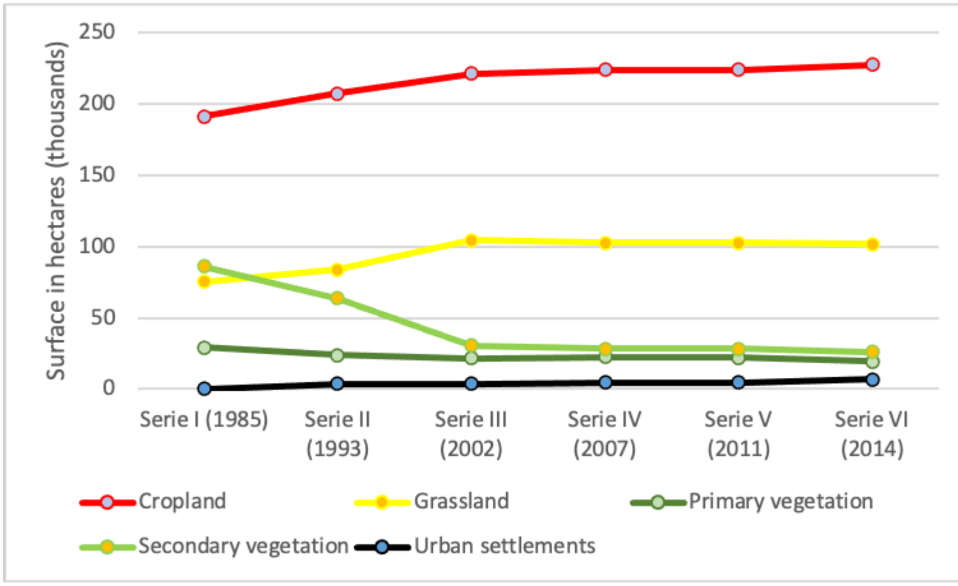


Figure 1.39. Changes in vegetation and land use in the Jamapa river basin between 1985 and 2014.

Figure 1.40 shows the spatial concentration of changes in vegetation (loss, gain, or changes between types of vegetation in the last 11 years). The data in this figure were obtained from a study by the European Space Agency (ESA) within the framework of the C6 project and for this, high-resolution Rapid eye images were used. Through a higher spatial resolution, it is possible to observe that in the whole of the basin the dynamics of change in vegetation has been concentrated in its lower-middle part, especially in the limits of the metropolitan area of Veracruz-Boca del Río, which it has experienced strong urban growth in the last decade, affecting mangrove areas, jungles, and wetlands.

In the sub-basins of the intervention of the RIOS project, the greatest loss of vegetation (forests) has occurred in the middle part where agricultural and livestock activities have been established. In the upper part of the sub-basins, where agroforestry activities such as shade-grown coffee are carried out, the vegetation has presented less loss.

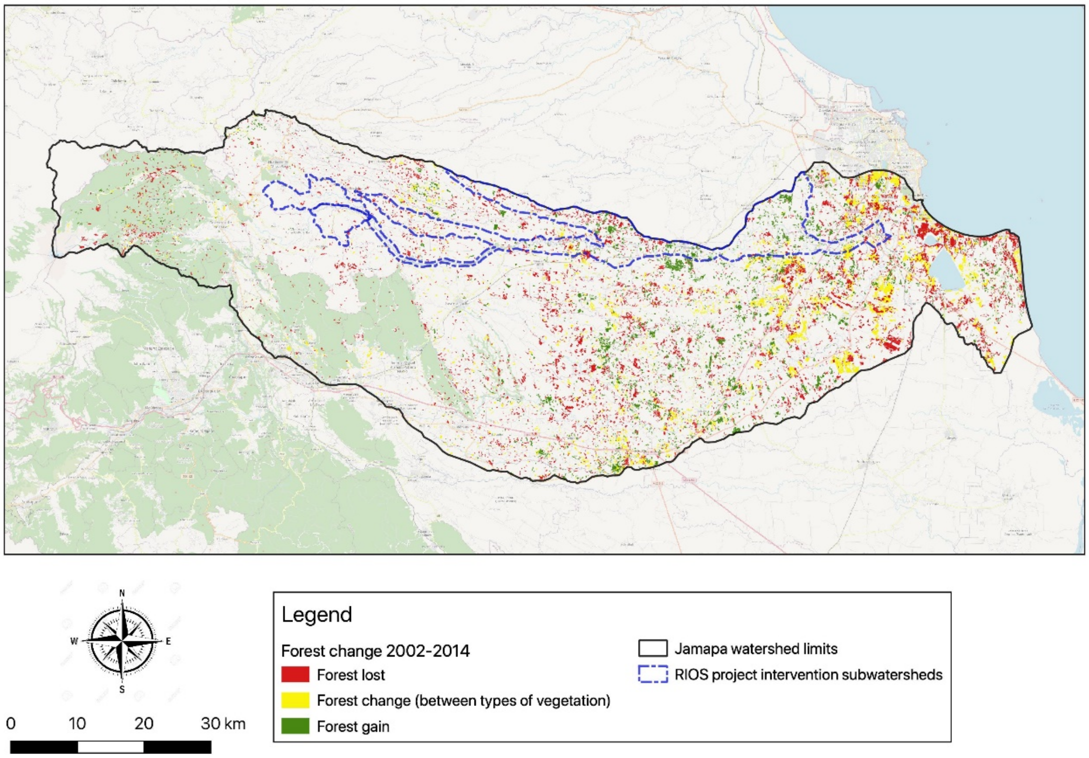


Figure 1.40. Vegetation changes in the Jamapa basin and in the intervention sub-basins of the RIOS project (2003-2014).

Through the analysis carried out by ESA, it is possible to know the forest density of the vegetated areas in the basin and sub-basins of intervention (Figure 1.41). Forest density makes it possible to assess indirectly, the level of degradation of natural ecosystems. In the basin, the areas with less degraded natural vegetation are located in the upper part where the natural vegetation is concentrated. The scattered patches of the middle and lower zone have low and very low densities (0% -40%). In the intervention sub-basins, the same dynamics are observed, since the sub-basins of the upper zone maintain a higher forest density in compact patches, while in the middle and lower zones of the sub-basins, we find scattered patches of vegetation with low forest densities and very low, it is in these areas where the RIOS project will focus on restoration activities.

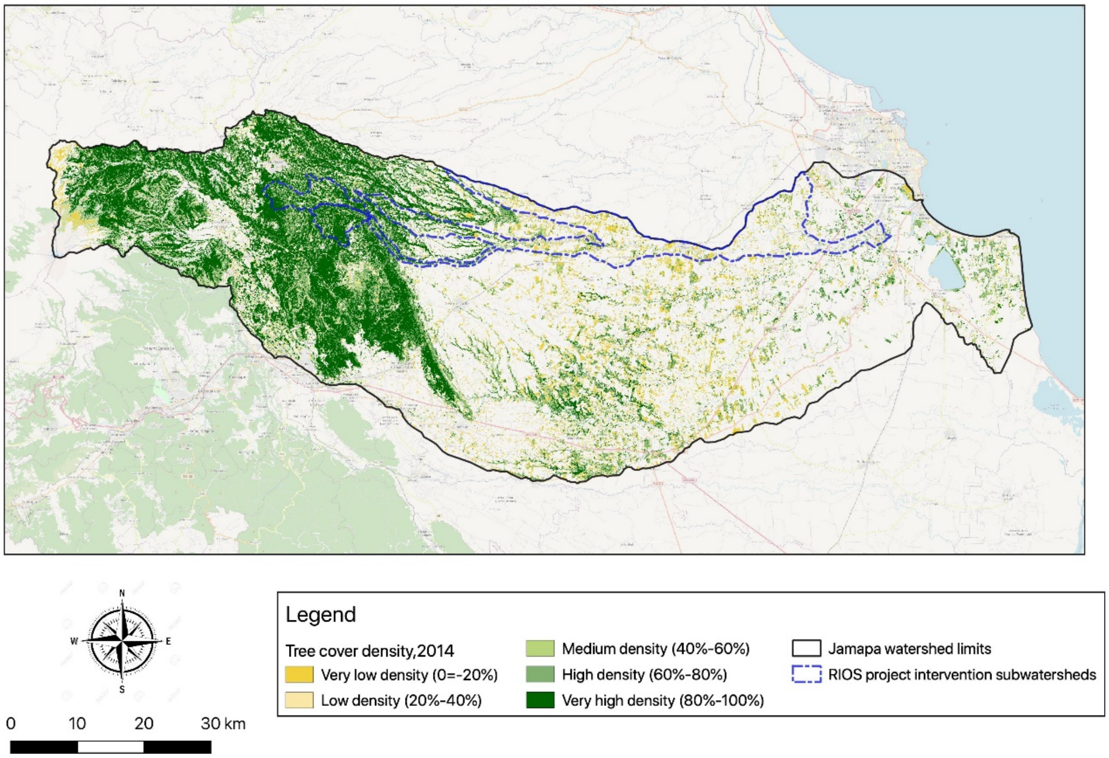


Figure 1.41. Forest density in the Jamapa river basin and in the intervention sub-basins of the RIOS project, 2014.

Forest density has also changed between 2003 and 2014. Forest degradation has been concentrated in the middle zone of the basin around the town of Tenejapa and in the lower zone of the basin around the city of Boca del Río and the Mandinga lagoon (Figure 1.42).

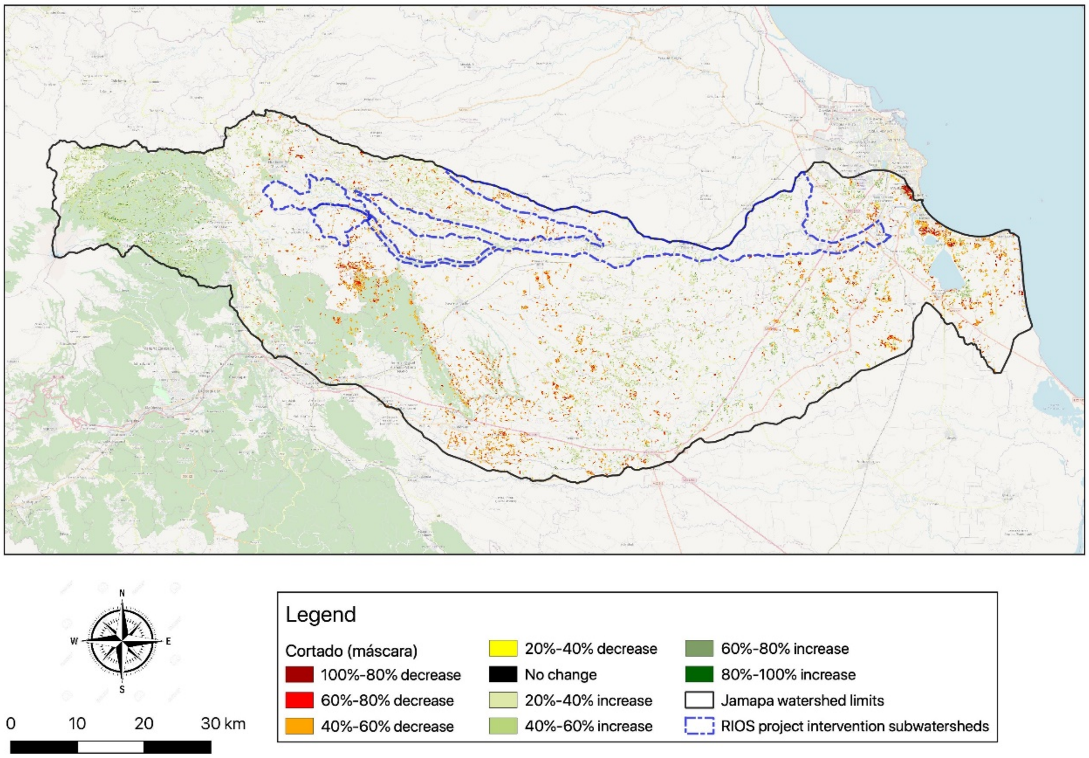


Figure 1.42. Changes in forest density in the Jamapa river basin and in the intervention sub-basins of the RIOS project, 2003-2014.

The loss of natural vegetation in the Jamapa watershed is due to land-use changes promoted by livestock and agriculture. Erosion, loss of wildlife, soil transportation, reduction of carbon sequestration, climate changes, but above all, the lowering of aquifers are the main effects brought about by the loss of forest cover.

Importance of livestock production in target areas within Jalisco and Veracruz [21]

The states of Veracruz and Jalisco are the first and second producers of beef with 13% and 12% of the 2018 national production, respectively. Jalisco is also one of the top producers of milk, while there is potential to increase milk production in Veracruz.

Livestock activities have been the driving force of deforestation and land degradation in the RIOS targeted landscapes. During the last century, public subsidies promoted the transformation of forests into pastures to release pressure from populated areas. Territories were turned into small units of extensive and inefficient cattle ranching. High use of agrochemicals resulted in land degradation and loss of ecosystem services. Ranching keeps further expanding into upper watersheds, exacerbating the environmental degradation.

[21] This information was taken from the socio-economic and environmental diagnosis on livestock activities for the Project CONECTA.

Climate change is contributing to this upward migration since regions to grow high-quality pastures are now found at higher elevations where the cloud forest is found.

Livestock production consists of small family production units that mainly serve local markets and meet their own consumption needs. Communal landholders participate and benefit from livestock businesses. In terms of labor practices, family members participate in cattle raising under the figure of generational ranching. Teenagers help their parents in cattle raising as a way to learn about the management and administration of livestock businesses and be ready to take them over when needed. Generational ranching has become significantly relevant to pass on traditions, attachment to land to younger generations of ranchers, and to ensure continuity of ranching, particularly in the current context, where young ranchers have lost interest in livestock businesses and prefer migrating to urban areas to work in more profitable sectors such as the tourist industry, as in the case of Jalisco. When needed, additional workers are hired to support specific activities across the value chains. Women mostly participate in the dairy activities and work across the value chain, yet their work is mostly "invisible" and non-remunerated as it is part of the family economy.

In general, producers do not have records on inputs used, labor expenses or productive, health, or reproductive instruments. Moreover, sanitary and security measures are minimal and sometimes non-existent. The drugs for the control of ticks and parasite and agro-chemicals for the restriction of weeds in rangelands are applied without technical guidance or proper training. In most cases, the products employed are highly toxic to human health or the environment.

Ranchers perceive that cattle ranching has marginal profitability, yet many continue because of the social status achieved and the love for animals and country life. Thus, training, technical assistance, and accompaniment are essential to promote sustainable, profitable and climate-resilient food production systems.

Characterization of River degradation

Through restoration actions in strategic places, the project seeks to address two agents contributing to river degradation: 1) perturbation of riparian vegetation due to land-use and 2) erosion of slopes adjacent to rivers. The analysis of these two factors assumes that the potential perturbation of riparian areas and the potential erosion are directly related to land-use. Thus, the rivers near or adjacent to anthropogenic land-uses devise a greater level of alteration than those connected to native vegetation.

The potential perturbation of riparian vegetation due to land-use was analyzed as follows:

1. A buffer of 100 m was created at both sides of the river, including intermittent and perennial and considering third order and over water flows, using INEGI's hydrological network map (scale 1:50,000).

2. The watersheds´ altimetric zones, included in the IWAPs of Vallarta and Jamapa and built from INEGI's digital elevation model 1:50,000, were used to delimit three basin areas: upper, middle, and lower part.
3. The riparian buffer was intersected with INEGI's VI series on vegetation and land-use (scale 1: 250,000).
4. Four levels of perturbation were defined for the different sections of the rivers based on land-use:

Land-use	Potential perturbation of riparian vegetation
Primary vegetation	Low
Secondary vegetation	Medium
Agriculture (including grassland)	High
Human settlements, urban areas, and areas without vegetation	Very High
Bodies of water	Does not apply

The potential erosion of slopes adjacent to rivers was analyzed as follows:

1) A buffer of 100 m was created at both sides of the river, including intermittent and perennial and considering third order and over water flows, using INEGI's hydrological network map (1:50,000).
2) The watersheds´ altimetric zones, included in the IWAPs of Vallarta and Jamapa and built from INEGI's digital elevation model 1:50,000, were used to delimit three basin areas: upper, middle, and lower part.
3) The values of potential soil loss (USLE 30m / pixel) for the riparian buffer were obtained through mask extraction from the PAMICs of each basin.
4) The level of the potential erosion of rivers was determined based on the ranges of potential soil loss values. The range values of potential soil loss (ton/ha*year) used were taken from Montes León et al., 2011 applied in the National Map of Potential Erosion.

USLE range (ton/ha*year)	Potential erosion
0 a 50	Low
50.01-100	Medium
100.01-150	Considerable
150.01-200	High
200.01-250	Very High
>250	Extreme

Ameca-Mascota watershed

a) Potential perturbation of riparian vegetation due to land-use

In the middle and lower parts of the watershed, there is a very high perturbation of the riparian vegetation due to human settlements and urban areas (127.5 ha; Table 1.25). The upper basin registered the lowest degree of alteration.

Table 1.25. Level of potential perturbation of riparian vegetation associated with land-use in the Ameca-Mascota watershed within its three altitudinal zones.

Altitudinal zone	Level of Perturbation	Area (ha)	%
Low Basin	Very High	57	0.5
	High	4,636	37
	Medium	3,330	26
	Low	4,641	37
	Subtotal	12,664	100
Middle Basin	Very High	70	0.4
	High	5,957	37
	Medium	4,655	29
	Low	5,224	33
	Subtotal	15,906	100
Upper Basin	Very High	0	0
	High	414	8
	Medium	772	16
	Low	3,774	76
	Subtotal	4,960	100
Ameca-Mascota Basin Total	Very High	127	0.4
	High	11,007	33
	Medium	8,757	26
	Low	13,639	41
	Subtotal	33,530	100

The Talpa-Mascota sub-basin (project´s target sub-basin) has 63% of altered riparian vegetation (Table 1.26), with 1678 ha with a high and very high alteration. This percentage is higher than the average for the basin as a whole (33.4%) and the average for each of the three altitudinal zones, 37.5% in the lower and middle parts of the basin, and 8% in the upper basin.

Table 1.26. Level of potential perturbation of riparian vegetation associated with land-use in the Talpa-Mascota sub-basin.

Level of Perturbation	Area (ha)	%
Very High	55	2
High	1,623	61
Medium	438	17
Low	538	20

Subtotal	2,654	100

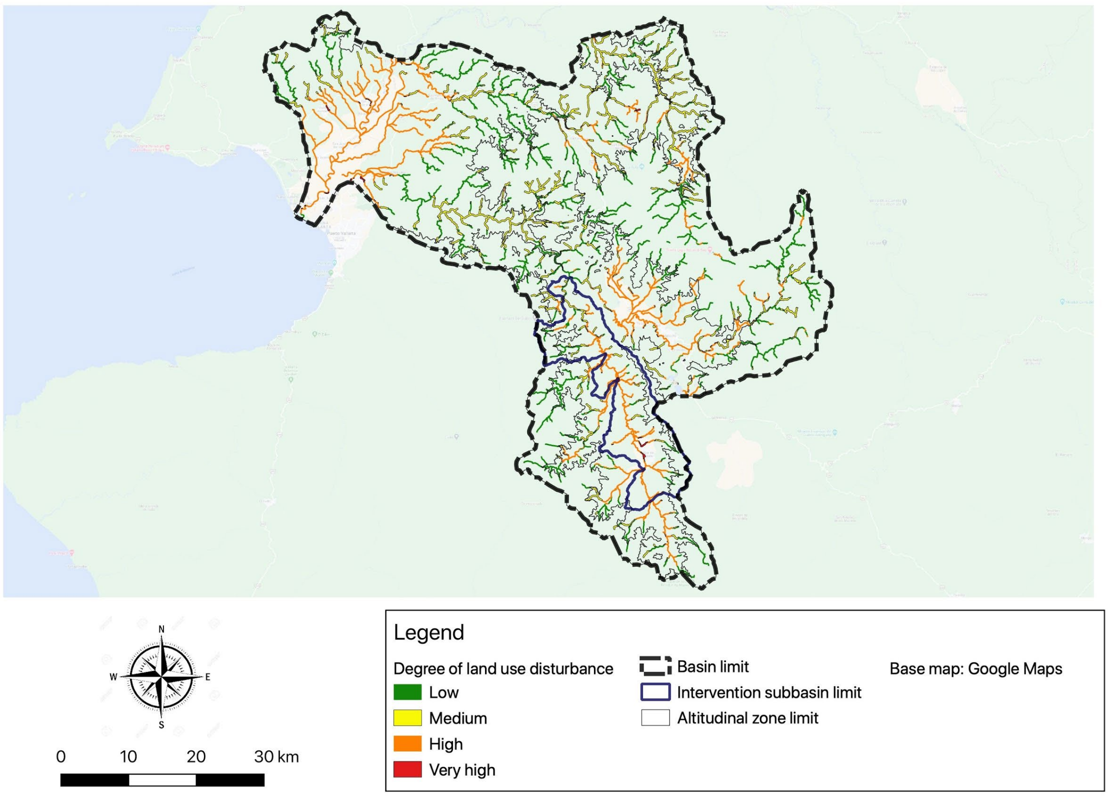


Figure 1.43. Level of potential perturbation of riparian vegetation associated to land-use in the Ameca-Mascota watershed and the Talpa-Mascota sub-basin.

b) Potential erosion of slopes adjacent to rivers

Around 2.3% of the riparian area presents high, very high, and extreme degrees of potential soil loss in the entire Ameca-Mascota river basin, representing 773 ha. These zones are concentrated in the middle basin, where high degrees of erosion represent 3.6% of the area's surface. The Talpa-Mascota sub-basin is located mainly in the middle zone of the basin, 3.8% of its surface has high, very high, or extreme erosion. These values are higher than the average value of the basin (2.3%) as well as the average of each of the altitudinal zones, 1% for the lower basin, 3.6% for the middle basin, and 1.6% for the upper basin.

Jamapa watershed

a) Potential perturbation of riparian vegetation due to land-use

The greatest alterations associated with land-use in the Jamapa basin occur near the cities of Córdoba and Veracruz in 458 ha. These areas with very high potential for river degradation correspond to sections that have suffered urbanization or are devoid of vegetation. A high degree of alteration is observed in the grasslands and agricultural areas, which are the most numerous in the basin (25,867 ha). These are concentrated in the middle and lower areas of the basin. 84% of the riparian land use in the Jamapa basin is high or very highly altered. The sections with medium and low alterations associated with primary and secondary vegetation are less extensive (4854 ha) and are distributed throughout the entire basin, although those with medium-grade alterations are observed more concentrated in the middle basin, and the upper basin those of low-grade alterations.

Table 1.29. Level of potential perturbation of riparian vegetation associated with land-use activities in the Jamapa watershed within its three altitudinal zones.

Altitudinal zone	Level of perturbation	Area (ha)	%
Low Basin	Very High	161	2
	High	9,057	85
	Medium	1,217	11
	Low	249	2
	Subtotal	10,684	100
Middle Basin	Very High	269	2
	High	13,135	86
	Medium	1,786	12
	Low	143	1
	Subtotal	15,333	100
Upper Basin	Very High	28	1
	High	3,675	71
	Medium	815	16
	Low	644	12
	Subtotal	5,162	100
Jamapa Basin Total	Very High	458	1
	High	25,867	83
	Medium	3,818	12
	Low	1,036	3
	Subtotal	31,179	100

The three intervention sub-basins in Jamapa have 92% of their riverbank areas with a high and very high degree of alteration associated with land use (Table 1.30). This percentage is higher than the average for the basin as a whole (84%) and the average for each of the three altitudinal zones, 87% in the lower basin, 88% in the middle basin, and 72% in the upper basin.

Table 1.30. Level of potential perturbation of riparian vegetation associated with land-use in the Jamapa sub-basins.

Level of perturbation	Area (ha)	%
Very High	51	1
High	3,95 1	91

Medium	285	7
Low	68	2
Subtotal	4,355	100

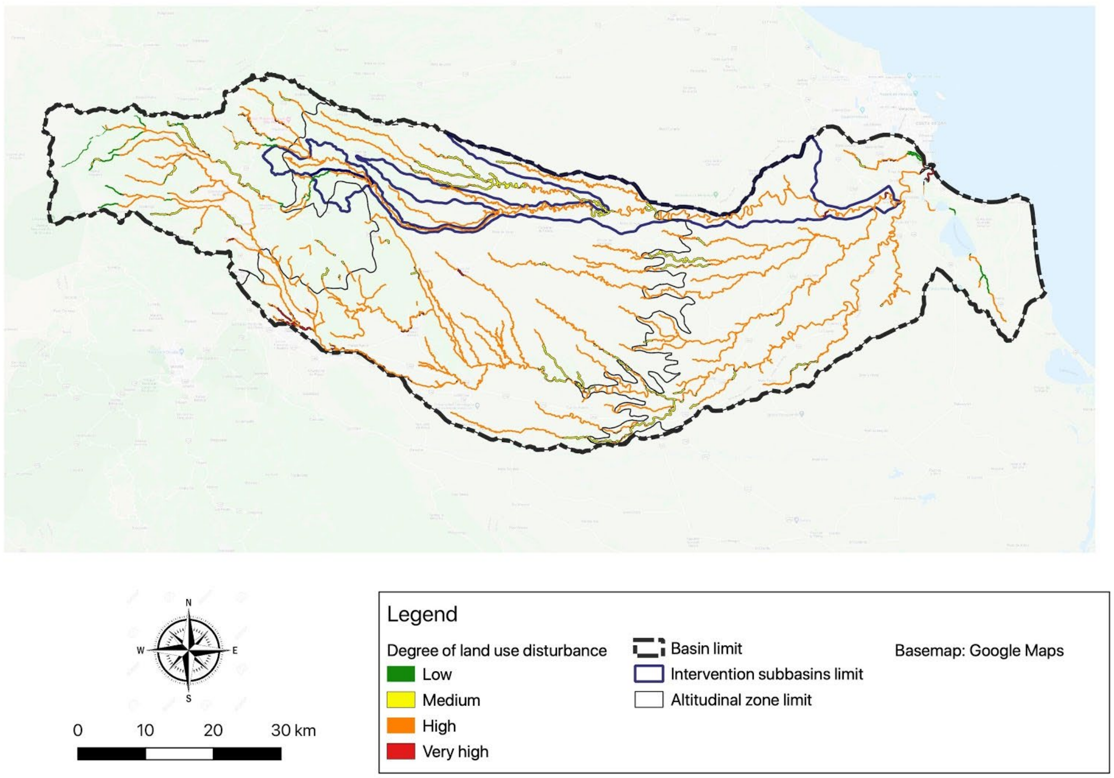


Figure 1.49. Level of potential perturbation of riparian vegetation associated with land use activities in the Jamapa watershed and the Jamapa sub-basins.

b) Potential erosion of slopes adjacent to rivers

The zones with high, very high, and extreme degrees of potential soil loss in the Jamapa watershed are concentrated in the upper zone of the basin, where high degrees of erosion. The intervention sub-basins present 181 ha with a medium and considerable degree of erosion.

Potential Environmental and Social Risks

The project is expected to have a positive impact on diverse habitats and landscapes, as well as on improving the livelihoods of the population inhabiting the target watersheds and that depend on natural resources to develop their socio-economic activities. Moreover, RIOS is expected to comply with the applicable environmental, social, and gender performance standards to manage environmental and social risks and impacts that may arise from the activities financed by the GCF. Table 1.33 provides a general overview of the project´s environmental and social risks and mitigation measures per outcome, output, and activity; while Table 1.34 compiles some good practices to mitigate potential adverse impacts of productive practices in the target areas.

In this regard, FMCN has proven experience concerning labor and working conditions to:

- Promote the fair treatment, non-discrimination, and equal opportunity of workers.
- Establish, maintain, and improve the worker-management relationship.
- Promote compliance with national employment and labor laws.
- Protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the supply chain.
- Promote safe and healthy working conditions and the health of workers.
- Avoid the use of forced labor.
- Advocate to organizations implementing grants to comply with Mexican Labor Law and best hiring practices.

The Mexican Labor Law is recognized internationally as one of the most complete. FMCN has a strong track record of adhering to it and helping associates and recipients to understand and follow its requirements. FMCN does not have a standard of its own related to labor and working conditions and this may be perceived as a risk. Thus, in the following months FMCN will incorporate this standard based on the lessons learned in applying the Mexican Labor Law.

Besides the screening process and the ESA, the project also developed the following supplementary instruments to avoid, minimize, and manage other specific environmental and social risks and impacts:

- Risk Assessment and Management (Annex 7)
- Environmental and Social Action Plan (Annex 12)
- Gender Assessment and Gender Action Plan (GAP, Annex 4)
- Analysis of climate change risks, impacts, and vulnerability analysis (Chapter 1.2)
- Project activities (Chapter 3)
- Stakeholder analysis and Stakeholder Engagement Plan (Chapter 5.1)
- Grievance Redress Mechanism (Chapter 5.4)

Table 1.33. Overview of environmental and social risks and mitigation measures by component and activity of the project.

Project Outcome	Project Output	Project Activities	Environmental Risks	Social Risks	Mitigation Measures
1. Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices	1.1 Increased area of land conserved, restored, or under best management practices that reduce climate vulnerability.	1.1.1. Provide funding -through different schemes- to subprojects to conserve, restore and improve management practices to increase adaptive capacities trough river restoration. 1.1.2. Support subprojects to implement procedures to maximize environmental and social benefits, with a gender approach.	• The number of potential beneficiaries who voluntarily apply to receive support is less than expected, and proposals do not achieve the desired geographic connectivity (refer to Annex 7 and 12 for more detail). • The expected environmental outcomes are not achieved.	• Lack of credibility in the process of evaluating and selecting proposals. • The project may exclude marginalized/vulnerable groups from participatory processes or project benefits. • The project may reproduce discriminations against women based on gender, especially regarding participation in design and implementation or access to opportunities and benefits. • Social conflicts within or among communities/ organizations/people to access to the project benefits.	• Design the call for proposals founded on social inclusion to favor sub-projects from different groups (organized or unorganized communities/organizations/people, women, youth, vulnerable groups, among others). • Include in the call for proposals clear selection criteria subject to review to build transparency in the process. • Develop a strategy for the dissemination of the RFP culturally appropriate (considering language, location, literacy levels, among others) and widely distributed by different communication channels (e.g. local radio, newspaper, social media, among others) to encourage participation. • Invite external evaluators to the proposal selection process. • Publish the results of the selection process in the same communication channels used to disseminate the call. • Additional incentives for increasing forest and water connectivity area, such as Payment for Performance schemes, are authorized according to sub-project results. • The Gender Action Plan (GAP) contains specific associated mitigation measures to promote women´s active participation (refer to the GAP). • The Grievance Redress Mechanism (GRM) is operational during all the lifetime of RIOS to receive ongoing feedback (refer to the Appendix 4.4).

			• Disregard the recommendations of scientific and technical studies.	• Lack of technical and administrative capacities.	• Strengthen the capacities of the executors of the sub-projects through technical assistance, workshops, and the learning community. • The project´s qualified staff advises and gives a close follow-up to the development of the sub-projects. • Fulfill periodic assessments for all the sub-projects, including progress reports and follow-up field visits. • Deliver reports to the Technical Committee (TC) and the GCF on how the ESAP is being addressed and respected. • An environmental and social specialist hired to observe and manage the potential risks arising during the sub-project's operation. • The GRM is operational during all the lifetime of RIOS to receive ongoing feedback. • The contracts between FMCN and sub-project executors include specific clauses requiring compliance with FMCN´s NSASG and projects related performance standards.
	1.2. Target communities have applied a participatory methodology for	1.2.1. Monitor biodiversity and water quality impact of subprojects through community participation.	• Disregard the recommendations of scientific and technical studies.	• Absence of participatory processes to adjust the existing methodologies.	• The Stakeholder Engagement Plan (SEP) is operational to support participatory and inclusive processes and achieve stakeholders´ active engagement and awareness (refer to the Appendix 4.1).

	monitoring biodiversity and water quality to provide inputs for an evaluation of the ecosystem and social vulnerability of the basins.	1.2.2. Evaluate vulnerability of the watershed-dependent communities with a participatory methodology.		• Insufficient information and awareness on the ecosystem and social vulnerability and the benefits of monitoring. • Lack of appropriation of the monitoring methodologies. • Exclusion of marginalized/vulnerable groups from training and monitoring activities.	• Develop a communication strategy on the importance and usefulness of vulnerability monitoring to sensitize local actors. • The capacity building program for the adoption of the monitoring methodologies is culturally appropriate and gender-responsive in terms of language, methodology, content, and logistics (e.g. time and place suitable for women and other vulnerable groups). • Disseminate the results of vulnerability assessed through culturally appropriate materials, workshops, and the learning community.
	1.3. A learning community fostering knowledge has exchanged and coordinated experiences between watersheds and with key actors to increase functional connectivity.	1.3.1. Develop a multi-stakeholder knowledge exchange platform to mainstream river restoration. 1.3.2. Scale-up lessons learned from subprojects to inform local and national policies and programs.		• Exclusion of marginalized/vulnerable groups.	• Develop a strategy for dissemination on the importance and usefulness of connectivity instruments. • Design a culturally appropriate communication strategy, including experience exchange workshops, communication materials and platforms, and the learning community. • The GRM is operational during all the lifetime of RIOS to receive ongoing feedback (refer to the Appendix 4.4).
2. Alignment of public and private investments through natural capital accounting for scaling-up activities for	2.1. Investments of public programs in targeted watershed catalyzed towards climate	2.1.1. Assess the economic value of ecosystem services to catalyze public financing.		• Insufficient lobbying and lack of appropriation.	• Map public programs with investments in connectivity at the beginning of the activity. • Develop and implement a strategy for dissemination and advocacy on the importance and convenience of investing in connectivity and vulnerability reduction. • Align incentives and public policy advocacy for a paradigm shift in financial markets.

the restoration of rivers for adaptation to climate change	resilience have increased.	2.1.2. Promote the alignment of regulatory instruments and programs at the federal / state level to promote river restoration through EbA.			• Strategically use private investment to leverage public funding.
	2.2. Investments of private programs in targeted watershed catalyzed towards climate resilience have increased.	2.2.1. Conduct assessment of the economic value of ecosystem services to promote private incentives.	• Dearth of empirical evidence and systematic knowledge of the financing scope specifically directed towards environmental and developmental sustainability action including climate mitigation and adaptation, holistic landscape approaches, ecosystem services, green supply chains, and biodiversity conservation.	• Insufficient lobbying and appropriation. • Short-term investments.	• Deepen the mapping of stakeholders at the beginning of the activity to identify the specific list of key private contributors. • Develop and implement a strategy for dissemination and advocacy on the importance and convenience of investing in connectivity and vulnerability reduction. • Strategically guide public funding to leverage private sector investment. • Provide sufficient empirical evidence on project performance and financial viability by the Natural Capital Accounting System to incentivize private sector investments. • Use the IWAPs to locate the best areas in the territory to promote connectivity for the efficient allocation of capital from the private sector.
		2.2.2. Facilitate the implementation of schemes that link the private sector to river restoration as an adaptation measure.			

	2.3. Dedicated credit lines, and financial products and services developed towards climate resilience have increased.	2.3.1. Develop/improve dedicated credit lines and financial products to catalyze financing for EbA activities related to river restoration.	• The indicative properties for sustainable products and operations are not appropriately established or unrelated to environmental activities.	• Market and policy barriers and gaps. • Weak demand for environmental finance. • Environmental lending may be perceived as more complex to appraise, more difficult to promote to customers, and more onerous in terms of reporting. • Absence of capacity and willingness of local financial institutions to develop products for environmental activities and the ability of international financial institutions to support them. • Lack of awareness and willingness among end borrowers to invest in environmental activities. • Producers cannot access the dedicated credit line due to intricate due diligence requirements. • Over indebtedness among borrowers.	• Dialogue with relevant stakeholders: national authorities, international institutions, professional and business associations, financial institutions, among others, for support and strategic focus. • Position environmental lending as a potentially profitable market. • Provide technical assistance to financial intermediaries for designing and effectively disbursing environmental credit lines but with strict technical performance standards. • Assess and understand the internal capabilities and resources of the financial institution to determine the additional support and incentives needed to reduce risks of failure in the product launch.

				• Producers cannot access specialized credit lines.	• Invest in addressing specific capacity gaps related to technical, organizational, financial, and commercial skills, for producers to prioritize and develop bankable projects and meet due diligence requirements. • Provide TA to producers to improve their capacity to understand credit appraisal processes and prepare business plans, and credit proposals to evaluate their market position and the financial options available for accelerating the transition to climate-resilient sustainable production systems in non-forest areas.
3. Design of a National River Restoration Strategy for climate change adaptation	3.1. The design of the National River Restoration Strategy has been supported.	3.1.1. Design and agree with key stakeholders on a National River Restoration Strategy.	• Disregard the recommendations of scientific and technical studies.	• Absence of participatory processes to design the NRRS. • Do not consider local people´s access and customary use of natural resources.	• Deepen the mapping of stakeholders at the beginning of the activity to identify the specific list of key people to involved in the design of the NRRS. • Develop participatory processes to incorporate different points of view, experiences, and practices in the design of the NRRS. • The GRM is operational during all the lifetime of RIOS to receive ongoing feedback (refer to the Appendix 4.4).
	3.2. Legislators and officials have actively participated to operationalize the National River Restoration Strategy.	3.2.1. Involve key stakeholders on EbA for river restoration, with a gender approach.		• Insufficient lobbying and appropriation.	• Assess the policy and regulatory framework, sector, and policy priorities. • Deepen the mapping of key legislators. • Develop and implement a strategy for dissemination and advocacy on the importance and convenience of the NRRS.

Table 1.34. Potential negative impacts of productive activities and best productive practices to implement.

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GREEN CLIMATE FUND

FONDO MEXICANO PARA LA CONSERVACIÓN DE LA NATURALEZA, A.C. FMCN INSTITUCIÓN PRIVADA

Productive activity	Action	Environmental/social impact to be avoided	Best Productive Practice
Riparian systems	Establish seed banks and nurseries for reforestation /restoration of riparian areas with native germplasm	Collect seed without control of origin and quality.	Follow collection protocols to ensure that biodiversity is not negatively impacted and that the origin and quality of the seed can be traced.
	Community work on reforestation/restoration of riverbanks (for example, watershed committees)	The employment generated for reforestation/restoration activities is concentrated in a few people.	Promote that the jobs generated are openly convened through traditional or new governance spaces.
		Jobs are generated without elementary conditions of job security.	Community jobs should ensure minimum safety conditions at work.
	Restoring riverbanks with native vegetation	The restoration areas are returned to the previous productive use, since they can mean loss of productive surface for the farmer / livestock farmer.	Preferably promote use of local species, with use or economic value for farmers / ranchers.
			Promote the economic valuation of restored areas with payment schemes for CO_2 capture or environmental services.
	Establish organic fertilizer production systems (vermicomposting, bocashi, supermagro)	High demand for labor in the production of organic fertilizers and repellents makes it difficult for farmers and ranchers to adopt them.	Promote the adoption of organic fertilizer self-produced or biofactories for local consumption: local production units managed by women and men capable of supplying local demand at competitive prices with respect to industrial agro-inputs.
		Low quality controls in the production of organic fertilizers and repellents reduce their effectiveness.	Establish biofactories: local production units managed by women and men trained to produce organic fertilizers following standardized procedures and protocols (formulations, labeling, etc.) that allow quality control.
Restoration	Reforest with native species	Failure or low percentage of survival derived from poor selection of areas and techniques for reforestation	Avoid bad plant adaptation by using native plants and having nurseries in the area. Consider local and scientific knowledge about the habits and phenology of local species to determine which are most suitable for reforestation with native species.

		Reforestations located without considering priority areas.	Guide, as far as possible, the location of reforestations in priority areas.
	Restore forests with native species	Poor selection of native species does not allow the restoration of original forest composition and structure.	Select species for restoration considering the composition, structure and successional stages of native forests.
	Restore patches to increase connectivity	Connectivity is promoted only between forest areas.	Connectivity is promoted considering the strategic importance of agroforestry areas (e.g. shade coffee).
	Establish Units for Management and Sustainable Use of Wildlife (private and community areas dedicated to manage wildlife with expected economic returns, including conservation in situ, reproduction in captivity for sustainable use, reduction of loss of habitat)	UMAs do not remain because of economic unfeasibility.	Determine the feasibility of establishing UMAs considering their economic sustainability.
	Manage forest areas sustainably through plant health, clearing and pruning	Restoration activities without technical bases have high costs and low effectiveness.	Provide training based on proven and effective restoration experiences.
	Eradicate invasive exotic species	Use of agrochemicals to eradicate invasive/exotic species.	Training in integrated plague and nutrient management and promote the responsible and safe use of agrochemicals to eradicate invasive/exotic species.
			Generate jobs that value the work of manual eradication of exotic/invasive species.
	Maintain and manage reforested areas (fire prevention, promote activities that increase regeneration).	Unsuccessful reforestation or total loss due to high cost and low motivation for maintenance	Consider in the budget's costs of maintenance and replacement of plants at least three years after the establishment of the reforestation.
			Include other reforestation alternatives not based solely on tree planting (e.g. cattle exclusion fencing to encourage passive reforestation, establishment of perch trees to attract seed dispersers, promote seed banks etc.)
	Establish and maintain nurseries	Few nurseries are established for the production of native species, and	Promote the participation of women in nursery

	with native species.	women's capacity to operate them is not used.	projects.
	Restore wetlands and their natural dynamics	Unsuccessful wetland restoration or total loss due to high cost and low motivation for maintenance.	Consider in the budgets costs of maintenance and replacement of plants at least three years after the establishment of the reforestation.
	Develop capacities in restoration techniques	Restoration activities without technical bases have high costs and low effectiveness.	Provide training based on proven and effective restoration experiences.
Managing forests for conservation and connectivity	Identify, evaluate and control pests and diseases with integrated pest management practices (based on natural enemies)	Nurseries do not remain because of economic unfeasibility.	To link the authorized nurseries with CONECTA projects and other initiatives to ensure continuous purchase of plants.
		Worms used in vermicompost are exotic and may displace local worm species.	Consider recent studies on the impacts of the displacement of local species by exotic worms and test the efficiency of local species to produce vermicopost.
		The Integrated Management of Pests and Vectors (IMPV) approach is not adopted. Farmers / ranchers return to conventional practices of agrochemical use.	Train/sensitize in IMPV and on impacts on human health and the environment due to the use of agrochemicals.
			Training on the responsible and safe use of agrochemicals, including knowledge of regulations, as well as the use of personal safety equipment.
	Train and acquire equipment for fire prevention, control and management	The brigades are not permanent due to the lack of community agreements.	Promote, together with other institutions (e.g. CONAFOR, CONANP), the organization / coordination of fire management at the community, ejido, municipality and regional levels.
	Establish agreements to restore and conserve areas released from livestock use, promoting their formalization as ADVCs.	Rotational/rational grazing increases the rate of grazing, which could lead to the expansion of livestock, rather than the area released from grazing being used for restoration.	Establish agreements with the owners of the land to improve the pasture index and other productive parameters of the livestock, while freeing up grazing areas for restoration.
	Build firebreaks and conduct actions for fire prevention, control and management	Fire breaks disabled due to lack of maintenance.	Promote, together with other institutions (e.g. CONAFOR, CONANP), the organization / coordination of fire management at the

			community, ejido, municipality and regional levels.
	Identify plants of interest and use by local communities	The potential of local species for food, productive and medicinal uses for people and animals is not being realized.	Promote local knowledge about plants (workshops to rescue and socialize traditional knowledge) and incorporate its use.
	Build nurseries for medicinal plants and plants for other uses	Little interest to establish nurseries for medicinal plants and other uses.	Promote the participation of women in nursery projects and seed banks.
	Define the species that are adequate for restoration	The use of unsuitable local species may delay or fail restoration.	Consider local and scientific knowledge about the habits and phenology of local species to determine which are most suitable for restoration.
			Consider local knowledge and perspectives on the uses of the species to try to make restoration compatible with the needs and expectations of the farming families.
Regenerative livestock	Grassland improvement (evaluation, pasture enrichment, rotation, introduction of trees, shrubs and herbs, e.g. legumes)	Dependence on purchase of seed from commercial annual pastures.	Evaluate the biological and economic relevance of grass, herbaceous and shrub species to be used for pasture improvement, prioritizing the selection of local and perennial species and highly nutritional species.
		Introduction of invasive alien species [22] of trees, herbs and shrubs.	Promote management practices that prevent the spread of invasive species, whether local or exotic.
		Inappropriate management of native species [23] that causes them to act as invasive species[24].	

[22] Exotic species are those species that are not native to a specific country or region and that arrived intentionally or accidentally, usually as a result of human activities. Alien species that become established in a new site, reproduce and spread uncontrollably, causing damage to the ecosystem, native species, health or economy are called invasive alien species.

[23] Native species are those species that are found within their natural or original (historical or current) range, according to their natural dispersal potential and are part of the natural biotic communities of the area.

[24] Invasive species are those species that were introduced to a country, region or ecosystem on purpose or accidentally and become a problem, as they displace, compete, prey on, parasitize, transmit diseases or change the habitat of native species and cause serious damage to natural systems.

	Divisions of grazing areas designed from contour lines to conserve soil.	Design of divisions of grazing areas without considering the slope, which can lead to gullies and soil erosion.	Train in sustainable technologies, including "Key line" type designs in the fixed and semi-fixed divisions of grazing areas.
	Establish exclusion fencing for livestock in riparian areas, springs and areas of reforestation, conservation or restoration.	Felling of trees to make the wooden posts to which the barbed wire is attached.	Promote exclusion fencing using electric fence, live fences to attach the wire, dead wood for posts, or buy posts from sustainable forestry companies.
		Livestock farmers "lose" pasture area when restoring riparian areas and see the profitability of their production units affected.	Plant local species with economic or use value for farmers within the riparian areas to be restored.
	Reforest/restore riparian vegetation along streams and rivers (ideally 15 meters or more on each side), excluding livestock or limiting their access points.	When their profitability is affected, the farmers convert the restored areas back into pasture.	Promote the economic valuation of restored areas with payment schemes for CO_2 capture or environmental services.
		Use of exotic species to restore or mismanage native species.	Use local timber and non-timber species to restore riparian areas.
	Establish drinking troughs to prevent animals from accessing bodies of water.	The bad location of the drinking troughs increases the probability of diseases and energy expenditure of the cattle to move, reducing productivity in meat/milk.	The design of grazing and rotational areas should incorporate the strategic location of drinking troughs and, if necessary, pumping systems (ram or other).
		Entry of livestock into bodies of water negatively impacts their quality (pollution by excreta), affecting vegetation and soil stability in riparian areas.	The exclusion of livestock from riparian areas and water bodies in general avoids negative impacts.
	Improve the sanitary management of livestock (vaccination schedules, use of products friendly to soil biodiversity, disease and vector schedules, etc.), improving animal welfare and complying with the legal framework. Improve the reproductive	Poor sanitary and reproductive management hinders the improvement of productive and reproductive parameters of livestock.	Training in basic health and reproductive management practices and on keeping good records (logs) of vaccination, deworming, estrus, etc.
		The non-adoption of good health/reproductive practices hinders raising standards and sales in formal and better paid commercial channels.	Training in basic accounting records and analysis of economic losses due to poor sanitary (e.g. loss of milk due to mastitis due to lack of hygiene in milking) and reproductive management.

	management of livestock (appropriate breeds, reproductive schedules, etc.), improving animal welfare and complying with the legal framework.	Misuse of drugs affects biota, their life cycles and reproduction.	Promote an Integrated Management of Pests and Vectors (IMPV) to avoid the use of drugs that affect biota or decrease their use under technically appropriate practices.
	Establish articulated biological corridors (reforestation, forest patches, riparian corridors, continuous areas of native grasslands, etc.) at the property level and between different properties.	Connectivity is established between forest patches that are not located within the priority areas.	Prioritize, to the extent possible, connectivity between forest patches located in priority areas, considering the strategic importance of agroforestry areas (e.g. shade coffee).
	Natural multipurpose barriers (trees, native grasslands) for live fences and against the wind.	Use of invasive alien species in living fences and windbreaks.	Promote preferably local species, with use or economic value for farmers.
	Intensive and rotary grazing by means of pasture division and scheduled rotation with fixed, mobile and electric fences, etc.	Mismanagement of intensive grazing systems can lead to soil compaction, overgrazing and loss of natural or induced pastures.	Training and punctual accompaniment to guarantee that the adoption of intensive and rotational grazing is done correctly, adapting it to local conditions.
	Manure management for incorporation into the soil.	Misuse of drugs such as ivermectins interrupts the life cycle of degrading organisms, causing pests (e.g. flies).	IMPV training to break pest life cycles and in the correct use of medicines (dose, time of application).
	To advise on the design of systems for watering livestock according to a grazing and water management plan.	Inadequate adoption of intensive/rotational grazing practices causes stress by limiting free access to water for livestock and generates erosive processes (e.g. gullies).	Promote the adoption of rotational/intensive grazing within the framework of an integrated management plan for pastures, soils and water.
	Development of local inputs for integrated pest and disease control.	Development of inefficient inputs due to poor technology adoption, without understanding the principles behind the use of local inputs as part of an IMPV plan.	Training and accompaniment to ensure the correct appropriation of the principles of the development and use of local inputs as part of an IMPV plan.
	Advise and promote best practices for storage of fodder/supplements for livestock feeding.	Poor fodder storage and feed supplement processing due to poor technology adoption, without understanding the principles behind these technologies.	Training and accompaniment, based on creative learning (such as farmer's schools), to foster the capacity to innovate among farmers.

	Recover native grassland coverage to achieve ecological connectivity.	Mismanagement of native grasslands can induce the invasion of other ecotones into the landscape.	Promote the care and recovery of native grasslands as part of a biodiversity management plan.
	Promote ecotechnologies that improve energy efficiency (biodigesters and solar electric fences).	The failed use of ecotechnologies due to a poor adoption of technology and without understanding the principles behind them, causes their abandonment and generates the perception that such alternatives are not effective.	Training and accompaniment, based on creative learning (such as farmer's schools), to foster the capacity to innovate among farmers.
Agroforestry systems	Enrich fallow areas.	Fallow areas impoverished by bad practices: abuse in the use of fertilizers, not considering the slope, excessive tilling kills the soil, etc.	Promote good soil management practices in fallow areas: zero, minimum or conservation tillage, incorporation of stubble with fallow, use of organic fertilizers, etc.
	Establish seed banks and nurseries for trees, grasses and other species.	Encourage the excessive extraction of seeds for the production of native species.	Follow collection protocols to ensure that biodiversity is not negatively impacted and that the origin and quality of the seed can be traced.
	Develop capacity in best practices for collecting honey, use of sotol, candelilla, oregano, orchids, mushrooms, palms, epiphytes, etc.	Best practices are not adopted for lack of economic benefit to farmers.	Generate payment schemes that value timber and non-timber forest products collected under sustainable practices.
	Conserve soils with agro- ecological practices (live fences, stubble, cover crops, organic fertilization, productive diversification).	Limited adoption of soil conservation and organic fertilization and productive diversification, due to its high demand for labor.	To train and raise awareness about the economic and environmental impacts of the loss of soils and their fertility due to bad practices.
			Exchange experiences between farms where good soil conservation and fertility practices generate economic and environmental benefits for farming families.
	Cultivate on slopes from strips following the contour lines and incorporating stubble and vegetation. Promote conservation tillage.	Limited adoption of the use of contour lines and conservation tillage, because they involve high demand for labor and do not represent immediate benefits.	Train / raise awareness of the economic and environmental impacts of soil loss and fertility due to poor practices.
			Exchange experiences between farms where good soil conservation and fertility practices generate economic and environmental benefits for farming families.

			Promote the economic valuation of restored areas with payment schemes for CO_2 capture or environmental services.
	Promote existing traditional family production systems (milpa with fruit trees - backyard - edible forest / mushrooms - wood - ornamental and medicinal plants).	Limited participation in the rescue and promotion of family production systems, because they involve high demand for labor and do not provide high monetary income.	Raise awareness of the economic and environmental impacts of the loss of agrobiodiversity. Exchange experiences between farms where good conservation practices of traditional family production systems generate economic and environmental benefits for farming families.
	Train and establish systems for the local production of fertilizers and organic inputs (worm compost, bokashi compost, supermagro, natural repellents and others).	Inadequate adoption of organic input production practices leads to problems with viruses, fungi, which affect production.	Training and technical support to ensure the understanding and adoption of the principles of safety in the production of organic inputs.
Other activities in livestock and agroforestry landscapes	Establish and maintain nurseries of native species (grasses, trees, legumes, etc.) that enrich forest systems with worm compost and other sustainable ecotechniques.	Encourage the excessive extraction of seed for the production of native species.	Follow collection protocols to ensure that biodiversity is not negatively impacted and that the origin and quality of the seed can be traced.

RIOS Exclusion List

The following is a list of activities that the project will not support:

- Activities that may increase greenhouse gases substantially or contribute to target areas´ increased vulnerability to natural disasters.
- Activities that support changes in land-use, clearing of native forests, degradation or any other alteration of natural habitats, or any unsustainable exploitation of natural resources.
- Introduction of non-native species or genetically modified organisms.
- The purchase of agrochemicals and chemicals for pest control, potentially harmful and that are currently prohibited in the country.
- Any kind of infrastructure that may promote deforestation, degradation, or any other alteration of natural habitats.
- Illegal trade of any wildlife or wildlife products under national laws and regulations, or international conventions, agreements, and bans.
- Activities that create adverse significant impacts on local people, even with the mitigation measures developed in their participation.
- Activities that result in a negative change to existing legitimate tenure rights or the involuntary resettlement of households.
- Activities carried out on land in litigation, dispute, or in ejidal/communal lands without the support of the Assembly.
- Activities resulting in significant damage or loss to cultural heritage, including archeological, paleontological, historical, religious, or unique natural values sites.
- Activities that support elections or political campaigns.
- The development of crops associated with the production of alcoholic beverages or drugs.
- Activities that may violate human rights.

1.8 Policy landscape

International background

For the past two-and-a-half decades, Mexico has been an international pioneer to tackle climate change, helping to advance international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC).

In December 2010, Mexico adopted the Cancun Agreements at the 16th Conference of the Parties (COP16) to establish a framework on Reducing Emissions from Deforestation and Forest Degradation (REDD+) and promote the conservation, sustainable management of forests and enhancement of forest carbon stocks. A breakthrough of the Agreements is the guidelines established to carry out REDD+ activities in a manner that safeguards important rights and guarantees.

In December 2011, Mexico embraced the Durban Outcomes at the 17th Conference of the Parties (COP17) for 1) the renewal of the Kyoto Protocol; 2) the funding and design of the work program for the Green Climate Fund, which would allocate USD $100 billion per year by 2020 to developing countries for climate change adaption; and 3) the reduction of global greenhouse gas emissions to apply to all countries, not only developed nations. An important result of COP 17 was the guidelines on the social and environmental safeguards to extend to all mitigation, adaptation, and emissions reduction actions undertaken by countries.

In September 2015, Mexico accepted the 2030 Agenda for Sustainable Development, its cross-cutting principles and 17 Sustainable Development Goals (SDGs), a roadmap to comprehensively achieve the world's main aspirations in terms of social justice, inclusive economic growth, and environmental protection, including those that contribute to the reduction of vulnerability and adaptation to climate change.

In December 2015, Mexico also signed the Paris Agreement to limit the increase in global average temperature to 2°C by the end of the century and reduce the impacts of climate change. By ratifying the Agreement in September 2016, Mexico committed to contributing to its fulfillment through a series of mitigation and adaptation goals, condensed in its Nationally Determined Contribution (NDC).

National scope

Mexico has taken proactive steps in international commitments, but also in national actions to address the challenge of climate change and the transition to a low carbon emission economy (Figure 1.44).

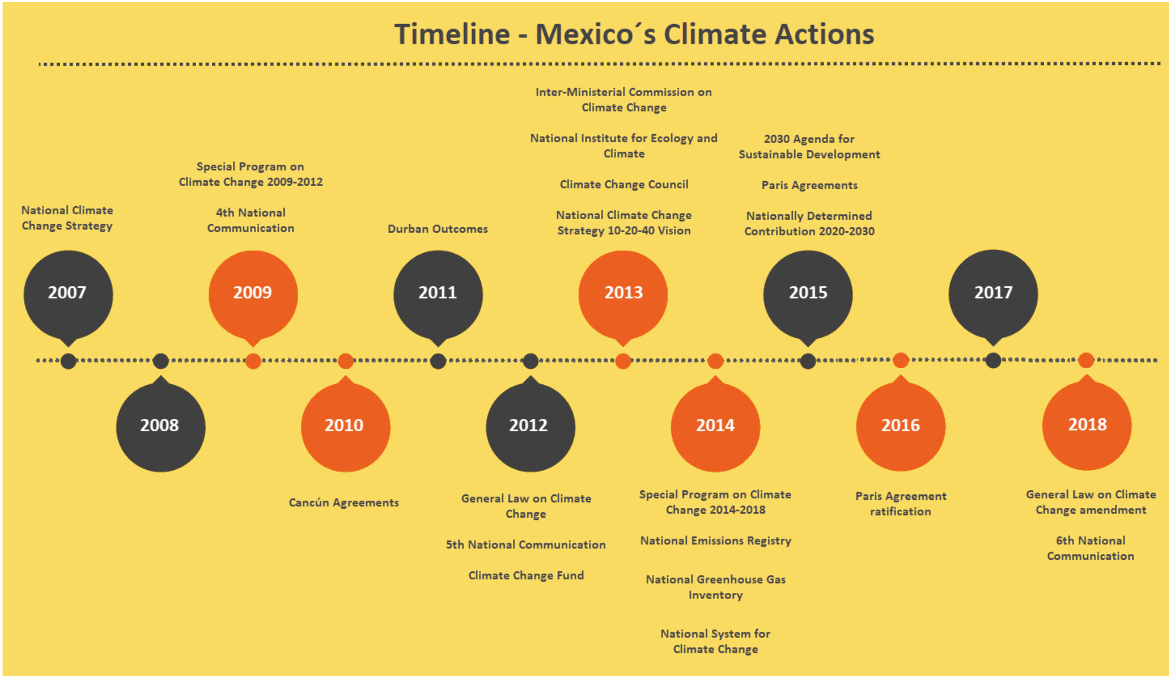


Figure 1.44. Mexico´s climate action timeline. Source: Own elaboration.

1. General Law on Climate Change (GLCC)

In April 2012, Mexico issued its General Law on Climate Change (GLCC) as its main policy instrument to reduce greenhouse gas (GHG) emissions and regulate the national mitigation and adaptation policy in compliance with the commitments made at COP16 and COP17. Its objectives are to: (1) reduce the vulnerability of the population, ecosystems, and infrastructure; (2) minimize risk and damage considering the current and future scenarios; (3) identify the vulnerability and capacity; (4) establish mechanisms for immediate attention; and (5) facilitate and promote food security. The law sets a target for a 30% reduction in GHG emissions below "business as usual" (BAU) by 2020 and a 50% reduction by 2050, concerning those issued in the year 2000 (baseline).

The GLCC establishes two main climate-planning instruments:

a) National Climate Change Strategy (ENACC)

In 2007, Mexico formulated its first National Climate Change Strategy (ENACC, Spanish acronym). The ENACC identifies opportunities for emissions reductions voluntarily, as well as measures for the development of necessary national and local capacity for response and adaptation. In 2013, Mexico reaffirmed the ENACC providing a long-term vision for the country with a time horizon of 10, 20, and 40 years. Its main strategic adaptation axes are to: (1) reduce vulnerability and increase the resilience of the social sector; (2) reduce vulnerability and increase the resilience of strategic infrastructure and productive systems; and (3) conserve and sustainably use ecosystems and maintain the environmental services they provide. The ENACC defines the objectives and specific actions for mitigation and adaptation every six years, so it is in the process of being updated.

b) Special Program on Climate Change (PECC)

In 2009, Mexico published its first Special Program on Climate Change (known in Spanish as PECC), containing its long-term climate change agenda for the country, together with medium-term goals for adaptation and mitigation.

In 2014, Mexico published the PECC 2014-2018 establishing the targets, strategies, actions, and goals to address climate change by defining priorities in terms of adaptation, mitigation, research and assignment of responsibilities, coordination of actions, and results. It is strongly linked to the National Development Program and the sectoral development programs of the Ministries of State. Its two objectives for Mexico´s adaptation to climate change are to: (1) reduce vulnerability and increase the resilience of the population, the productive sectors and strategic infrastructure; and (2) conserve, restore and sustainably manage ecosystems, guaranteeing their environmental services for mitigation and adaptation to climate change.

The GLCC also created the National System for Climate Change (SINACC), an institutional framework that emphasizes the need for a cross-cutting, cross-sectoral approach to climate change, and the critical importance of achieving wide stakeholder participation and efficient coordination between the public, private and social sectors, with the following structure and functions (Figure 1.45):

- ***Inter-Ministerial Commission on Climate Change*** (CICC, for its acronym in Spanish). A commission of 14 federal government ministries: Ministry of Environment and Natural Resources (SEMARNAT), Ministry of Foreign Affairs (SRE), Ministry of Energy (SENER), Ministry of Finance and Public Credit (SHCP), Ministry of Social Development (SEDESOL, since 2018 named Ministry of Welfare), Ministry of the Interior (SEGOB), Ministry of the Navy (SEMAR), Ministry of Economy (SE), Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA, now SEDEMA), Ministry of Communications and Transportation (SCT), Ministry of Public Education (SEP), Ministry of Health (SSA), and Ministry of Tourism (SECTUR). Its mandate includes 1) to formulate and implement national policies on climate change mitigation and adaptation, by mainstreaming climate action in sector-level programs and actions; 2) to develop criteria for the cross-cutting public climate change policies; 3) to approve the National Climate Change Strategy, and 4) to participate in the elaboration and implementation of the PECC.
- ***Climate Change Council*** (C3). A permanent advisory body of the CICC composed of at least 15 leaders from the government, private sector, academia, and society, with renowned merit and experience in climate change. Some of its responsibilities include 1) to advise the CICC and provide recommendations to conduct studies, policies, actions, and goals to combat climate change, and 2) to promote social participation, through public consultation processes.

- ***National Institute for Ecology and Climate Change*** (INECC, as known in Spanish, Technical leader of this proposal). A federal agency with a mandate including climate change scientific and technological research and policy advice, GHG inventories and reporting under the UNFCCC, and evaluation of climate change policies and programs.
- ***Federal Congress***, comprised of the Senate and the Congress to propose, discuss, and approve laws or amendments to existing legislation that lead to a reduction of greenhouse gas emissions, climate change mitigation, and adaptation strategies. In the Senate, this work is done by the Special Commission on Climate Change and by the Commission on the Environment and Natural Resources. In the Congress, the Climate Change Commission does this work.
- ***State governments.*** State government representatives 1) develop, conduct, and evaluate the state-level climate change policy, such as implementing climate change mitigation and adaptation actions, 2) develop comprehensive greenhouse gas mitigation strategies, programs, and projects to promote efficient and sustainable public and private transportation, 3) process and integrate state-level emission source data for incorporation into the National Emissions Inventory and the state risk atlas, and 4) develop and implement their climate change programs.
- ***National Associations of Municipals Officials***, composed of the Mexican National Confederation of Municipalities, the Mexican Association of Local Authorities, and representatives of the federal legislature. Some of its responsibilities include: 1) to develop, conduct, and evaluate municipal climate change policy, as well as strategies, programs, and projects on climate change mitigation, 2) process and integrate municipal-level emissions source data for incorporation into the National Emissions Inventory, and 3) participate in the design and implementation of incentives.

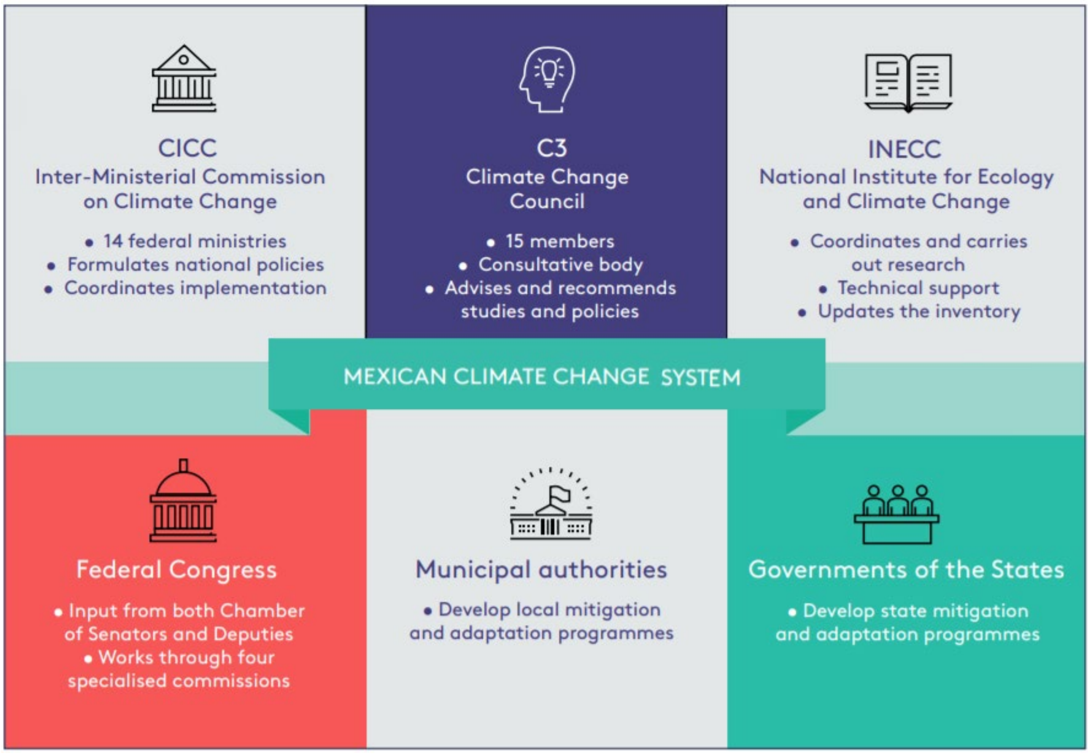


Figure 1.45. Structure and functions of the National System on Climate Change (SINACC). Source: Averchenkova & Guzmán (2018).

On financing, the GLCC provides the legal basis for market-based instruments, such as emissions trading and carbon taxes. It also creates the Climate Change Fund, to help finance climate projects in the country.

In 2018, the GLCC was amended to bring it into greater consistency with the Paris Agreement, incorporating the goal to limit the increase of the average temperature of the planet less than 2°C. It adopts Nationally Determined Contribution (NDC) as an associated instrument in combination with the development of a transparency framework.

2. Nationally Determined Contributions (NDC)

The Nationally Determined Contributions (NDC) is the agreement of the countries to submit a plan of action for reducing GHG to the UNFCCC.

In 2015, Mexico became the first country to include climate adaptation goals and actions in its intended NDC leading up to the adoption of the Paris Agreement. The commitments that Mexico assumed in its NDC are in line with the objectives, priorities, and mandates established in the GLCC.

These NDC are structured in two components, one for mitigation and another related to adaptation. The mitigation component includes two types of measures: unconditional and conditional. The unconditional set of measures are those that Mexico will implement with its own resources, while the conditional actions are those that could be implemented if a new multilateral climate regime is established from which Mexico would obtain additional resources and would achieve effective mechanisms for technology transfer. Mexico has an unconditional commitment to reduce its greenhouse gas emissions by 22% and black carbon emissions by 51% by 2030, compared to BAU, and the conditional target of a 36% reduction of GHG and black carbon by 70% by 2030 under the NDC. The decree also introduced sectoral emission reduction targets and included provisions for new and strengthened existing policy mechanisms, including provisions for the National Adaptation Plan, emissions trading, and a transparency framework for the NDC.

Under the adaptation component, Mexico committed to improving resilience and reducing vulnerability to both extreme hydro-meteorological phenomena and long-term environmental degradation processes. The component includes measures in three main areas: adaptation of the social sector, ecosystem-based adaptation, and adaptation of strategic infrastructure and productive sectors. To reach these adaptation priorities, Mexico will strengthen the adaptive capacity of at least 50% of Mexico´s most vulnerable municipalities, protect the population through early warning systems and risk management, and achieve a zero rate of deforestation by the year 2030 (Table 1.35). During 2020, the NDCs will be updated.

Table 1.35. Adaptation measures for the implementation of Mexico´s NDC. Source: Ortega et al. (2018). Those measures with which the project contributes are marked in **bold**.

Sector NDC	Adaptation Measures
Adaptation of the social sector	**• Increase the resilience of 50% of the most vulnerable municipalities in the country.** **• Incorporate climate considerations, gender perspective, and a human rights approach in all instruments for territorial planning and risk management.** • Increase financial resources for disaster prevention and response. • Establish land use regulations in risk areas. **• Integrated watershed management to ensure access to water and food security, as well as biodiversity and soil conservation.** **• Ensure capacity building and social participation of all stakeholders, including local communities, indigenous groups, women, youth, civil organizations, and the private sector, in the planning of national and subnational climate change adaptation policy.** • Reduce the population's vulnerability and increase its adaptive capacity through early warning and risk management systems, as well as hydro-meteorological monitoring systems, in all levels of government.
Ecosystems-based adaptation	• Achieve a zero rate of deforestation by 2030. **• Reforest the upper, middle and lower basins, with special attention to riparian zones, considering their native species.** **• Increase ecological connectivity and carbon capture through conservation and restoration.**

	• Increase carbon sequestration and coastal protection through the conservation and recovery of marine and coastal ecosystems. • Substantially increase the number of Action Programs for Species Conservation to strengthen the protection of priority species facing the negative impacts of climate change. • Promote synergies between actions to reduce emissions from deforestation and forest degradation, to promote the sustainable management of forests, and to preserve and increase carbon stocks in forests (REDD+). • Promote integrated water management in its different uses (agricultural, ecological, urban, industrial, domestic).
Adaptation of strategic infrastructure and productive sectors	• Install early warning and risk management systems. • Guarantee and monitor the treatment of urban and industrial wastewater in human settlements larger than 500,000 inhabitants. • Ensure the safety of strategic infrastructure. **• Incorporate climate change criteria in agricultural and livestock programs.** • Apply environmental protection standards and specifications for adaptation in coastal touristic and real-estate developments. • Incorporate adaptation criteria in public investment projects that include infrastructure construction and maintenance.

3. National Adaptation Plan (NAP)

In 2018, Mexico began the formulation of its National Adaptation Plan (NAP) (SEMARNAT-INECC, 2018). In conjunction with INECC and SEMARNAT, Mexico submitted a proposal to the Readiness and Preparatory Support Program of the Green Climate Fund (GCF) for obtaining funding for its NAP.

The NAP will define how the NDC commitments will: (a) reduce the vulnerability of society and ecosystems from the effects of climate change through the promotion of adaptive capacity and resilience, and (b) integrate the adaptation to climate change approach into policies, activities and relevant programs (new and existing ones) in all sectors and at different levels, as appropriate, as established in the COP 16 and COP 17 (SEMARNAT-INECC, 2018).

The NAP conceptual framework consists of four stages: 1) assessment of vulnerability (diagnosis); 2) design of adaptation measures (planning); 3) implementation of adaptation measures; 4) monitoring reporting, verification, and evaluation of adaptation (Figure 1.46).

SEMARNAT, with the participation of the CICC, shall review the NAP at least every six years. Explanations must be provided for any deviations detected between the projected estimates and the results evaluated. Once committed, goals, projections, and objectives cannot be retracted or reduced in subsequent evaluations despite the progress noted. This is a clear indication of Mexico’s commitment to continuously move forward in its efforts to address climate change.

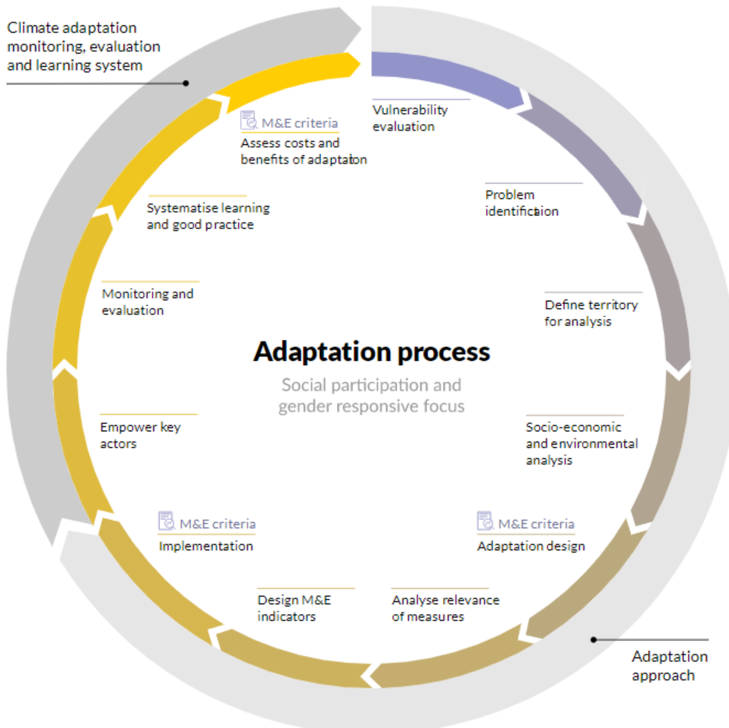


Figure 1.46. Mexico´s perspective on climate adaptation process and the role of monitoring and evaluation. Source: IIED (2019).

4. National Development Plan 2019-2024

The National Development Plan 2019-2024 (PND) sets objectives and strategies to combat climate change, as well as reducing greenhouse gas emissions. In its Cross-cutting Axis 3 "Land and sustainable development" it states that all public policy must consider, among its different considerations, the vulnerability to climate change and strengthening the resilience and capacities of adaptation and mitigation, especially if it impacts the most vulnerable populations or regions. Among others, the PND proposes:

- To keep on with the Sustainable Development Goals (Agenda 2030) and combating climate change.
- To strengthen the capacity of adaptation to climate change of populations, ecosystems, and strategic infrastructure, under a human rights-based approach and climate justice, incorporating traditional knowledge and technological innovation.
- To promote the sustainable use of natural resources, soil, and water, considering the effects of climate change on agricultural production, aquaculture, and fisheries.
- To encourage economic development for the reduction of greenhouse gas emissions and greenhouse gas compounds and adaptation to climate change to improve the population's quality of life.

- In rural areas, to develop programs of reforestation and ecosystem protection for the conservation, sustainable management, restoration and connectivity of natural ecosystems to facilitate adaptation to climate change, since the restoration helps to reduce various impacts, including floods and soil erosion, and facilitates the adaptation of the flora and fauna and crops to climate change.
- To stimulate investment in mitigation and adaptation to climate change and enable the conditions to foster the transfer of other international and private financial flows in favor of its combat.
- To support the productive inclusion through climate change mitigation and adaptation activities based on the productive vocation and the knowledge of the territories with a medium- and long-term vision.

5. State Programs on Climate Change

The participation, concurrency, and coordination of the three orders of government (federal, state, and municipal) are key elements for the consolidation of the national policy on climate change in Mexico.

In this sense, the federal entities have the responsibility to develop their climate change programs for formulating, conducting and evaluating its climate change policy, following the national policy to include diagnoses of current and future vulnerability and adaptive capacity to climate change, and define actions for adaptation to climate change with indicators for monitoring and evaluation.

a) Veracruz

The Program on Climate Change of Veracruz (PVCC, Spanish acronym) was published in 2009. The fundamental purpose of the PVCC is to provide trustworthy information to Veracruz´s society and decision-makers so that they can understand the phenomenon of climate change and its possible consequences in the state. The PVCC includes the state inventories of GHG emissions; an analysis of regionalized climate change scenarios; and the assessment of vulnerability in key sectors, such as biodiversity, water, and other resources. Likewise, it includes proposals for mitigating GHG emissions and climate change adaptation; containing an analysis of the state´s legal framework, outreach and dissemination activities on the topic, and the creation of specialized human resources.

Additionally, in 2010 Veracruz established its State Law for Climate Change Mitigation and Adaptation and created the Secretariat of Environment of the State of Veracruz with a Climate Change Unit. In 2011, the state developed its Strategy for Climate Change Mitigation and Adaptation. In 2012, Veracruz established its State Council for Climate Change Mitigation and Adaptation, as well as the Municipal Climate Action Plans.

b) Jalisco

When it comes to climate change actions, Jalisco has positioned itself as a good example thanks to its constant work on developing its climate change policy and the institutional arrangements to address the problem.

This state has published its Climate Change Action Law for the State of Jalisco (LACCEJ in Spanish), its State Climate Change Action Program (PEACC); a Monitoring, Reporting, and Verification (MRV) and Monitoring and Evaluation (M&E) System that helps monitor 83 measures and 124 actions of the State Government. It also has a Climate Change Action Inter-Institutional Commission and Inter-Municipal Environmental Boards that provide technical support on various topics, including climate change. Additionally, the LACCEJ requires that municipalities develop Municipal Climate Change Programs (PMCCs).

Jalisco has also been a leader in exploring initiatives such as the "Low Carbon State Program", which involves the development of a carbon management tool oriented to reduce the energy consumption of the state government; the consumption of electricity from the recently inaugurated Los Altos wind farm; the cooperation with ICLEI-Local Governments for Sustainability, for the development of several municipal climate action plans, among other projects, all which enable Jalisco to play a significant role in the Mexican environmental policy and political development. Moreover, the Governor of Jalisco recently signed the Subnational Global Climate Leadership Memorandum of Understanding (Under 2 MOU). The guiding principle is the reduction of GHG emissions by 2050 to limit global warming to less than 2°C; this means pursuing emission reductions consistent with a trajectory of 80 to 95% below 1990 levels by 2050 and/or achieving a per capita annual emission goal of less than 2 metric tons by 2050.

1.9 Legal landscape

Regulatory Framework on Climate Change	
Mexico	
Mexican Constitution	Includes economic, social, and cultural rights of the Mexican people and calls for a federal government that takes an active role in promoting those rights. **Article 4.** The Mexican State has the obligation to guarantee to all persons a healthy environment for their development and well-being. **Article 25**. The Mexican State has to ensure that national development is integrated and sustainable.
General Law on Climate Change	Establishes key elements to encourage adaptation of Mexico's natural and human systems to climate change. It lays the general foundations for regulating greenhouse gases emissions and compounds; regulating climate change mitigation and adaptation actions; reducing the vulnerability of the population and ecosystems to the adverse effects of climate change; conserving forest land uses and preventing its degradation and deforestation; promoting the efficient and sustainable use of energy resources; and in general, transitioning to a green economy. Federal, state, and municipal authorities will all be responsible for meeting concrete goals, such as the development of risk maps, urban development programs that consider climate change, and a subprogram for the protection and sustainable management of biodiversity to face climate change.
General Law of Ecological Balance and Environmental Protection (LGEEPA)	Addresses a broad range of environmental matters including water, air and ground pollution, resource conservation and restoration, and environmental enforcement. **Article 2.** It is of public utility the formulation and implementation of actions towards mitigation and adaptation to climate change. **Articles 5, 7, and 8.** The federal, state, and municipal authorities are responsible for the formulation and implementation of actions towards mitigation and adaptation to climate change. **Article 15.** There shall be incentives to whoever protects the environment, promote or perform actions on mitigation and adaptation to climate change, and take advantage of natural resources in a sustainable manner. **Article 23.** The federal authorities, the federal entities, and municipalities, in its sphere of competence, must avoid human settlements in areas where populations are exposed to natural disasters resulting from the adverse impacts of climate change. **Article 39.** The competent authorities shall promote topics on ecology, sustainable development, mitigation, adaptation and reducing vulnerability to climate change, protection of the environment, knowledge, values, and skills in the various educational cycles, especially at the basic level, as well as in the cultural formation of children and youth. **Article 41.** The Federal Government, the federal entities, and municipalities shall promote scientific research, technological development, and innovation that make it possible to determine the vulnerability, as well as measures to mitigate and adapt to climate change. This law also regulates in its transitory articles the development of the National Atlas of Vulnerability to Climate Change.

General Law for Sustainable Forest Development	Seeks to regulate and promote the conservation, protection, restoration, production, organization, and management of Mexico's forests to secure sustainable forest development. **Article 2.** To promote actions to comply with international treaties on climate change, biological diversity, and others. **Article 3.** Among its specific objectives are: • To promote the design and application of measures of prevention, mitigation, and adaptation to climate change. • To promote sustainable forest management to maintain and increase the gains of carbon, reduce emissions from deforestation and forest degradation, as well as reduce vulnerability, and strengthen resilience and adaptation to climate change. • To establish, regulate and implement the actions for mitigation and adaptation to climate change, following the General Law on Climate Change, the international treaties to which the Mexican State is a party and other applicable legal provision. • To design strategies, policies, measures and actions to achieve a zero percent loss of carbon, according to the General Law on Climate Change and the National Climate Change Strategy, and its incorporation into the planning instruments of forest policy, considering sustainable economic development of forested regions and community forest management. **Articles 10, 11, and 13.** The federal, state, and municipal authorities are responsible for developing actions that contribute to climate change adaptation and mitigation, as well as to combating desertification and degradation of forest land. **Article 47.** The data included in the National Inventory of Forestry and Soils (INFyS) will be the basis for the development of programs and climate change adaptation and mitigation strategies. It facilitates the implementation of the REDD+ mechanism, taking a critical step towards ensuring that local communities who sustainably manage their forests receive economic benefits derived from any future carbon payment scheme.
National Water Law (LAN)	Regulates the exploitation, use, and management of all national waters, surface or groundwater, its distribution, and control, as well as the preservation of its quantity and quality to achieve its integrated and sustainable development. **Article 84.** The National Water Commission (CONAGUA) will determine the operation of hydraulic infrastructure for flood control and shall take the necessary measures to follow up on extreme weather events, promoting or carrying out preventive actions that may be required; besides, it will perform the necessary steps, agreed with its technical advisory council, to address the hydraulic emergency zones or those affected by extreme weather events, in coordination with the competent authorities.
Law on Sustainable Rural Development	Promotes the sustainable rural development in the country, ensuring an adequate environment and the rectory of the State and its role in the promotion of equity, including planning and organization of agricultural production, industrialization and commercialization, and the other goods and services, and all those actions aimed at raising the quality of life of the rural population. **Article 116.** To establish a financial system for sustainable rural development with multiple modalities, instruments, institutions, and agents, which allows producers in all strata and their economic organizations and social enterprises to adapted, sufficient, timely, and accessible financial resources to successfully develop their economic activities. Preference will be given to small producers and economic agents with a low income, within areas of the country with lower economic and social development, with profitable productive projects or that are highly generators of employment, those who employ technologies for

	mitigation and adaptation of climate change, as well as the integration and strengthening of social banking.
Jalisco	
Law for Climate Change Action for the state of Jalisco (LACCEJ)	Defines the principles, criteria, instruments, and bodies for the implementation of the State Policy on climate change and to establish the basis for developing state and municipal public policies with cross-cutting criteria in the prevention, adaptation, and mitigation of climate change. The actions of adaptation and mitigation shall contribute to biodiversity, ecosystems and their services, to protect and improve the livelihoods of the population, and to guide the institutions, the productive sector and civil society toward sustainable development. Under the adaptation component, the LACCEJ commits to improving resilience and reducing the vulnerability of society, watersheds, natural ecosystems, and urban and agricultural systems to both extreme hydro-meteorological phenomena and long-term environmental degradation processes.
Municipal Program of Climate Change of Puerto Vallarta, Jalisco, 2020-2030 (PMCC PV)	Identifies the priority actions to be carried out in the municipality to reduce emissions of greenhouse gases and its vulnerability to climate change with scope to 2030. To achieve its objective, the PMCC PV has 61 adaptation and mitigation measures grouped into the following strategic areas: 1. Sustainable Productive Activities, 2. Energy Transition, 3. Integral Waste Management, 4. Ecosystem conservation and management, 5. Integral Water Management, 6. Sustainable mobility, and 7. Enabling Conditions. The strategic area on Ecosystem Conservation and Management contemplates measures to promote the sustainable use of natural capital, and focuses on ecosystems that are natural and cultural milestones, carrying out its restoration, conservation, and protection of its environmental services. Such ecosystems include natural reefs, beaches, forest areas, green areas, and wetlands.
Veracruz	
State Law of Mitigation and Adaptation to the effects of Climate Change	Sets the concurrency of the State and municipalities in the formulation and implementation of public policies for climate change adaptation, mitigation of its adverse effects, to protect the population and contribute to sustainable development.

The conservation and restoration of riparian forests depend on the legal aspects governing land ownership and use. Nevertheless, riparian forests in Mexico are often not considered as ecosystems in government programs or public policies related to natural resources management. To date, in the Mexican legal framework there is no instrument specifically or explicitly designed for the conservation of these ecosystems with a perspective of the ecotone, nor to set a minimum width of the strip of conservation for the maintenance of its biodiversity and ecological functions. However, some provisions that apply to their conservation, management, and restoration follow.

Regulatory Framework on Restoration and Riparian Forests	
Mexico	
General Law on Climate Change	**Article 7.** The Federal Government will establish, regulate and implement the actions for mitigation and adaptation to climate change in the field of preservation, restoration, conservation, management and sustainable use of natural resources, terrestrial ecosystems, aquatic, marine, coastal islands, cays, coral reefs, and water resources.

	Article 26. In the formulation of the national policy on climate change, the principle of environmental responsibility will be observed, especially those who perform activities that affect or may affect the environment will be obliged to prevent, minimize, mitigate, repair, restore, and, ultimately, to compensate for the damage done. **Article 29.** Be considered as adaptation actions: • The management, protection, conservation, and restoration of ecosystems, forest resources, and soils. • The watershed programs. • The establishment and conservation of natural protected areas and biological corridors. • The development of the atlas of risk. • The programs of conservation and sustainable use of biodiversity. • The strategic infrastructure in the area of water supply. **Article 30.** To strengthen the resistance and resilience of terrestrial ecosystems, beaches, coasts, and federal maritime zone land, wetlands, mangroves, coral reefs, marine, and freshwater ecosystems, through actions for the restoration of the ecological integrity and connectivity. Also, to establish new natural protected areas, biological corridors, and other forms of priority areas for ecological conservation to facilitate genetic exchange and promote the natural adaptation of biodiversity to climate change, through the maintenance and increase of the native vegetation, wetlands, and other management measures. **Article 33.** To promote the alignment and consistency of the programs, budgets, policies, and actions of the three orders of government to halt and reverse deforestation and degradation of forest ecosystems. **Article 34.** The Federal Government, federal entities, and municipalities will reduce emissions and carbon capture in the sector of agriculture, forestry, and other land use and preservation of ecosystems and biodiversity by strengthening systems for sustainable management and restoration of forests, forests, wetlands, and coastal marine ecosystems, particularly mangroves and coral reefs. Also, to design policies and actions for the protection, conservation, and restoration of riparian vegetation in the use, development, and exploitation of the riversides or federal zones, following the National Water Law. **Article 82.** The Climate Change Fund resources will be allocated in projects that contribute simultaneously to the mitigation and adaptation to climate change, increasing natural capital, with actions aimed to reverse deforestation and degradation; conserve and restore soils to improve carbon sequestration; implement sustainable agricultural practices; recharge aquifers; preserve the integrity of beaches, coasts, federal maritime zone land, and any other deposit that forms with maritime waters, wetlands, and mangroves; promote connectivity of ecosystems through biological corridors, preserving the riparian vegetation, and to take advantage of the biodiversity sustainably.
National Water Law (LAN)	**Article 7.** Are considered to be of public utility the protection, improvement, conservation, and restoration of watersheds, aquifers, waterways, vessels, and other water reservoirs of national ownership, catchment areas, federal zones, as well as natural or artificial infiltration of water to replenish aquifers following the Mexican Official Standards and the derivation of the waters of a river basin or hydrological region toward others. **Article 14 BIS.** CONAGUA, together with the federal entities and municipalities, the Watershed Organisms and Councils, and the Water Advisory Council, will sign agreements with water users for the conservation, preservation, restoration, and efficient use of water. In this regard: • The conservation, preservation, protection, and restoration of water in quantity and quality is a matter of national security; therefore, non-sustainable exploitation and the adverse ecological effects must be avoided. • Any person or legal entity that pollutes water resources is responsible to restore its quality, applying the principle that "who pollutes pays". **Article 41.** The Federal Executive may declare or decree the total or partial reservation of national waters to ensure the minimum flows for ecological protection, including the conservation or restoration of vital ecosystems. **Article 47 BIS.** The Water Authority will promote among the public, private and social sectors, the efficient use of water in towns and urban centers, the improvement in water administration, and the actions of management, preservation, conservation, restoration, and reuse of wastewater according to its use.

	Article 86 BIS 1. To propose the Mexican Official Standards to preserve, protect and, where appropriate, restore wetlands, the national waters that feed them, and the aquatic and hydrological ecosystems that are part of them. Also, to promote and, where appropriate, to perform the actions and measures necessary to rehabilitate or restore wetlands, as well as to fix a natural environment or perimeter of protection of the wet zone to preserve its hydrological conditions and the ecosystem.
General Law of Ecological Balance and Environmental Protection (LGEEPA)	**Article 1.** To promote sustainable development, conservation, and restoration of the soil, water, and other natural resources, so that they are compatible with the economic gains and the activities of the society towards the preservation and enhancement of the ecosystems. **Article 2.** Are considered to be of public utility the establishment, protection, and preservation of natural protected areas and areas of ecological restoration. **Article 3.** For this Law, restoration is the set of activities aimed at the recovery and reinstatement of the conditions conducive to the evolution and continuity of natural processes. **Articles 4, 5, 7, 8, and 11.** The Federal Government, federal entities, and municipalities will be responsible for the conservation and restoration of the ecological balance and environmental protection. **Articles 19, 20, and 20 BIS**. The Program for Ecological Ordering of the territory shall determine the ecological guidelines and strategies for the preservation, protection, restoration, and sustainable use of natural resources, as well as to the location of productive activities and human settlements. **Article 28.** The environmental impact assessment is the process by which SEMANRNAT sets out the conditions to activities that may cause ecological imbalance or exceed the limits and conditions outlined in the applicable provisions to protect the environment and preserve and restore ecosystems, to avoid or minimize their negative effects on the environment. Specially: • Land-use changes in forest areas, as well as jungles and arid zones. • Activities in wetlands, coastal ecosystems, lagoons, rivers, lakes, and estuaries connected with the sea, as well as in their coastlines or federal zones. • Fishing, aquaculture, or livestock activities that may endanger the preservation of one or more species or cause damage to ecosystems. **Article 53.** The areas of protection of natural resources are those aimed for the preservation and protection of the soil, watersheds, water, and, in general, the natural resources located in forest land. Within this category are the reserves and forest areas, areas of protection of rivers, lakes, lagoons, springs, and others considered as national waters, particularly when these are intended to supply water to the population. **Article 78.** In those areas that present processes of degradation or desertification, or serious ecological imbalances, SEMARNAT should formulate and implement Programs for Ecological Restoration, for the recovery and restoration of conditions conducive to the evolution and continuity of natural processes. In the formulation, implementation, and monitoring of those programs, SEMARNAT will promote the participation of the owners, possessors, public or private social organizations, indigenous peoples, local governments, and other interested persons. **Article 78 BIS.** When accelerated processes of desertification or land degradation involve the loss of resources difficult to regenerate, recover or restore, or exist irreversible damages to ecosystems or its elements, SEMARNAT will encourage the Federal Government for the establishment of Zones for Ecological Restoration and will develop the studies that justify them. **Article 90.** SEMARNAT, in coordination with the Ministry of Health, will issue Mexican official standards for the protection of rivers, springs, deposits and, in general, sources of water supply for populations and industries, and will promote the establishment of reserves of water for human consumption. **Articles 98 and 99.** In areas affected by degradation or desertification, actions of regeneration, recovery, and rehabilitation as necessary must be carried out to restore them. This criterion must be observed obligatorily in activities such as the creation of centers of population, the determination of the coefficients of rangeland or programs for the protection and restoration of soils in agricultural, forestry, and hydraulic activities. **Article 101.** In forest areas, the Federal Government will promote the regeneration, recovery, and rehabilitation of the areas affected by degradation or desertification, to restore them.

	Article 103. Those who engage in agricultural and livestock activities must carry out the conservation, sustainable use, and restoration practices necessary to prevent soil degradation and ecological imbalances and, where appropriate, to achieve their rehabilitation.
General Law for Sustainable Forest Development	**Article 2.** To conserve and restore the natural heritage and contribute to the social, economic, and environmental development in the country, through the sustainable management of forest resources in watersheds, with an ecosystem approach within the framework of the applicable provisions. To promote the prevention and integrated management of disruptive agents that affect forest ecosystems, mitigating its effects, and restore the damage caused by these. **Article 3.** Promote actions for purposes of conservation and restoration of soils and watersheds. **Article 4.** It is considered of public utility the conservation, protection, and restoration of forest ecosystems, watersheds, and their elements; as well as the execution of activities intended for the conservation, restoration, protection, and/or generation of environmental goods and services. **Article 7.** For this Law, restoration is the set of activities aimed for the rehabilitation of a forest ecosystem to recover partially or completely its original functions. **Articles 10, 11, 13, 15, and 20.** The Federal Government, through the National Forestry Commission (CONAFOR), federal entities, and municipalities will be responsible for: • Issuing rules for reforestation in areas of conservation and restoration and monitoring their compliance. • Promoting and participating in the restoration of forest ecosystems affected by wildfires. • Participating in the planning, implementation, and supervision of reforestation, soil restoration, and conservation of forest environmental goods and services, within its territorial sphere of competence. **Article 25.** CONAGUA and the Federal Electricity Commission (CFE) will coordinate with SEMARNAT and CONAFOR to develop actions and budgets for the integrated management of watersheds, as well as to promote reforestation of geographical areas with a natural vocation that benefits the recharge of the aquifers, in the valuation of environmental goods and services of forests in the watersheds and participate in the response to natural disasters or emergencies. **Article 117.** To prohibit the granting of land-use changes in forest land burned down before 20 years of age, unless it can be shown conclusively to the SEMARNAT that the ecosystem has been regenerated in its entirety. **Article 122.** CONAFOR, listening to the opinion of the Councils and considering the requirements of recovery in degraded areas and the socio-economic conditions of its inhabitants, will promote the development and implementation of programs and economic instruments that may be required to promote the conservation and restoration of forest resources and watershed management. **Article 123.** When existing processes of degradation or desertification, or serious ecological imbalances in forest land, CONAFOR shall formulate and implement, in coordination with the Federal Entities and the owners and legitimate possessors, ecological restoration programs for the recovery and restoration of its natural processes, including the maintenance of the hydrological regime, the prevention of erosion, the restoration of degraded soils, as well as the implementation of mechanisms for evaluation and monitoring of such actions. **Article 125.** For restoration and conservation, SEMANRNAT, listening to the technical opinion of CONAGUA and, where appropriate, of the National Commission of Natural Protected Areas (CONANP), will declare Areas for Forest Protection in those stripes along the rivers, ravines, permanent streams, banks of natural or artificial lakes and reservoirs, areas of recharge of the aquifers, with the limits, extensions, locations, and relevant requirements and based on criteria, indicators or the Mexican Official Standard. In all cases, the owners and holders of the land must be heard previously. **Article 126.** SEMARNAT will issue Mexican Official Standards aimed at preventing and controlling overgrazing in forest land; determine rangeland coefficients; to assess damage to soils and pastures; regulate the processes of reforestation and restoration of affected areas, and to reconcile silvopastoral activities. **Article 127.** The reforestation activities with purposes of conservation and restoration in degraded forest land will not require authorization and only be subject to the Mexican Official

	Standards, about not harming biodiversity; encouraging reforestation with native forest species. **Articles 135 and 136.** The Mexican Government, the federal entities, and CONAFOR will design, develop, and implement economic instruments to restore degraded forests. **Articles 155, 156, 157, 158, and 159.** Infractions, fines, and penalties for not complying with the regulations, including the related to not carrying out actions for restoration or mitigation being forced to do so.
General Wildlife Law	Regulates the conservation of wildlife and its habitat, through the protection and maintaining optimal levels of sustainable use, so that simultaneously to maintain and promote the restoration of its diversity and integrity, as well as increase the well-being of the inhabitants of the country. **Article 5.** The owners and legitimate possessors of the land where the wildlife distribute, as well as the people who share their habitat, shall participate in conservation, restoration, and the benefits derived from the sustainable use. **Articles 39 and 40.** The Management Units for the Conservation of Wildlife (UMA) will target the conservation of natural habitats, populations, and specimens of wild species, with specific objectives of restoration, protection, maintenance, recovery, reproduction, repopulation, reintroduction, research, rescue, shelter, rehabilitation, exhibition, recreation, environmental education, and sustainable use. The UMA shall register and develop a management plan. **Articles 60.** SEMARNAT will promote and encourage the conservation and protection of species and populations at risk, through the development of conservation and recovery projects, the establishment of special measures for the management and conservation of critical habitats and areas of shelter to protect aquatic species, the coordination of permanent monitoring programs, as well as for the certification of sustainable use, with the participation of people who manage these species or populations and others involved. **Article 60 TER.** It is forbidden the removal, filling, transplanting, pruning, or any activity that may affect the integrity of the hydrologic flow of the mangrove; of the ecosystem and its zone of influence; of its natural productivity; of the natural carrying capacity of the ecosystem for tourism projects; of the zones of nesting, reproduction, shelter, food, and hatchery; or of the interactions between the mangrove, the rivers, the dune, the adjacent maritime zone, and the corals, or to bring about changes in the characteristics and ecological services; except for activities designed to protect, restore, investigate or conserve mangrove areas. **Articles 61 and 62.** SEMARNAT shall draw up the lists of priority species and populations for conservation and programs for their recovery. **Article 70.** When destruction, pollution, degradation, desertification, or imbalance of wildlife habitat exist, SEMARNAT shall formulate and implement, as soon as possible, prevention, emergency, and restoration programs to the recovery and reinstatement of the conditions conducive to the evolution and continuity of natural processes of wildlife.
Law on Sustainable Rural Development	**Article 111.** The actions for sustainable rural development through infrastructure and the promotion of economic activities and generation of goods and services within all the productive chains in the rural environment shall be carried out following criteria for preservation, restoration, and sustainable use of natural resources and biodiversity, as well as prevention and mitigation of environmental impact. **Article 131.** The Federal Government will formulate and keep up to date the Risk Chart in the watersheds to establish disaster prevention programs, including actions for the conservation of soil, water, and surface runoff management.
NOM-060-SEMARNAT-1994	Establishes the specifications to mitigate the adverse effects caused to the soils and water bodies by forest exploitation. It does not use the concept of restoration but refers to one of its actions: reforestation. Specifies that the reforestation efforts must be made with native species as a preventive measure of erosion. Besides, it particularizes the reforestation of riparian vegetation when present signs of deterioration. **4.4.** Riparian vegetation should be preserved respecting its natural distribution on the shore of the water bodies; when present signs of deterioration, its recovery will be by reforestation with native species and soil management to achieve stability. **4.5.** In areas of distribution of riparian vegetation, forest sanitation may be carried out when technically be credited in the management program. **4.6.** The planning of the management of riparian vegetation will be carried out considering the following:

	• The stabilizing role of soils and the retention of materials carried by runoff from the high parts. • The habitat and the coverage of displacement of wildlife species. • The ecotonal function between adjacent plant communities and aquatic ecosystems. • The role of buffer zones in the fluctuations of temperature in water bodies, due to its shade.
NOM-022-SEMARNAT-2003	Establish specifications governing the sustainable use in coastal wetlands to prevent their deterioration, encouraging their conservation and restoration. Recognizes the value of wetlands, as well as the implementation of actions for protection and restoration, considering the original forest structure to prevent its loss and its dynamic hydrology. **3.58.** For this NOM, restoration is the set of activities aimed at rehabilitating degraded land, to regain and maintain part or all of its soil, hydrological dynamics, vegetation structure, and biodiversity. This standard includes two definitions of restoration. Active restoration applies to disturbed sites that require the actions of man, using techniques of ecology and engineering, to recover in some way its pre-existing situation. Passive restoration refers to coastal wetlands where the natural processes can return, as far as possible, to precondition the disturbance once human alterations are removed from the site. **4.36.** The mangrove areas located on the shores and interiors of the bays, estuaries, coastal lagoons and other water bodies, that serve as biological corridors and which facilitate the free transit of wildlife must be restored, protected or conserved. **4.40.** It is strictly prohibited introducing exotic species for the activities of coastal wetland restoration. **4.41.** Most of the coastal wetlands restored will require at least three to five years of monitoring, to ensure that the coastal wetland reaches maturity and optimal performance.
NOM-152-SEMARNAT-2006	Regulates the contents of the forest management programs for the utilization of forest resources timber and non-timber, in forests and vegetation in arid zones. **5.2.2.d** Includes the restoration of areas with severe erosive processes and affected by forest fires, pests, and diseases, as well as sites of low density or partially deforested, as one of the specific objectives of forest management programs. **5.2.14.** The forest management program shall indicate the actions that will be taken in these areas, such as reforestation, soil and water conservation, management of resources for the implementation of rehabilitation actions, soil treatments, grazing control, maintenance of activities already established, among others. This shall be indicated in the general technical specifications of each of the actions to develop, their estimated programming (month and year), and location of the property.
Jalisco	
Law for Climate Change Action for the state of Jalisco (LACCEJ)	**Article 3** establishes as an objective of the LACCEJ to promote policies that permit the restoration of degraded areas and ecosystem services for provisioning water and food, the conservation and sustainable management of ecosystems to reduce emissions from deforestation and forest degradation, and enhance the sequestration of greenhouse gases and their storage in sinks and reservoirs. **Article 23.** It is a priority issue for the State Policy towards adaptation to reduce vulnerability and strengthening the resilience of society, watersheds, and natural ecosystems, urban and agricultural systems in the face of the adverse effects of climate change. **Article 25** considers as adaptation activities: • The establishment and conservation of priority protected areas for adaptation and food-producing areas, with attention to the natural vocation of the soil, the maintenance of biological connectivity and the improvement in its conservation and utilization, the control of invasive species, management, protection, conservation and restoration of ecosystems and geosystems, and their provisioning and regulation services. • The exposure reduction to the hydro-meteorological disasters, through planning, quality assurance, the restoration of soils, and the rehabilitation of beaches and watersheds, valuing and preserving the regulation services provided by coastal, lake, forest, mountain, and agricultural ecosystems. • The establishment and modification of water supply infrastructure, management alternatives for water consumption under schemes of efficiency, technological change

	and culture for reducing water demand, and the protection and restoration of watersheds. • The establishment of procedures for assessing payments for conservation and restoration of ecosystem services, considering their circumstances and effective actions that perform the owners involved. **Article 26.** The Federal Government, federal entities, and municipalities will select, design, and implement actions that increase the resilience of watersheds and ecosystems, as well as the ecological integrity and connectivity. **Article 33** reflects that the mitigation policies and actions associated with the reduction of emissions in the generation and use of energy include: • Develop and strengthen sustainable management and restoration schemes of forests, wetlands, and coastal marine ecosystems. • Assess the needs and opportunities for ecosystem conservation and restoration, develop and implement programs of conservation and restoration through policies that establish the payment for environmental services in natural protected areas and priority areas for adaptation, sustainable forest management units, and those who participate in programs of measures aimed at reducing emissions from deforestation and forest degradation. **Article 81** focuses on the development and implementation of economic instruments that encourage the protection, preservation, and restoration of the environment.
Municipal Program of Climate Change of Puerto Vallarta, Jalisco, 2020-2030 (PMCC PV)	The strategic area on Ecosystem Conservation and Management considers the following 10 measures: 4.1 Implement conservation actions on beaches and installing protective infrastructure. 4.2 Instrument firefighting and prevention measures. 4.3 Increase the area under conservation through schemes, such as Natural Protected Areas (ANP), Areas intended voluntarily to Conservation (ADVC), Sustainable Forest Management (SFM), Payment for Environmental Services (PES). 4.4 Encourage the development of emission reduction projects or carbon capture in the forestry sector. 4.5 Restoration of natural reefs and installation of artificial reefs (or similar systems). 4.6 Implement actions to conserve and restore the middle and upper parts of the watersheds for ensuring the provision of environmental services in the lower part of the basin. 4.7 Establish a local mechanism for compensation and payment for environmental services (MLCPSA). 4.8 Establish a network of green areas in the urban and peri-urban areas. 4.9 Develop a Municipal Reforestation Program (PMR). 4.10. Implement actions for wetlands conservation and management.
Veracruz	
State Law of Mitigation and Adaptation to the effects of Climate Change	**Article 27.** The criteria for adaptation to climate change will be considered in the management, protection, conservation, and restoration of ecosystems, forest resources, and soils.

1.10 Climate financing in Mexico

During the 2014-2018 period, Mexico received US $ 28 billion from National, International, Private sector and Green Bonds for climate financing. $3.23 billion were from public multilateral and bilateral sources, to finance 75 projects. The distribution of resources by climate change thematic area corresponds to 47% for cross-cutting projects (adaptation and mitigation), 46% for mitigation projects and 7% for adaptation projects. The main financial instruments were loans (86%), followed by grants (9%) and technical assistance (3%). The most financed sectors were energy (45%), and housing (23%). Environment and natural resources, and agriculture received less than 10% of the financing together. In the same period, the sectors of environment and natural resources and agriculture received less than 1% of the private financing.

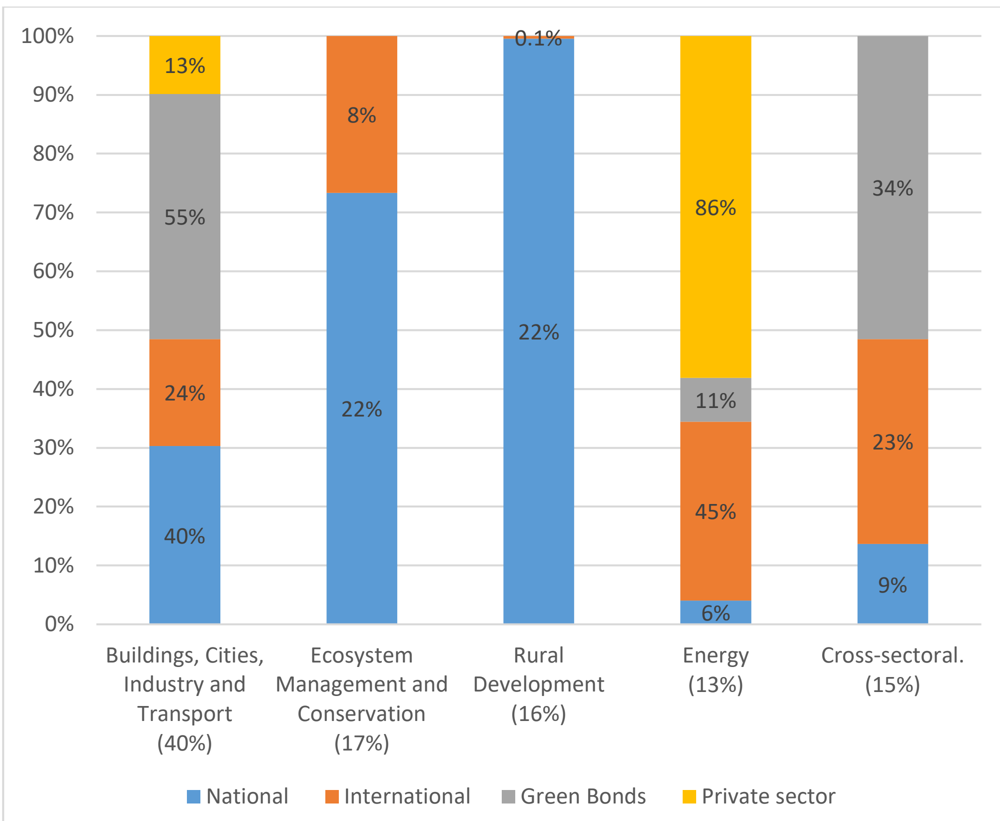


Figure 1.47. Climate finance in Mexico 2014-2018

Source: GGGI from GFLAC, 2018

Although the NDC highlights the LULUCF sector as the most ambitious with a potential reduction of GHG of -144%, the total climate budget for ecosystem management and conservation is only 17%.

Chapter 2. CLIMATE CHANGE, RIVER ECOSYSTEMS AND ADAPTATION OPTIONS

2.1 Rivers and riparian corridors in Mexico

Rivers are complex socio-ecological systems with highly-valued ecosystem goods and services (Zamora et al, 2017). Rivers are essential to human well-being. Riparian habitats — the forest-like vegetation that surrounds rivers, streams, and creeks — are crucial components of a life-sustaining ecosystem and a sustainable local economy (Michel and Graizbord, 2002). Rivers have the potential to provide a wide range of benefits to society; for example, supporting key livelihood activities and economic sectors, and contributing to strategic goals such as poverty reduction and climate resilience (Parker and Oates, 2016). The variety of ecosystem services that they provide and associated benefits will depend on the pattern of human development and river management (Parker and Oates, 2016). However, degradation or risk of degradation undermines their ability to provide critical ecosystem services and related benefits (Parker and Oates, 2016).

Riparian vegetation corridors regulate processes that result in valuable ecosystem services such as uptake, infiltration, and retention of sediments and contaminants from human activities (González et al., 2013). In the face of climate change, riparian ecosystems will experience an increase in air and surface water temperatures, alterations in the magnitude and seasonality of precipitation and run-off, and shifts in reproductive phenology and distribution of plants and animals (Meyer et al. 1999, Barnett et al. 2005, Parmesan 2007, Palmer et al. 2008, Rosenzweig et al. 2008). [ii]

Mexico has a startling mountainous topography. Two major mountain systems, the Sierra Madre Oriental and the Sierra Madre Occidental serve as the main drainage divisions for the Pacific and Atlantic Oceans. Between them lies the extensive Mexican Altiplano (or Mesa del Norte), bounded to the south by the Trans-Mexican Volcanic Belt. Further south is the Sierra Madre del Sur. The combination of its topography and geographical location between two major biogeographical provinces (Nearctic and Neotropical) significantly influence precipitation, producing a diversity of runoff patterns and river environments.

The country has approximately 150 rivers (Hudson et al., 2005). Two-thirds drain westward into the Pacific Ocean and the rest eastward into the Gulf of Mexico and the Caribbean. These rivers flow from the mountains and plateaus, intertwine valleys with coastlines, transport nutrients and organic compounds to feed plains and deltas, and maintain diverse ecosystems and human activities along their way to the ocean. The spatial and temporal distribution of the rivers is very heterogeneous, defining a complex mosaic of physical, biotic, and socioeconomic relations that requires effective forms of management and protection (Carabias et al., 2015). Thus, the shift towards sustainable river management can only be performed through a watershed approach, allowing to maintain ecosystem services, provide the rural population with sustainable grazing, forestry products, and agriculturally productive areas, and increase resilience to climate change.

In Mexico, it is estimated that over half of the watersheds have degraded rivers, and 68% of riparian corridors in Mexico present medium, high or very high degradation (Garrido et al. 2010). This is related to the pressures of land use change caused by the deterioration in territorial suitability for agricultural and livestock activities, which leads to decline of the hydrological cycle and loss of soils. Other barriers are lack of local governance, poorly-articulated territorial planning policies, limited institutional coordination, and deficient alignment of public and private investments. Climate change will add to and magnify risks that are already present through its potential to alter rainfall, temperature, runoff patterns, and to disrupt biological communities and sever ecological linkages. Chapter 1 analyzes the vulnerability to climate change of watersheds targeted by RIOS as well as other barriers.

Under a climate change perspective, growing environmental awareness and concern about the scarcity of clean water and loss of biodiversity in river systems prepare the way to a new policy for river restoration (Pedroli, 2002). It is currently a priority within the NDC, including actions to reforest and restore the watersheds from deforestation, with distinctive attention to riparian zones. Practices for maintaining water quality and reduce water pollution are likewise highlighted.

River restoration

River restoration refers to ecological, physical, and management measures and practices aimed at enhancing and rehabilitating the functionality of the river system in support of ecosystem services. Many successful river restoration measures have been reported, which support improvements to ecosystem services (Lago., 2014). Some common goals of river restoration are to improve water quality, re-establish river type-specific habitats and ecosystem functioning, aid in species recovery, and maintaining the provision of ecosystem services (Lago, 2014).

Restoration measures can take either passive or active forms and may be combined during implementation. Passive techniques (e.g., pulse flows, changes in watershed land use, creation of buffer strips, etc.) rely on the natural recovery process and therefore require a longer time to make an impact. Active techniques are used when longer recovery times are incongruent with meeting management or environmental policy goals and attempt to mimic the form of analogous natural structures/features (Lago, 2014).

A holistic view of river rehabilitation that recovers the ecological functions and adaptive capacity of rivers to buffer climate-change impacts and provide additional environmental benefits has been gaining traction within the restoration community (Lago, 2014). In general, nature-based solutions are preferable since they are cost-effective and provide additional ecosystem, social, and economic benefits, such as health and food security, access to natural goods, recreation opportunities, among others (Daigneault et al., 2016; Iacob et al., 2014). Nevertheless, engineering alternatives become critical in cases of strong hydrological constraints or severe environmental degradation, especially in arid and semiarid ecosystems, where water supplies are difficult to measure, and anthropogenic footprints last a long time (Norman, 2020). For flooding risk reduction, for example, riparian buffers planting appears to be the most cost-effective option while upland afforestation provides the greatest natural advantages overall. Among hard adaptation approaches, river dredging renders the best results; however, the costs of this approach are high relative to the benefits since it does not reduce the flood risk in communities in the upper catchment only downstream. Other examples of river restoration practices benefits include the following (Ficke et al., 2008; Nelson et al., 2009; Shields et al., 2003):

River Restoration Practices	Benefits
Protect riparian buffers and reforest catchments in the upper area of the basin	• Provide water storage. • Increase bank stability (erosion control). • Slow and disperse the overland flow. • Produce a physical barrier that restricts the flow of pollutants and sediments and prevents them from being washed into the aquatic ecosystem. • Improve water quality problems due to lower suspended sediment loads. • Provide shade, temperature control, refugia, and enough water flow to protect sensitive populations of flora and fauna, especially in arid regions.
Restore and manage wetlands and coastal areas	• Sustain or improve water quality by trapping sediments, filtering pollutants, and absorbing nutrients. • Increase biodiversity and improve connectivity between habitats. • Lower flood peaks downstream/Protect coasts against storms and inundation.
Re-naturalization of riverbed and tributaries	• Reconnect watercourses with their associated groundwater.
Reconnect rivers to floodplains	• Increase natural storage capacity. • Reduce flood risk.
Modify or removal of dams and promote re-meandering	• Restore river dynamics and ecological continuity. • Slow down the river flow. • Reduce erosion and sedimentation problems. • Recover aquatic and land habitats for plants and animals. • Improve esthetics.

The RIOS project uses a holistic view, based on the principles of Ecosystem-based Adaptation (EbA).

2.2 River Ecosystems and Adaptation options

Rivers are inherently dynamic systems, and therefore are constantly adjusting to changes in sediment and water inputs by migrating across the landscape and by changing their channels´ depth, width, and sinuosity. These changes are part of a healthy river's response to changes in the landscape and the climate regime. However, the expected variations in temperature and precipitation regimes as a result of climate change will occur much more quickly than historical shifts. At the same time, because many rivers are affected by development, their ability to adjust to changes may be impaired (Palmer, et al. 2009).

Table 2.1 shows a few categories of climate change adaptation measures in rivers and rationale for application under RIOS (Palmer et al. 2018 and 2019). The table describes each category, explains the rationale for the inclusion of this adaptation measure under RIOS and provides some examples, in each category, of activities supported under RIOS (for a full list of activities, see Chapter 3.3). As the project aims to reduce exposure and increase adaptive capacity to landslides, floods, and drought in the Ameca-Mascota and Jamapa watersheds, the specific local adaptation activities proposed in Table 2.1 respond to climate change impacts identified in Chapter 1 by:

- Protecting against substantial erosion and landslides.
- Reducing the amount and speed of rainwater runoff.
- Controlling the soil and stabilizing stream banks.
- Reducing vulnerability to hydrometeorological phenomena (e.g., storms) in locations with steep terrain.
- Decreasing peak temperatures in river environments.
- Implementing land-use planning focused on climate change impacts (IWAPs).
- Collecting and disseminating critical information and data to orient land management decisions at the regional and local levels.
- Mainstreaming investments across federal government agencies and private sectors for climate-related activities, including access to credit.
- Raising awareness about climate change impacts and risk management through EbA.

Table 2.1. Categories of climate change adaptation measures in rivers and rationale for application under RIOS

Category	Description	Included in RIOS	Rationale for including/excluding it in RIOS	Examples of activities related to the category supported by RIOS	Adaptation benefits
Bank Stabilization	Practices designed to reduce/eliminate erosion or slumping of bank	Yes	There is evidence of erosion in the banks of rivers in the target basins (see Chapter 1.4)	Localized planting to stabilize bank areas.	• Slow runoff • Reduce and control erosion and/or sediment delivery • Improve soils

	material into the river channel.				• Increase water infiltration, storage and/or groundwater recharge • Flood risk reduction • Create aquatic and riparian habitats • Natural biomass production • Recreational opportunities
Stormwater and Sediment Management	Management of the area to modify the release of storm runoff or sediments flux into rivers and reservoirs.	Yes	Evidence of excess of sediments and potential to reduce them (see Chapter 1.4)	Contribute to hillside stability and reduce sediment deposits that limit water flow (e.g. reforestation, restoration of riparian buffers, and soil conservation practices).	• Slow runoff • Reduce and control erosion and/or sediment delivery • Intercept and reduce pollutants • Improve water quality • Flood risk reduction • Biodiversity conservation
Flow Modification	Practices that alter the timing and delivery of water quantity.	No	Typically, associated with releases from impoundments and constructed flow regulators, which is not the case in the region.	n.a.	n.a.
Channel Reconfigurati on	Alteration of channel plan form or longitudinal profile and/or day-lighting. Includes stream meander restoration and in-channel structures that alter the thalweg of the stream.	No	There is no evidence of need to change the thalweg of the stream in the targeted basins. This is a strongly reactive measure that should only be undertaken if damage to a river is severe.	n.a	n.a
Riparian Management	Revegetation of riparian zone and/or removal of exotic species (e.g. weeds, cattle).	Yes	Riverbank stabilization through reforestation/ restoration	Riverbank reforestation/ restoration. Improve productive systems in transition to sustainable livestock, including an integrated approach to the productive unit	• Slow runoff • Reduce and control erosion and/or sediment delivery • Intercept and filtrate pollutants and nutrients • Reduce peak temperatures • Improve water quality • Increase infiltration and/or groundwater recharge • Increase evapotranspiration and enhance precipitation

					• Create riparian and aquatic habitats • Biodiversity conservation • Natural biomass production • Absorb/retain CO2 • Recreational opportunities
In-Stream Species Management	Practices that directly alter aquatic native species distribution and abundance through the addition (stocking) or translocation of animal and plant species and/or removal of exotics. Excludes physical manipulations of habitat/breeding territory (see In-stream Habitat Improvement)	Yes	Evidence of importance of biological diversity in the targeted basins (see Environmental Assessment, Chapter 1.6)	Restoration of riparian corridors with species of ecological relevance and with potential to address impacts of climate change	• Fish stocks and recruiting • Biodiversity conservation • Recreational opportunities
Dam Removal/Retrofit	Removal of dams and weirs or modifications/retrofits to existing dams to reduce negative ecological impacts.	No	In Jamapa there is large gray infrastructure. In the lower basin, gabions are usually present as containment walls (USD$ 45.1 million investment by CONAGUA). Also land use change, due to construction in floodplains and coastal areas, has resulted in the loss of wetlands, mainly mangrove systems, resulting in serious flooding in cities and towns in the lower basin. There is only one small dam in Ameca-Mascota sub-basin.	n.a.	n.a
Floodplain Reconnection	Practices that increase the flood frequency of floodplain areas and/or promote flux of organisms		This requires infrastructure and therefore a B safeguards category.		• Slow runoff • Retention of rainwater • Increase infiltration and/or groundwater recharge

	and material between riverine and floodplain areas.				• Reduce and control erosion and/or sediment delivery • Improve soils • Flood risk reduction • Natural biomass production • Create riparian habitats • Biodiversity preservation • More sustainable agriculture and forestry • Recreational opportunities • Aesthetic/cultural value
In-Stream Habitat Improvement	Altering structural complexity to increase habitat availability and diversity for target organisms and provision of breeding habitat and refuge from disturbance and predation.	Yes	Need to restore habitat, mainly related to the potential loss of connectivity.	Restoration of riparian corridors with species of ecological relevance and with potential to address impacts of climate change.	• Create terrestrial habitats • Biodiversity conservation • Natural biomass production • Absorb and/or retain CO2 • Increase evapotranspiration • Reduce peak temperatures • Improve soils • Increase soil water retention and infiltration • Groundwater/aquifer recharge • Erosion/sediment control • Intercept and reduce pollutants • Improve water quality • Flood risk reduction • More sustainable agriculture and forestry • Recreational opportunities • Aesthetic/cultural value
Aesthetics/Recreation/Education	Activities that increase community value: use, appearance, access, safety, knowledge.	Yes	By increasing local knowledge, communities will have a higher willingness to participate in restoration activities.	Community monitoring of water and biodiversity related to river restoration. Capacity building and re-appropriation of traditional knowledge in the communities where the	• Recreational opportunities • Aesthetic/cultural value

				project is implemented, which could be used in other sustainable activities such as ecoturism.	
Water-Quality Management	Practices that protect existing water quality or change the chemical composition and/or suspended particulate load.	Yes	Implementation of conservation agriculture and improved animal husbandry practices in the target watersheds would improve water quality.	Establish organic farming systems using bio-fertilizers (e.g., vermicomposting, bocashi, supermagro and others) for the reduction of diffuse contamination; promote soil conservation and water flow control practices (e.g. onboard ditches, filter dams, etc.) and sustainable livestock (or best management practices).	• Erosion/sediment control • Intercept and reduce pollutants • Improve water quality • Create habitats • Biodiversity conservation • More sustainable agriculture and forestry • Recreational opportunities • Aesthetic/cultural value
Land Acquisition	Practices that obtain lease/title/easements for stream-side land for the explicit purpose of preservation or removal of impacting agents and/or to facilitate future restoration projects.	No	The project is built on a strong local experience working with local communities and CSOs that are willing to change their practices with the correct incentives and training.	n.a.	n.a.

Other sectors that support river restoration in the context of climate change in Mexico

River ecosystems are naturally resilient, but the quality of the ecosystem services that they provide depends on climate change impacts, the degree of intervention and the fragmentation caused by human development patterns. For this reason, functional connectivity at watershed level is crucial. Functional connectivity is provided by biological corridors that improve ecosystem services, which are directly linked to increased resilience to the effects of climate change.

To achieve functional connectivity, it is critical to engage other key sectors in the restoration efforts. In the targeted watersheds, we have identified two productive practices that are directly related to river restoration: improved livestock management and agroforestry. In the absence of the project, conventional extensive ranching and agriculture activities will continue to expand unsustainably; those productive activities will enlarge the agricultural frontier and increase pressure on ecosystems through deforestation, loss of soil, intensive water use and pollution of rivers, among others. All this will generate a reduction on adaptive capacity, a loss of carbon sinks and an increase in greenhouse gas emissions. This will also generate a loss of other ecosystem services (see Chapter 4). It has been identified that in the targeted watersheds, a notable portion of the territory is susceptible for improvement in productive practices. Most economic activities present in the watersheds could transition to sustainable livestock management and agroforestry practices. This will strengthen people's adaptive capacity, and long-term economic and financial sustainability.

Livestock and climate change in Mexico

Degradation of river water quality has been linked to livestock practices in many parts of the world. Livestock presence in or near streams can negatively affect water quality, channel morphology, hydrology, riparian soil structure, instream and stream bank vegetation. Causes of these negative impacts include: livestock urine and manure deposition into streams, in-stream trampling, increased bank erosion due to reduced vegetation, stream bank breakdown by livestock and soil compaction (Trimble and Mendel, 1995; Mosley et al., 1997; Belsky et al., 1999).

Livestock production represents the main land use in Mexico, occupying around 56 percent of the Mexican territory (Atlas Agroalimentario, 2019), and contributing to 30 percent of the agricultural sector's GDP (FIRA, 2020). Mexico is among the top producers of livestock goods globally, occupying the 11th place in primary cattle production and 8th position in world milk production (Atlas Agroalimentario, 2019). The states of Veracruz and Jalisco are the first and second producers of beef, with 13 and 12 percent of the 2018 national production, respectively.

Livestock activities have been the driving force of deforestation and land degradation in the RIOS targeted landscapes. During the last century, public subsidies promoted the transformation of forests into pastures to release pressure from populated areas. Territories were turned into small units of extensive and inefficient cattle ranching. High use of agrochemicals resulted in land degradation and loss of ecosystem services. Ranching keeps further expanding into upper watersheds, exacerbating the environmental degradation. Climate change is contributing to this upward migration since regions to grow high-quality pastures are now found at higher elevations where the remaining forests are found.

Much of Mexico's land is already marginal for beef production (Buechler, 2009) and climate change will increase existing stresses. A study in Veracruz indicates that the effects of projected maximum summer temperatures on livestock heat stress are expected to reach the "danger level" in this decade and continue to rise (Hernández et al., 2011). Both Jamapa and Ameca-Mascota are vulnerable to the effects on climate change related to extensive livestock farming exposed to flooding and water stress (see Section 1.2 for a full list of vulnerabilities in the targeted basins).

At the same time, in relation to GHG emissions produced during livestock activities, according to the Sixth national communication of Mexico to the UNFCCC, 10.1% of the GHG emissions are related to livestock activities (70,567.60 Gg of CO2 e), from which cattle is the largest emitter in the category with 89.25%.

However, these negative impacts that affect both GHG emissions and reduced adaptation capacity, can be minimized or eliminated with correct livestock management. For this reason, sustainable livestock production practices are promoted under RIOS, such as supporting silvo-pasture systems, which combines trees, shrubs, and livestock; incorporating plant species rich in protein in live fences (e.g., legumes); reducing chemical fertilizers, among others (see Section 3.3 for a full list of activities). Moreover, based on previous studies, sustainable livestock production practices have a positive economic cost-benefit ratio and Net Present Value (see Section 4.2).

Agroforestry and Climate Change in Mexico

An agroforestry system is where forest, agricultural and cultural components interact to provide ecological, social, cultural and economic benefits to the families, communities and societies that manage them (Red Temática de Sistemas Agroforestales de México and SEMARNAT, 2019). Agroforestry can reduce climate change risks and promote sustainable food production under shifting climate by: (i) establishing a microclimate, which reduces climate impacts and enhances resilience in the agricultural landscape, (ii) facilitating species movement to more favorable conditions, (iii) increasing ecosystem services by reducing pollutants into rivers and other water bodies, and (iv) sequestering carbon and reducing greenhouse gas emissions (Bentrup et al., 2018). Although agroforestry practices can provide these positive adaptation and mitigation services, at the same time they can be vulnerable to climate change.

As Chapter 1 describes, coffee is one of the main crops in the targeted watersheds. Coffee production is projected to decline 34% by 2020 in Veracruz if historic temperature and precipitation trends continue (Gay et al., 2006). Concerning the hazard of flooding in the lower basin, 26.9% of shade coffee plantations in the coastal plain of the Jamapa River is susceptible of climate-change related risks, such as floods, droughts, frosts, and heat waves (INECC, 2019b). Moreover, local evidence suggests that coffee plantations could be expanding upstream to cope with the reduction in productivity; this will increase deforestation and forest degradation and further decrease the adaptive capacity of the watershed.

Agroforestry, by means of its diversified production, offers a substantial number of risk management strategies and options to adapt to climate-induced disturbances, increasing farmers' resilience to the impacts of climate change. This kind of integrated production system on farms provides opportunities for intensified cycling of nutrients, water, and energy, ensures the stability of production, and reduces environmental impacts (e.g., pollution and waste) and operating costs (e.g., fertilizers). Because it is a mixed system, it also favors agricultural biodiversity and promotes habitat connectivity, trophic networks, and interactions between taxa, such as soil fauna, pollinators, pests, and predators.

The design and management of agroforestry systems proposed in RIOS project consider how these systems can incorporate resiliency into agriculture in ways that the systems could adapt to these changing conditions, such as organic fertilizing, cover crops, multi-layer and multi-species crops, among others (see Section 3.3 for a full list of activities supported under the project). Moreover, based on previous studies, it ensures a positive economic cost-benefit (see Section 4.2).

2.3 Ecosystem-based Adaptation

The environmental, social, and economic impacts of climate change increase the vulnerabilities of people and nature. Adaptation serves as an important strategy to cope with a changing climate and its impacts. In response to climate change effects, a likely selection is to invest in traditional options such as infrastructure for flood control, and reservoirs for water shortages. These selections are likely to be costly and generally do not consider the conservation of ecosystems and biodiversity (Baig, et al. 2016).

As discussed in this Chapter, the RIOS project proposes a proactive response for river adaptation to the climate change events. Moreover, it uses an Ecosystem-based Adaptation approach. Ecosystem-based Adaptation (EbA) is "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change" and takes into account "the multiple social, economic and cultural co-benefits for local communities" (CBD, 2014). EbA offers a valuable yet under-utilized approach for climate change adaptation (Baig, et al. 2016). EbA uses ecosystem services as part of an overall adaptation strategy to help people adapt to the negative effects of climate change at different levels (local, national, regional, and global). Additionally, EbA provides important co-benefits crucial for local livelihoods (Baig, et al. 2016). EbA initiatives can also contribute to climate change mitigation by reducing emissions from ecosystem degradation, enhancing carbon sequestration, and prevention of deforestation and land degradation, which aids in limiting further greenhouse gas emissions (Baig, et al. 2016, and Lago, 2014). Due to the potential benefits and co-benefits of EbA in the context of river restoration, RIOS uses an EbA approach (see Chapter 4 for a full analysis of expected benefits and co-benefits).

Additional to the climatic benefits, the EbA activities in RIOS have been selected because: (i) in the stakeholder consultation they were identified as culturally-appropriate, (ii) they have been successfully accepted and implemented in the selected watersheds by both men and women within the framework of other projects, mainly C6 (see Chapter 1.6) , (iii) in the case of productive activities, they have a positive financial return (see Chapter 4), (iv) compared to gray infrastructure, they are more cost-effective and provide significant sustainable development-oriented co-benefits, and (v) allow to re-evaluate ecosystem services as critical assets to maintain the livelihoods of the most vulnerable populations.

In general, nature-based solutions are preferable since they are cost-effective and provide additional ecosystem, social, and economic benefits, such as health and food security, access to natural goods, recreation opportunities, among others (Daigneault et al., 2016; Iacob et al., 2014). Nevertheless, engineering alternatives become critical, especially in arid and semiarid ecosystems, where water supplies are difficult to measure, and anthropogenic footprints last a long time (Norman, 2020).

For flooding risk reduction, for example, riparian buffers planting are the most cost-effective option while upland afforestation provides the greatest natural advantages overall (Daigneault et al., 2016). Among hard adaptation approaches, river dredging renders the best results; however, the costs of this approach are high relative to the benefits since it does not reduce the flood risk in communities in the upper catchment only downstream (Daigneault et al., 2016).

In Mexico, around 162,000 km2 of the territory (8%) are vulnerable to flooding with a socio-economic impact equivalent to billions of dollars (Arreguín-Cortés & Cervantes-Jaimes, 2017). Thus, more than 5000 levees and dams for flood and siltation control have been constructed to protect the population, industrial, and agricultural areas (Arreguín-Cortés & Cervantes-Jaimes, 2017; CONAGUA, 2017; Figure 2.1).

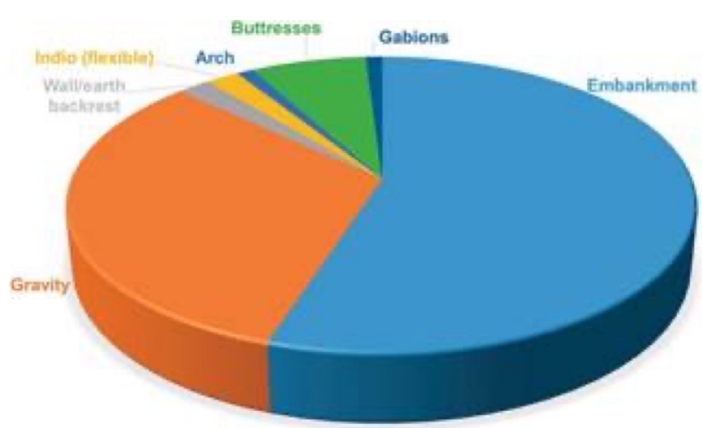


Figure 2.1. Types of dams in Mexico. Source: Arreguín-Cortés & Cervantes-Jaimes, 2017.

In the state of Veracruz, flood mitigation has focused on increasing dikes, armoring riverbanks, dam construction, and building channels to drain and guide water towards the mangroves to reduce the overflow of the Jamapa River rather than taking advantage of connectivity with the groundwater, the value of wetland vegetation or the ecological processes occurring in the coastal zone (Neri-Flores et al., 2019). While the construction of infrastructure has brought some protection, these actions have further degraded local wetlands and augmented the overall costs of flooding (Tovar et al., 2015). In Jalisco, in contrast, much has been learned about the importance of natural defenses to face climatic emergencies. In 1995, hurricane Patricia hit Jalisco's coast about 180 miles south of Puerto Vallarta. The forest cover of the surrounding mountains (eg., Sierra El Cuale, Sierra Vallejo) formed a natural barrier that helped diminish the force of the hurricane, absorbing much of the impact of torrential rains, powerful winds, landslides, and flooding (Martínez, 2019).

In the Jamapa watershed, there are 30 storage dams in the municipalities of Paso del Macho, Camarón de Tejeda, Soledad de Doblado, and Comapa, and 507 wells and 188 norias in the rest of the basin (DOF, 2015). All these infrastructures were installed to store small volumes of water, especially in the dry season. While in the upper part of the Ameca-Mascota watershed, there is a dam located on the Mascota River. It has a total capacity of 29 million m3 and a useful capacity of 16.5 million m3 and is mainly used for flood control and the irrigation of 2,500 hectares of crops during the dry season (SINA, sf). In the lower basin, there is a water board to protect population centers and the agricultural fields of the irrigation district 043. As grey infrastructure available in both watersheds is scarce and small-scale, it was not included in the hydrological models presented in Chapter 1 since it does not influence the scope of the model as large-scale infrastructure such as hydroelectric dams will. There is no official information on governmental plans to build grey infrastructure in the watersheds soon. Consequently, this does not represent a risk to include in Annex 7.

Chapter 3. PROJECT DESCRIPTION

3.1 Detailed Component description

RIOS has three components: i) Component 1: Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices, ii) Component 2: Alignment of public and private investments through natural capital accounting for scaling-up activities for the restoration of rivers for adaptation to climate change, and iii) Component 3: Design of a National River Restoration Strategy (NRRS) for climate change adaptation.

Component 1: Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices. This Component will finance activities to strengthen capacities in producers and landholders along the Ameca-Mascota and Jamapa watersheds to conduct activities on their land that promote ecosystem-based adaptation through functional connectivity. Functional connectivity refers to biological corridors that improve ecosystem services, which are directly linked to increased resilience to the effects of climate change. INECC -the National government agency that coordinates climate change research and policy, and the technical leader of this project- has identified the required actions to reduce climate change vulnerability through Integrated Watershed Action Plans (IWAPs) built with key local stakeholders. The IWAPs were developed during the Global Environmental Facility GEF-Financed C6 Project coordinated by FMCN in 2013-2018 (Chapter 1).

Output 1.1 Increased area of land conserved, restored, or under best management practices that reduce climate vulnerability.
Activities:

- 1.1.1 Provide funding -through different schemes- to subprojects to conserve, restore and improve management practices to increase adaptive capacities trough river restoration.
- 1.1.2 Support subprojects to implement procedures to maximize environmental and social benefits, with a gender approach.

Output 1.2: Target communities have applied a participatory methodology for monitoring biodiversity and water quality to provide inputs for an evaluation of the ecosystem and social vulnerability of the basins.
Activities:

- 1.2.1 Monitor biodiversity and water quality impact of subprojects through community participation.
- 1.2.2 Evaluate vulnerability of the watershed-dependent communities with a participatory methodology.

Output 1.3: A learning community fostering knowledge has exchanged and coordinated experiences between watersheds and with key actors to increase functional connectivity.
Activities:

- 1.3.1 Develop a multi-stakeholder knowledge exchange platform to mainstream river restoration.
- 1.3.2 Scale-up lessons learned from subprojects to inform local and national policies and programs.

This component will be implemented through subprojects financed with GCF resources and executed by selected community, civil and private organizations working with producers on the ground to increase capacities in: (i) **rehabilitation and restoration** of forests along rivers and springs (increase coverage with native species, soil restoration); (ii) **protection and conservation** of forests; and (iii) **productive activities** that promote connectivity for river restoration (agroforestry and sustainable livestock management). These subprojects comprise a portfolio of four type of schemes, depending on the nature and objective of the activity (see Table 2.2). Schemes are not mutually exclusive and not progressive.

- **Scheme 1:** Grants through request for proposals**.** FMCN will launch a demand-based request for proposals (RFP) through Regional Funds (RF) to Civil Society Organizations (CSO) that group landholders and producers, including communities, *ejidos*, small landowners, and community enterprises.

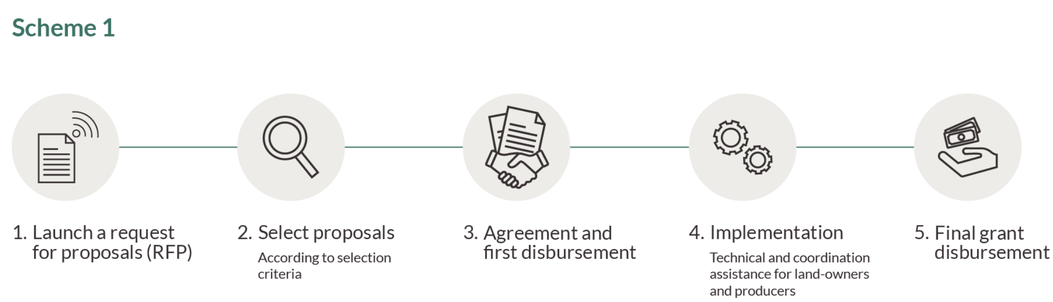


Figure 3.1. Summary of the process for Scheme 1 Grants and matching grants.

- **Scheme 2: Payment-for-Performance (PfP).** This scheme will serve to pilot a results-based mechanism to a subset of subprojects selected for the grant scheme (scheme 1). It will be a sub-group from the subprojects of Scheme 1. It will be implemented as a hybrid grant and pay-by-performance model that rewards the results that generate an increase in functional connectivity and climate adaptation. It will pay a final bonus of 10% to those sub-projects that achieve the expected and agreed outcomes, at the final project year. All disbursements will be attached to intermediate results through proxy indicators.

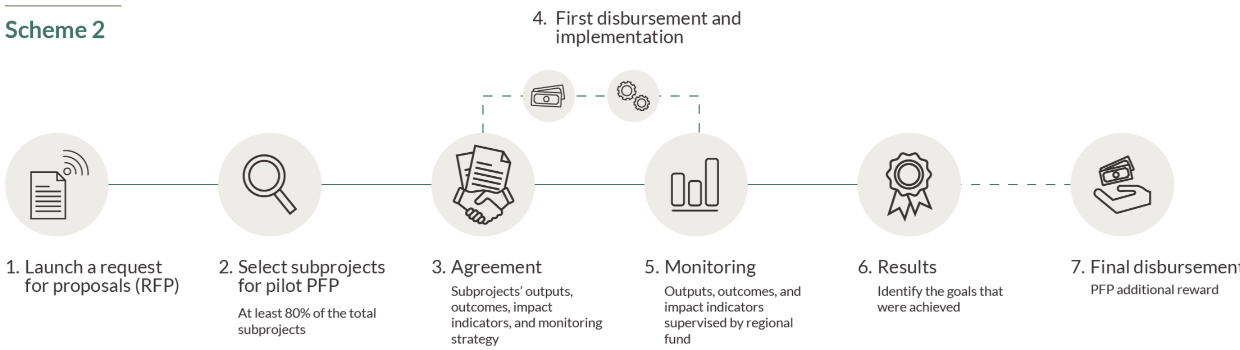


Figure 3.2. Summary of the process for Scheme 2 Pay-for-Performance (PfP).

- **Scheme 3**: **Public-Private Payment for Ecosystem Services (PES)**. Regional Funds (RFs) will provide technical assistance to communities identified in the IWAPs as important suppliers of HES. The RF will support those communities to develop proposals to access to the Payment for Ecosystem Services (PES) matching fund scheme from the Mexican Forest Commission (CONAFOR). Under Component 2, the project will identify private sector institutions downstream that demand and benefit from those HES, and will link them to these communities seeking their matching contribution to the PES concurrent scheme.

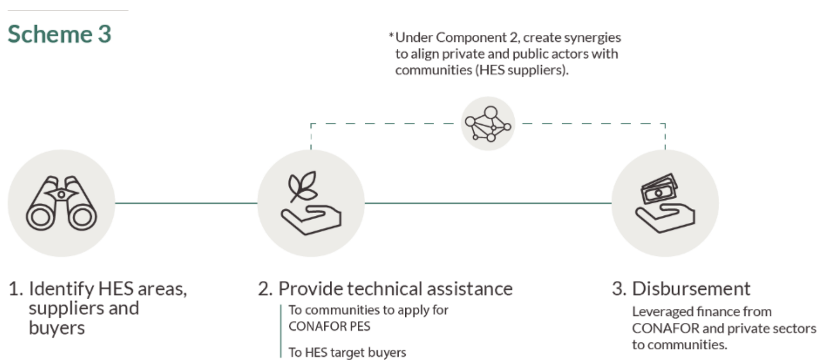


Figure 3.3. Summary of the process for Scheme 3 Public-Private Payment for Ecosystem Services (PES).

- **Scheme 4**: **Business development and facilitate access to credits**. FMCN will launch a demand-based RFP through the Regional Funds to Local Providers of Technical Assistance (PLATs, for its acronym in Spanish), which are consulting firms or CSOs focused on promoting organizational and business management skills of Producer Groups (PG) in an integral manner. This scheme will be co-financed by the CONECTA project, financed by a GEF grant (2021-2026, see Chapter 1.6). The PLATs will prepare producers implementing livestock, agroforestry and other EbA activities to apply to credits developed under Component 2.

Figure 3.4. Summary of the process for Scheme 4 Facilitate access to credits.

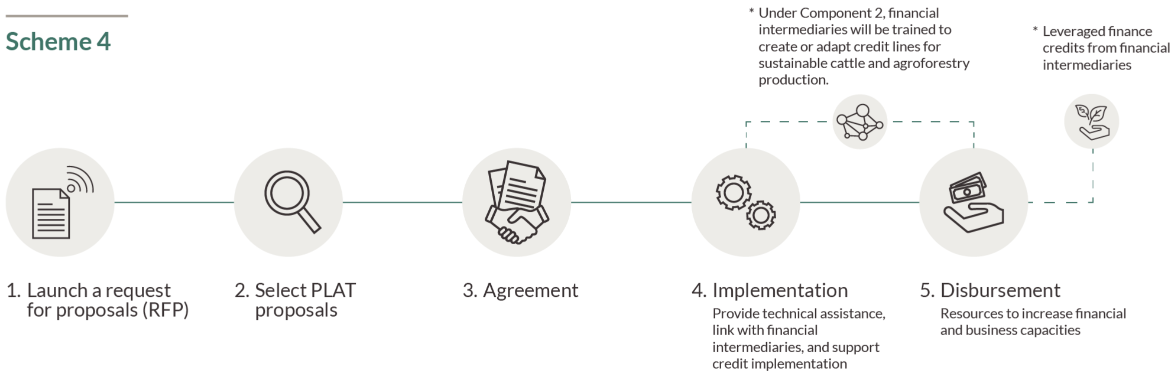


Figure 3.4. Summary of the process for Scheme 4 Facilitate access to credits.

Table 2.2. Portfolio of schemes supported under Subcomponent 1.1

Type of Scheme	Type of support	Target beneficiaries	Example of systems supported	Maximum amounts (per year)
Scheme 1: Grants through Request for Proposals (Subactivity 1.1.1.5)	Financial resources to implement EbA conservation, restoration and productive activities. Provide funding through grants to implement activities that promote functional connectivity and climate adaptation.	CSOs that group landholders and producers, including communities, *ejidos*, small landowners, and community enterprises, in the upper and middle basin.	Rehabilitation and restoration of forests along rivers and springs. Protection and conservation of forests. Productive activities (agroforestry and sustainable livestock systems) that require technical assistance and have a high starting cost.	USD$55K per subproject
Scheme 2: Payment-for-Performance (PfP) (Subactivity 1.1.1.5)	Financial resources to implement EbA conservation, restoration and productive activities. Grant plus pay-by-performance model that rewards the results that generate an increase in functional connectivity and climate adaptation. This scheme envisages payment to CSOs and local communities for performance. Under this Scheme, those Beneficiaries (i) whose Sub-Projects have received funding under Scheme 1, and (ii) who have exceeded performance results, as set out in the Operations Manual, will receive an additional sub-grant in the amount of ten per cent (10%) of the respective Sub-Project's budget. The rewarded amount will be proportional to the target, up to 10% of the total grant amount when the goal is achieved. This scheme will serve to pilot PfP to a subset of subprojects selected for the grant scheme.	CSOs that group landholders and producers, including communities, *ejidos*, small landowners, and community enterprises, in the upper and middle basin.	Activities with measurable impact within the project timeframe and learning potential. Productive activities (sustainable livestock and agroforestry) that require flexibility in management options and have adaptation learning potential. Rehabilitation and restoration of forests along rivers and springs. Protection and conservation of forests.	USD$5.5K Bonus to the grant awarded in Scheme 1 per subproject
Scheme 3: Public-Private Payment for ecosystem services (PES) (Subactivity 1.1.1.8)	Liaison between communities, private and public sectors, and capacity building. Support local communities to access and implement public-private schemes for PES.	Local communities identified in the IWAPs as important providers of HES in the upper and middle basin.	Protection and conservation of forest and riparian areas.	USD$550 per ha maximum 3,000 ha (leveraged funding)
Scheme 4: Facilitate access to credits (Subactivity	Finance PLATs for capacity building. Build business and organizational capacity of livestock and/or agroforestry Producer Groups (PGs) for sustainable rural production	Producer Groups implementing income-generating	Productive activities (sustainable livestock and agroforestry) carried-out by PGs that have the potential for private financing.	US$ 25K

1.1.1.9)	Trough Component 2, FMCN and the Regional Funds will create synergies with financial institutions and intermediaries to develop dedicated credit lines (with co-financing from CONECTA) and train them in the development of financial products that promote sustainable practices. Through Component 1 with the co-finance from GEF project CONECTA, the project will develop capacities in producers on financial literacy and business and will provide technical assistance on sustainable practices during credit implementation.	sustainable livestock and agroforestry activities mainly in the middle basin.		per PLAT

Selected practices are proved to be effective to increase adaptation and will be appropriate for the regions. The RfPs will promote the inclusion of women, through dissemination in appropriate spaces, and gender-sensitive activities (see Gender Action Plan -GAP). Subprojects will be linked to private and public financial sources aligned under Component 2. The final selection criteria will be defined by the Technical Committee during the design of the RfP. Some preliminary selection criteria are:

Beneficiary category	Definitions	Activities supported	Selection criteria
Communities	They are the final beneficiaries of Schemes 1 and 2. Communities includes communities, ejidos, small landowners, and community enterprises.	Finance subprojects that implement: Rehabilitation and restoration of forests along rivers and springs. Protection and conservation of forests. Productive activities (agroforestry and sustainable livestock systems)	Under Scheme 1 and 2, CSOs will apply to the RFP by grouping communities. Selection criteria for this RFP includes: 1. Relevance: the sub-project is aligned with the objective and eligible activities of this call for proposals; 2. Strategic planning: the sub-project has a clear objective. The expected results and the activities are aligned with the objective; 3. Financial planning and viability: The budget is congruent with the proposed activities and the resources requested are sufficient to ensure the implementation of the project; 4. Impact: the proposal clearly defines the forest area it will conserve, will use sustainably or restore. The selected indicators are measurable and correspond to the results included in the planning; 5. Social participation: the local community, the owners of the resources and / or the users participated in the preparation of the proposal and show clear ownership of the project; 6. Organization and governance: the sub-project supports the community involved in its integration, strengthening and in transparent decision making around the management of natural resources; 7. Scientific / technical / social support: the proposed interventions have a clear scientific, technical, social, legal and / or economic basis; 8. Complementarity with additional initiatives: the project promotes or strengthens synergies and inter-institutional collaboration, for example, it is linked to other public or private investments and attracts them as counterpart funding; 9. Institutional capacity: the proposing organization has the experience and human, technical and administrative capabilities to successfully carry out the project.
Civil Society Organizations (CSOs)	They apply to Schemes 1 and 2 by grouping landholders and producers, including communities, *ejidos*, small landowners, and community enterprises.		

			10. Continuity: the strategy of the proposal contemplates actions that will allow the impact of the project to be long-term. For example, the proposals include productive activities based on business plans and contemplate links with markets, or encourage the creation of revolving funds that ensure financing productive activities in the long term.
Community enterprises and Producer Groups	Community enterprises, family businesses or producer groups implementing sustainable livestock and agroforestry activities.	Technical assistance on managerial aspects, governance, financial and accounting training, marketing, and market access. Specialized consultancies and technical inputs can be financed in parallel for the selected PGs, including but not limited to sustainable milk processing, cheese production, eco or agritourism services, commercialization of sustainably produced goods, and access to credit markets for sustainable production.	Under Scheme 4, PLATs will apply to the RFP by matching with one or more community enterprise or producer group. Selection criteria for this RFP includes: 1. Location and knowledge of the territories involved in the project, 2. Experience in working with PGs in the region, 3. Experience of technical assistance services to similar production groups with a climate change adaptation focus, 4. Knowledge of the technical activities of the project, organizational aspects of production and business management and 5. Knowledge of producer organizations and government actors in the region.
Local Providers of Technical Assistance (PLATs)	Consulting firms or CSOs focused on promoting organizational and business management skills of Producer Groups		

In equal circumstances, the additional selection criteria to be considered by the Project Technical Committee are the following:

1. Gender approach: the proposal has an approach that favors equality in the relationship between men and women;
2. Surface area: the proposal offers a greater surface of forest attended with relation to the alternative proposal;
3. Diversity of organizations: the set of proposals comes from the largest number of organizations, although those organizations that submit more than one proposal will be considered;
4. Linking between sub-projects: the proposal includes synergies with other proposals for sub-projects and are territorially related.

This Component will also support institutional strengthening of local actors to enhance coordination and connectivity in the basins. It will create a "learning community" that will meet annually to exchange experiences between beneficiaries, engage regional and national actors to coordinate activities and achieve connectivity in the watersheds. This learning will be scaled-up nationally under Component 4. Activities will include workshops, publications, and dissemination events. The learning community will be co-financed by the CONECTA project.

This Component will also adapt existing methodologies to evaluate the vulnerability by the communities of the project basins continuously and to monitor the provision of ecosystem services that (biodiversity, soil and water quality). It will provide subprojects, particularly those under the PFP scheme, with technologies and assistance to learn about vulnerability and monitor project benefits and co-benefits. The results will serve to: i) determine the level of reward for the beneficiaries under the PFP scheme, ii) improve adaptive capacity in communities, iii) support the vulnerability assessment to be conducted by INECC at the onset and end of project, and iv) provide inputs for impact evaluation. Additionally, the protocol developed will support the National River Restoration Strategy (NRRS), designed under Component 3.

Sample activities supported under Component 1, including their expected impact in terms of increased adaptation capacity and reduced vulnerabilities to climate change, follow:

Type of vulnerabilities to climate change:

1. Vulnerability of human settlements to flooding (VPI)
2. Vulnerability of human settlements to landslides (VPDes)
3. Vulnerability of extensive livestock farming to flooding (VGI)
4. Vulnerability of extensive livestock farming to water stress (VGEH)
5. Vulnerability of forage production to water stress (VFEH)

Systems		Eligible activities	Main ecosystem services provided/improved by those practices	Expected climate change adaptation impact	Vulnerability addressed	Sources
River restoration	**Riparian restoration**	Community work on reforestation/ restoration of riverbanks (for example, watershed committees)	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities • Moderate extreme temperature thanks to vegetation coverage	Increased capacity building and re-appropriation of traditional knowledge in the communities where the project is implemented to promote riverbank reforestation/restoration for flood risk reduction.	VPI, VGI	Meli, 2011 Mushamuka, 2011 Chazdon, R., 2008 Riis et al., 2020
		Restoring riverbanks with native vegetation		Increased hillside stability and reduced sediment deposits that limit water flow Improved capacity of riparian ecosystems to provide soil retention and water provision services.		Tillery, and Renges., forthcoming Addy, 2016 Dixon, et al., 2016
	Restoration	Restore forests with native species	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration	Maintained biodiversity of ecosystems to improve the provision of ecosystem services and the capacity to respond to possible impacts of climate change.	VFEH, VGEH	Ministerio Medio Ambiente Chile, 2014 Chazdon, R. L., 2008
		Restore patches to increase connectivity		Increased connectivity and habitat corridors of species of ecological relevance and to		Fundación Biodiversidad, 2016 Useche, 2006

			• Moderate extreme temperature thanks to vegetation coverage	improve the provision of ecosystem services and the capacity to respond to possible impacts of climate change.		Riis et al., 2020
		Recover and restore soils	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Conserve soil for productive activities	Promoted the recovery of soil ecosystems to contribute to the storage of carbn in the roots of plants and soil, in order to mitigate greenhouse gas emissions to the atmosphere. Improved soil retention to reduce flood risk and drought. The restoration of the land stores not only gives quick results, but also is economical, generates jobs and ensures food security.		UNFCCC, 2019 Ortiz H, 2007 Riis et al., 2020
Forest protection and conservation	**Agroecological practices**	Conserve soils with agroecological practices (living fences, stubble, cover crops, organic fertilizing, productive diversification)	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Conserve soil for productive activities	Increased implementation of sustainable production practices to reduce potential sources of diffuse pollution to water bodies, improve diets, and adapt practices to climatic events.	VFEH, VGEH, VGI VPI, VPDes	Martínez-Rodríguez, M.R., et al. 2017 Keenan, R. J., 2015 Garbach et al., 2014
		Train and acquire equipment for fire prevention, control and management	• Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Moderate extreme temperature thanks to vegetation coverage	Decreased risk of fires and reduced impact from fires that do occur b early warning and fire prevention mechanisms as a potential impact of climate change. Incorporate fire spread prevention measures that compromise the maintenance of biodiversity and environmental services.		UNDP, 2017 Giannakopoulos, C. et al., 2012 Garbach et al., 2014
		Build capacities in communities for extraction and sustainable use of plants of interest (seed banks, nurseries, cover crops, organic	• Moderate extreme temperature thanks to vegetation coverage	Increased use of biodiversity in a sustainable manner in order to minimize the potential effects of climate change on biodiversity.		Cach, J., 2016 Garbach et al., 2014

		fertilizing, productive diversification)				
		Develop green business and sustainable certification plans	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities Moderate extreme temperature thanks to vegetation coverage	Improved systems that promote provision of ecosystem services and increase the commercial value of products.		Ochoa, J., 2018 Garbach et al., 2014
Productive practices	**Sustainable livestock management**	Improve livestock practices in transition to sustainable livestock management including silvopastoral systems.	• Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities	Reduced sources of diffuse contamination to water bodies. Restored the water flow to contribute to the connectivity of the basin to reduce the risks of landslides un the upper basin and floods downstream.	VFEH, VGEH, VGI	FAO, 2011 Gaccio, 2011 SEMARNAT, 2011 FAO, 2000 Hoffmann et al., 2014 Riis et al., 2020
		Living fences (fruit and fodder trees)	• Moderate extreme temperature thanks to vegetation coverage			
		Improvement of pastures (grass enrichment, rotations,leguminous, fodder)	• Moderate extreme temperature thanks to vegetation coverage			
		Reforest/restore riparian corridors along streams and rivers, excluding cattle or limiting access points	• Moderate extreme temperature thanks to vegetation coverage • Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses			

			• Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities			
	Agroforestry	Enrich fallow areas	• Moderate extreme temperature thanks to vegetation coverage • Reduce soil erosion to decrease sediments, improve water quality and diminish silting of watercourses • Increase the time that water remains within the basin, decreasing the force and speed of runoff, as well as increasing infiltration • Conserve soil for productive activities	Increased productivity and, reduced losses due to climate impacts by implementing practices resilient to climate change.	VFEH, VGEH, VGI, VPDes	Torres, Tenorio, & Gómez, 2008 Armelinda, 2013 Jose, 2009
		Develop sustainable management programs (diversified systems, shadow coffee)		Improved systems that promote provision of ecosystem services and increase the commercial value of products.		CIGAR, 2017 Jose, 2009
		Develop business plans for shade systems like coffee or diversified systems.		Improved systems that promote provision of ecosystem services and increase the commercial value of products.		Bunn C., et al, 2018 Baker P. and J. Haggar, 2007 Jose, 2009

Output 1.1. Increased area of land conserved, restored, or under best management practices that reduce climate vulnerability.

Activities:
1.1.1 Provide funding -through different schemes- to subprojects to conserve, restore and improve management practices to increase adaptive capacities trough river restoration.
- Define detailed selection criteria for each scheme under a participatory approach.
- Disseminate the RFP.
- Rate proposals by external evaluators.
- Select the proposals by the Technical Committee.
- Award contracts to organizations whose subprojects were selected.
- Support the implementation subprojects through the provision of funding.
- Monitoring and reporting of the implementation subprojects.
- Provide technical assistance on sustainable practices.
- Support the development of capacities in producers on financial literacy and business management.
- Evaluate and, where appropriate, extend annual contracts with the organizations in charge of the subprojects.

1.1.2 Support subprojects to implement procedures to maximize environmental and social benefits, with a gender approach.
- Supervise administrative management of subprojects.
- Supervise the implementation of the Environmental and Social Action Plan.
- Supervise the implementation of the gender action plan.

Output 1.2. Target communities have applied a participatory methodology for monitoring biodiversity and water quality to provide inputs for an evaluation of the ecosystem and social vulnerability of the basins.

Activities:
1.2.1 Monitor biodiversity and water quality impact of subprojects through community participation.
- Adjust existing community monitoring methodologies for assessing the ad hoc vulnerability of the project.
- Raise awareness of local actors on the issue of vulnerability through workshops and training related to the effects of climate change.
- Train local actors and communities to implement monitoring methodologies.

1.2.2 Evaluate vulnerability of the watershed-dependent communities with a participatory methodology.
- Evaluate vulnerability of baseline, medium term and final project.
- Communicate the results of vulnerability assessed to provide feedback on adaptation actions at the community level.

Output 1.3. A learning community fostering knowledge has exchanged and coordinated experiences between watersheds and with key actors to increase functional connectivity.

Activities:
1.3.1 Develop a multi-stakeholder knowledge exchange platform to mainstream river restoration.
- Incentivize the linkage of connectivity instruments (from federal, state and municipal actors).
- Conduct national and local experience exchange workshops.
- Design and publish communication materials to communicate to key stakeholders project´s lessons learned.
- Adjust existing communication platforms and adapt them to project needs.

1.3.2 Scale-up lessons learned from subprojects to inform local and national policies and programs.
- Scale-up lessons learned from subprojects to inform private and public programs under Component 2 and National strategies under Component 3.

Component 2: Alignment of public and private investments through natural capital accounting for scaling-up activities for the restoration of rivers for adaptation to climate change. This Component aims to implement coordination activities to align public and private investments, including credits, to scale-up the best practices supported under Component 1. It includes three strategies: (i) promote the alignment of local and national public programs related to connectivity (including CONAFOR Payment for Ecosystem Services, Sillvopastoral Program in Jalisco, and others); (ii) mobilize investment of private funds in watershed connectivity in target and additional basins, for example, coming from the tourism industry and water service providers; (iii)promote an enabling environment and improve capacities of producers benefited by Component 1 to access dedicated credit lines for sustainable, climate-resilient productive practices in sustainable ranching and agroforestry. It is expected to have leveraged finance for PES from: State Ministries of Rural Development, CONAFOR, CONAGUA, the French Development Agency – AFD – for the development of credit lines, the Institutionalized Trusts for Agriculture (FIRA) – for the development of credit lines, Financial Institutions (see Chapter 5.1 for a list), Tourism sector (hotels and restaurants) and water concessions. It is expected to have a leveraged finance of at least 50% of the total amount of subprojects´ financing (USD$ 1,785,500).

Financial institutions will be selected to be trained based on (i) presence in the region; (ii) experience working with small rural producers; and (iii) expertise tailoring financial products to sustainable producers. Private sector will be selected based on: (i) their proven capacity to provide funding for more than 3 years, and (ii) direct linkage as receivers of ecosystem services provided by the communities in the watershed.

This Component will also implement a Natural Capital Accounting system, to serve as a basis to increase private and public investments focused on river restoration for climate vulnerability reduction that will be leveraged under this Component. This will be implemented through an economic valuation of selected ecosystem services to quantify, valuate, and attribute the contribution of river restoration to the reduction of climate vulnerability.

Output 2.1. Investments of public programs in targeted watershed catalyzed towards climate resilience have increased.
Activities:
2.1.1 Assess the economic value of ecosystem services to catalyze public financing.
- Evaluate economic contribution of ecosystem services toward vulnerability reduction related to public programs.

2.1.2 Promote the alignment of regulatory instruments and programs at the federal/state level to promote river restoration through EbA.
- Identify public programs with investments in connectivity (existing and potential).
- Analyze and propose regulatory instruments and programs at the federal/state level.

Output 2.2. Investments of private programs in targeted watershed catalyzed towards climate resilience have increased.
Activities:
2.2.1 Conduct assessment of the economic value of ecosystem services to promote private incentives.
- Evaluate economic contribution of ecosystem services toward vulnerability reduction related to private incentives.

2.2.2 Facilitate the implementation of schemes that link the private sector to river restoration as an adaptation measure.
- Identify potential private contributors.
- Design linkage schemes with the private sector in connectivity investments as an adaptation measure.
- Conduct awareness workshops with private actors to promote connectivity investments.
- Supervise that private sector investments land correctly in the territories.

Output 2.3. Dedicated credit lines, and financial products and services developed towards climate resilience have increased.
Activities:
2.3.1 Develop/improve dedicated credit lines and financial products to catalyze financing for EbA activities related to river restoration.
- Promote the development of dedicated credit lines with Development Finance Institutions.

Train financial intermediaries to develop financial products and services that promote sustainable and climate-resilient practices.

Component 3: Design of a National River Restoration Strategy for climate change adaptation. Under the leadership of INECC, this Component will support the design of the NRRS to strengthen the country's adaptation to climate change. It will identify relevant stakeholders for the design of the strategy; establish a Design Committee and its institutional arrangements; incorporate lessons learned from intermediate results from Components 1 and 2; organize workshops to define objectives, scope, and guidelines of the NRRS. It will also support the work with public officials and legislators to: define the legal framework of the strategy; identify relevant key decision-makers and legislators that require strengthening in their knowledge on climate change adaptation, and develop and launch a communication strategy for the NRRS. Those relevant key decision-makers and legislators will be selected based on their ability to influence the development of the NRRS, their interest on climate change and sustainability and their interest to participate.

Once approved, the NRRS will expect to become: (i) a strategic plan for river restoration at the national level, as well as the inter institutional alignment of productive and conservation sectors, financing and actions in priority sites, with a basin approach in the context of climate change; (ii) an instrument at the national level that contributes to increasing the population's capacity to adapt to climate change, as well as actions for the restoration and connectivity of rivers that improve the quality of ecosystems and the population well-being; (iii) a tool for documenting, assessing, and scaling-up decision making at the national level, in the context of the NRRS; and (iv) a link to the NDCs 2020.

RIOS will engage and work closely with the federal government agencies to proactively prioritize efforts across their full range of operations to foster the alignment of investments, programs, subsidies, and activities for supporting and scaling-up long-term low-GHG and climate-resilient development. On this matter, the RIOS Coordinating Committee (CC) will be key to strengthen collaboration between federal-level environmental, agricultural, water, and rural finance entities participating as project partners. The CC will be composed of INECC, the FMCN that also serves as its Technical Secretariat, and the following key government agencies: Secretariat of Environment and Natural Resources (SEMARNAT), Secretariat of Agriculture and Rural Development (SADER), Secretariat of Welfare (BIENESTAR), National Commission for Protected Areas (CONANP), National Forestry Commission (CONAFOR), National Water Commission (CONAGUA), Mexican Institute of Water Technology (IMTA) and National Trust for Rural Development (FIRA).

Output 3.1. The design of the National River Restoration Strategy has been supported.

Activities:
3.1.1 Design and agree with key stakeholders on a National River Restoration Strategy.Identify and convene relevant actors for the design of the NRRS.

- Establish the inter-institutional arrangements of the Design Committee.
- Incorporate lessons learned from IWAPs, project and similar initiatives.
- Develop workshops to define objectives, scope and guidelines of the Strategy.

Present and agree on a proposal of a NRRS with key stakeholders from the environmental sector.

Output 3.2: Legislators and officials have actively participated to operationalize the National River Restoration Strategy.
Activities:
3.2.1 Involve key stakeholders on EbA for river restoration, with a gender approach.

- Train legislators and officials on the importance of EbA for river restoration, with a gender approach.
- Definition of the legal framework in which the Strategy may be incorporated.

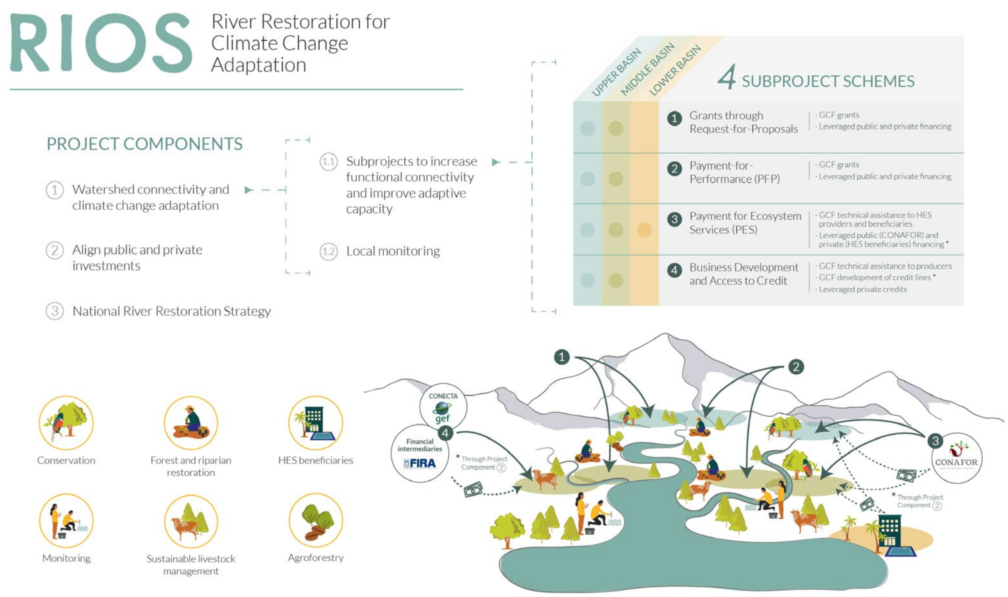


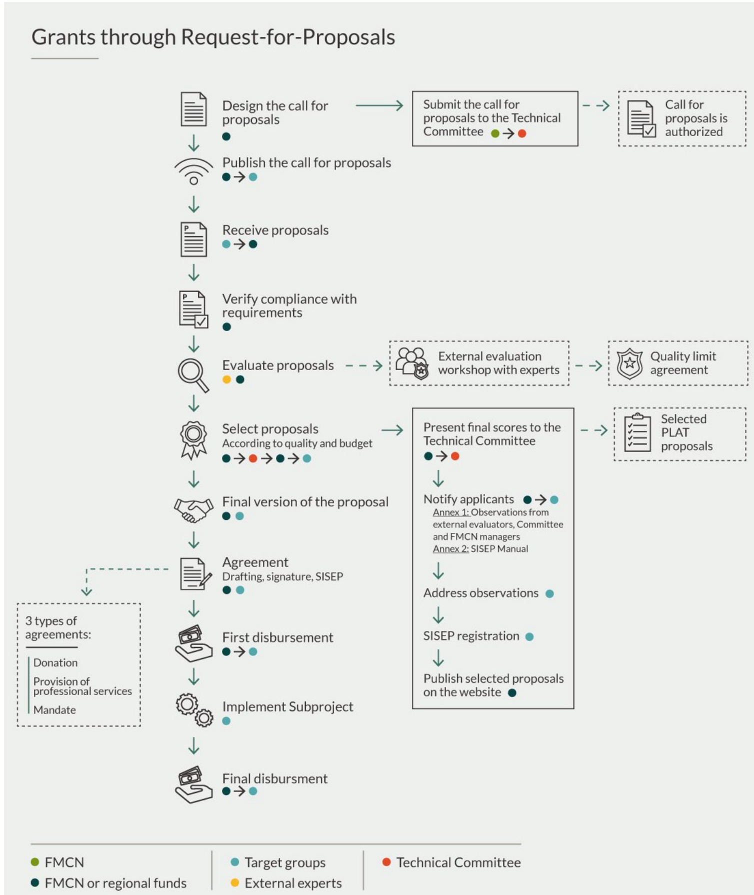
Figure 3.5. Summary of RIOS Project's Components.

3.2 Detailed description of subproject schemes under Component 1

This component will be implemented through subprojects awarded to selected community, civil and private organizations working with producers on the ground to increase capacities in: (i) **rehabilitation and restoration** of forests along rivers and springs (increase coverage with native species, soil restoration); (ii) **protection and conservation** of forests; and (iii) **productive activities** that promote connectivity for river restoration (agroforestry and sustainable livestock management). These subprojects include a portfolio of four financing schemes, depending on the nature and objective of the activity (see Table 2.2).

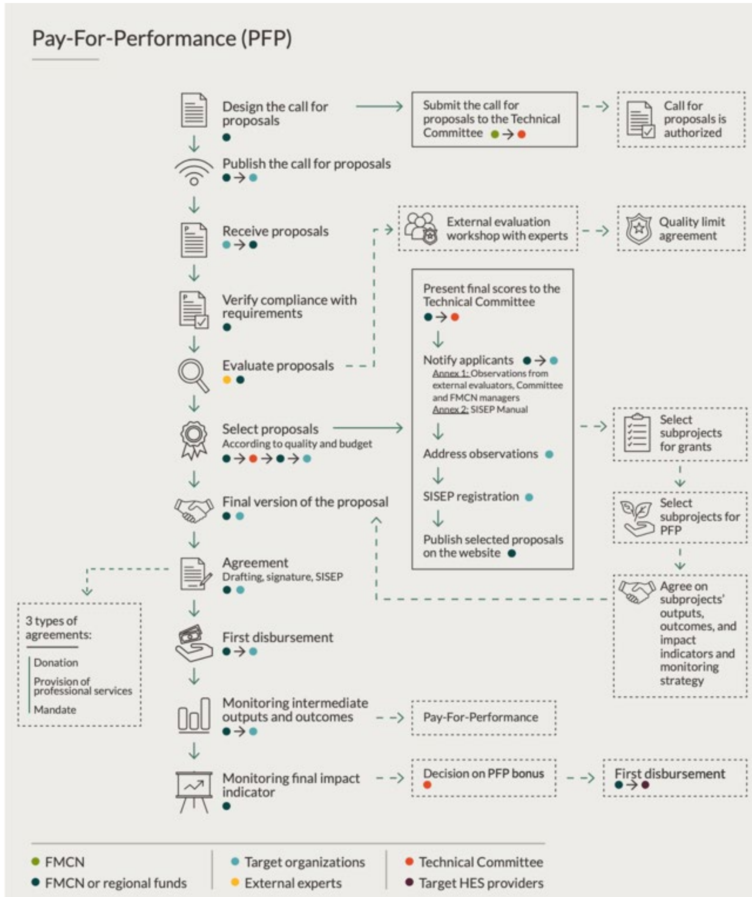
Scheme 1: Grants through Request for Proposals. FMCN will launch a demand-based request for proposals (RFP) through the Regional Funds (RF) to Civil Society Organizations (CSO) that group landholders and producers, including communities, *ejidos*, small landowners, and community enterprises.

- **Selection:** FMCN will launch a demand-based request for proposals (RFP) through the Regional Funds. Selection criteria include: (i) financial planning and technical viability, (ii) adaptation impact potential, (iii) social participation, (iv) institutional capacity, (v) complementarity with additional initiatives, and (vi) continuity.
- **Implementation:** OSC will provide technical and coordination assistance to support landholders and producers to implement the agreed activities.
- **Disbursement:** Grant is disbursed as established in the grant agreement, most of them linked to activities performed.



Scheme 2: Pay-for-Performance (PfP). This scheme will serve to pilot PfP to a subset of subprojects selected from the grant scheme. It will be implemented as a hybrid grant and pay-by-performance model that rewards the results that generate an increase in functional connectivity and climate adaptation.

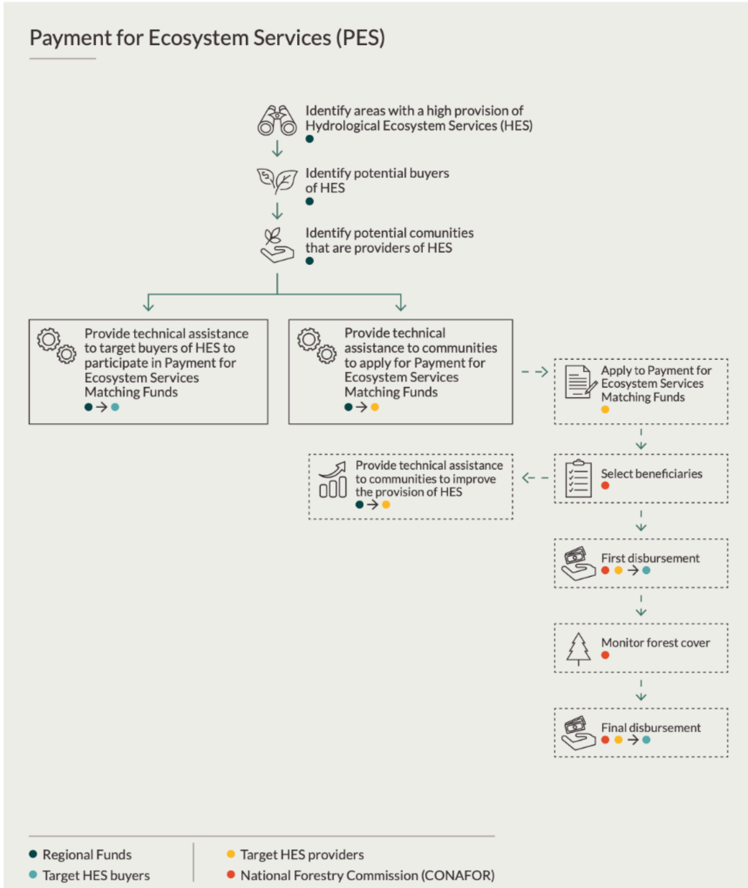
- **Selection:** FMCN will launch a demand-based RFP through the Regional Funds. FMCN will select at least 80% of the total subprojects for this pilot PfP. The selection criteria will be based on those activities that have potential for learning and measurable impact within the timeframe, and learning potential.
- **Implementation**: CSO and RF will agree at onset on tailored performance and impact indicators and targets. CSO and communities will monitor outcomes, supervised by a third party (RF). Beneficiaries will have a binnacle to associate changes in management practices to impact, and adapt actions.
- **Disbursement:** By the project's end an additional reward will be paid only after monitoring the successful delivery of results. The rewarded amount will be proportional to the target, up to 10% of the total grant amount when the goal is achieved. If the goal is surpassed, an additional 5% will be awarded for a total maximum of 15%.



Scheme 3: **Public-Private Payment for Ecosystem Services (PES)**. Regional Funds (RFs) will provide technical assistance to communities identified in the IWAPs as important suppliers of HES. RFs will support them to develop proposals to access the Payment for Ecosystem Services (PES) matching fund scheme from the Mexican Forest Commission (CONAFOR). Under Component 2, the project will identify private sector institutions downstream that demand and are beneficiaries of those HES.

- **Selection:** Regional Funds will provide technical assistance to communities identified in the IWAPs as important suppliers of HES. The RF will support them to develop proposals to access to PES matching fund scheme from the Mexican Forest Commission (CONAFOR).
- **Implementation:** Under Component 1, Regional Funds will support communities that provide HES to develop proposals to access funds from CONAFOR PES matching grant scheme.
- Under Component 2, FMCN and the RFs will create synergies to align private and public actors that demand hydrological ecosystem services (HES) downstream with communities upstream that are supplying those services.

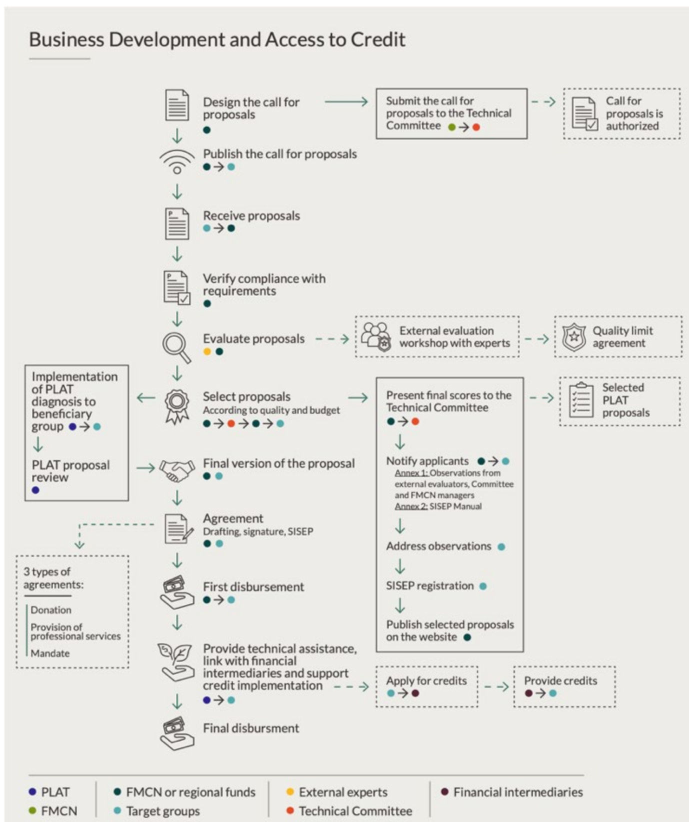
- **Disbursement**: Leveraged finance from CONAFOR (50%) and private actors (50%) will be disbursed directly to the communities through the Mexican Forest Fund.



Scheme 4: **Business development and facilitate access to credits**. FMCN will launch a demand-based RFP through the RFs to Local Providers of Technical Assistance (PLATs, for its acronym in Spanish), which are consulting firms or CSOs focused on promoting organizational and business management skills of Producer Groups (PG) in an integral manner. PLATs will be hired based on their long-term accompaniment strategies with one or more livestock and/or agroforestry PG(s) at the community level, going beyond traditional yearly TA and implementing a 4-year action plan. This scheme will be co-financed by the CONECTA project, financed by a GEF grant (2021-2026, see Chapter 1.6).

- **Selection:** FMCN will launch a demand-based request for proposals (RFP) through the RFs to Local Providers of Technical Assistance (PLATs,). Some preliminary criteria include: i) Location and knowledge of the territories involved in the project, ii) experience in working with PGs in the region, iii) experience of technical assistance services to similar production groups with a climate change adaptation focus, iv) knowledge of the technical activities of the project, organizational aspects of production and business management and v) knowledge of producer organizations and government actors in the region

- **Implementation:** PLATs will work directly with producer groups and will be supervised by the RFs. Among potential topics of assistance are managerial aspects, governance, financial and accounting training, marketing, and market access. Specialized consultancies and technical inputs can be financed in parallel for the selected PGs, including but not limited to sustainable milk processing, cheese production, eco or agritourism services, commercialization of sustainably produced goods, and access to credit markets for sustainable production. Under Component 2, Financial intermediaries will be trained to create or adapt credit lines for sustainable cattle and agroforestry production. Under Component 1, Regional funds will link potential PGs with the financial intermediaries trained under Component 2 and other potential financial intermediaries to access said credit lines.
- **Disbursement:** PLATs will receive the resources to increase financial and business capacities of PGs under the GEF CONECTA Project. PGs will receive the credits from the leveraged finance from the financial intermediaries.



Selection criteria

In equal circumstances, the additional selection criteria to be considered by the Project Technical Committee are the following:

1. **Gender approach**: the proposal has an approach that favors equality in the relationship between men and women;
2. **Surface area**: the proposal offers a greater surface of forest attended with relation to the alternative proposal;
3. **Diversity of organizations**: the set of proposals comes from the largest number of organizations, although those organizations that submit more than one proposal for incubating or accelerating new organizations or businesses will be considered;
4. **Linking between sub-projects**: the proposal includes synergies with other proposals for sub-projects and are territorially related.

3.3 Detailed description of activities and relation with the reduction with climate change vulnerability

Table 2.3 describes the activities supported under Component 1 and the relation with the reduction of climate change vulnerability. It will be implemented through subprojects awarded to selected community, civil and private organizations working with producers on the ground to increase capacities in: (i) **rehabilitation and restoration** of forests along rivers and springs (increase coverage with native species, soil restoration); (ii) **protection and conservation** of forests; and (iii) **productive activities** that promote connectivity for river restoration (agroforestry and sustainable livestock management).

The pre-feasibility study in Chapter 4, shows a detailed analysis of ecosystem services provided, benefits and co-benefits related to these supported practices. The type of vulnerabilities to climate change addressed under this project are: (i) Vulnerability of human settlements to flooding (VPI), (ii) Vulnerability of human settlements to landslides (VPDes), (iii) Vulnerability of extensive livestock farming to flooding (VGI), (iv) Vulnerability of extensive livestock farming to water stress (VGEH) and (v) Vulnerability of fodder production to water stress (VFEH).

Additional to the climatic benefits, these activities have been selected because: (i) the stakeholder consultations identified them as culturally appropriated, (ii) have been successfully accepted and implemented by both men and women within the framework of other projects, mainly C6 (see Section 1.6) , and (iii) in the case of productive activities, have a positive financial return (see Section 4).

Table 2.3. Example of activities supported under Component 1 and expected impact to increase adaptation to climate change reducing vulnerabilities to climate change.

Systems		Examples of eligible activities	Expected climate change adaptation impact	Vulnerability addressed	Sources
River restoration	**Riparian restoration**	Establish seed banks and nurseries for reforestation /restoration of riparian areas with native germplasm	Increased maintenance of the biodiversity to strengthen the response capacity of ecosystems to possible impacts of climate change.	VPI VGI	FAO, 2015 Romero, 2014 Midgley, Guy, et al. 2012
		Community work on reforestation/restoration of riverbanks (for example, watershed committees)	Increased capacity building and re-appropriation of traditional knowledge in the communities where the project is implemented to promote riverbank reforestation/restoration for flood risk reduction.		Meli, 2011 Mushamuka, 2011 Chazdon, R., 2008
		Restoring riverbanks with native vegetation	Increased hillside stability and reduced sediment deposits that limit water flow Improved capacity of riparian ecosystems to provide soil retention and water provision services.		Tillery, and Renges., forthcoming Addy, 2016 Dixon, et al., 2016 Robles, 2011
		Establish organic fertilizer production systems (vermicomposting, bocashi, supermagro)	Contributed to the reduction of diffuse contamination in water bodies and increase water quality.		Mota, et. al, 2019 UNW-DPAC, 2015
	Restoration	Reforest with native species	Contributed to the ecological connectivity of ecosystems for vulnerable species to possible impacts of climate change and conserve environmental services. Preserving biodiversity of ecosystems to strengthen their capacity to respond to climate change.	VFEH VGEH	Botero, 2015 Nisbet et al., 2011 CONAFOR, 2010
		Restore forests with native species	Maintained biodiversity of ecosystems to improve the provision of ecosystem services and the capacity to respond to possible impacts of climate change.		Ministerio de Medio Ambiente de Chile, 2014 Chazdon, R. L., 2008
		Restore patches to increase connectivity	Increased connectivity and habitat corridors of species of ecological relevance and to improve the provision of ecosystem services and the capacity to respond to possible impacts of climate change.		Useche, 2006
		Establish Units for Management and Sustainable Use of Wildlife (private and community areas dedicated to manage wildlife with expected economic	Improved sustainable management of the territory, and diversify income to increase adaptation to climate change.		CONAFOR, 2019 SEMARNAT, 2018

		returns, including conservation in situ, reproduction in captivity for sustainable use, reduction of loss of habitat)			
		Manage forest areas sustainably through plant health, clearing and pruning	Improved regulation of the air and soil moisture. These factors lead to the establishment of a microclimate and mitigate the effects of extremes of heat, winds and heavy rains. Increased mitigation of emissions from climate change.		FAO, 2010
		Recover and restore soils	Promoted the recovery of soil ecosystems to contribute to the storage of carbon in the roots of plants and soil, in order to mitigate greenhouse gas emissions to the atmosphere. Improved soil retention to reduce flood risk and drought. The restoration of the land stores not only gives quick results, but also is economical, generates jobs and ensures food security.		Orjuela h., 2018 CONAFOR, 2012 European Commision, 2012 Robert, M., 2002
					UNFCCC, 2019 Ortiz H, 2007
		Eradicate invasive exotic species	Structure recovered and improved functioning of ecosystems to reduce the potential impacts of climate change and loss of biodiversity.		Moreno, J. and H. Ruiz, 2016 CONABIO, 2010
		Maintain and manage reforested areas (fire prevention, promote activities that increase regeneration).	Improved regeneration of key ecosystems to reduce the potential impacts of climate change and maintain environmental services.		Sanchez, L., and O. Reyes, 2017 Vanegas, M. 2016
		Establish and maintain nurseries with native species	Increased maintenance of the biodiversity to strengthen the response capacity of ecosystems to possible impacts of climate change.		Vargas, O., 2016
		Develop capacities in restoration techniques	Improved local knowledge related to adaptation based on traditional knowledge in the communities of the intervention areas.		Ministerio de Cultura de Peru, 2018 Watanabe, J. et al., 2018
		Diversify plantations with timber and non-timber native species	Improved conservation and sustainable use of forests in the areas of intervention, and thus avoid deforestation and loss of environmental services.		SEGOB, 2018 CONAFOR, 2008
		Restore wetlands and their natural dynamics	Improved restoration of water flow to ensure water availability.		RAMSAR, 2015 Lindig-Cisneros, R. and Zedler, 2010

	Agroecological practices	Conserve soils with agroecological practices (living fences, stubble, cover crops, organic fertilizing, productive diversification)	Increased implementation of sustainable production practices to reduce potential sources of diffuse pollution to water bodies, improve diets, and adapt practices to climatic events.	VGI VPI VPDes	PRIICA, 2016 Escobar, J, 2003
		Landscape contours on slopes, incorporate stubble and vegetation stripes	Reduced sediment deposits in order to restore water flow, as well as flood reduction by reducing the speed of water.		FAO, 2005 FAO, 1997
		Plant native palms in palm groves	Improved the provision of environmental services.		FAO, 2009
Forest protection and conservation		Conserve soils with agronomic practices: vegetation stripes, use of leguminous plants (Lupinus), firebreaks at slopes	Improved soil retention to reduce flood risk and drought and maintained biodiversity.	VFEH VGEH VGI VPI VPDes	Martínez-Rodríguez, M.R., et al. 2017 Keenan, R. J., 2015
		Establish and maintain nurseries and seed banks of native species that enrich forest systems with vermicomposting	Increased adaptation by promoting diverse forest ecosystems that respond better to the possible effects of climate change.		Williams, M. &, R. Kasten, 2014
		Identify, evaluate and control pests and diseases with integrated pest management practices (based on natural enemies)	Improved practices that prevent the potential impacts of climate change regarding the spread of pests and loss of biodiversity and food sovereignty.		Deutsch, C. A. et al., 2018 FAO, 2008
		Train and acquire equipment for fire prevention, control and management	Decreased risk of fires and reduced impact from fires that do occur by early warning and fire prevention mechanisms as a potential impact of climate change. Incorporate fire spread prevention measures that compromise the maintenance of biodiversity and environmental services.		UNDP, 2017 Giannakopoulos, C. et al., 2012
		Build firebreaks and conduct actions for fire prevention, control and management	Decreased the impact of fires by improving fire prevention measures to maintain biodiversity and environmental services.		SEMARNAT, 2009
		Identify plants of interest and use by local communities	Increased conservation and sustainable use of traditional species in order to strengthen the capacities of communities.		Botero, 2015.
		Build capacities in communities for extraction and sustainable use of plants of interest (seed banks, nurseries, cover crops, organic fertilizing, productive diversification)	Increased use of biodiversity in a sustainable manner in order to minimize the potential effects of climate change on biodiversity.		Cach, J., 2016

		Develop green business and sustainable certification plans	Improved systems that promote provision of ecosystem services and increase the commercial value of products.		Ochoa, J., 2018
		Build nurseries for medicinal plants and plants for other uses	Increased maintenance of the biodiversity to strengthen the response capacity of ecosystems to possible impacts of climate change by rescuing traditional knowledge and strengthening of communities.		IUCN, 2013
		Define the species that are adequate for restoration	Improved ecological restoration, in order to promote ecosystems with greater integrity to face the possible impacts of climate change.		Fundación Biodiversidad, 2016
Productive practices	**Sustainable livestock management**	Improve livestock practices in transition to sustainable livestock management including silvopastoral systems.	Reduced sources of diffuse contamination to water bodies. Restored the water flow to contribute to the connectivity of the basin to reduce the risks of landslides un the upper basin and floods downstream..	VFEH VGEH VGI	FAO, 2011 Gaccio, 2011 SEMARNAT, 2011 FAO, 2000
		Living fences (can include fruit trees)			
		Improvement of pastures (evaluation, grass enrichment, rotations, introduction of trees			
		Reforest/restore riparian corridors along streams and rivers excluding cattle or limiting access points			
		Establish troughs to avoid animals entering streams			
		Connect reforested fragments belonging to different owners (for example, 5 ha fragments from 4 different owners to achieve a 20 ha forest)			
		Conserve springs through introduction of trees			
		Natural Windbreaks			
	Agroforestry	Enrich fallow areas	Increased productivity and, reduced losses due to climate impacts by implementing practices resilient to climate change.	VFEH VGEH VGI VPDes	Torres, Tenorio, & Gómez, 2008
		Develop sustainable management programs (diversified systems, shadow coffee)	Improved systems that promote provision of ecosystem services and increase the commercial value of products.		Armelinda, 2013

		Establish seed banks	Increased maintenance of the biodiversity to strengthen the response capacity of ecosystems to possible impacts of climate change.		PNUD, 2019
		Develop sustainable management programs	Improved systems that promote provision of ecosystem services and provide economic resources to local communities.		CGIAR, 2017
		Build capacities in best practices for collecting non-timber forest products	Improved systems that promote provision of ecosystem services and provide economic resources and reduce food insecurity.		Balama, Ch. 2016 FAO, 2001
		Establish edible forests	Improved the presence of trees to reduce the exposure to the sun, wind and rain and regulates the air and soil moisture. These factors lead to the establishment of a microclimate and mitigate the effects of extremes of heat, winds and heavy rains, as well as droughts and frosts in the crops.		UNEP, 2018
		Develop business plans for shade systems like coffee or diversified systems.	Improved systems that promote provision of ecosystem services and increase the commercial value of products.		Bunn C., et al, 2018 Baker P. and J. Haggar, 2007

3.4 Sustainability and exit strategy

The long-term sustainability strategy gathers experiences from FMCN and the RFs to ensure that the project activities continue once the project is completed. RIOS will replicate and improve the sustainability strategy implemented in C6. For example, an evaluation 16 months after the C6 ended showed that 90% of the subprojects continued their operation and obtained additional financing from other sources, including public (Sembrando Vida, Jóvenes Construyendo el Futuro) as well as private investments (Coca-Cola, ADO transportation). The main aspects of the exit strategy for long-term sustainability are:

- **Include activities with positive economic returns to ensure long-term sustainability** Chapter 4.3 shows that activities have a positive return of investment. A detailed financial analysis was carried out on sustainable livestock activities and showed that they are profitable. The activities have a high probability of continuing once the project ends.

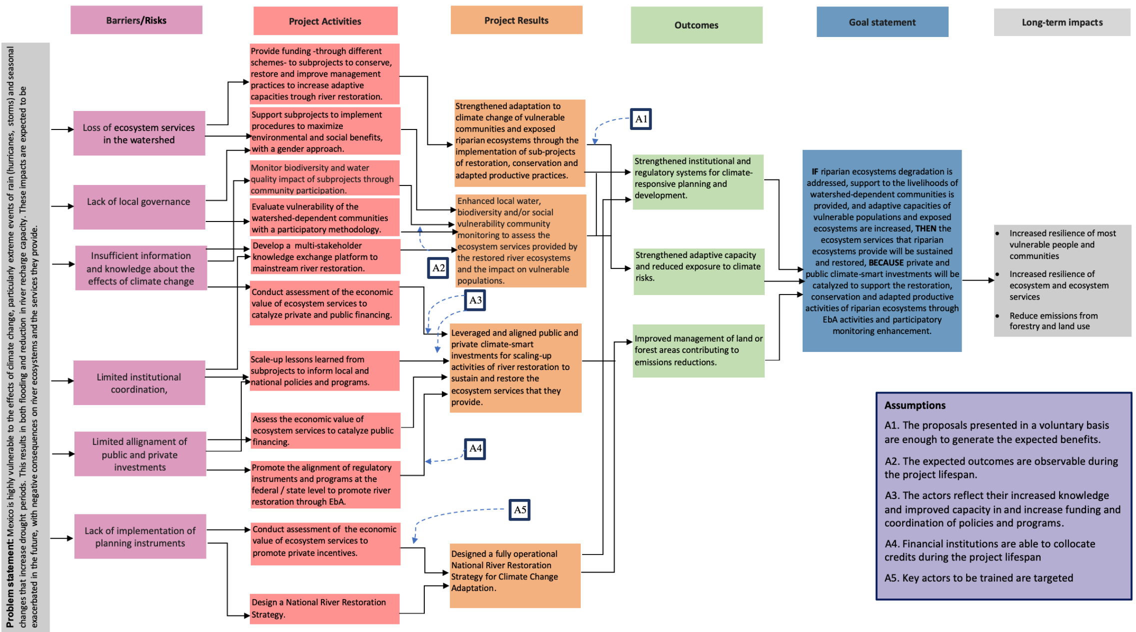
- **Mobilize public and private investments to reduce risks and ensure continuity after project ends**. RIOS allows to leverage financial resources in a tailored way, depending on the type of activity. For those with positive private returns, such as sustainable livestock, it will be complemented with credits. For activities with a positive impact on ecosystem services such as upstream conservation, a Payment for Environmental Services program will be incorporated, catalyzing public-private investments. This variety of financing sources reduces risks and increases long-term sustainability.

- **Demonstrate the positive impact of the activities through robust monitoring.** Through intensive monitoring, the economic valuation of ecosystems, and the implementation of a PfP, the initiatives' positive impact will be apparent to both landowners and the public and private sectors. This will allow the creation of long-term sustainable financing mechanisms based on the activities' real and monitored impact.

- **Allow replication and systemic change through a National Strategy**. Rather than implementing stand-alone subprojects, RIOS is designed to expand the lessons learned from Component 1 to support a National River Restoration Strategy for greater impact.

3.5 Logical framework and theory of change

Theory of change



If riparian ecosystems degradation is addressed, support to the livelihoods of watershed-dependent communities is provided, and adaptive capacities of vulnerable populations and exposed ecosystems are increased, then the ecosystem services that riparian ecosystems provide will be sustained and restored, because private and public climate-smart investments will be catalyzed to support the restoration, conservation and adapted productive activities of riparian ecosystems through EbA activities and participatory monitoring enhancement. In this way, the objective of RIOS is to increase adaptive capacity in watersheds vulnerable to climate change through river restoration and connectivity by: (i) conducting restoration, conservation and improved productive activities, implemented by local organizations in the states of Jalisco and Veracruz, (ii) increasing local monitoring capacities to reduce climate vulnerability, (iii) catalyzing public and private climate-smart investments; and (iv) supporting the development of climate policy in a National River Restoration Strategy.

Mexico is highly vulnerable to the effects of climate change, particularly extreme events of rain (hurricanes, storms) and seasonal changes that increase drought periods. This results in both flooding and reduction in river recharge capacity. These impacts are expected to be exacerbated in the future, with negative consequences on river ecosystems and the services they provide. Although the origin of the potential impacts identified in target watershed is in the physical-geographic and climatic domain, these impacts are exacerbated by inadequate land-use planning, that results in drivers such as the expansion of human settlements, environmental deterioration and deforestation in the upper parts of the basins (INECC, 2019). Six main barriers have been identified in the two watersheds: (i) loss of ecosystem services, (ii) lack of local governance, (iii) insufficient information and knowledge about the effects of climate change, (iv) limited institutional coordination, (v) limited alignment of public and private investments, and (vi) lack of implementation of planning instruments.

The objective of RIOS is to increase adaptive capacity in watersheds vulnerable to climate change through river restoration and connectivity by: (i) conducting restoration, conservation and improved productive activities, implemented by local organizations in the states of Jalisco and Veracruz, (ii) increasing local monitoring capacities to reduce climate vulnerability, (iii) catalyzing public and private climate-smart investments; and (iv) supporting the development of climate policy in a National River Restoration Strategy. If riparian ecosystems degradation is addressed, support to the livelihoods of watershed-dependent communities is provided, and adaptive capacities of vulnerable populations and exposed ecosystems are increased, then the ecosystem services that riparian ecosystems provide will be sustained and restored, because private and public climate-smart investments will be catalyzed to support the restoration, conservation and adapted productive activities of riparian ecosystems through EbA activities and participatory monitoring enhancement.

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Logical framework

	Expected Result	Indicator	Means of Verification (MoV)	Baseline	Target Mid-term (if applicable)	Target Final	Assumptions
FUND-LEVEL RESULTS	A1.0 Increased resilience and enhanced livelihoods of the most vulnerable people, communities and regions	A1.2 Number of males and females benefiting from the adoption of diversified, climate resilient livelihood options (including fisheries, agriculture, tourism, etc.)	Official data from national population surveys (census, and inter census data) triangulated to project data where the activities are being financed	0 people	Male = 12,250 Female = 12,750 Total= 25,000	Male = 31,016 Female = 32,278 Total= 63,294	The adoption of diversified, climate-resilient livelihood practices will directly benefit the inhabitants from the localities of all the basin by increasing the provision of ecosystem services. This will increase their resilience to climate change effect.
	A4.0 Improved resilience of ecosystems and ecosystem services	A4.1 Coverage/scale of ecosystems protected and strengthened in response to climate variability and change	Publications endorsed by the government (IWAPs), independent water community monitoring evaluation and field visits	64,348 ha	100,000 ha	260,000 ha	Areas with improved ecosystems endorse the Integrated Watershed Action Plans IWAP (co-financed by GEF CONECTA project) and are strengthened via a reduction in the risk of deforestation and improved management. Baseline includes those areas that currently have a formal protection/conservation strategy (i.e. Pico de Orizaba and Sierra Vallejo Natural Protected Areas).
	M4.0 Reduced emissions from land use, reforestation, reduced deforestation, and through sustainable forest management and conservation and enhancement of forest carbon stocks	M4.1 Tonnes of carbon dioxide equivalent (t CO2eq) reduced or avoided (including increased removals) as a result of Fund-funded	Ex-Act, and BUR and triangulated with geospatial data (for ex - post)	Without project 335,733 tCO_2e	120,000 tCO_2e net carbon sink	2.391 M t CO_2 eq net carbon sink	GHG estimates are based on the twenty-year project asset lifespan, estimated with the EX-ACT tool complemented with national official data (BUR, NIR). Reduced or avoided means the area for which new and/or improved sustainable landscape management has been promoted

		projects/programmes					through IWAPs and by practices introduced through the project.
OUTCOMES	A5.0 Strengthened institutional and regulatory systems for climate-responsive planning and development	A5.2 Number and level of effective coordination mechanisms[25]	Publication of rules of operation in the official National Gazette, Memorandums of understanding and other formal agreements. Relevant minutes.	1 Mechanism = Level 3	1 Mechanism= Level 3 1 Mechanism= Level 4	2 Mechanism = Level 3 2 Mechanism = Level 4	Baseline agreement is the mechanism agreed by INECC-CONAFOR for the selection criteria of the PES project under IWAPs priority areas.
	A7.0 Strengthened adaptive capacity and reduced exposure to climate risks	A7.1: Use[26] by vulnerable households, communities, businesses and public-sector services of Fund supported tools, instruments, strategies and activities to respond to climate change and variability	Pre-post project survey, and field data	Level= 2 0% of subprojects have been trained	Level =3 50% of subprojects have been trained	Level =4 80% of subprojects have been trained	Fund-supported tools, instruments, strategies, and activities mean the social vulnerability assessment tool developed under Component 1. The baseline tool is the National Atlas for Vulnerability, developed by INECC.
	M9.0 Improved management of land or forest areas contributing to emissions reductions	M9.1 Hectares of land or forests under improved and effective management that contributes to CO_2 emission reductions	Georeferenced databases, drone photos, and databases verified by a third party in the mid-term	0 ha	4,000 ha	7,725 ha	Land or forest areas are the number of hectares under rehabilitation, restoration, and improved management practices under Component 1. Based on CIF Forest Investment Program (FIP) indicator guidance: reduction/avoidance/removals refer to greenhouse gas emissions, mainly CO2, and enhancement of carbon stocks.

[25] Use Level 1 = no coordination mechanism; Level 2 = coordination mechanism in place; Level 3 = coordination mechanism in place, meeting regularly with appropriate representation (gender and decision-making authorities); Level 4 = coordination mechanism in place, meeting regularly, with appropriate representation, with appropriate information flows and monitoring of action items/issues raised.

[26] Level 1 = no social vulnerability assessment tool exists at national level; Level 2 = the social vulnerability assessment tool has been adapted at local level with a participatory inclusive approach (including gender aspects); Level 3 = at least 50% of subprojects have been trained on how to implement the the social vulnerability assessment tool; Level 4 = at least 80% of subprojects have been trained on how to implement the the social vulnerability assessment tool and are implementing it.

			and independent evaluations				

	Expected Outputs	Indicator	Means of Verification (MoV)	Baseline	Target		Description/Assumptions
					Mid-term (if applicable)	Final	
PROJECT-LEVEL OUTPUT	COMPONENT 1						
	Output 1.1 Increased area of land conserved, restored, or under best management practices that reduce climate vulnerability.	Cumulative number of ha conserved, restored or under best management practices.	Georeferenced databases, drone photos, and databases verified by a third party in the mid-term and independent evaluations	0 ha	4,000 ha	7,725 ha	Land is the number of hectares of forest, riverbanks, and farm land that contribute to river restoration under rehabilitation, restoration, and improved management practices under Component 1. Rehabilitation, restoration, and improved management practices contribute directly to river restoration.
	Output 1.2: Target communities have applied a participatory methodology for monitoring biodiversity and water quality to provide inputs for an evaluation of the ecosystem and social vulnerability of the basins.	Extent[27] of implementation of an adequate water, biodiversity and/or vulnerability monitoring system.	Project databases, independent water community monitoring evaluation, field visits and public reports.	Extent = 1 0% of subprojects have a monitoring system	Extent = 3 70% of subprojects with grants, or pay-by performance schemes have a monitoring system validated by the community	Extent = 4 70% of subprojects with grants, or pay-by performance schemes have a monitoring system and local data is analyzed	Local communities apply the monitoring system effectively after training. Local data is aggregated and analyzed to assess the ecosystem and social vulnerability of the basins.

[27] Extent 1 = there is not a monitoring system for social vulnerability, water and/or biodiversity in the subprojects in targeted watersheds. Extent 2 = over 70% of subprojects with grants, or pay-by performance schemes have been trained on participatory monitoring system for social vulnerability, water and/or biodiversity monitoring. Extent 3 = 70% of subprojects with grants, or pay-by performance schemes have a monitoring system for social vulnerability, water and/or biodiversity monitoring, validated by the community. Extent 4 = over 70% of subprojects with grants, or pay-by performance schemes have a monitoring system for social vulnerability, water and/or biodiversity monitoring, validated by the community and local data is analyzed to evaluate the ecosystem and social vulnerability of the basins.

	Output 1.3: A learning community fostering knowledge has exchanged and coordinated experiences between watersheds and with key actors to increase functional connectivity.	Extent[28] of a fully operational learning community	Learning community reports available in the project website.	Extent = 2	Extent = 3	Extent = 4	The learning community allows the effective exchange of experiences and links subprojects with the private sector, national government, local government, academia, and civil society
	COMPONENT 2						
	Output 2.1: Investments of public programs in targeted watershed catalyzed towards climate resilience have increased.	Percentage of total subproject financing leveraged from public sources	Project records, agreements under the project and minutes from the Coordinating Unit	0% subproject financing	10% subproject financing	25% subproject financing	Public funds would not be aligned with project priorities without the activities implemented under Component 2.
	Output 2.2 Investments of private programs in targeted watershed catalyzed towards climate resilience have increased.	Percentage of total subproject financing leveraged from private sources	Project records and agreements under the project	0 % subproject financing	10 % subproject financing	25 % subproject financing	Private funds would not be aligned with project priorities without the activities implemented under Component 2.
	Output 2.3: Dedicated credit lines, and financial products and services developed towards climate resilience have increased.	Extent[29] implementation of dedicated credit lines towards river restoration and connectivity (including agroforestry	Letter of commitment of co-finance, strategic plan and report of	Extent = 2 0 financial intermediaries with credit lines without	Extent = 3 3 financial intermediaries are receiving a comprehensive	Extent = 5 3 financial intermediaries developed/improved their credit lines	Financial entities will place credits as agreed during the project implementation.

[28] Extent 1 = there are no meetings in topics related to river restoration in targeted watersheds between actors representing the private sector, national government, local government, academia and civil society. Extent 2 = there are informal meetings with actors representing the private sector, national government, local government, academia and civil society. Extent 3 = at least 70% of the subprojects from each basin had participate in at least one meeting with actors representing the private sector, national government, local government, academia and civil society. Extent 4 = at least 70% of the subprojects from each basin had participate in biennial meetings with actors representing the private sector, national government, local government, academia and civil society and a virtual learning community.

[29] Extent 1 = there are no credit lines or financial intermediaries (micro finance institutions, banks, cooperatives, NGOs, etc.) financing climate-smart activities related to river restoration and connectivity. Extent 2 = there are credit lines or financial intermediaries financing climate-smart activities related to river restoration and connectivity, but without specific products targeted to the activities in the region, without strong social and environmental safeguards, and without specific training on gender approach. Extent 3 = at least 3 financial intermediaries are receiving a comprehensive training to develop climate-smart dedicated credit line, including strong social and environmental safeguards, and specific training on gender approach. Extent 4 = at least 3 financial intermediaries developed/improved their credit lines to finance climate-smart activities related to river restoration and connectivity. Extent 5 = at least 3 financial intermediaries developed/improved their credit lines to finance climate-smart activities related to river restoration and connectivity and are placing credits.

		and sustainable livestock)	a full-training delivery	specific products targeted to the activities in the region, without strong social and environmental safeguards, and without specific training on gender approach	training to develop climate-smart dedicated credit line		
	COMPONENT 3						
	Output 3.1: The design of the National River Restoration Strategy has been supported.	National River Restoration Strategy (NRRS) Prepared and implemented[30]	Project documents, workshops' list of attendants	0	Level= 2	Level=5	The project will generate the enabling conditions for the full operability of NRRS. Once fully designed, the Government will implement the strategy. Within the lifespan of the project, a goal of 4 in the scorecard seems reachable.

[30] Level 1 = Identify relevant actors (including women) for the strategy design. Level 2 = Establish the inter-institutional arrangements of the Design Committee. Level 3 = Incorporate lessons learned from IWAPs, RIOS project and similar initiatives. Level 4= Develop workshops to define objectives, scope and guidelines of the Strategy, including training on gender perspective. Level 5 = National River Restoration Strategy has been designed and agreed with key. Stakeholders from the environmental sector. Level 6= National River Restoration Strategy has been fully designed and presented to be included in the legislation.

	Output 3.2: Legislators and officials have actively participated to operationalize the National River Restoration Strategy.	Increased knowledge and leadership of legislators and public officials of the need for the National River Restoration Strategy.	Pre-post knowledge survey	Tbc from baseline survey	n.a.	+ 80% people increase knowledge from baseline	Key actors (including legislators and public officials) that are sensitized will promote the NRRS.

Output	Activity	Inputs
Output 1.1 **Increased area of land conserved, restored, or under best management practices that reduce climate vulnerability.**	1.1.1 Provide funding -through different schemes- to subprojects to conserve, restore and improve management practices to increase adaptive capacities through river restoration.	Consultant - Individual - Local
		Equipment
		Materials & Goods
		Salaries and benefits
		Travel
		Workshop/Training
	1.1.2 Support subprojects to implement procedures to maximize environmental and social benefits, with a gender approach.	Consultant - Individual - Local
		Materials & Goods
		Professional Services – Companies/Firm
		Salaries and benefits
		Technical assistance and inputs for subprojects
		Travel
		Workshop/Training
Output 1.2 **Target communities have applied a participatory methodology for monitoring biodiversity and water quality to provide inputs for an evaluation of the ecosystem and social vulnerability of the basins**	1.2.1 Monitor biodiversity and water quality impact of subprojects through community participation.	Consultant - Individual - Local
		Equipment (monitoring Backpack, trap camera, drones,)
		Equipment (Weather stations Extech SD700 Hydrometric stations Extech SD700)
		Materials & Goods
		Professional Services – Companies/Firm
		Salaries and benefits

		Travel
		Workshop/Training
	1.2.2 Evaluate vulnerability of the watershed-dependent communities with a participatory methodology.	Salaries and benefits
		Consultant - Individual - Local
		Travel
Output 1.3 **A learning community fostering knowledge has exchanged and coordinated experiences between watersheds and with key actors to increase functional connectivity.**	1.3.1 Develop a multi-stakeholder knowledge exchange platform to mainstream river restoration.	Consultant - Individual - Local
		Materials & Goods
		Professional Services – Companies/Firm
		Salaries and benefits
		Travel
		Workshop/Training
	1.3.2 Scale-up lessons learned from subprojects to inform local and national policies and programs.	Consultant - Individual - Local
		Salaries and benefits
		Travel
Output 2.1 **Investments of public programs in targeted watershed catalyzed towards climate resilience have increased.**	2.1.1 Assess the economic value of ecosystem services to catalyze public financing.	Consultant - Individual - Local
		Equipment
		Salaries and benefits
		Travel
	2.1.2 Promote the alignment of regulatory instruments and programs at the federal / state level to promote river restoration through EbA.	Consultant - Individual - Local
		Materials & Goods
		Salaries and benefits
		Travel
		Workshop/Training
Output 2.2 **Investments of private programs in targeted watershed catalyzed**	2.2.1 Conduct assessment of the economic value of ecosystem services to promote private incentives.	Consultant - Individual - Local
		Salaries and benefits
		Travel

towards climate resilience have increased.	2.2.2 Facilitate the implementation of schemes that link the private sector to river restoration as an adaptation measure.	Consultant - Individual - Local
		Materials & Goods
		Salaries and benefits
		Travel
		Workshop/Training
Output 2.3 **Dedicated credit lines, and financial products and services developed towards climate resilience have increased.**	2.3.1 Develop/improve dedicated credit lines and financial products to catalyze financing for EbA activities related to river restoration.	Consultant - Individual - Local
		Professional Services – Companies/Firm
		Salaries and benefits
		Workshop/Training
Output 3.1 **The design of the National River Restoration Strategy has been supported.**	3.1.1 Design and agree with key stakeholders on a National River Restoration Strategy.	Consultant - Individual - Local
		Equipment
		Materials & Goods
		Salaries and benefits
		Travel
		Workshop/Training
Output 3.2 **Legislators and officials have actively participated to operationalize the National River Restoration Strategy.**	3.2.1 Involve key stakeholders on EbA for river restoration, with a gender approach.	Consultant - Individual - Local
		Professional Services – Companies/Firm
		Salaries and benefits
		Travel

3.6 Project monitoring and evaluation

Monitoring and evaluation are a key component of RIOS. The objective will be to: 1) monitor overall project progress, 2) complement available climatic information and help to solve knowledge gaps, and 3) monitor subprojects' impact to attribute results, and scale-up the knowledge to incorporate it in the NRRS.

During implementation, the FMCN will be responsible for the overall project monitoring in conjunction with INECC. Progress will be measured against the Logical Framework. Technical reports will be prepared by the Regional Funds under the oversight of FMCN. The FMCN will conduct a mid-term and a final evaluation, including quantitative assessment of outcomes and analysis of achievements and difficulties encountered, compliance with environmental, gender and social standards, and lessons learned. The final review will focus on the achievement of indicators, sustainability of results, and final lessons learned and recommendations. Moreover, the PfP component of RIOS will be designed with an experimental approach, to be able to attribute environmental impact to the activities implemented by the subprojects. The team is currently collaborating with J-Pal affiliated researcher to incorporate an experimental design.

The FMCN has developed strong monitoring and evaluation systems and capacity; the results information on Component 1 will rely on the FMCN Information System for Project Follow-up (Sistema de Información y Seguimiento de Proyectos, SISEP) developed for the GEF-funded Consolidation of the Protected Area System (SINAP II) project and improved under the GEF-funded C6 project, both implemented by the FMCN through the World Bank.

INECC will develop under Component 1 a social vulnerability community assessment that will be applied and monitored during project implementation. This will empower local communities to monitor and adapt after project ends. The community monitoring of water quality and biodiversity supported under Component 3 will be designed by INECC and FMCN, selecting the monitoring points based on scientific models and cost-effectiveness. The Regional Funds will help to collect and analyze said information, which may be the basis for the bonus under the PfP. This local monitoring is based on citizen science, promoting public participation in climate adaptation and management of local habitats, landscapes, and ecosystems to prioritize areas adaptation options and for species management. Its results aim at improving the information base on which decisions are made and filling many data gaps with regards to biodiversity information, such as taxonomic, spatial, and temporal gaps, which may contribute to state and national large-scale policy objectives for wildlife conservation.

Community monitoring activities will include monitoring ecosystem composition, structure, and processes. The taxa selected will serve as indicators of habitat quality and the effects of perturbation and disturbance. The methodology chosen is repeatable, cost-effective, achievable with minimal training and equipment, and produces data with statistical validity, comparable over time and between sites. The resulting information will provide a sound understanding on the success of management/restoration actions on different taxa, including many forest-dependent and endangered species, and will offer clues on which sustainable production practices are enhancing or could improve habitat heterogeneity, landscape connectivity, and biodiversity conservation (e.g. multi-species live fences in cattle ranches).

The role of natural forests in the target areas will be measured above and below ground using a temperature and humidity data logger. The recorded data may be used for monitoring weather patterns, seasonal variations and climate change; for comparing soil and air temperature to understand the microclimate of the forest; for temperature monitoring in rivers to record the effects of weather and climate change; and for carbon dynamics (carbon emissions and sequestration). The equipment has proven to be accurate, reliable, robust, waterproof, durable, and the software is easy to use. By incorporating the influence of fine-scale topography and hydrology, the accuracy of climate models will greatly improve.

3.7 COVID-19

Since March 2020, exposure to the COVID-19 pandemic needs to be considered among the key risks that will require specific management in compliance with evolving national regulations and international good practices, particularly those of the World Health Organization (WHO). The International Monetary Fund (IMF) announced that the global health emergency has also translated into a global economic recession. COVID-19 may condition or restrict foreseen project activities to warrant the safety of the involved people, communities and/or their relations to natural resources and productive activities; such as, restrictions to face-to-face workshops, less private funds to complement the PES, reluctance of financial institutions to participate into innovative credit lines, less capacity of producers to apply for loans, among others.

FMCN has already introduced measures to address the immediate COVID-19 challenges, while continuing the project preparation in compliance with national requirements and international recommendations in line with the objectives of the relevant Environmental and Social Safeguards. The activities under the project will support long-term and sustainable recovery and contribute to a more resilient development in rural areas, incorporating a wide definition of the One Health concept that will be disseminated and addressed. The One Health concept will raise awareness of the multiple interlinkages between human, animal and ecosystem/environmental health and contribute to building of related knowledge to effectively address threats and reduce risks of detrimental zoonotic diseases at the animal-human-ecosystem interfaces within the project context.

The current COVID-19 crisis is an opportunity to build more sustainable, creative, inclusive and resilient systems, where prosperity can be shared by all communities and people. Mapping innovative solutions of startups, companies and organizations with relevant solutions and implementation capacity to address the social and health implications of COVID-19 in all sectors will be critical, in conjunction to monetary, financial, fiscal, economic and social measures to support micro, small and medium firms to protect jobs and boost critical household incomes.

The project will grow particular benefits to COVID-19 pandemic not only contributing to get local economies and livelihoods back on their feet, but also safeguarding social and environmental prosperity for the longer term. By aligning public and private investments to finance nature-based solutions, augmenting communities´ resilience to climate impacts under a well-being and inclusiveness approach, promoting the transition to long-term low-carbon initiatives, and increasing circularity of supply chains, the project will be protecting livelihoods in the face of abrupt losses of income and supporting its resilience for future similar scenarios.

3.8 Complementarity and coherence with other Projects

RIOS will be complemented by the following projects:

CONECTA Project. CONECTA will provide the co-financing for RIOS. It will be financed by the World Bank, through a Global Environment Facility (GEF) USD$15 million grant, to be implemented during 2021-2026. The objective of CONECTA is to improve integrated landscape management in selected watersheds in the states of Chihuahua, Chiapas, Jalisco and Veracruz. The components are: (i) Development and Promotion of Integrated Landscape Management, (ii) Strengthening Business Skills for Sustainable Rural Production, (iii) Conservation and Implementation of Sustainable Productive Practices in Cattle and Agroforestry Landscapes, and (iv) Monitoring and Project and Knowledge Management. The co-finance from CONECTA to RIOS will be for the support of livestock and agroforestry producers to access credits, the implementation of a learning community and a community water monitoring system, all of which are activities under RIOS Component 1.

FIRA/AFD ProSostenible. RIOS will support the development of new credit lines and train FIRA financial intermediaries through Component 2, and through Component 1 communities will receive support to access to FIRA´s intermediaries' credits. Since 2013, the European Union, through the Latin American Investment Fund (LAIF) and the French Development Agency (AFD), have established actions with FIRA to support the development of mitigation and adaptation projects to climate change in Mexico in the agricultural, livestock, forestry, fishing and rural sectors, mainly with the implementation of a financial support and technical support program.

Payment for Ecosystem Services matching fund scheme from the Mexican Forest Commission (CONAFOR). RIOS will catalyze PES under Component 1. This is a scheme that allows private institutions who are users of ecosystem services to take co-responsibility in the maintenance of watersheds and biological corridors. In this effort, the user of the service pays at least 50% of the required amount and CONAFOR the remaining amount. The payment has a multi-annual commitment.

National and local public programs. National and local public programs will be aligned under Component 2. Some pre-identified public programs that could be aligned in the target watersheds are:

National:

1. CONAFOR´s reforestation and soil restoration
2. SADER livestock programs
3. Bienestar Sembrando Vida Program
4. FIRA´s Livestock Development Program

In Jalisco:

1. Silvopastoral program from the Jalisco State Government
2. Attention to producers in the agricultural sector of Jalisco
3. Integrated Rural Training and Extensionist Program
4. Women in the countryside
5. Livestock and Dairy Sector Support Program
6. Low-Carbon States Program
7. Program to Support Strategic Agricultural, Fisheries and Aquaculture Projects of the State of Jalisco
8. Sustainable agricultural production promotion programme

In Veracruz:

1. Territorial Development Projects (PRODETER)
2. Livestock Development Program (Infrastructure)
3. Agricultural Promotion Programme (Coffee)
4. Welfare Production Program
5. Social and Sustainable Agribusiness Program
6. Social milk wares

Chapter 4. IDENTIFICATION OF BENEFITS, CO-BENEFITS AND ECONOMIC ANALYSIS

4.1 Direct mitigation and adaptation benefits

Adaptation and mitigation measures help address climate change but also have a range of positive human health, ecosystem functioning, macroeconomic, social, and equity side benefits that, in some cases, outweigh the importance of climate change adaptation and mitigation benefits (co-benefits).

As direct mitigation and adaptation benefits, RIOS will expand coverage and connectivity of the remaining native vegetation in the target watersheds; reduce carbon emission from deforestation and augment carbon intake by restoration and regeneration of degraded land; increase the flow of ecosystem goods and services; and create social and economic sustainable development opportunities for rural communities, as shown in the following table:

Direct beneficiaries are 63,294 people (51% women) that live in the localities in the target sub-basins where subproject activities will be implemented. Because in the target basins live some of the most vulnerable population to climate change in Mexico, the adoption of practices that have a positive impact in the provision of ecosystem services according to the monitoring, will directly benefit the inhabitants from the localities of all the basin. Indirect beneficiaries are 865,634 people (52% women).

Expected Result	Indicator	Target	Description	Assumptions
A1.0 Increased resilience and enhanced livelihoods of the most vulnerable people, communities and regions	1.2 Number of males and females benefiting from the adoption of diversified, climate resilient livelihood options (including fisheries, agriculture, tourism, etc.)	63,294 (51% women)	*Adoption* means that subproject activities are being implemented and have a positive impact in the provision of ecosystem services according to the social vulnerability, biodiversity, or water participatory monitoring system. *Diversified, climate resilient livelihood options* are all the activities supported by subprojects under Component 1, including restoration, conservation, agroforestry and sustainable livestock practices.	Because in the target sub-basins live some of the most vulnerable population to climate change in Mexico, the adoption of practices that have a positive impact in the provision of ecosystem services according to the monitoring, will directly benefit the inhabitants from the localities of all the basin.

				Number of females. Are the number of females that live in the localities benefiting from the increased provision of ecosystem services from the adoption of sustainable practices.	
	A4.0 Improved resilience of ecosystems and ecosystem services	4.1 Coverage/scale of ecosystems protected and strengthened in response to climate variability and change	260,000	*Coverage/scale are* the cumulative number of hectares supported by the Project activities under Component 1 and Component 2. *Ecosystems protected and strengthened* includes the area under Integrated Watershed Management Action Plans (IWAPs), and areas with subprojects under Component 1.	Areas with improved IWAP (financed by co-finance GEF CONECTA project) are strengthened via a reduction in the risk of deforestation and improved management. Baseline are those areas that currently have a formal protection/conservation strategy (i.e. Pico de Orizaba and Sierra Vallejo Natural Protected Areas).
	M4.0 Reduced emissions from land use, reforestation, reduced deforestation, and through sustainable forest management and conservation and enhancement of forest carbon stocks	4.1 Tons of carbon dioxide equivalent (t CO2eq) reduced or avoided (including increased removals) as a result of Fund-funded projects/programmed – forest and land-use sub-indicator	2,534,015	*Reduced or avoided* means the area for which new and/or improved sustainable landscape management has been promoted through IWAPs and by practices introduced through the project under Component 1.	Areas with IWAP have a reduction on deforestation, and therefore enhancement of carbon stocks.

4.2 Identification of benefits and co-benefits

Rivers provide a range of services that benefit local and downstream communities. Parker & Oates (2016) developed a conceptual framework to visualize the complex interactions between the river and society, this framework illustrates the relationship between the river health, ecosystem services, and different societal benefits. These relationships are depicted in relatively simple terms while acknowledging that the links between river health and societal benefits are complex (Parker and Oates, 2016).

We use this conceptual framework to illustrate the expected benefits and co-benefits from RIOS. Improved river ecosystem connectivity and functionality under RIOS will have implications for the portfolio of services a river can provide, and therefore the benefits society can receive (Figure 4.1 and Table 4.1). Riverine ecosystems have the potential to sustain livelihoods and commercial production (agriculture, livestock, and fisheries), provide water for domestic consumption and industries, and are used for tourism. These all contribute to local and national economic growth and poverty reduction (Emerton and Bos, 2004; TEEB, 2013).

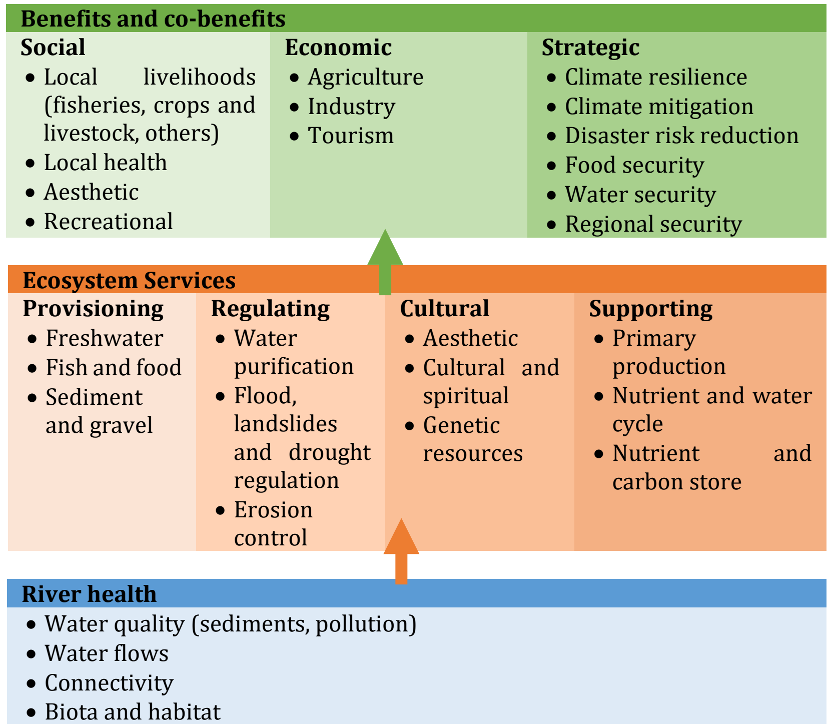

Figure 4.1. Relationship between river health, ecosystem services, benefits and co-benefits in the context of RIOS
Source: Own elaboration, based on typology proposed by Parker, H., & Oates, N. (2016)

Healthy rivers also play a critical regulatory function in the environment, regulating floods (riparian vegetation slows and dissipates stormwater flows), maintaining biodiversity (including native pollinators), transporting sediment and nutrients, and diluting pollutants (Parker and Oates, 2016; Michel and Graizbord, 2002). It is estimated that riparian areas can reduce the nitrogen concentration in water runoff and floodwater by up to 90 percent and reduce the phosphorus concentration by as much as 50 percent (Jones, 2008), reducing the associated costs of removing these nutrients and increasing water quality for ecosystem and human consumption

Social benefits and co-benefits are those which contribute to the well-being of individuals and communities in local areas where RIOS will be implemented. Many of these benefits do not have a market value.

Economic benefits and co-benefits are those which contribute to the national economy and/or provide employment; some examples are agricultural production, industrial development, and tourism. The economic benefits could be at a macro-scale, but can also be reflected in local household incomes. Therefore, there may be some overlap with the livelihoods dimension and the social benefits dimension. For example, in the case of RIOS the risk reduction from landslides in the upper previously deforested watersheds, as well as a decrease in catastrophic floods downstream, have both social and economic co-benefits.

Strategic benefits and co-benefits are those that contribute to national and trans-national interests. They are complex and may require the interaction of several ecological and social factors. They include climate resilience and mitigation (which are the benefits of RIOS), poverty reduction and economic growth, water and food security, and disaster risk reduction.

Table 4.1. Typology of main benefits and co-benefits expected from the project

Typology of benefit/co-benefit	Type of benefit/co-benefit	Description of benefit/co-benefit	Estimated potential beneficiaries identified
Social	Local livelihoods (fisheries, crops and livestock)	Freshwater fisheries can provide an important source of protein and income, particularly in developing countries (Hoeinhaus et al., 2009); floodplain and irrigated agriculture support subsistence of farmers in riverine areas, (HLPE, 2015); rivers provide water for livestock consumption, grazing areas and fodder, important for pastoral communities (HLPE, 2015).	9590 producers as farmers in the basins benefiting from year-round water, aquifers recharging, and increased biodiversity in the agricultural environment. In the watersheds, over 80% of water volume granted per year fulfills the agricultural demand.
	Local livelihoods (others)	Harvest of non-timber forest products (NTFP) and wild foods and animals for local consumption can provide an important source of nutrient; wood for fuel and local construction; harvest of local medicinal plants (Scholes et al. 2010).	63,294 direct beneficiaries as property owners and people living in the watersheds that depend on natural resources for freshwater and income.
	Local health	Healthy freshwater ecosystems support dilution and filtration of agricultural and industrial pollutants, human and animal waste. Healthy freshwater ecosystems reduce waterborne or water-related diseases, from using clean water for drinking, cooking, bathing and washing clothes, and the reduced risk of vector-borne infections (Vörösmarty et al., 2005).	63,294 direct beneficiaries 865,634 indirect beneficiaries as the population in the basins, which will be the beneficiary of cleaner and healthier freshwater resulting from riparian restoration and best land-management practices.
	Aesthetic	Aesthetic enjoyment from the appreciation of natural features (Finlayson and D'Cruz, 2005; EEA, 2010).	865,634 indirect beneficiaries as the population in the basins, benefiting from a better aesthetic in the basin from riparian restoration and best land-management practices. 6,533,569 tourists per year.
	Recreational	Local recreational activities e.g. walking, swimming, boating, fishing, bird watching (Finlayson and D'Cruz, 2005; EEA, 2010).	6,533,569 tourists per year that benefit from cultural, religious and recreational activities. 63,294 direct beneficiaries watersheds as property owners and people living in the watersheds.
Economic	Agriculture	Agriculture depends on water of sufficient quality and quantity; sediment flows and	9590 producers as farmers in the basins benefiting from year-round

		nutrient cycles directly influence crop yields (HLPE, 2015). Commercial irrigation can provide benefits in terms of employment, tax revenues, and food security (Oates et al., 2015).	water, aquifers recharging, and increased biodiversity in the agricultural environment. In the watersheds, over 80% of water volume granted per year fulfills the agricultural demand.
	Industry	Water is an important input for a variety of industries downstream; effective operation of industry requires a constant supply of water in quantity and quality (WWAP, 2012).	Arco Iris Hydroelectric, S.A. de C.V., which has a concessioned volume of water of 78,840,000 m3 per year.
	Tourism	Rivers and downstream areas can be important destinations for both local and international tourists for activities such as fishing, boating, and wildlife viewing, which can provide tax revenue and employment (e.g., see Butler et al. 2009). In Project sites, downstream tourism is key, mainly in the Jalisco area (see Chapter 1). Downstream touristic areas require constant water supply as well as quantity and quality, as well as aesthetic value.	6,533,569 tourists per year but only 326,678 tourists will be considered as 5% of water volume granted per year serves to cover public use.
Strategic	Climate resilience	River ecosystems have some natural capacity to buffer against climate variability and change (TEEB, 2013) (see Chapter 4); human resilience is also achieved through the realization of other social and economic benefits.	63,294 direct beneficiaries in both watersheds and 865,634 indirect beneficiaries as the population in the basins, which will be the beneficiary of climate change risk reduction in the watersheds, such as flood, droughts, among others.
	Climate mitigation	The reduction in vegetation degradation, and an increase in forest cover and improved production practices, directly contributes to climate change mitigation. (see Chapter 4)	
	Disaster risk reduction	Healthy wetlands and riparian forests can help mitigate the impacts of flooding, including in urban areas, and river catchments can play a role in drought mitigation (Emerton and Bos, 2004)	
	Water security	Water security means having sufficient water quantity and quality for humans' needs (Mason and Calow, 2012). Local and downstream inhabitants are benefited from river restoration.	63,294 direct beneficiaries in both watersheds and 865,634 indirect beneficiaries as the population in the basins, which will be the beneficiary of cleaner and healthier freshwater resulting from riparian restoration and best land-management practices.
	Food security	There is a strong link between water security and food security, as agriculture water is also essential for good nutrition and health, inter-dependent and related to the health of the water system (HLPE, 2015).	63,294 direct beneficiaries in both watersheds property owners and people living in the watersheds that depend on natural resources for food and income. 9590 producers as farmers in the basins benefiting from year-round water, aquifers recharging, and increased biodiversity for food production.
	Regional security	River degradation can contribute to political tensions. Cooperation on transboundary waters can bring economic, environmental,	

		social and political gains (Sadoff and Grey, 2005; Rasul, 2015).	

Source: Own elaboration, based on typology proposed by Parker, H., & Oates, N. (2016)

In the absence of the RIOS project, beneficiaries would likely remain without access to financing and other support to transition or improve practices that support river restoration and connectivity in the targeted watersheds. The basins in Jamapa and Ameca-Mascota would continue the trend of deforestation, soil degradation and vulnerability to climate risks. Conventional extensive ranching and agriculture activities would continue to expand unsustainably; those productive activities would enlarge the agricultural frontier, intensify water use and pollute rivers, increase landslides and flood risk. All this would generate a reduction on adaptive capacity, a loss of carbon stocks and an increase in GHG emissions. This will also generate a loss of other Ecosystem Services (ES).

For the *without project* scenario, we assume that the future will continue recent past trends and no changes in local or national policies and practices will occur in the area. Without the project, the budget forecast to be allocated for river restoration and sustainable watershed management would be limited.

For the *with project* scenario, the GCF incremental support will strengthen the watersheds' health with river restoration and improvement of sustainable production practices, and it is long-term economic and financial sustainability. The project will support alternative instruments to foster the paradigm shift to overcome national budget limitations, the lack of inter-institutional coordination, poor land-management practices for enhancing investment alignment, climate-resilient production practices, specific instruments for river restoration, and involving new public and private stakeholders to address policies related to river connectivity. The cost effectiveness of the solutions proposed, once tested and monitored, will be incorporated into national strategies to escalate their application.

Table 4.2 describes the expected improvement in ecosystem services and project benefits and co-benefits. The Table illustrates the additionality of the project activities concerning the deviation from the baseline scenario; it also shows the expected social, economic, and strategic benefits and co-benefits resulting from river restoration and transitioning towards more sustainable production patterns.

Table 4.2. Deviation of baseline (benefits and co-benefits) by type of supported system under RIOS

Systems	**Example of actions supported under RIOS**	**Deviation from baseline scenario and expected benefits and co-benefits**				
		Improved Ecosystem Services	**Contribution to Ecosystem Services**	**Social co-benefits**	**Economic co-benefits**	**Strategic benefits**
River restoration and conservation activities	• Develop associative forms that make watershed management more efficient through IWAPs. • Incorporate criteria for the conservation of biodiversity (especially species at risk) in production landscapes. • Carry out measures to prevent, control, and fight fires, pests, and zoonotic diseases in forest and grassland areas. • Establish and execute restoration actions. • Strengthen monitoring systems. • Incorporate the management of diverse ecosystems. • Promote agreements with landholders for establishment of voluntary areas for conservation.	• Provisioning: freshwater • Regulating: water purification, erosion control • Supporting: nutrient and carbon store • Cultural: aesthetic	• Increase erosion control by stabilizing eroding banks caused by degradation and deforestation. • Increase the filtering capacity to reduce the excess of nutrients and coliforms. • Contribute to maintaining or improving habitat connectivity. • Maintain or improve the heterogeneity of the landscape. • Protect critical ecosystems, including springs and other bodies of water. • Prevent the disappearance, reduction, or fragmentation of habitats. • Prevent increases in deforestation and maintain more stable habitats for wildlife and pollinators. • Recover vegetation and forest areas. • Guarantee the integrity of ecosystems.	• Contribute to strengthening local economic growth, productivity, and profitability of producer organizations, communities, and producers. • Contribute to strengthening local livelihoods of most vulnerable populations (women and indigenous peoples). • Maintain the local consumption and commercialization of non-timber forest	• Maintain or increase water quality for its different uses in the basins, including ecological, tourist and agricultural. • Maintain or increase water quality for industries downstream. • Maintain or increase water quality for household consumption in downstream cities.	• Increase local resilience to the effects of climate change. • Enhance carbon stocks by reducing vegetation and forest degradation. • Decrease risk due to extreme climatic events, mainly landslides in the upper basin, and floods downstream.

				products (NTFP). • Improve activities and processes related to community economy. • Strengthen local capacities and social and cultural participation in support of conservation activities. • Increase competitive capacities in the management of natural resources at the community level. • Increase in aesthetic enjoyment with better conserved vegetation.		

Sustainable silvopastoral systems	• Increase food production based on diversification of pasture areas. • Incorporate food processing technologies. • Semi-confined herd structure. • Incorporate living fences and divide pastures to manage pasture area and rotate grazing animals. • Manage and conserve water sources.	• Provisioning: freshwater • Regulating: water purification, erosion control • Supporting: nutrient and carbon store	• Increase the stabilization of eroding banks caused by degradation and deforestation by including vegetation. • Incorporate trees (at low density) in deforested areas. • Reduce impacts on soil compaction and degradation from overgrazing. • Reduce deforestation in areas adjacent to pastures. • Manage streams and waterways near livestock areas.	• Increase income and wealth (more assets in animal production units). • Contribute to strengthening local livelihoods of most vulnerable populations (women and indigenous peoples). • Increase sustainable productivity. • Stronger technical capacity to manage natural resources and livestock. • Reduce production costs. • Diversification of income from by-products derived from sustainable livestock production (sales of	• Maintain or increase water quality for its different uses in the basins, including ecological, tourist, and agricultural. • • Maintain or increase water quality for industries downstream. • Maintain or increase water quality for household consumption in downstream cities. • Increase need for labor, which generates employment.	• Increase local resilience to the effects of climate change. • Enhance carbon stocks by reducing vegetation and forest degradation. • Reduce GHG emissions by improving livestock practices. • Decrease risk due to extreme climatic events mainly landslides in the upper basin, and floods downstream.

				fodder and seed, sales for milk and beef, etc.).		
Agroforestry Systems	• Training and technical assistance to Producer Groups in the process to be formalized, dedicated to agroforestry systems. • Improve the application of technologies that promote climate change mitigation and adaptation. • Promote agroecological practices to conserve soil and restore degraded (pasture) lands. • Eradicate unsustainable agricultural practices that cause environmental degradation. • Improve landscape connectivity and biological corridors in fragmented agroforestry and livestock landscapes .	• Provisioning: freshwater • Regulating: water purification, erosion control • Supporting: nutrient, water cycle and carbon store • Cultural: genetic resources	• In situ conservation of agrobiodiversity to the increased resilience of agricultural systems. • Reduction of pest and disease damage. • Avoid the risk of ecosystem services deteriorating or diminishing. • Reduce or avoid deforestation and degradation of natural resources. • Manage streams and waterways near agroforestry areas. • Protect pollinators species richness, crop visitation rates, and pollination success	• Conservation of the social value of native species? • Recognition of traditional knowledge. • Increase income, and productivity for producers. • Improve links to more diverse markets as a result of surplus production.	• Maintain or increase water quality for its different uses in the basins, including ecological, tourist, and agricultural. • Maintain or increase water quality for industries downstream. • Maintain or increase water quality for household consumption in downstream cities. • Increase need for labor, which generates employment.	• Increase local resilience to the effects of climate change. • Enhance carbon stocks by reducing vegetation and forest degradation. • Reduce GHG emissions by improving agricultural practices. • Reduce pressure on forests from the expansion of the agricultural frontier. • Decrease risk due to extreme climatic events mainly landslides in the upper basin, and floods downstream.

Source: Own elaboration based on typology proposed by Parker, H., & Oates, N. (2016) and information adapted from World Bank (2020).

4.3 Valuation of benefits from river restoration

It is difficult to quantify the effects of river restoration on human well-being in monetary terms. Non-market benefits are usually the most difficult to quantify and monetize, but may play a crucial role in the cost-benefit analysis informing policy and decision-making with respect to river restoration (Lago, 2014).

In the case of Mexico, we identified five studies that valuate the benefits of river restoration. All of them used Contingent Valuation to assess the households' Willingness to Pay (WTP). Ojeda et al. (2008) studied the Yaqui River Delta in Sonora. They found that households' WTP in a downstream city Ciudad Obregon was US$ 5.5 monthly per household to preserve riparian vegetation, recreation services, the fauna habitat, local fisheries and diluting pollutants. Donoso (2009) analyzed the Apatlaco River Morelos and estimated US$ 7.7 monthly per household for a program offering strategic basin management. Ayala and Abarca (2014) analyzed the WTP to improve water quality in a section of Lerma River, and estimated that households' WTP was between US$ 3-3.7. Soto and Ramirez (2017) analyzed the WTP of households in the Atoyac river and found a US$ 4.13 WTP monthly per household (Lago, 2014).

Also, an Economic Valuation of ecosystem services in the Puerto Vallarta Region carried out by INECC (2018) shows the importance of the ecosystem services in the area, which overlaps TIOS Ameca-Mascota Basin. The study used as a background the Common International Classification of Ecosystem Services and the Economy of Ecosystems and Biodiversity (TEEB). It identified the following ecosystems services that the Vallarta watershed provides: (i) provision services: fishing and water for human consumption, water for industrial and agricultural uses; (ii) regulation services: storage and carbon sequestration, coastal protection, cycle maintenance, regulation of water flows, water purification, soil conservation, agricultural products and livestock products; and (iii) cultural services: recreation, scenic beauty and sport fishing. The analysis conducted a Discrete Choice Experiment which concluded that there was a positive willingness to pay of 30.4% of the tourists of $ 2,056 pesos per visit (about US$ 110) for the conservation of hydrological services and $ 2,372 pesos (about US$ 120) per visit for scenic beauty. These results support the importance of ecosystem services in the region. Those results provide a positive potential for a PES scheme in the region.

Globally, Lago (2014) analyzed 30 environmental economics papers published in academic journals during of 2000-2013 that valuated the benefits from river restoration. The majority were related to European river restoration projects (19 papers), followed by American (7 papers) and Asian (4 papers). The most commonly considered benefits were higher wildlife and aquatic life diversity, improved water quality, flood protection, carbon sequestration, erosion protection, better river appearance and recreational amenities of a riparian forest, better possibilities of recreation activities, and nitrate and phosphorus cycling and retention. The majority of reviewed studies (23) assumed that the primary beneficiaries of river restoration were local households. They used different forms of contingent valuation studies or discrete choice experiments to elicit their valuation of the restoration projects. Most WTP estimates were within the US$ 25-80 range. Most of them were per household per month.

The mentioned global and Mexican studies on the valuation of river restoration projects were performed with different goals and, consequently, using different valuation techniques. As a result, monetary estimates are not directly comparable. Furthermore, different cases assume a variety of payment vehicles. Thus, the estimates of the value of ecosystem services were stated monthly, bi-monthly or annual payments, and one-time contributions or daily access fees.

In the context of RIOS, the value of ecosystem services per hectare of the restored river would be an ideal measurement unit that would allow the comparison of costs and benefits of river restoration. Still, the majority of the available valuation studies provide WTP estimates per household derived from stated choice experiments (Lago, 2014). Moreover, those cases do not valuate the actual benefits of the communities implementing restoration activities, and none of them mentions the implementation of sustainable productive practices to restore rivers. Therefore, the use of those cases to quantify ex-ante RIOS benefits and co-benefits may not be suitable. To complement the limited ex-ante information, the project will implement a series of analysis related to the valuation of ecosystem services under Component 2.

Economic analysis of RIOS

We decided to apply an approach similar to the World Bank economic analysis of recent rural development projects in Mexico (World Bank 2020, 2019 and 2018). This approach allows valuating benefits at the watershed level, comparing the costs as a future step, and comparing the benefits of other projects that are currently being implemented in Mexico (for example, CONECTA).

Economic valuation of benefits and co-benefits from RIOS

We anticipate that RIOS is expected to provide three main economic benefits: (i) the improved provision of ecosystem services through river restoration and improved watershed management, (ii) enhanced carbon stocks and sequestration through the activities implemented, and (iii) associated with the sustainable livestock and agroforestry activities at the producer level that have positive private (financial) and social returns. In direct terms, all three relate the most with Component 1 of RIOS. In contrast, Component 2 and 3 will aim to indirectly increase the first and second benefits, and to provide sustainability to the third benefit.

Benefit stream 1: Improved provision of ecosystem services through river restoration and improved watershed management. For this benefit, healthy watersheds provide many ecosystem services that are necessary for social and economic well-being. These services include water filtration and storage, cleaning of air, nutrient cycling, soil formation, recreation, food, and timber (see Table 4.3). To estimate the benefits, it considers the reduction in total hectares of landscapes under deforestation pressure due to project intervention as defined in the Project Logical Framework. Following the World Bank (2020), we assumed that the total area is homogenously divided and is based on the triangular number distribution[31] [32] for five project years, that is, the project divided by 15 to obtain the factor that is each year added to the growth of the previous year.

Monetary value associated with key ecosystem services is taken from recognized studies that assessed the incremental economic benefits of the ecosystem services in Mexico. Based on previous studies related to the valuation of river restoration (see Chapter 4.2), we followed World Bank (2020) approach and used two meta-analyses of ecosystem services: an upper bound and a lower bound. The upper bound is from Lara-Pulido, Guevara-Sanginés, and Arias (2018), who provide specific estimates for Mexico based on 106 studies. The lower bound is taken from Siikamäki et al. (2015), who offer global estimates based on 123 robust analytical reviews and project estimates per country, including Mexico.

Table 4.4 shows those two different bounds of ecosystem services valuation. The selected ecosystem services are the most relevant identified in Chapter 4. Siikamäki et al. (2015) include relevant services such as Recreation (US$ 28.1/ha/year), habitat (US$ 3/ha/year), climate (US$ 26.2/ha/year), non-timber forest products (NTFPs, US$ 26.2/ha/year), and water (US$ 86.4/ha/year), giving a total of (US$ 143.70/ha/year). The upper bound represents an aggregate value of ecosystem services (US$ 293) valued by Lara-Pulido et al. (2018), which includes the conservation of coastal zones (US$ 252/ha/year), wetlands (US$ 315/ha/year), cultivated areas (US$ 212/ha/year, for provisioning), and forest (US$ 291/ha/year). Both studies have been used in previous similar analysis (see World Bank 2020), are methodologically sound, focused on Mexican territory, and relevant for the present analysis.

Table 4.4 Overview of Study Estimates on Economic Values of relevant Ecosystem Services in Mexico (per hectare)

Ecosystem Services (Mexico)	**Lower Bound US$**	**Ecosystem Services (Mexico)**	**Upper Bound US$**
	Siikamäki et al. (2015)		**Lara-Pulido et al. (2018)**
Recreation	28	Coastal zones	252
Habitat	3	Wetlands	315
NWFPs	26	Cultivated (for provisioning)	212
Water	86	Forest	291
Total	**143**	**Total (Aggregate value)**	**293**

Source: Own elaboration by the World Bank Task Team.

[31] The triangular number is n (n+1)/2, and for five project years 5 x 6 / 2.
[32] The formula for year n is therefore: n x n (n+1) / 2.

Benefit stream 2: Reduction of carbon emissions. Due to restoration activities, agroforestry activities, and sustainable livestock, improved vegetation leads to a reduction in carbon emissions and the enhancement of carbon stocks. Estimates by activity by the co-financed project CONECTA were used.

The social cost of carbon (SCC) is a commonly-estimated measure of the economic benefits of greenhouse gas (GHG) emission reductions (EPA, 2010). In this project, SCC represents the global social benefits of emission reductions by avoiding deforestation and sustainable, productive activities in RIOS. Monetary SCC values were taken from the World Bank (2017), which estimates the carbon social value, in US$ 60 as an upper bound and US$ 40 as a lower bound. To provide a carbon value closer to the market value, we use in the analysis the value of voluntary carbon market US$ of 3.01 t/C (Forest Trend's Ecosystem Marketplace, 2019).

According to the High-Level Commission on Carbon Prices and aligned with the economic analysis of World Bank (2020) it is recommended that the project's economic analysis use a low and high estimate of the carbon price and take a value that is consistent with achieving the core objective of the Paris Agreement of keeping temperature rise below 2 degrees C. For the last reason, a higher value (US$ 60) was taken as an objective indicator in the economic analysis.

Benefit stream 3. Private-level benefits for landowners. The main assumption under this type of benefit is that landowners voluntarily decide to participate, and therefore we can assume that private benefits surpass the costs. It is considered that three types of activities are going to be financed at the producer level: (i) agroforestry systems, (ii) sustainable livestock systems, and (iii) conservation and restoration activities. Because the final number of hectares will be based on a voluntary request for proposals (RFP), for this analysis it is assumed that the total area for each type of activity is homogenously divided and is based on the triangular number distribution [33] for five project years (see Table 4.5) [34] and that they are equally distributed in both regions.

According to the World Bank (2020) there are two potential ways to assess economically this benefit stream: (i) estimating the difference of benefits between conventional (current or baseline scenario) and regenerative production practices (sustainable practice scenario), or (ii) taking a percentage that represents an improvement in benefits for adopting regenerative production practices compared to conventional. Here, the second approach is adopted, given that RIOS has a specific target on productivity for the activities. The benefit of the second approach is that it allows to re-assess the economic benefits ex-post, after the project is implemented. Following the CONECTA assumptions, we assume 70 percent of the beneficiaries implementing the sustainable activities will increase in their their utility by at least 10 percent

[33] The triangular number is n (n+1)/2, and for five project years 5 x 6 / 2.
[34] The formula for year n is therefore: n x n (n+1) / 2.

(this is an assumption included in the outcome indicators of the co-financed CONECTA project).

Table 4.5. Distribution of the increase of areas under landscape management through sustainable practices (in ha)

Producer level activities	Expected number of ha
1. Area of landscapes under agroforestry system (cumulative)	732
2. Area of landscapes under sustainable livestock system (cumulative)	6,592
3. Area of landscapes under river restoration (cumulative)	402
4. Area of landscapes under conservation and reduced pressure of deforestation (cumulative)	260,333
Total area	268,059

Source: Own elaboration

The four types of selected activities are the agroforestry system, sustainable livestock system, and conserved and restored areas taken from Lara-Pulido et al. (2014). Lara-Pulido et al. (2014) provide the socio-economic value of these activities for Mexico additional to the private (financial) return. The direct and indirect costs and benefits and externalities were quantified. Direct costs and benefits are generated by the operation of activity and generally translate into monetary flows, for example, income from the sale of a forest product. The indirect ones are costs and benefits generated by the operation of the project, and that affect it, but that are generally not monetized; for example, unsustainable agricultural practices generate erosion, which eventually translates into a decrease in productivity, but the producer does not consider this. Therefore, there may be an underestimation of the benefits.

Costs and benefits of RIOS

Aligned with other previous studies and GCF implementation plan, it is assumed: (i) a 20-year period to assess the economic feasibility of the project, aligned with the RIOS period; (iii) that there are no further incremental changes of project-generated benefits beyond the 20-year project evaluation period; (iii) that project costs are only in the five years of project implementation, but the benefits and opportunity costs are assumed to be generated beyond the implementation period (for 15 more years); (iv) and because the areas per activity will be based on a voluntary RfP more time is required at the start than at a later point of the project, and (iv) that the distribution of benefits (an increase of areas under improved landscape management and sustainable practices) is based on the triangular number[35] for five project years; the project divided by 15 to obtain the factor that is added to the growth of the previous year each year.[36]

[35] The triangular number is n (n+1)/2, and for five years 5 x 6 / 2.
[36] The formula for year n is therefore: n x n (n+1) / 2.

The distribution of project costs is assumed to follow the same pattern, having lower investment costs in the early years and increasing project investments in later project years. Project costs over the implementation period are approximated considering the project financing of US$10 million by GCF (including US$1 million co-financed). The opportunity costs of traditional agricultural production (US$ 54.65) and traditional cattle ranching (US$ 120.99) in the intervened areas taken from Lara-Pulido et al. (2014),[37] and an assumption of two percent, as an additional operating cost, were added along with the projection of a 20-year project evaluation that will be added for the incremental economic analysis.

To assess project robustness, we followed the approach used for the CONECTA economic analysis and included a sensitivity analysis mainly in the discount rate (alternative rates of six and nine percent) and project horizon (10 and 20 years). This set of sensitivity assessments enables a comprehensive analysis of the economic robustness of the project concerning the changing or differentiated value parameters.

Table A10.1 shows the results and sensitivity analysis, including Net Present Value (NPV) and Benefit-Cost Ratio. The Benefit-Cost ratio = (benefits with the project) –(the opportunity costs that is the "without project" scenario + project costs). The first panel shows the 20-year baseline scenario. The second panel decreases the project lifetime from 20 years to 15 years. The third panel reduces further project lifetime to ten years.

Table A10.1. NPVs (US$) and BC Ratio under Different Scenarios Robustness Check 1. Realistic scenario: project implementation of 20 years and project costs included

		Upper Bound		Lower Bound	
		NPV	BC-Ratio	NPV	BC-Ratio
Carbon Price (US$ 60)	Discount rate 6%	$101,430,579	2.94	$63,961,536	2.22
Carbon Price (US$ 60)	Discount rate 9%	$78,969,160	2.94	$58,680,308	2.24
Carbon Price (US$ 40)	Discount rate 6%	$74,016,527	2.41	$36,547,484	1.70
Carbon Price (US$ 40)	Discount rate 9%	$57,151,187	2.40	$33,529,802	1.71
Carbon Price (US$ 3.01)	Discount rate 6%	$23,314,237	1.44	($14,154,806)	0.73
Carbon Price (US$ 3.01)	Discount rate 9%	$16,798,846	1.41	($12,986,060)	0.72

Robustness Check 2.Intermediary scenario: project lifetime 15 years and project costs included

		Upper Bound		Lower Bound	
		NPV	BC-Ratio	NPV	BC-Ratio
Carbon Price (US$ 60)	Discount rate 6%	$83,639,614	2.91	$53,400,105	2.22
Carbon Price (US$ 60)	Discount rate 9%	$51,529,849	2.88	$44,174,201	2.25

[37] Number converted from Mexican Peso Currency to U.S. Dollars at April exchange rate, which is equivalent to 24.39 currency units per U.S. Dollar.

Carbon Price (US$ 40)	Discount rate 6%	$60,426,542	2.38	$30,187,034	1.69
	Discount rate 9%	$36,191,121	2.32	$24,908,494	1.70
Carbon Price (US$ 3.01)	Discount rate 6%	$17,493,967	1.40	($12,745,542)	0.71
	Discount rate 9%	$7,822,143	1.29	($10,723,430)	0.70

Robustness Check 3. Conservative scenario: project lifetime 10 years and project costs included

		Upper Bound		Lower Bound	
		NPV	BC-Ratio	NPV	BC-Ratio
Carbon Price (US$ 60)	Discount rate 6%	$59,831,289	2.86	$39,266,528	2.22
	Discount rate 9%	$51,529,849	2.88	$34,301,623	2.25
Carbon Price (US$ 40)	Discount rate 6%	$42,240,078	2.31	$21,675,316	1.67
	Discount rate 9%	$36,191,121	2.32	$18,962,895	1.69
Carbon Price (US$ 3.01)	Discount rate 6%	$9,705,132	1.30	($10,859,629)	0.66
	Discount rate 9%	$7,822,143	1.29	($9,406,083)	0.66

The results of the economic analysis highlights that all scenarios have a positive NPV and C-B Ratio except the case with lower bound economic values of ecosystem services and carbon Price at voluntary market. In all cases the NPV and C-B ratio is positive when considering the carbon shadow price. This highlights the importance of the Project for global social benefits, and justifies the need for certain activities that may not have a private NPV but have a positive social NPV when considering the shadow carbon price.

Economic analysis of sustainable livestock

One of the main strengths of RIOS is the capacity to leverage private funding, and ensuring long-term sustainability by promoting profitable sustainable practices. This analysis proves that, from a private perspective, RIOS will bring socio-economic co-benefits to the farmers transitioning to sustainable livestock practices. These results sustain the rationale of the schemes supported under Component 1.

There are different ways of implementing livestock activities, with varying levels of technology and interaction with the natural environment. In a complementary approach, there are also the Intensive Silvopastoral Systems (ISPS), a technological module that can be incorporated into grazing systems and consists of establishing protein sources (generally shrubs) for livestock the use of trees to provide shade and enrich the soil. This system has the objective of creating an interaction between vegetative material and livestock, which has been found to significantly increase the productivity of the activity and preserve or restore the ecological integrity of the territory (Azuara-Morales et al., 2020; Chará et al., 2019).

ISPS can produce 12 times more meat than extensive grazing and 4.5 times more than improved pastures without trees, but methane ($CH4$) emissions do not increase in the same proportion, being 6.8 and 2.8 times higher in ISPS respectively, which is why which emissions of the same gas per ton of meat are 1.8 times lower in the ISPS than in extensive grazing (Murgueitio, Chará, Barahona, Cuartas, & Naranjo, 2014). In Mexico, an SSP with *Leucaena leucocephala* and *Cocos nucifera* retains between 101.19 and 128.62 tons of carbon per hectare per year (Anguiano, Aguirre, & Palma, 2013). Also, ISPS maintains soil moisture, reduces high ambient temperatures in pastures, improves the productivity and quality of forages, and reduces the seasonality of meat and milk production (Murgueitio et al., 2014). On the other hand, it is pertinent to point out that ISPS is suitable for tropical climates. In dry environments (as in Chihuahua), the low productivity of the soil makes this type of technology unaffordable the investment is well above the increase in productivity.

Table 4.7. Basic parameters for the cost-benefit analysis

Parameter	Units	Jalisco	Veracruz
Ecosystem [a, b,]	Type	Temperate forest Jungles Scrub Pastureland	Pine-oak forests Mountain mesophilic forests Low, high and medium forests Coastal dunes Mangroves
Production system (s) [a, b]	Type	Meat production Milk production	Double purpose Broodstock Fattening
Cattle stocks [c]	Heads	3,290,786	4,306,215
Surface [d]	he has	3,726,000	3,600,000
Animal load	Heads/ha	0.883	1,196
Range coefficient	ha/head	1.1	0.8
Weighted range coefficient [b]	ha / AU	8.5	1.8
Cattle standing [e]	ton	432,079.19	479,077.52
Carcass [e]	ton	238,585.99	257,934.74
Meat/hectare [e]	kg / ha	64.0	71.6
Lechel [e]	thousands of liters	2,433,016.85	723,614.93
Milk/hectare	lt / ha	653.0	201.0
Emissions/head [f]	tCO2e / head	1.40	1.40
Emissions	Gg CO2e / year	4607.1	6028.7
Emissions / hectare	ton CO2e / ha	1.24	1.67

Source: Own elaboration with information from a. FONNOR (2020), b. Gulf of Mexico AC Fund (2020), c. SADER (2019a), d. SEMARNAT (2018), e. SADER (2019b), f . IPCC (2014).

Data and methods

For the cost-benefit analysis, data were collected from reports commissioned within the framework of the GANARE project of the Mexican Fund for the Conservation of Nature (FMCN) financed with resources from the French Development Agency (AFD). Additionally, for the maintenance costs of infrastructure and facilities, information on the technological packages for conventional livestock generated by the Instituted Trusts in Relation to Agriculture (FIRA) was considered the maintenance cost of the facilities that were not reported by the previously referred reports. Other sources were used to estimate greenhouse gases (GHG) produced by this economic activity. In particular, data from Tubiello et al. (2015) to assign methane emissions from livestock, and World Bank (2017) to establish a social valuation of said emissions.

Also, a carbon price of $5per ton was considered to approximate the commercial value of these emissions. The latter was considered to compare the social value of carbon (taking into account the value referred to by the World Bank) with the market value of carbon.

Table 4.8 presents the base data used for each state. The data were used to obtain the baseline of the livestock activity's profitability in the states under analysis. Information regarding the additional investment is required to analyze the profitability of alternative livestock farming, the additional annual costs, and the effect that said investments have on the system's productivity, which is presented below.

Table 4.8. Livestock data for the cost-benefit analysis

Jalisco				
Parameter	**Unit**	**Average value**	**Minimum value**	**Maximum value**
Animal load	Heads/ha	1.45	1.25	1.54
Surface	Hectares	19	5	33
Bellies in production	Heads	28	one	fifty
Milk days	Days/year	290	260	300
Milk production	Liters / day	8.25	6.5	10
Calf weight	Kg	200	300	150
Finished animal weight	Kg	200	198	205
Waste animal weight	Kg	530	500	550
Fertility	Animal / cow / year	one	0.50	one
Total heads	Heads	55	two	100
Cows in milk production	Cows	0	0	0
Belly weight	Kg	600	600	600
Percentage of heads of waste	%	10	10	10

Source: Own elaboration with information from FONNOR (2020).

Veracruz				
Parameter	**Unit**	**Average value**	**Minimum value**	**Maximum value**
Animal load	Heads/ha	one	0.4	one
Surface	Hectares	10	10	2 0
Bellies in production	Heads	10	one	fifteen
Milk days	Days/year	290	260	300
Milk production	Liters / day	16	14	18
Calf weight	Kg	190	180	200
Finished animal weight	Kg	200	198	205
Waste animal weight	Kg	530	500	550
Fertility	Animal / cow / year	0.67	0.67	0.67
Total heads	Heads	17	two	25
Cows in milk production	Cows	10	0	fifteen
Belly weight	Kg	600	600	600
Percentage of heads of waste	%	10	10	10

Source: Own elaboration with information from the Gulf of Mexico Fund (2020).

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Jalisco. Prices and quantities.							
Parameter	**Unit**	**Average amount**	**Minimum amount**	**Maximum quantity**	**Average price (pesos)**	**A minimum price (pesos)**	**Maximum price (pesos)**
Feeding							
Balanced food [to]	Head/year	28	10	Four. Five	5913.00	2190.00	13140.00
Supplements [to]	Head/year	28	10	Four. Five	985.50	365.00	2190.00
Vitamins [a]	Head/year	28	10	Four. Five	197.10	73.00	438.00
Mineral salts [a]	Head/year	28	10	Four. Five	492.75	182.50	1095.00
Health							
Ticks [to]	Head/year	28	10	Four. Five	295.65	109.50	657.00
Antibiotics [a]	Head/year	28	10	Four. Five	295.65	109.50	657.00
Vaccines [to]	Head/year	28	10	Four. Five	197.10	73.00	438.00
Dewormers [to]	Head/year	28	10	Four. Five	197.10	73.00	438.00
Mantto. of paddock							
Barbed wire [a]	Head / year	28	10	Four. Five	197.10	73.00	438.00
Wire for elec fence. [to]	Head / year	28	10	Four. Five	98.55	36.5	219
Grass seed [a]	Head / year	28	10	Four. Five	197.10	73.00	438.00
Herbicides [a]	Head / year	28	10	Four. Five	295.65	109.50	657.00
mosquicidas [to] pesticides [to]	Head / year	28	10	Four. Five	197.10	73.00	438.00
Others							
Earrings [a]	Head/year	28	10	Four. Five	98.55	18.50	1095.00
Labor [to]	Head / year	28	10	Four. Five	855.18	1282.77	641.39
Maintained and installed. [b]	Head / year	28	10	Four. Five	470.00	470.00	470.00
Income							
Milk	Liters / year	0	0	0	5.5 6	5.08	7.44
Calves	Calves / year	25	0.50	Four. Five	8,160	7,350	8,970
Waste animals	Heads / year	3	one	5	10,600	8,500	14,850
Emissions							
Capture of CO_2e in vegetation	tCO_2e	0	0	0	1,380	920	1,840
Methane emissions [c]	tCO_2e / head	1,344	1,176	1,512	1,380	920	1,840

Source: Own elaboration with information from a. FONNOR (2020) , b. FIRA (2016) , c. Tubiello et al. (2015) and World Bank (2017) .

Veracruz. Prices and quantities.							
Parameter	**Unit**	**Average amount**	**Minimum amount**	**Maximum quantity**	**Average price (pesos)**	**Minimum price (pesos)**	**Maximum price (pesos)**
Supplies							
Food , stubble, vaccines, dewormer [a]	Head / year	10	7	1 7	12,605	6,948	18,262
Labor [to]	Head / year	10	7	1 7	5,533	5,533	5,533
Fuels and lub. [b]	Head / year	10	7	1 7	253	154	614
Others							
Maintained and installed. [c]	Head / year	10	7	1 7	470	470	470
Income							
Milk [to]	Liters / year	43,152	0	75,330	6.24	5.00	11.22
Calves [to]	Calves / year	5.6	0.5 6	8. 5	6,080	6,798	8 800
Waste animals [to]	Heads / year	one	0. 7	1. 7	10,600	8,500	14,850
Cheese [a]	Kg / year	3,020	0	5,273	40	40	90

Emissions							
Capture of CO_2e in vegetation	tCO_2e	0	0	0	1,380	920	1,840
Methane emissions [d]	tCO_2e / head	1,344	1,176	1,512	1,380	920	1,840

Source: Own elaboration with information from a. Gulf of Mexico Fund (2020), b. FONCET (2020) , c. FIRA (2016) , d . Tubiello et al. (2015) and World Bank (2017).

To characterize the transformation of conventional livestock activity towards a sustainable option, the work of Azuara-Morales et al. (2020), who report the parameters of increase in productivity of silvopastoral systems in tropical climates and of Muñoz-González, Huerta-Bravo, Lara Bueno, Rangel Santos, & Arana (2016) for the productivity parameters of conventional livestock . For the establishment costs of this type of systems, information from Hernandez Trujillo (2013) was considered, who reports establishment costs for different arrangements of silvopastoral systems .

For the analysis, 3 scales of producers were considered according to the size of their herd and its surface. Table 4.9 presents a description of these scales, the production system and the reduction of greenhouse gas emissions due to technological improvement.

Table 4.9. Characterization of production systems

Parameter	Unit	Jalisco	Veracruz
Transformation option	Type	ISPS	ISPS
Surface			
Small Prod.	Hectare	5 [a]	10 [b]
Medium Prod.	Hectare	19 [to]	10 [b]
Large Prod.	Hectare	33 [to]	20 [b]
Heads			
Small Prod.	Heads	10 [to]	7 [b]
Medium Prod.	Heads	28 [to]	10 [b]
Large Prod.	Heads	45 [to]	17 [b]
Increase in productivity	%	412.9 [c]	625.8 [c]
Carbon capture	$tCO2e$ / ha	24.5 [d]	24.5 [d]
Cost of ISPS	Weights / ha	62,931 [e]	284,601 [e]
Reduction of methane emissions	%	20 [f]	20 [f]

Source: Own elaboration with information from a. FONNOR (2020), b . Gulf of Mexico AC Fund (2020), c . Muñoz-González et al. (2016) and Azuara-Morales et al. (2020), d . Chará et al. (2019), e . (Hernandez Trujillo, 2013) f. DeRamus, Clement, Giampola, & Dickison (2003).

The process to perform the cost-benefit analysis was as follows: First, the conventional livestock activity and the option of transformation into a silvopastoral system were parameterized. Then, tables of costs and benefits were generated for each state, both for the baseline and alternative options (see table 4.8). These tables (baseline and alternative livestock system) were processed in the tool available on the website www.acbgiz.org , which allows obtaining the profitability indicators mentioned in Table 4.9. It should be noted that this tool allows a statistical analysis to be carried out to estimate the profitability indicators and their confidence interval, which is estimated from the variation in the input parameters (for example, in sales prices, in the amount of produced milk, etc.). Subsequently, a sensitivity analysis was performed on alternative scenarios with differences in costs and benefits.

The assumptions used for the analysis are a discount rate of 6 and 8%. A period of 20 years was considered to be aligned with the life of the project. The extension of the baseline is maintained, so the adoption of alternative livestock generates an increase in the animal load; that is, more is produced with the same. For Jalisco, it is assumed that l to livestock production is car ne for Veracruz that l to livestock is dual purpose, and l 100% of cows produce milk e l 7% milk becomes cheese

The analysis does not consider other potential benefits to be derived from the processing of livestock, including those highlighted in Chapter 4.2. In particular, Pezo, Ney RIOS, & Gómez (2018) identify the following co-benefits derived from ISPS: (i) Nutrition and animal welfare. This benefit is directly translated into higher system productivity, which is why it is indirectly considered in the economic analysis; (ii) Nutrient cycle. The ISPS benefits the soil, the feces benefit the plants, and these, in turn, provide the animals with minerals that help their metabolism. Similarly, this benefit is indirectly reflected in the productivity of the system. (iii) Nitrogen fixation and carbon sequestration. The additional vegetation implied by the ISPS increases the levels of nitrogen and carbon in the soil. Carbon sequestration is considered in the economic analysis as previously described. Regarding nitrogen fixation, Solorio et al. (2017) find that this type of system can fix around 400 kg/ha/year, which avoids the purchase of fertilizers such as Urea 46. Conservation of biodiversity. According to the findings of Chará, Murgueitio, Zuluaga, & Giraldo (2011), this type of system can increase the presence of birds by around 32% and of dung beetles by 56%. Water infiltration. According to Villanueva Najarro, Casasola Coto, & Detlefsen Rivera (2018), surface runoff can be reduced from 48% in an overgrazed area to 5% in an ISPS. Erosion avoided. Based on the results of Chará et al. (2011), ISPS can reduce soil erosion by 740 kg/ha / year.

Results

Table 4.10 shows the profitability indicators for conventional livestock. From the private perspective (column 4 of Figure 2), profitability is only found for all types of producers in Veracruz. These results should not be interpreted as in other cases and places this generates activity losses, because e sto s have several interpretations, to name a few : (i) Only farms with scale some profiteers because they have better indicators of productivity and lower costs at scale, (ii) they have a percentage of labor that is not paid (the analysis assumes that all labor is paid), (iii) producers receive subsidies that keep the activity apparently profitable, (iv)

Producers have alternative activities from which they receive income and do not perceive the losses that they are obtaining from livestock.

The mentioned scale factor can be confirmed by looking at the column "probability of success," which indicates the proportion of cases in which a positive profit is obtained. As can be seen for Jalisco and Veracruz, profitability increases as the size of the producer increases, confirming that, to larger areas, larger l herd, better technology, and the probability of profit is higher. This is not to say that the recommendation is to expand the livestock frontier; it is simply found that the largest producers have a higher chance of success, which is a common finding in economic activities regardless of the sector.

The results in Table 4.10 serve as a baseline for comparison with an alternative option. In particular, the establishment of ISPS for Jalisco and Veracruz is considered.

Other relevant information presented in Table 4.10 is the net present value from a social perspective (second column). This indicator records the economic value of GHG emissions generated by livestock activity. For this, the social value of carbon estimated by (World Bank, 2017) is used. As can be seen, social profitability is always lower than private profitability (column 4), which is because emissions from livestock have a negative impact on the world. Similarly, these values serve as a baseline for comparison with alternative livestock to identify the mitigation contribution of this second option. The third column presents the economic profitability, including GHG emissions, but considering a price of $ 5 per tCO_2e. This value is considered because it is close to the carbon exchange prices that currently exist in Mexico.

In summary, column 2 indicates the social net present value (SNPV), that is, how much livestock is worth to humanity (using the social value of carbon), column 3 what the market value of livestock considering GHG emissions and column 4 what the private value of this activity is is.

Table 4.10. Profitability indicators for conventional livestock

Producer type	S NPV (thousands of pesos) (social value of C2Oe)	S NPV (thousands of pesos) (market price of CO2e)	NPV (thousands of pesos)	ICB (social)	ICB (private)	Chance of Success (Private)	Surface (ha)	Herd (animals)
				Jalisco				
Small	-401.9	-121.5	-99.6	-0.34	-0.11	42%	5	10
Medium	-1,155.9	-386.8	-326.7	-0.35	-0.13	35%	19	28
Large	-1,808.8	-551.5	-453.2	-0.34	-0.11	36%	33	Four. Five
				Veracruz				
Small	679.3	772.4	779.6	0.94	1.25	84%	10	7
Medium	1,738.1	1,970.6	1,988.8	0.98	1.31	91%	10	10
Large	1,742.7	1,975.2	1,993.3	0.99	1.31	94%	twenty	17

Source: Own elaboration. N / A: Not available.

Table 4.10 . Profitability indicators for alternative livestock

Producer type	VPNS (thousands of pesos) (social value of C2Oe)	VPNS (thousands of pesos) (market price of CO2e)	NPV (thousands of pesos)	ICB (social)	ICB (private)	IRR (private)	Chance of Success (Private)	Optimal density (plants / ha)	Surface (ha)	Herd (animals)
					Jalisco					
Small	2,792.1	1,751.7	1,670.4	1.52	0.91	40.8	86%	7000	5	35
Medium	8,385.0	4,184.6	3,856.4	1.66	0.76	37.1	94%	6000	19	87
Large	14,432.9	7,068.7	6,493.4	1.79	0.8	36.6	98%	6000	33	141
					Veracruz					
Small	5,504.7	3,032.1	2,838.9	1.86	0.96	44	82%	6000	10	22
Medium	12,926.8	10,562.5	10,377.8	1.11	0.89	39.2	90%	12000	10	52
Large	13,241.5	8,331.0	7,947.3	1.7	1.01	45.5	92%	7000	twenty	59

Source: Own elaboration. N / A: Not available.

Table 6 shows the results of the option of transformation to a silvopastoral system. E l analysis assumes that the producer chooses a proportion of land with this system, and plant density maximizes its profit. This exercise was carried out, and it was found that the most profitable is to establish the ISPS on the whole farm, and the plant density depends on the scale and the state.

The results in table 6 indicate that the productive conversion is profitable from the private perspective in all cases since the profitability is positive (column 4). The probability of success is high in most cases. Furthermore, the Internal Rate of Return (IRR) is high in most cases. From the social perspective, the conversion is profitable in all cases, which means that humanity, the country, and the producers would all benefit from the productive transformation.

Breakeven point

Table 4.11 shows how the cash flow becomes positive (the breakeven point) and the term in which the investment is recovered (payback period). As can be seen, the terms are short; this means that only in the second year, the producers in Jalisco and Veracruz would have enough cash flow to pay possible financing to establish the ISPS. The table compares other states to demonstrate the feasibility of these systems in selected states.

Table 4.11. Break-even point and payback period (years).

State	Scale	Breakeven	Recovery period
Chiapas	Small	3	3
Chiapas	Medium	2	2
Chiapas	Large	2	2

Chihuahua (rot)	Small	6	17
Chihuahua (rot)	Medium	9	18
Chihuahua (rot)	Large	9	18
Chihuahua (int)	Small	8	> 20
Chihuahua (int)	Medium	10	> 20
Chihuahua (int)	Large	10	> 20
Jalisco	Small	2	2
Jalisco	Medium	2	2
Jalisco	Large	2	2
Veracruz	Small	2	2
Veracruz	Medium	2	2
Veracruz	Large	2	2

Source: Own elaboration.

Mitigation potential

To incorporate the emission reductions into the analysis, it was considered that an ISPS captures between 17 and 32 tCO_2e / ha per year and that there is a reduction of enteric emissions of 20%, according to Chará et al. (2019). Table 4.12 shows the mitigation potentials of GHG emissions for the different states, types of producers, and types of livestock. As can be seen, ISPS generates a reduction in GHG emissions in all states. From a per hectare perspective, the conversion to ISPS generates a reduction of approximately 25 tCO_2e / ha. This reduction comes from two ways, the reduction in enteric fermentation because the ISPS provides a better diet and through the capture of carbon by the vegetative material.

Table 4.12 . GHG mitigation parameters.

Status / size	Conventional	Alternative	Change in emissions	Average hectares	tCO2e / ha / year
Jalisco					
Small	27.2	-99.3	-6.3	0.3	-25.3
Medium	74.4	-402.7	-23.9	1.0	-25.1
Large	121.5	-707.0	-41.4	1.7	-25.1
Veracruz					
Small	9.1	-237.2	-12.3	0.5	-24.6
Medium	22.5	-225.7	-12.4	0.5	-24.8
Large	22.5	-470.3	-24.6	1.0	-24.6

Source: Own elaboration

The results indicate that investment in ISPS is a profitable option. ISPS generates significant benefits from both the private and social perspectives. The results observed in this analysis support the promotion of livestock transformation to a more sustainable not only option as a green investment but also as an opportunity to improve the livelihoods of the people dedicated to this activity.

Efficiency in achieving project outcomes

The project costs per ha in RIOS is based on the costs of the C6 Project. The C6 Implementation Completion and Results Report rated the project efficiency as substantial. The sustainable forest management and agroecology subproject efficiency, the project reported at closing a cost per hectare of USD $279 over four years or USD $69.75 annually. This cost included the payment of salaries of technicians in the field who advised the beneficiaries, labor and inputs equipment and training. The C6 costs remain relatively efficient as compared to other similar projects where studies have estimated costs of USD$ 230.77/ha/year for agroecosystem activities and US$446.15/ha/year for sustainable forest management activities according to CONAFOR`s data in 2014.

Within the general average, the project reported also the associated costs for the management of one hectare of agroforestry and the establishment of one hectare of silvopastoral systems at US$150 annual and US$450 annual respectively. The purchase of specialized equipment as scales and dryers for coffee or electric fences and solar cells for the silvopastoral systems, made the difference in costs per hectare. These costs also included the additional training and technical follow-up provided across subprojects. The C6 efficiency and the expected RIOS efficiency in this regard can also be attributed to the array of outcomes additionally benefiting project areas.

GCF funding is crucial due to the limited national budget channeled to increase adaptive capacity in basins vulnerable to climate change. The project objectives are directly linked to Mexico´s NDCs and National Development Plan, in specific related to (i)reforestation in watersheds, with particular focus on riparian ecosystems; (ii)conservation and restoration of ecosystems; (iii)integral watershed management, and (iv)integration of climate change criteria into agricultural and livestock programs. However, the required investment for climate adaptation needs cannot be met with the national budget alone. The national Budget reductions in 2019 included reductions in the environmental sector, were 32% compared to the allocation of 2018. According to the Think Tank FUNDAR this budget reduction “risks the capacity to meet Mexico´s goals of the Paris Agreement on Climate Change” (FUNDAR, 2019). The low costs compared to the expected benefits of the RIOS project will be an essential element to incentivize public investment in the future. GCF funding will allow showcasing efficient local and sustainable examples, that can be linked to the regional alignment of private and public funding, as well as national strategies.

RIOS will provide the incremental cost for a new output that will result in an important adaptation impact in Mexico, which is ecosystem based adaptation (EbA) through river restoration. At this point, riparian restoration through natural processes does not have public investments or policies, so the baseline scenario is zero. Present public investments to address landslides and floods, which are the main effects of climate change in rivers, are costly infrastructure projects.

The project mobilizes public and private investments to reduce risks and align the limited investments in the basins to respond to climate adaptation needs . The GCF investment will allow for coordination of multiple agents in the watersheds to increase climate adaptation through river restoration. RIOS leverages and catalyzes finance in a tailored way, depending on the type of activity. For those with positive private returns, such as sustainable livestock, it will be complemented with credits. For activities with a positive impact on ecosystem services such as upstream conservation, a Payment for Environmental Services program will be incorporated, catalyzing public-private investments. This coordination of funding sources from RIOS is required to improve forests and river connectivity to increase the adaptive capacity in basins vulnerable to climate change. Moreover, the demonstration of costs and results of ecosystem based adaptation in rivers through the constant monitoring included in RIOS will aim at the paradigm shift required to mobilize both public and private finance by the end of the project. It is expected to have a leveraged finance from private and public resources of at least 50% of the total amount of subprojects´ financing (USD$ 1,785,500).

The concessionally of this project is only for the activities that wouldn't occur by private pf public investors in the absence of this grants, and have high environmental and social co-benefits. The economic analysis (see FS Section 4.3) includes all the activities supported by the project, including conservation, restoration, and improved productive practices. The analysis shows that the net present value (NPV) is projected to reach US$ 30.6 million (lower bound), and US$ 68 million (upper bound) in the baseline scenario (20 years, carbon social price of US$ 60, and 6 percent discount rate). The investments evaluated for the economic analysis have a Benefit-Cost ratio between 1.58 and 2.30 and an internal rate of return (IRR) between 54.89 and 95.08 percent. The results of the quantitative simulations are robust in terms of sensitivity analyses by increasing the discount rate from six to nine percent, reducing the carbon social price (from US$ 60 to US$ 40), as well as adopting the value of voluntary carbon market (US$ 3.01), and using more conservative estimates regarding the value of ecosystem services provided.

RIOS will be complemented and co-financed by the GEF- financed CONECTA Project. CONECTA will provide the co-financing for RIOS, which will be financed by the World Bank, through a GEF USD$15 million grant, to be implemented during 2021-2026. The objective of CONECTA is to improve integrated landscape management in selected watersheds in the states of Chihuahua, Chiapas, Jalisco and Veracruz. (see FS Section 1.6). RIOS complements the integrated landscape approach of CONECTA, with a climate mitigation and adaptation impacts.

Chapter 5. IMPLEMENTATION ARRANGEMENTS

5.1 Stakeholders analysis and evidence of consultations and stakeholder engagement plan

This section presents the Stakeholder Engagement Plan (SEP) for the RIOS proposal, to be implemented by the Mexican Fund for the Conservation of Nature (FMCN) and financed by the Green Climate Fund (GCF). This document has been prepared with the aim of guiding the stakeholder communication and meaningful consultation during the implementation of the project and across its lifetime.

The central purpose of this plan is to allow the stakeholder engagement to be undertaken systematically to let the various stakeholder groups to express their distinct views and opinions, and the project to appropriately respond to them. The plan is aimed at enabling dynamic meaningful engagement with the stakeholder groups by identifying different mechanisms for the participation of stakeholder groups, especially vulnerable groups.

As part of this project and in keeping with the applicable reference framework, an Environmental and Social Assessment (ESA), an Environmental and Social Action Plan (ESAP), a Gender Action Plan (GAP), and a Grievance Redress Mechanism were developed and linked to the SEP (see Chapter 5.4).

Objectives and applicability of the SEP

Stakeholder engagement can be defined as a dialogue-oriented approach to enhance local inclusive decision making for social learning, which includes diverse stakeholders creating a shared vision and shared objectives for raising awareness, changing attitudes, affecting behaviors, promoting equity, building social capital, reducing conflict, encouraging innovation, facilitating spin-off partnerships, and increasing ownership of the project (Mathur et al., 2008; UNEP, 2007).

This conceptualization highlights that stakeholder engagement is a continuous process or series of actions, impacts, and outcomes, and not one single activity. The approach recognizes the need for stakeholder involvement in its activities and phases hence the process is inclusive, transparent, and fair.

The specific objectives of the SEP are:

- Identify and analyze the stakeholder groups and their profiles, interests, issues/impacts, and concerns relevant to the project.
- Detect specific measures to allow meaningful engagement with the different stakeholder groups in a manner that is transparent and accessible and using culturally appropriate communication methods with an explicit focus on vulnerable groups.

- Allow for a relationship to be built with the various stakeholders of the project based on mutual respect and trust.
- Facilitate adequate and timely dissemination of information to the stakeholder groups in a culturally appropriate manner.
- Provide systems for prior disclosure/dissemination of information and consultation, including seeking and incorporating inputs from affected persons or groups, as applicable, and providing feedback to affected persons/groups on whether and how the contribution has been incorporated.
- Ensure mechanisms for stakeholders to provide feedback, asks questions, raise concerns, and dispute resolution.
- Providing a mechanism for documentation of the activities undertaken and the reporting and monitoring of the same.

This document applies to the entire life cycle of the project with a specific focus on the implementation of the other plans referred to above. The SEP needs to be considered as a living document, to be updated regularly based on the emerging needs and patterns for engagement with the various stakeholders.

Brief project understanding

The objective of the project RIOS is to increase adaptive capacity in two watersheds highly vulnerable to climate change through river restoration and connectivity by:

Component 1: Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices. This Component will strengthen capacities in producers and land-owners in the Jamapa watershed, within the Matlaluca-Medellín, Ixcatla, and Tlamatoca sub-basins, and in the Ameca-Mascota watershed, within the Talpa-Ameca sub-basin, to conduct activities on their land that promote ecosystem-based adaptation through functional connectivity. Functional connectivity represents biological corridors that improve ecosystem services, which are directly linked to increased resilience to the effects of climate change. INECC -the National government agency that coordinates climate change research and policy- has identified the required actions to reduce climate change vulnerability through Integrated Watershed Action Plans (IWAPs) built with key local stakeholders, during the Global Environmental Facility GEF-Financed C6 Project coordinated by FMCN in 2014-2019.

Component 2: Alignment of public and private investments through natural capital accounting for scaling-up activities for the restoration of rivers for adaptation to climate change. This Component will implement coordination activities to align public and private investments, including credits, to scale-up the best practices supported under Component 1. It includes three strategies: (i) alignment of local and national public programs related to connectivity (including CONAFOR Payment for Ecosystem Services, Sillvopastoral Program in Jalisco, and others); (ii) mobilized investment of private funds in watershed connectivity in target and additional basins, for example, coming from the tourism industry and water service providers; (iii) improve enabling environment and capacities for producers benefited by Component 1 to access to dedicated credit lines for sustainable, climate-resilient productive practices in sustainable ranching and agroforestry. It is expected to leverage finance from: State Ministries of Rural Development, CONAFOR, CONAGUA, FIRA (Trust Funds for Agriculture, Ranching and Fisheries, a national development bank)– for sustainable credit lines, Financial Institutions, Tourism sector (hotels and restaurants) and water concessions. This Component will also implement a Natural Capital Accounting system through an economic valuation of selected ecosystem services to quantify and attribute the contribution of river restoration to the reduction of climate vulnerability. This will serve as a basis to increase private and public investments focused on river restoration for climate vulnerability reduction that will be leveraged under this Component.

Component 3: Design of a National River Restoration Strategy for climate change adaptation. Under the leadership of INECC, this Component will support the design of the NRRS to strengthen the country's adaptation to climate change. It will: (i) identify relevant stakeholders for the design; (ii)establish a Design Committee and its institutional arrangements; (iii) incorporate lessons learned from intermediate results from Components 1 and 2; (iv) develop workshops to define objectives, scope, and guidelines of the NRRS. It will also support the work with public officials and legislators to:(i) define the legal framework of the strategy; (ii) identify relevant key decision-makers and legislators that require strengthening in their knowledge on climate change adaptation and (iii) develop and launch a communication strategy.

Consultation and multi-stakeholder engagement activities undertaken during project design

This section describes the multi-stakeholder consultation process and engagement plan undertaken so far as part of the project design, during the environmental and social assessment process. Stakeholders for this SEP were identified based on this prior engagement and ensuring a gender-inclusive approach. Engagement activities undertaken to-date were critical for identifying stakeholders and formulating the SEP for the remaining life of the project.

In 2019, FMCN recruited two Regional Funds to undertake the ESA and the engagement activities, FONNOR in Jalisco and Fondo Golfo de México (FGM) in Veracruz; which will be the project Executing Entities. These Regional Funds serve as the local point contact between the project and the stakeholders and play a significant role in the implementation of the stakeholder engagement process.

The essential engagement activities carried out as part of the impact assessment process during project design were:

a) **ESA.** The project engaged with the watersheds stakeholders through key informant interviews to develop an environmental and socio-economic baseline of the project area in Jalisco and Veracruz, to predict potential impacts due to project activities, and to document the community's perception of the project and its activities (refer to Appendix 2.1 Environmental and Social Assessment).

b) **Consultations to support the preparation of the GCF proposal.** Three consultation workshops were also undertaken as part of the process (Table 7.1). The purpose of these consultations was to develop an understanding of:

- The local stakeholder's perception of the project and its activities.
- The impacts of the project on the community, and the possible restoration activities that can be introduced.

Based on these consultations, local stakeholders confirmed that the overall perception of the project is positive and well received. The stakeholders were interested mainly in on the timing of the project, on how the eligible areas were chosen, the mechanisms of operation of the project, the amount of funds that will be allocated to field activities, and the expected impacts and benefits.

Table 5.1. List of the consultations undertaken.

State	Watershed	Place	Date	Number of participants	Stakeholder group
Jalisco	Ameca-Mascota	Offices of the Trust for the administration of the Forestry Development Program of Jalisco (FIPRODEFO) Guadalajara.	March 4th, 2020	18	• Governmental agencies (7) • Academia (1) • Civil society organizations (7) • Producers (1) • Technical advisors (2)
		Office of the Mascota town hall.	March 5th, 2020	42	• Governmental agencies (6) • Academia (8) • Civil society organizations (6) • Producers (19) • Technical advisors (3)
Veracruz	Jamapa	Facilities of the Instituto Tecnológico de Veracruz, Veracruz.	March 3th, 2020	21	• Governmental agencies (3) • Academia (7) • Civil society organizations (6) • Producers (3) • Technical advisors (2)

c) **Meetings with stakeholders from the private sector.** Information regarding the project, including its scope, location, activities, and potential benefits, was disclosed during the following meetings with various private stakeholders:

Jalisco

- ADAPTUR First Regional Encounter - Tourism and adaptation to climate change: keys to increase the competitiveness of the sector in the Nayarit-Jalisco Riviera. It took place on November 11th and 12th, 2019, in Puerto Vallarta, Jalisco.
- Working Meetings among the Association of Entrepreneurs of Puerto Vallarta and Banderas Bay (AEBBA), GIZ - ADAPTUR, the National Forestry Commission (CONAFOR), the Tourism Secretariat (SECTUR) and the Government of the State of Nayarit and Jalisco to support climate change adaptation measures in the Tourism Sector through Payment for Environmental Services schemes. The first meeting was held in the board room of the Business Center in Nuevo Vallarta on January 17th, 2020, and the second one in the classroom "Mayto" of the International Convention Center of Puerto Vallarta on February 07th, 2020.

Veracruz

- Meetings with the Water Operating Agencies from the municipalities of Veracruz and Medellín (MAS Group), which included the participation of the Metropolitan Water Institute.

Stakeholder identification and analysis

This section provides a qualitative analysis of the key stakeholders identified for the project. A stakeholder is an individual, group or organization that are likely to be impacted/affected/interested by the project actions, objectives, and policies, and on the significance of the impact/influence of each individual/group/organization on the project activities. This information was used to formulate the SEP and the corresponding measures to address the interests of the stakeholders during the project life cycle.

The initial list of stakeholders was developed based on the Regional Funds experience and updated following the ESA, meetings, and consultation process described above. The stakeholders are classified under Primary Stakeholders, those who are likely to be directly impacted or have a direct impact on the project activities, and Secondary Stakeholders, who are likely to have an indirect impact or are to be indirectly impacted (Table 5.2).

Table 5.2. Stakeholder group categorization.

Stakeholder Group	Primary Stakeholders	Secondary Stakeholders
Community	• Local communities • Ranchers, farmers, cooperatives (e.g. farmer cooperatives), and local small and medium enterprises • Vulnerable groups	
Institutional Stakeholders	• Civil Society Organizations • Private sector (e.g. hotelier)	• Academia

	• Financial intermediaries	
Governmental agencies	• INECC • CONAGUA	• SEMARNAT • IMTA • CONAFOR • CONANP • FIRA • SADER • BIENESTAR

The relative influence that these different individuals and groups have over the project as well as the influence of the project over them was examined through a Stakeholder mapping process. The significance of a stakeholder group is categorized considering the magnitude of the impact of the project on the stakeholder or degree of influence (power, proximity) of a stakeholder group on the project functioning. The significance of the stakeholder group´s importance for the project and the requirement for engaging with them is identified as an interaction of the impact and influence. Table 5.3 and Figure 5.1 provide an initial categorization and a brief profile of the most relevant stakeholders identified, according to their potential interest and influence. The stakeholder groups to be engaged will be extended and updated as the project evolves to identify supplementary groups.

As one of the guiding principles of inclusive engagement, the project is committed to working with stakeholders who are hard to reach, such as:

- Women
- Young and elderly people
- People with disabilities
- Indigenous stakeholders

Although there are no indigenous communities in the project´s target areas, RIOS will ensure that all indigenous peoples present can participate in the project activities. If indigenous peoples are detected before or during the project´s implementation, an appropriate strategy to privilege their participation will be developed. For example, culturally appropriate materials will be translated into their language and placed in visible strategic locations used most by the target audience (e.g., ejidal house, schools, local market, others) to increase their awareness about the project, its activities, means of participation, and the grievance redress mechanism. An Indigenous Peoples Plan (IPP) shall also be developed to ensure their meaningful involvement and participation.

Table 5.3. Stakeholder mapping.

Stakeholder Group	Profile	Impact/Influence of the project on the Stakeholder Group	Impact/Influence of the Stakeholder Group on the project	Expectations and Concerns	Significance of the Stakeholder Group
Local communities	• A total population of 850,604 individuals in the two watersheds included in the project, which are expected to be directly and indirectly impacted.	• Benefit from enhanced environmental services. • May participate in restoration activities through the subprojects. • Subproject activities may be carried out on social property land.	• Play a critical role in the formation of public opinion towards the project and allowing for its efficient functioning.	• High expectations from the project in terms of opportunities for livelihood generation and community development. • Some of the key expectations include: - Timely and clear disclosure of information regarding the project and the call for proposal for subprojects (e.g. details, requirements, and timelines). - Access to the GRM established for the project.	High
Ranchers, farmers, cooperatives and local small and medium enterprises	• Direct land-user group, highly dependent on natural conservation and pasture land conditions. They own land where conservation, restoration, and best management practices may be developed.	• May participate in conservation / restoration / better management activities through the subprojects. • Subproject activities may be carried out on their properties. • Training on the right skills related to technical, organizational, financial, and commercial skills and connecting them to credit opportunities.	• Play a critical role in the formation of public opinion towards the project and allowing for its effective functioning.	• High expectations from the project in terms of opportunities for livelihood generation and support for establishing business enterprises and their linkage to sale goods and services. • Low to medium awareness of ecosystem degradation but with a slight interest in reducing livestock or cropland. • Access to the GRM established for the project.	High
Vulnerable groups	• Those who may have a significant challenge to participate in the project due to their socio-cultural and economic status.	• Positive impact by assigning priority to them for employment and capacity building opportunities within the	• Limited influence on the project, owing to its socioeconomic and exclusion status.	• The primary expectation pertains to the selection of proposals for subprojects, in which preferential treatment will be provided to proposals	Moderate

Stakeholder Group	Profile	Impact/Influence of the project on the Stakeholder Group	Impact/Influence of the Stakeholder Group on the project	Expectations and Concerns	Significance of the Stakeholder Group
	• This group is comprised of: - People without land. - People without any potential source of income. - Single women-headed households. - Young and elderly family members. - Physically or mentally disabled. - Indigenous Peoples.	implementation of the subprojects. • Any intervention by the project focused on them will result in a significant improvement in the living standards of this stakeholder group due to their present status.		where vulnerable groups are integrated. • Access to the GRM established for the project.	
Civil Society Organizations	• Third-party conservation / restoration / best management practices experts who will be engaged for implementing the subprojects collaborating with farmers, ranchers, and local communities.	• Adequate planning and budget allocation for the smooth implementation of the selected subprojects, which in turn may have an impact on the target watersheds. • The timely provision of information and resources by the project is critical for the performance of this stakeholder group.	• Play a critical role in the effective functioning and timely implementation of selected subprojects and benefit-sharing. • The work of this group on the ground will influence the opinions of the local stakeholders about the project.	• The key expectations of the stakeholder group from the project pertain to: -Timely and complete provisioning of information on the project objectives, components, and implementation process. -The timely provision of financial resources and technical assistance for the implementation of the subprojects. - Compliance with the regulatory requirements and environmental and social standards applicable to the project. - Ensuring the safety of the local community, workers, and the environment. - Access to the GRM established for the project.	High

Stakeholder Group	Profile	Impact/Influence of the project on the Stakeholder Group	Impact/Influence of the Stakeholder Group on the project	Expectations and Concerns	Significance of the Stakeholder Group
				• High awareness of and interest in conservation and empowering local communities.	
Governmental agencies	• Regulatory authorities at the national level that are responsible for the technical orientation, public policy connection, and aligning investments for the project.	• Significant policies and monitoring instruments will be developed through the project to reduce ecosystem and social vulnerability in the watersheds.	• Play a critical role in providing technical and policy orientation and support for the functioning of the project.	• Compliance with all applicable guidelines, policies, and laws. • Timely disclosure of information and provisioning of updates throughout the life of the project. • High involvement in decision-making.	High
Private sector	• Financing individuals, groups, agencies who are exploring an investment opportunity in the project.	• Potential interest in obtaining technical knowledge as well as policy-relevant awareness produced by the project. • Impact that the project's performance will have on the private investor public opinion in the local area, country, and international arena.	• This stakeholder group's influence on the project will primarily pertain to the determination of the project's financial feasibility in the long-term.	• Clear communication in terms of tasks, roles, and responsibilities and timelines for the project. • Low to medium interest in conservation.	High
Financial intermediaries	• Financing agencies who are exploring an investment opportunity in the project.	• A sustained opportunity to this group through the development of dedicated credit lines and financial products and services.	• Play a critical role in the formation of public opinion towards the project and allowing for its effective functioning and timely implementation. • In addition to the national rules and regulations, the project is required to comply with the internal standards of these financial institutions.	• The main expectations and concerns of this stakeholder group from the project are as follows: - Timely completion of the project activities. - Ensuring that the project complies with the applicable reference framework, especially in terms of environmental management, vulnerable groups, and disclosure of information.	High

Stakeholder Group	Profile	Impact/Influence of the project on the Stakeholder Group	Impact/Influence of the Stakeholder Group on the project	Expectations and Concerns	Significance of the Stakeholder Group
Academia	• Researchers and research institute interested in the development of climate-resilient production systems.	• Sharing research results on time, and for disseminating them at various levels (e.g. technical level, policy level, local community level, among others).	• This stakeholder group's influence on the project will primarily pertain to technical advice on project field activities about environmental conditions.	• Dissemination of results and increasing awareness.	Moderate

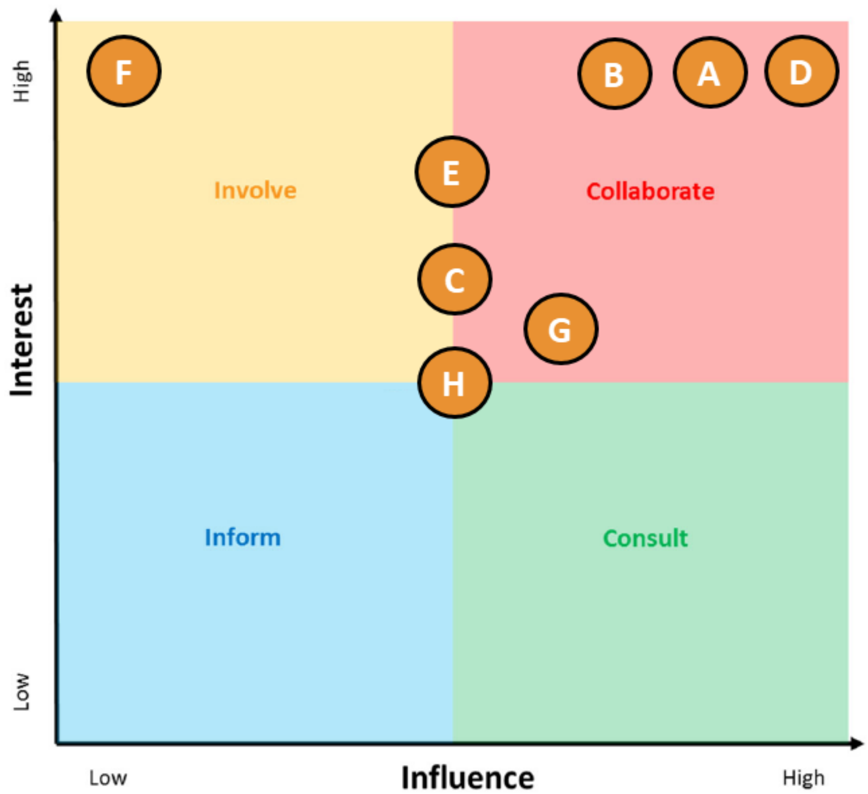


Figure 5.1. Stakeholder importance and influence matrix. Initial qualitative allocation of the stakeholder groups into engagement level categories according to their potential interest and influence. A: Civil Society Organizations; B: Producers (farmers, ranchers, among others); C: Private sector; D: National authorities; E: Local communities; F: Vulnerable groups; G: Financial institutions; and H: Academia.

Stakeholder Engagement Plan

Based on the previous engagement activities and the stakeholders mapping, the project will undertake regular engagement activities with the key stakeholder groups identified to interact and contribute towards planning in an effective and culturally appropriate manner (Table 5.4). For all activities implemented at the local level, participation will be voluntary and based on the principle of Free, Prior, and Informed Consent.

For this project, different methods of engagement will be considered to address the diverse individual profiles, concerns, and expectations of the stakeholder groups identified, among others, are detailed in Table 5.4.

Table 5.4. Engagement methods.

	Engagement method	Key issues	Limitations
Inform	**Communication materials and media** (fact sheets, infographics, posters, radio spots, websites and social media posts, among others)	• Disseminate project information to a large number of stakeholders through a variety of channels. • Simple and efficient to reach those who may be harder to involve. • Can be adapted to a particular stakeholder group (for example, vulnerable stakeholders) to make it culturally appropriate or relevant to the needs of the recipients.	• Written materials may not be accessible to people with visual impairment or low literacy levels. • Websites and social media are limited to those with access to IT. • Must be kept up-to-date frequently.
	Information sessions	• Present project information to a large group of stakeholders. • Should be tailored to the stakeholder group needs. • Record comments/questions raised and responses. • Enable people to come and go at their convenience. • Participants can provide contact details and be kept in touch with updates.	• Written materials may not be accessible to people with visual impairment or low literacy levels. • Do not generally support direct involvement in decision-making and need to be a clear explanation of how feedback will be used in the action planning process.
Consult	**Workshops**	• Facilitated event for presenting project information to a large group of stakeholders. • Use participatory methods to facilitate group discussions, brainstorm issues, analyze data, competing options, and developing ideas, and recommendations. • Allow the group of stakeholders to provide feedback, concerns, and opinions. • Encourage active joint working and problem-solving. • Record comments/questions raised and responses.	• Facilitation is crucial for obtaining the expected outcome.
	Public meetings	• Open invitation to all interested, rather than those explicitly invited. • Present project information to a big audience and distribute relevant non-technical materials. • Allow the stakeholders to raise issues and ask questions, as well as to provide feedback, opinions, and comments. • Opportunity to gather support for new ideas and build relationships. • Record comments/queries raised and responses.	
	Academic presentations, forums, and focus groups	• Gather opinions from a range of objective experts on a specific subject. • Allow open discussion, maximizing participation. • Produce in-depth analysis.	• The process may be too "exclusive". • If the group is big, facilitation will be necessary to keep the crowd focused.
	Webinars	• Internet forums to enable stakeholders to contribute their views and provide feedback. • Useful for diverse and extensive input. • Measuring website statistics can also track stakeholder interest.	• Participation is limited to those with access to IT.

Involve and Collaborate	**Learning community**	• Multi-stakeholder forum. • Opportunity to build relationships for networking.	• Need to be very well structured and facilitated. • Significant lead time, preparatory work, and resourcing required.
	Key stories, opinion pieces, and newspaper publications	• Easily transmittable to a wide audience across a range of platforms. • Positive narrative to connect with stakeholders and maximize opportunities to shape the project. • Work on emotions and help to develop shared perspectives and understandings. • Focus on relevant examples, approaches, or solutions to a particular issue. • Can be used effectively and relatively inexpensively at all stages of engagement.	• Requires regular updating or interest and commitment to the project can be lost. • Consideration of presentation and visual elements are needed to reduce the use of printed words. • Written materials may not be accessible to people with visual impairment or low literacy levels.
	Fundraising events and field trips	• Project information can be delivered to key influencers. • Can quickly build relationships and support for a process. • Effective in accessing hard-to-reach groups with special interests. • Can build ambassadors for the project.	• Needs to be well organized, which is often time-consuming. • Should be used sparingly and for only high priority issues as it is labor, resource, and time-intensive.
Empower	**Coordination Committee**	• Bring together a group with diverse expertise and a high level of interest in the action planning project. • Meet regularly. • Build understanding, relationships, and consensus. • Provide technical and policy advice.	• Tend to be small and representation can be difficult to achieve. • Need to be well chaired as members can have strongly opposing views, which must be carefully managed.

Processes are designed to be flexible, adapting and responding to national and local conditions and activity requirements. As the SEP is a living document, the engagement activities proposed, their frequency, and operation will be updated as required through the life of the project, based on the monitoring process and feedback of the stakeholders. The Stakeholder Engagement Plan can be found in Table 5.5.

Table 5.5. Stakeholder engagement plan for RIOS, ensuring a gender-inclusive approach as considered in the Gender Action Plan (GAP).

Phase of the project		Target stakeholder group	Method of engagement	Responsible party	Year	Frequency
Design	Design the proposal for the project RIOS.	• Producers • Vulnerable groups • Civil Society Organizations • State and municipal authorities • Academia	• Information sessions and workshops	Regional Funds	2019 Completed	During the process of project design.
Implementation	Component 1. Increase in forest and water connectivity with a vision of adaptation to climate change through the implementation and participatory monitoring of sub-projects of restoration, conservation, and best production practices.	• Producers • Civil Society Organizations • Vulnerable groups	• Workshops • Tailored communication channels and materials by geographical location • Local media (community radio, print media) • Webpage • Social media	FMCN and Regional Funds	2020 second semester	During the period of dissemination of the call for proposals of sub-projects
		• Producers • Vulnerable groups • Civil Society Organizations • Academia	• Tailored communication channels and materials • Workshops • Webpage • Social media • Learning community • Key stories behind selected subprojects showcasing on-ground actions • Science and research publications • Regular meetings and field visits	FMCN and Regional Funds	2021 - 2025	From the beginning of the sub-projects and during the whole sub-project lifetime, at least every six months
	Component 2. Catalyze and align public and private investments through natural capital accounting for scaling-up activities for the	• Private sector • Federal, state, and municipal authorities • Financial institutions • Producers	• Fact sheets and infographics • Webpage • Social media • Webinars • Learning community • Key stories behind each subproject showcasing on-ground actions • Field days to show media progress on key projects	FMCN	2021-2025	From the beginning of the phase and ongoing, at least every six months or as needed

Phase of the project		Target stakeholder group	Method of engagement	Responsible party	Year	Frequency
	restoration of rivers for adaptation to climate change.		• Opinion pieces for newspapers • Academic presentations /forums • Fundraising activities and events • Public meetings			
	Component 3. Design of the National River Restoration Strategy (NRRS) for climate change adaptation.	• Federal, state, and municipal authorities • Producers • Civil Society Organizations • Academia	• Fact sheets and visual resources explaining the NRRS • Academic presentations/Focus groups • Workshops • Webinars • Public meetings	FMCN	2021-2025	Second year of operation of the project, at least every six months or as needed
Monitoring and reporting.	Monitoring and reporting.	• Civil Society Organizations • Producers and local communities	• Timely responses to issues raised by stakeholders according to the GRM • Quarterly data reports collating feedback from the website and social media • Quarterly reports on media issues • Update Issues Register	Regional Funds and FMCN	2020-2025	From the beginning of the project and during the whole project lifetime, reports every trimester
		• Federal authorities	• Briefing and meetings • Coordination Committee	FMCN	2020-2025	From the beginning of the project and during the whole project lifetime, reports every trimester

Roadmap to leverage private and public financing

A key component of RIOS is the leveraging of private and public funding. The project will first assess the economic value of ecosystem services, to quantify, valuate, and attribute the contribution of river restoration to the reduction of climate vulnerability. This data complemented with the strong water and biodiversity monitoring system, will serve will aim at the paradigm shift required to mobilize both public and private finance by the end of the project. The activities related to leveraging finance are described in Table 5.6:

Table 5.6. Activities to leverage private and public financing.

Actor	Strategy	Related activities
Financial institutions	Financial intermediaries including Microfinance Institutions, Multiple Purpose Financial Companies (SOFOMES), Credit Unions, Popular Financial Societies, and Savings and Loan Cooperative Societies (Cooperatives). The project will train these financial intermediaries to adapt their financial products to the needs of EbA and sustainable practices. Financial intermediaries will get an integral training from gender aspects to methodologies adjusted to climate variability, allowing them to understand the needs and associated risk to implement financial products adjusted to the needs of the clients that implement EbA. The project will also work under Component 1 with producer groups, to improve their financial and managerial capacities, supporting them to access to those credits and providing accompaniment for credit repayment. Financial institutions will benefit from increasing their participation in rural areas, diversifying their offer of financial products, improving their operational processes and reducing the associated risks.	• Promote the development of dedicated credit lines with Development Finance Institutions. • Train financial intermediaries to develop financial products and services that promote sustainable and climate-resilient practices.
Private sector in target watersheds	The EE will identify private companies and industries that are being benefited (hotels, restaurants, water companies, etc.) from the ecosystem services provided by the activities financed under Component 1. The valuation of the ecosystem services provided by the economic valuation will serve as a basis to stimulate the dialogue with the private sector that is being benefited by the provision of ecosystem services.	1. Evaluate economic contribution of ecosystem services toward vulnerability reduction related to private incentives. 2. Identify potential private contributors. 3. Design linkage schemes with the private sector in connectivity investments as an adaptation measure. 4. Conduct awareness workshops with private actors to promote connectivity investments.

	The EEs will promote linkage schemes between private contributors and financed subprojects under Component 1. Thanks to the strong monitoring systems, the project will demonstrate a real effect that links the financed activities with an increased provision of ecosystems services.	5. Supervise that private sector investments land correctly in the territories.
National and sub-national governments	The main institutions from the national government related to rural development <re part of the Coordinating Committee (CC). The CC will be composed by INECC, FMCN and the following participating government agencies: Ministry of Environment and Natural Resources (SEMARNAT), Ministry of Agriculture and Rural Development (SADER), Ministry of Welfare (BIENESTAR), National Commission for Protected Areas (CONANP), National Forestry Commission (CONAFOR), National Water Commission (CONAGUA), Mexican Institute of Water Technology (IMTA) and Institutionalized Trusts for Agriculture (FIRA). The CC will be responsible for providing policy guidance and will support coordination of project work among the participating agencies and promote their collaboration and align financing in the target areas. Under the CC, the AE and INECC will propose regulatory instruments and programs at the federal / state level. At local level, the EE will work closely with state and municipal governments to identify public programs with investments in connectivity and river restoration, to ensure that programs contribute to the project objectives.	1. Evaluate economic contribution of ecosystem services toward vulnerability reduction related to public programs. 2. Identify public programs with investments in connectivity (existing and potential). 3. Analyze and propose regulatory instruments and programs at the federal / state level.

Example of financial intermediaries in the target watersheds

Table 5.7 shows some examples of potential financial institutions and financial intermediaries that may be interested to invest in sustainable livestock and agroforestry projects promoted under RIOS.

Table 5.7. Financial institutions and financial intermediaries working in the targeted watersheds that may invest in RIOS subprojects

	Organization	Minicipality	Topic
Ameca-Mascota			
Financing	SIFRA Cooperative	Atenguillo	Credits for financing agricultural projects

Financing	Caja Popular Agustín de Iturbide	Regional	Credits for financing agricultural projects
Financing	Christopher Columbus Popular Fund	Regional	Credits for financing agricultural projects
Financing	FIRA	Federal	Farming
Financing	Consumer cooperative, supplies Livestock of Jalisco SC de RI de CV	Jalisco	Livestock
Non-profit organization	Jalisco Regional Livestock Union	Jalisco	Cattle raising
Non-profit organization	Local Livestock Associations	Talpa de Allende y Mascota	Cattle raising
state government	FIPRODEFO	Jalisco	Forest and agroforestry sector development
Jamapa			
Financing	Caja Popular de Ahorro Yanga, SC de AP de RL de CV	Regional	Credits for financing agricultural projects
Financing	Caja Zongolica, SC de AP de RL de CV	Regional	Credits for financing agricultural projects
Financing	Caja Popular Mexicana, SC de AP de RL de CV	Regional	Credits for financing agricultural projects
Financing	Financing to Campo Veracruzano SA de CV (FINCAVER)	Regional	Coffee
Financing	Livestock Union of the Central Region of Veracruz	Regional	Cattle raising
Non-profit organization	Solidarity savings banks	Municipality of Ixhuatlán del Café	Support for household economy

Source: Own elaboration

Example of pre-identified private sector companies that could be potential buyers of Ecosystem Services (ES) the target watersheds

The private sector identified for the project brings together various organizations and companies mainly dedicated to industrial processes, tourism, water management, sanitation, and product marketing at regional, national, and international levels. They have been selected as possible contributors for the payment of ecosystem services, considering their profile and needs of inputs for their activities.

Watershed	Private Sector Company	Profile
Jamapa, Veracruz	Grupo MAS	Municipal water management organism
	Hoteliers	Company dedicated to tourist services in different cities of the basin

	CAFIVER	Company with experience in the commercialization of shade coffee at national and international level
	Corporación CARABAS, S.R.L.	Company with agro-industrial experience
	Agroindustrias Unidas de México S.A. de C.V.	Company dedicated to export coffee
	API Veracruz	Port association of the port of Veracruz
	AIEVAC A.C.	Association of Industrialists of Veracruz
	Comercializadora e industrializadora agropecuaria (CIASA)	Company with experience in the commercialization of agricultural and livestock products
	Agroindistrias y Servicios Integrados de Veracruz S.A. de C.V.	Company with experience in the commercialization of agricultural and livestock products
	Productores y Engordadores de Bovinos del Centro de Veracruz, S.A de C.V.	Company with experience in the commercialization of agricultural and livestock products
	Procesos y Empacadados de Veracruz S.A. de C.V.	Company with experience in the commercialization of agricultural and livestock products
Ameca-Mascota, Jalisco	Hoteliers	Companies dedicated to tourist services
	Asociación de usuarios del distrito de riego 043	Public organization of agricultural producers
	PRODUCE fundation	Public organization with experience in production of agricultural and livestock products.
	Sistema de Agua Potable y Alcantarillado (SEAPAL)	Decentralized Public Organism, in charge of water management and administration
	API Puerto Vallarta	Port association of Puerto Vallarta
	Asociación de Empresarios de Punta Mita	Association of Industrialists of Punta Mita
	Asociación de Hoteles de Puerto de Vallara y Bahía de Banderas.	Association of companies dedicated to tourist services
	Asociación de Empresarios de Bahía de Banderas y Puerto Vallarta- AEBBA	Association of Industrialists of Bahía de Banderas y Puerto Vallarta
	Asociación de Prestadores de Servicios Turísticos	Association of Tourism Service Providers of Puerto Vallarta
	Cámara Nacional de la Industria de Restaurantes y Alimentos Condimentados (CANIRAC) – Delegación Puerto Vallarta	Association of the Food Industry of Puerto Vallarta
	Bahía Unida, A.C.	Private organization with experience in environmental conservation with

		tourism service providers of Puerto Vallarta and Bahía Banderas.

Example of CSO in the targeted watersheds that may apply to the CFP

Civil society organizations, which through open requests for proposals will implement the project's eligible activities, have historically worked in both regions through projects, government programs, or international cooperation initiatives. They are organizations with a track record and regional recognition, with social involvement and technically qualified personnel. Many of them have previously participated in the C6 project and the Biocultural Landscape of the Sierra Occidental de Jalisco.

Watershed	Organization	Profile
Ameca-Mascota, Jalisco	Espacios Naturales y Desarrollo Sustentable A.C. (ENDESU)	Civil society organization with experience in conservation, restoration and promotion of the sustainable use of natural resources in Mexico.
	Junta Intermunicipal de Sierra Occidente y Costa (JISOC)	Decentralized Public Organism, in charge of projects on rural development in the western sierra and coast region.
	The Nature Conservancy	Civil society organization with experience in nature conservation
	Fundación PRODUCE	Organization with experience in providing support to local producers through innovation, technological and industrial development.
	Nuestra Sierra, A.C.	Civil society organization with experience in community development and nature conservation.
	RASA Red de Agricultores Sustentables en Jalisco	Civil society organization with experience in agroecology.
	Asociación de Silvicultores de la Costa de Jalisco, A.C.	Civil society organization with experience in forest management.
	Unidad de Silvicultores Sierra del Oeste de Jalisco, A.C	Civil society organization with experience in forest management.
	Pronatura Noroeste, A.C.	Civil society organization with experience in the conservation of flora, fauna and priority ecosystems in Northwest Mexico.
	Alianza Jaguar A.C.	Civil society organization with experience in conservation of jaguar habitat (*Panthera onca*).
	Conservación de Especies Maravillosas de Bahía de Banderas A.C (CEMBAB)	Civil society organization with experience in conservation, protection, rescue and rehabilitation of wildlife, as well as environmental education in Bahia de Banderas

	Unidos por las Guacamayas A.C.	Civil society organization with experience in habitat and green macaw conservation
	Grupo Ecologico de la Costa Verde A.C.	Civil society organization with experience in the conservation of endangered species, along the Mexican Pacific coast
	Grupo Ecológico de Puerto Vallarta A.C.	Civil society organization with experience in natural conservation in Banderas Bay
	Fundación Punta Mita, A.C.	Civil society organization with experience in sustainable development, education, health, environment and community participation.
Jamapa, Veracruz	Consultora para el Desarrollo Rural y Ordenamiento Ambiental, S.A. de C.V. (CEDRO)	Private organization with experience in forest management
	Pronatura Veracruz, A.C.	Private organization with experience in agroecology and protected natural areas
	Vinculación y Desarrollo Agroecológico, A.C. (VIDA)	Private organization with experience in agroecology, shade coffee, marketing and gender
	Gruta del Río Jamapa, S.C. de R.L. de C.V.	Private organization with experience in managing shade coffee plantations and equitable access to water
	Productores de Alimentos para las zonas rurales de México, S.C.	Private organization with experience in managing shade coffee plantations and reproduction of native tree species
	Sistemas Productivos Rurales de Jamapa, S.C. de R.L.	Private organization with experience in sustainable food production
	Campesinos en la lucha agraria S.C. de .RL.	Private organization with experience in the commercialization of shade coffee at national and international level
	Coordinadora de organizaciones cafetaleras de Huatusco A.C.	Private organization with experience in the commercialization of shade coffee at national and international level
	CAFIVER	Private organization with experience in the commercialization of shade coffee at national and international level
	Unión Ganadera del Centro de Veracruz	Private organization with experience in livestock
	Uniones ganaderas locales	Private organizations with experience in livestock
	Las Cañadas	Private organization with experience in agroecology and permaculture

	Conecta Tierra A.C.	Private organization with experience in managing shade coffee plantations honey production and gender
	Global Water Watch México A.C.	Private organization with experience in community water monitoring

Information Disclosure

The process of the disclosure involves the provisioning of relevant project-related information in a timely and accessible manner to the various stakeholders to facilitate their meaningful, effective and informed participation.

Information disclosure is an important activity not just as a form of engagement, but also for enabling the other engagement activities to be undertaken in an informed and participatory manner. The disclosure mechanism not only allows to build trust among the stakeholders, but also permits for more constructive participation in the other processes of consultation and resolution of grievances due to the availability of accurate and timely information.

RIOS information about the impacts of the project, the advancement, and the means for raising grievances will be disclosed along the project cycle through FMCN´s and the Regional Funds´ websites and the learning community workshops and communication activities. This information will be provided in an accessible, gender-inclusive, and culturally appropriate manner. It will consider any vulnerable groups.

SEP implementation

To ensure the proper and effective implementation of the SEP, the project will ensure that this engagement process is given as much importance as the other project activities and safeguard the availability of the required resources.

The project has identified the qualified specific project personnel to oversee, guide, and coordinate the stakeholder engagement plan through the life of the project, including information disclosure, documenting the activities undertaken, reporting to the Technical Project Committee, monitoring stakeholder engagement, and updating the SEP promptly. These personnel will be established at FMCN and in each Regional Fund. The project will deliver sufficient training to increase the adequacy and capacity of these personnel in terms of their understanding of the SEP. The project will also guarantee that the budget formulated for the stakeholder engagement process is sufficient to meet the corresponding expenses.

The monitoring of the SEP operation will be undertaken on a biannual basis, containing:

- Auditing the implementation of the SEP.
- Monitoring the formal and informal consultation activities conducted with the stakeholder groups.

- Monitoring the effectiveness of the engagement processes in managing impacts and expectations by:
  - Tracking feedback received from engagement activities.
  - Recording and tracking commitments made to stakeholders.
  - Assessing the efficacy of the engagement activities in terms of the desired outcomes and the participation of the stakeholder groups.

Redress Mechanism

The Grievance Redress Mechanism (GRM; refer to Chapter 5.4) is another critical component of effective stakeholder engagement for the entire project life. Its purpose is to provide an accessible, understandable, and structured way of receiving and resolving internal and external stakeholders' concerns, queries, and issues. The GRM details clear procedures for managing claims and other feedback provided on the project, including standard time for responding to complaints or questions; levels at which the various grievances should be addressed, according to the severity of the accusation; mechanisms to record such claims, and clear roles and responsibilities for GRM management and maintenance at no cost and without retribution. The GRM allows for trust to be built among the different stakeholders and prevent the culmination of small issues into major community unrest.

5.2 Implementation arrangements and governance of the project

The FMCN is the Accredited Entity as well as the Executing Entity. INECC - the national government agency that coordinates research to feed policy on climate change in Mexico- is the technical leader of the project and will ensure country appropriation. Two Regional Funds, Fondo Golfo de México (FGM) in Veracruz and in Jalisco Fondo Noroeste (FONNOR), are the Executing Entities together with FMCN.

The governance structure of RIOS includes a Coordinating Committee (CC), a Technical Committee (TC), and a Technical and an Operational Coordinating Unit (TCU and OCU).

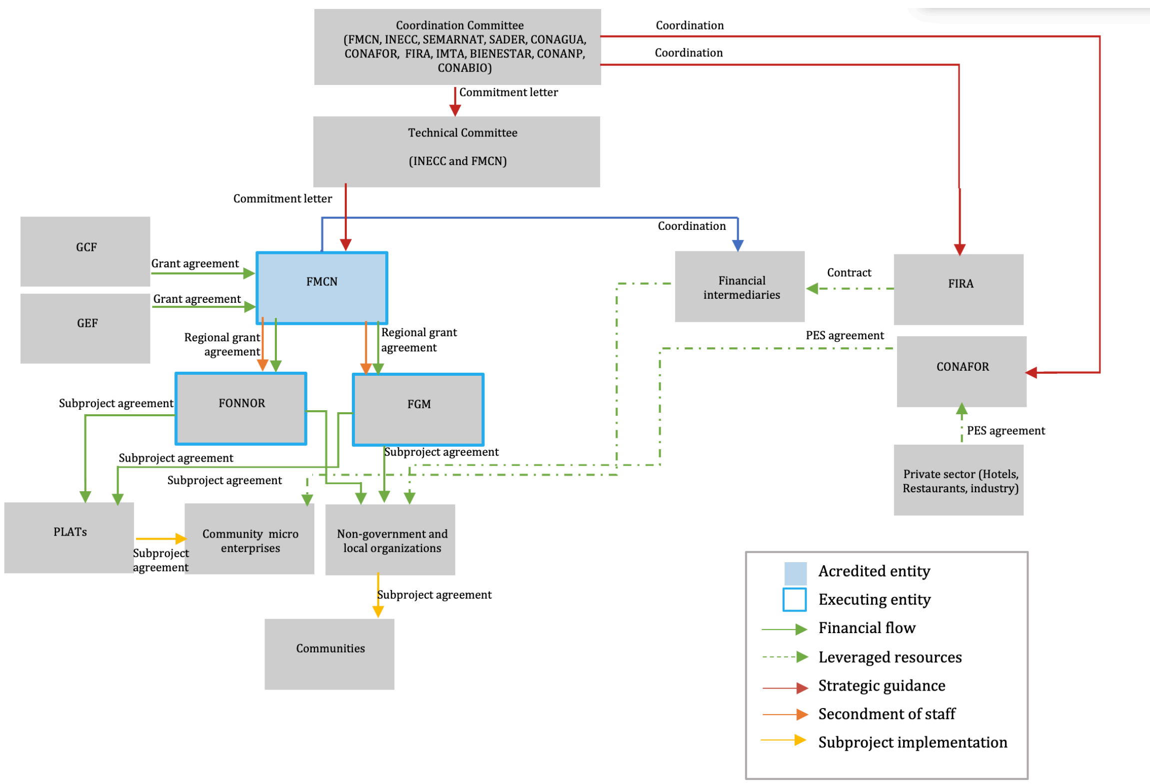
a) Instances of responsibility

Coordinating Committee (CC)	The CC will be composed by INECC, FMCN and the following participating government agencies: Ministry of Environment and Natural Resources (SEMARNAT), Ministry of Agriculture and Rural Development (SADER), Ministry of Welfare (BIENESTAR), National Commission for Protected Areas (CONANP), National Forestry Commission (CONAFOR), National Water Commission (CONAGUA), Mexican Institute of Water Technology (IMTA) and Institutionalized Trusts for Agriculture (FIRA). It will be responsible for providing policy

	guidance and will support coordination of project work among the participating agencies and promote their collaboration
Technical Committee (TC)	The TC will be composed of representatives from the National Institute of Ecology and Climate Change (INECC) and FMCN. The TC will meet at least three times a year and will monitor and supervise the operation of RIOS. The staff housed at INECC and FMCN will respond to the TC.
FMCN	FMCN will play the role of both Accredited Entity and Executing Entity. FMCN, as the Accredited Entity (AE), has the adequate capacity to carry out the administration and supervision of the Project, given its trajectory in implementing projects financed by international institutions such as the World Bank, the State Development Bank of the Federal Republic of Germany (KfW) and the Inter-American Development Bank (IDB), among others. FMCN's internal control is solid, since it has manuals, policies and operating procedures that will be applicable to the execution of the Project. FMCN will channel resources to two Regional Funds. FMCN will house: a Project director, technical coordinator, a safeguards specialist, an accounting assistant, a communication officer, and a technical assistant hired by the FMCN (the first three part-time). They will be responsible for administration, reports, audits, fiscal and legal aspects, compliance with fiduciary and procurement procedures, as well as guidance, supervision and reporting on the implementation of safeguards.
INECC	INECC is the national government agency that coordinates research to feed policy on climate change in Mexico and is the Project technical leader. The designated staff housed at INECC includes five specialists: River restoration Officer, Technical assistant adaptation to climate change, Policy Alignment Officer, Technical assistant analysis of environmental services, Technical assistant social safeguards and gender. They will oversee and generate the technical information for the project components and will be equipped by computers and specialized technology packages financed by the project. INECC will adapt monitoring systems from C6 and will complement under Component 1 a social vulnerability community assessment that will be applied and monitored during project implementation. Under the leadership of INECC, Component 3 will support the design of the NRRS to strengthen the country's adaptation to climate change. INECC involvement will ensure country appropriation.
Regional Funds (RF)	The project will be co-executed by two Regional Funds previously created by FMCN. These RF have been proved to reduce operation costs by working closer to local organizations and communities. In Veracruz, the FMCN will transfer funds to Fondo Golfo de México (FGM), and in Jalisco to Fondo Noroeste (FONNOR). The World Bank has supervised both RF for six years and highlights them as key for local engagement, supervision, and capacity building. They have the governance mechanism of non-profits and follow the standards established by FMCN and derived from the Practice Standards for Conservation Trust Funds developed by the Conservation Finance Alliance. Management units in each RF will consist of a a Monitoring and Evaluation Analyst, a Technical Analyst and an Administrative Assistant. The RF will be in charge, among other activities, of the request for proposals process and the selection, training, support, and supervision of subprojects, as well as the disbursements that will finance civil, community or private organizations that work directly with local communities and producers in Component 1. They will also be responsible for the socialization of the grievance redress mechanism in the watersheds, receiving and processing complaints and consultations related to the project and sending them to the FMCN safeguards specialist, as well as identifying problems and finding their solutions together with stakeholders.
Beneficiaries	The direct beneficiaries are the 63,294 inhabitants of the targeted sub-basins that will have increased provision of ecosystem services and reduced vulnerability to climate change. The main beneficiaries of subprojects are 6,000 men and women from vulnerable communities and producer groups that will implement activities related to conservation, restoration and

	adaptation of practices in target basins. Also, financial institutions will be trained in a variety of topics, including gender mainstreaming in their operation, and the design of dedicated sustainable credit lines. Legislators and key institutional actors will also be trained in various topics including gender aspects in the design of a NRRS. The indirect beneficiaries are over 850,00 people that live in the Ameca-Mascota and Jamapa basins, and will have improved provision of ecosystem services. Additionally, over 6,000,000 tourists that visit the both regions per year, will have better water quality and landscape aesthetics derived from the project.

Implementation Arrangements



Instances of responsibility

FMCN undertakes an AE role. FMCN as an Executing Entity (EE) will be responsible for carrying out activities 1.3.2, and most activities related to Component 2 and 3 (2.1.1, 2.1.2, 2.2.1, 2.3.1, 3.3.1, and 3.2.1). FONNOR and FGM as EEs will be responsible for carrying out activities 1.1.2 and 1.2.2. In relation to activities 1.1.1,1.2.1, 1.3.1 and 2.2.2, FONNOR and FGM will lead the sub-activities related to the local implementation in the field, and FMCN will be responsible of planning related sub-activities. Where a sub-activity is to be implemented by more than one EE, these EEs will be jointly responsible for implementation of such sub-activity. INECC acts as technical leader of the activities, and is a key actor to upscale lessons learned from the subprojects into the National River Restoration Strategy under Component 3.

Table 5.8. Instances of responsibility

Component	Output	Activities	Sub-activities	Executing Entities	
				Leads	Co-EE
Component 1: Increase in forest and water connectivity with a vision of adaptation to climate change through restoration, conservation and best productive practices	Output 1.1 Increased area of land conserved, restored, or under best management practices that reduce climate vulnerability.	1.1.1 Provide funding - through different schemes- to subprojects to conserve, restore and improve management practices to increase adaptive capacities through river restoration.	1.1.1.1 Define detailed selection criteria for each scheme under a participatory approach (all Schemes).	FMCN	
			1.1.1.2 Disseminate the RFP (Scheme 1,2, and 4).	FGM[1] FONNOR	
			1.1.1.3 Rate proposals by external evaluators (Scheme 1,2, and 4).	FGM FONNOR	
			1.1.1.4 Select the proposals by the Technical Committee (Scheme 1,2, and 4).	FMCN	
			1.1.1.5 Award contracts to organizations whose subprojects were selected (Scheme 1, and 2).	FGM FONNOR	
			1.1.1.6 Support the implementation subprojects through the provision of funding. (Scheme 1,2, and 4).	FGM FONNOR	
			1.1.1.7 Monitoring and reporting of the implementation subprojects (all Schemes).	FGM FONNOR	
			1.1.1.8 Provide technical assistance on sustainable practices (Scheme 3).	FGM FONNOR	
			1.1.1.9 Support the development of capacities in producers on financial literacy and business management (Scheme 4).	FGM FONNOR	
			1.1.1.10 Evaluate and, where appropriate, extend annual contracts with the organizations in charge of the subprojects (Scheme 1,2, and 4).	FGM FONNOR	FMCN

		1.1.2 Support subprojects to implement procedures to maximize environmental and social benefits, with a gender approach.	1.1.2.1 Supervise administrative management of subprojects (Scheme 1,2, and 4).	FGM FONNOR	
			1.1.2.2 Supervise the implementation of the Environmental and Social Action Plan (all Schemes).	FGM FONNOR	FMCN
			1.1.2.3 Supervise the implementation of the gender action plan (all Schemes).	FGM FONNOR	
	Output 1.2 Target communities have applied a participatory methodology for monitoring biodiversity and water quality to provide inputs for an evaluation of the ecosystem and social vulnerability of the basins	1.2.1 Monitor biodiversity and water quality impact of subprojects through community participation.	1.2.1.1 Adjust existing community monitoring methodologies for assessing the ad hoc vulnerability of the project (all Schemes).	FMCN	
			1.2.1.2 Raise awareness of local actors on the issue of vulnerability through workshops and training related to the effects of climate change (all Schemes).	FGM FONNOR	
			1.2.1.3 Train local actors and communities to implement monitoring methodologies (all Schemes).	FGM FONNOR	FMCN
		1.2.2 Evaluate vulnerability of the watershed-dependent communities with a participatory methodology.	1.2.2.1 Evaluate vulnerability of baseline, medium term and final project (all Schemes).	FGM FONNOR	FMCN
			1.2.2.2 Communicate the results of vulnerability assessed to provide feedback on adaptation actions at the community level (all Schemes).	FGM FONNOR	
	Output 1.3 A learning community fostering knowledge has exchanged and coordinated experiences between watersheds and with key actors to increase	1.3.1 Develop a multi-stakeholder knowledge exchange platform to mainstream river restoration.	1.3.1.1 Incentivize the linkage of connectivity instruments (from federal, state and municipal actors) (all Schemes, mainly Scheme 3)	FGM FONNOR	
			1.3.1.2 Conduct national and local experience exchange workshops (all Schemes).	FGM FONNOR	FMCN

	functional connectivity.		1.3.1.3 Design and publish communication materials to communicate to key stakeholders project´s lessons learned (all Schemes).	FMCN	
			1.3.1.4 Adjust existing communication platforms and adapt them to project needs.	FMCN	
		1.3.2 Scale-up lessons learned from subprojects to inform local and national policies and programs.	1.3.2.1 Scale-up lessons learned from subprojects to inform private and public programs under Component 2 and National strategies under Component 3 (all Schemes).	FMCN	
Component 2: Alignment of public and private investments through natural capital accounting for scaling-up activities for the restoration of rivers for adaptation to climate change	Output 2.1 Investments of public programs in targeted watershed catalyzed towards climate resilience have increased.	2.1.1 Assess the economic value of ecosystem services to catalyze public financing.	2.1.1.1 Evaluate economic contribution of ecosystem services toward vulnerability reduction related to public programs.	FMCN	
		2.1.2 Promote the alignment of regulatory instruments and programs at the federal / state level to promote river restoration through EbA.	2.1.2.1 Identify public programs with investments in connectivity (existing and potential).	FMCN	FGM FONNOR
			2.1.2.2 Analyze and propose regulatory instruments and programs at the federal / state level.	FMCN	FGM FONNOR
	Output 2.2 Investments of private programs in targeted watershed catalyzed towards climate resilience have increased.	2.2.1 Conduct assessment of the economic value of ecosystem services to promote private incentives.	2.2.1.1 Evaluate economic contribution of ecosystem services toward vulnerability reduction related to private incentives.	FMCN	
		2.2.2 Facilitate the implementation of schemes that link the private sector to river restoration as an adaptation measure.	2.2.2.1 Identify potential private contributors.	FMCN	FGM FONNOR
			2.2.2.2 Design linkage schemes with the private sector in connectivity investments as an adaptation measure.	FMCN	
			2.2.2.3 Conduct awareness workshops with private actors to promote	FMCN	

			connectivity investments.		
			2.2.2.4 Supervise that private sector investments land correctly in the territories.	FGM FONNOR	
	Output 2.3 Dedicated credit lines, and financial products and services developed towards climate resilience have increased.	2.3.1 Develop/improve dedicated credit lines and financial products to catalyze financing for EbA activities related to river restoration.	2.3.1.1 Promote the development of dedicated credit lines with Development Finance Institutions.	FMCN	
			2.3.1.2 Train financial intermediaries to develop financial products and services that promote sustainable and climate-resilient practices.	FMCN	
Component 3: Design of a National River Restoration Strategy for climate change adaptation	Output 3.1 The design of the National River Restoration Strategy has been supported.	3.1.1 Design and agree with key stakeholders on a National River Restoration Strategy.	3.1.1.1 Identify and convene relevant actors for the design of the NRRS.	FMCN	
			3.1.1.2 Establish the inter-institutional arrangements of the Design Committee.	FMCN	
			3.1.1.3 Incorporate lessons learned from IWAPs, project and similar initiatives.	FMCN	
			3.1.1.4 Develop workshops to define objectives, scope and guidelines of the Strategy.	FMCN	
			3.1.1.5 Present and agree on a proposal of a NRRS with key stakeholders from the environmental sector.	FMCN	
	Output 3.2 Legislators and officials have actively participated to operationalize the National River Restoration Strategy.	3.2.1 Involve key stakeholders on EbA for river restoration, with a gender approach.	3.2.1.1 Train legislators and officials on the importance of EbA for river restoration, with a gender approach.	FMCN	
			3.2.1.2 Definition of the legal framework in which the Strategy may be incorporated.	FMCN	

5.3 Capacity assessment and due diligence on the executing entities

This section briefly describes the process followed by the Accredited Entity (AE) Mexican Fund for the Conservation of Nature A.C. (FMCN) to conduct the Due Diligence (D.D.) of the organizations proposed to receive funds provided by the Green Climate Fund GCF. The D.D.'s involved the participation of different areas of the FMCN responsible for the review of administrative and institutional aspects, as well as RIOS Executing Entity (EE):

Accredited Entity (AE) FMCN
General Director (GD), Research and Development Area Director (RDAD) and Director of the Forest and Watershed Conservation Program (DFWCP), Administration Directorate (A.D.) and Administration Coordination (A.C.)

Executing Entities (EE)
Gulf of Mexico Fund A.C. (FGM) and Northwest Fund (FONNOR)

The FMCN established a D.D. mechanism to respond to the information requirements and institutional capacities requested in the GCF Capacity Assessment Questionnaire (CAQ) format. The phases are:

1. Reception and review of the CAQ format. The FMCN reviewed the draft CAQ provided by GCF in detail to determine if all the sections and questions correspond to the project requirements conditions.

2. Request for administrative and institutional information. The FMCN requested to the EEs the institutional, fiduciary and administrative information with their documentary evidence. In particular, the: (i) legal constitution, (ii) the governance model, (iii) the organizational structure, (iv) financial and procurement management, (v) and project management.

3. Preparation of information by EEs. With the accompaniment of the FMCN, the EEs filled out the CAQ form and opened online information box containing the documentary evidence. The organizations sent the information to the FMCN for the corresponding review and feedback.

4. Review of information and feedback. FMCN received the information the EEs prepared in the CAQ format. To comply with the detailed review, the FMCN designed an instrument called a "DD toolbox", which includes all the information from the CAQ format and feedback box with observations from the FMCN and the EEs´ specific responses.

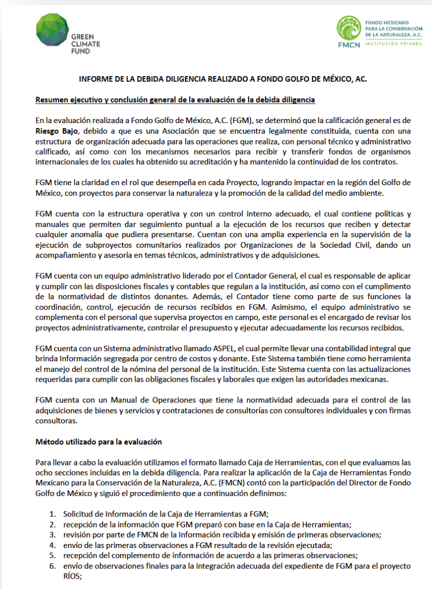
5. Responses by EEs. From the observations in the DD toolbox, the EEs prepared new specific responses in the CAQ format and the toolbox with the respective documentary evidence in the virtual box.

6. Information review. The FMCN received the information derived from the feedback in the CAQ format and the DD toolbox sent by the EEs with the evidence. FMCN carried out a new detailed review in the CAQ format and in the toolbox, which met the information and evidence requirements.

7. Integration of DD report. Derived from the revision of the CAQ format and the toolbox, the FMCN prepared a D.D. report for EEs which identifies the risk level of each section of the CAQ and a cumulative risk level for the organization (low, medium, high) and recommendations (Figure x).

Table 5.9 Phases and participation of organizations in the DD

Phase	FMCN	FGM	FONNOR
1. Reception and revision of the CAQ format	X		
2. Request for administrative and institutional information	X		
3. Preparation of information by EEs		X	X
4. Review of information and feedback	X		
5. Responses by EEs		X	X
6. Information review	X		
7. Integration of DD report	X		



GREEN CLIMATE FUND

FONDO MEXICANO PARA LA CONSERVACIÓN DE LA NATURALEZA, A.C.
FMCN INSTITUCIÓN PRIVADA

INFORME DE LA DEBIDA DILIGENCIA REALIZADO A FONDO GOLFO DE MÉXICO, AC.

Resumen ejecutivo y conclusión general de la evaluación de la debida diligencia

En la evaluación realizada a Fondo Golfo de México, A.C. (FGM), se determinó que la calificación general es de **Riesgo Bajo**, debido a que es una Asociación que se encuentra legalmente constituida, cuenta con una estructura de organización adecuada para las operaciones que realiza, con personal técnico y administrativo calificado, así como con los mecanismos necesarios para recibir y transferir fondos de organismos internacionales de los cuales ha obtenido su acreditación y ha mantenido la continuidad de los contratos.

FGM tiene la claridad en el rol que desempeña en cada Proyecto, logrando impactar en la región del Golfo de México, con proyectos para conservar la naturaleza y la promoción de la calidad del medio ambiente.

FGM cuenta con la estructura operativa y con un control interno adecuado, el cual contiene políticas y manuales que permiten dar seguimiento puntual a la ejecución de los recursos que reciben y detectar cualquier anomalía que pudiera presentarse. Cuentan con una amplia experiencia en la supervisión de la ejecución de subproyectos comunitarios realizados por Organizaciones de la Sociedad Civil, dando un acompañamiento y asesoría en temas técnicos, administrativos y de adquisiciones.

FGM cuenta con un equipo administrativo liderado por el Contador General, el cual es responsable de aplicar y cumplir con las disposiciones fiscales y contables que regulan a la institución, así como con el cumplimento de la normatividad de distintos donantes. Además, el Contador tiene como parte de sus funciones la coordinación, control, ejecución de recursos recibidos en FGM. Asimismo, el equipo administrativo se complementa con el personal que supervisa proyectos en campo, este personal es el encargado de revisar los proyectos administrativamente, controlar el presupuesto y ejecutar adecuadamente los recursos recibidos.

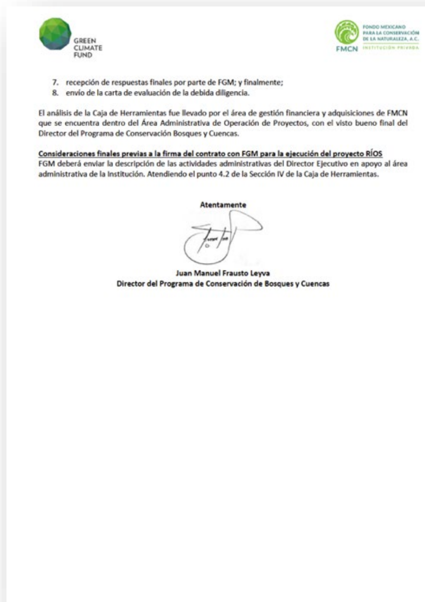
FGM cuenta con un Sistema administrativo llamado ASPEL, el cual permite llevar una contabilidad integral que brinda Información segregada por centro de costos y donante. Este Sistema también tiene como herramienta el manejo del control de la nómina del personal de la institución. Este Sistema cuenta con las actualizaciones requeridas para cumplir con las obligaciones fiscales y laborales que exigen las autoridades mexicanas.

FGM cuenta con un Manual de Operaciones que tiene la normatividad adecuada para el control de las adquisiciones de bienes y servicios y contrataciones de consultorías con consultores individuales y con firmas consultoras.

Método utilizado para la evaluación

Para llevar a cabo la evaluación utilizamos el formato llamado Caja de Herramientas, con el que evaluamos las ocho secciones incluidas en la debida diligencia. Para realizar la aplicación de la Caja de Herramientas Fondo Mexicano para la Conservación de la Naturaleza, A.C. (FMCN) contó con la participación del Director de Fondo Golfo de México y siguió el procedimiento que a continuación definimos:

1. Solicitud de Información de la Caja de Herramientas a FGM;
2. recepción de la información que FGM preparó con base en la Caja de Herramientas;
3. revisión por parte de FMCN de la Información recibida y emisión de primeras observaciones;
4. envío de las primeras observaciones a FGM resultado de la revisión ejecutada;
5. recepción del complemento de información de acuerdo a las primeras observaciones;
6. envío de observaciones finales para la integración adecuada del expediente de FGM para el proyecto RÍOS;



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7. recepción de respuestas finales por parte de FGM; y finalmente;
8. envío de la carta de evaluación de la debida diligencia.

El análisis de la Caja de Herramientas fue llevado por el área de gestión financiera y adquisiciones de FMCN que se encuentra dentro del Área Administrativa de Operación de Proyectos, con el visto bueno final del Director del Programa de Conservación Bosques y Cuencas.

Consideraciones finales previas a la firma del contrato con FGM para la ejecución del proyecto RÍOS
FGM deberá enviar la descripción de las actividades administrativas del Director Ejecutivo en apoyo al área administrativa de la Institución. Atendiendo el punto 4.2 de la Sección IV de la Caja de Herramientas.

Atentamente

Juan Manuel Frausto Leyva
Director del Programa de Conservación de Bosques y Cuencas

Figure 5.3. DD Report

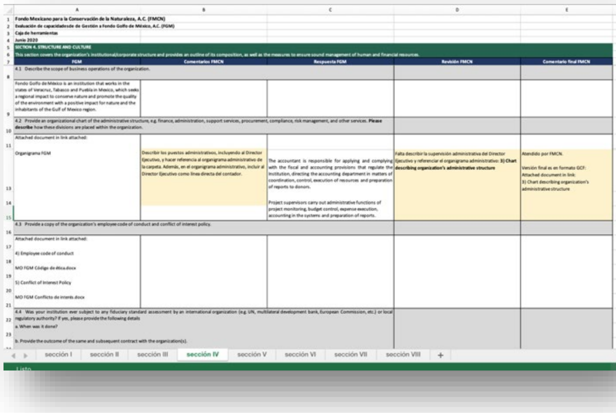

Figure 5.4. DD Toolbox

The result of the Due Diligence shows that both institutions have a low risk and therefore can be EA for the RIOS project.

5.4 Grievance redress mechanism

FMCN´s grievance redress mechanism

The Mexican Fund for the Conservation of Nature (FMCN) has an institutional grievance redress mechanism to receive and address complaints, suggestions, and queries, which is described in its Conservation Operation Manual (MOAC). Besides, FMCN has a Protection Policy for Complainants, a Policy for the Resolution of Procurement Disputes, a Policy for Prohibited Practices, an Anti-Fraud Policy, and a new Protection Policy against Sexual Exploitation, Sexual Abuse, and Sexual Harassment, which aim to prevent, terminate, mitigate and remediate institutional negative activities or misconducts. All these policies and procedures enhance the performance of FMCN to allocate financial resources for nature conservation, connecting the various actors that have a role to play in protecting Mexico's vast biodiversity.

FMCN´s grievance redress mechanism respects and follows the national and international human rights and is guided by principles of equity, transparency, effectiveness, accessibility, continuous learning, and culturally appropriate (Table 5.10).

Table 5.10. The guiding principles of FMCN´s grievance mechanism.

Accessibility	• Voluntary. • Known to all the intended stakeholder groups, providing adequate assistance for those who may face particular barriers to access. • Provides multiple channels for its wide dissemination: Phone, E-mail, SMS, WhatsApp, through FMCN´s staff, or follow-up field visits.
Transparency	• Respects confidentiality, when necessary. • Keeps parties informed about its progress and provide sufficient information about the mechanism's performance to build confidence in its effectiveness. • Reports on standards and their results.
Equity	• Offers a fair, informed, respectful, and professional treatment, adjusted to due process. • Provides reasonable common access to sources of information, advice, and expertise necessary to engage in the grievance process. • Does not restrict the right to other grievance mechanisms.
Effectiveness	• Defines clear procedures, with specific deadlines for each step and appropriate resources and personnel. • Easy to use.

Continuous learning	• Consulting the stakeholders' groups for improving the mechanism. • Regularly assess trends about grievances, including how outcomes are implemented.
Culturally appropriate	• Makes use of traditional systems for grievance resolution, which are locally effective and credible. • Designed with input from users.

For receiving and responding to grievances, FMCN has a complaint line (Figure 5.5), which can be directly accessed by any of the following channels:

- Website: www.fmcn.org
- E-mail: denuncia@fmcn.org
- Postal mail: Damas 49, San Jose Insurgentes, Benito Juarez, CDMX, 03900.
- Phone number: 55 5611 9779 ext. 220

Grievances should include at least the following information:

- Full name
- E-mail
- Description of the grievance in detail
- If any, evidence to support the grievance

Contact details are required to seek further clarification on the grievance, yet the party reporting the grievance may request that their identity remain confidential.

The General Direction will be the first instance of attention to possible complaints, through FMCN´s Internal Auditor. The Internal Auditor will use a simple grievance decision tree to determine if further investigation is required. If so, the Internal Auditor will identify the Policy and its sections which are relevant to the grievance. The Internal Auditor will establish contact with the complainant and formally extend an offer to engage in dialogue about the grievance. The Internal Auditor will then compile all available information about the complaint into a report which is then sent to the General Director and the Board of Directors for review. The Internal Auditor will maintain all the files and documents, including all the correspondences sent by the General Director and Board of Directors to external parties. The Board of Directors will determine whether an investigation is needed. If the complaint is unmerited or no field action is required, the Internal Auditor will submit a response letter to the grievance raiser. If the complaint is merited, the Internal Auditor will begin an investigation. Dialogue with the complainant will be maintained during this step to maintain accountability for the fair conduct of the grievance process.

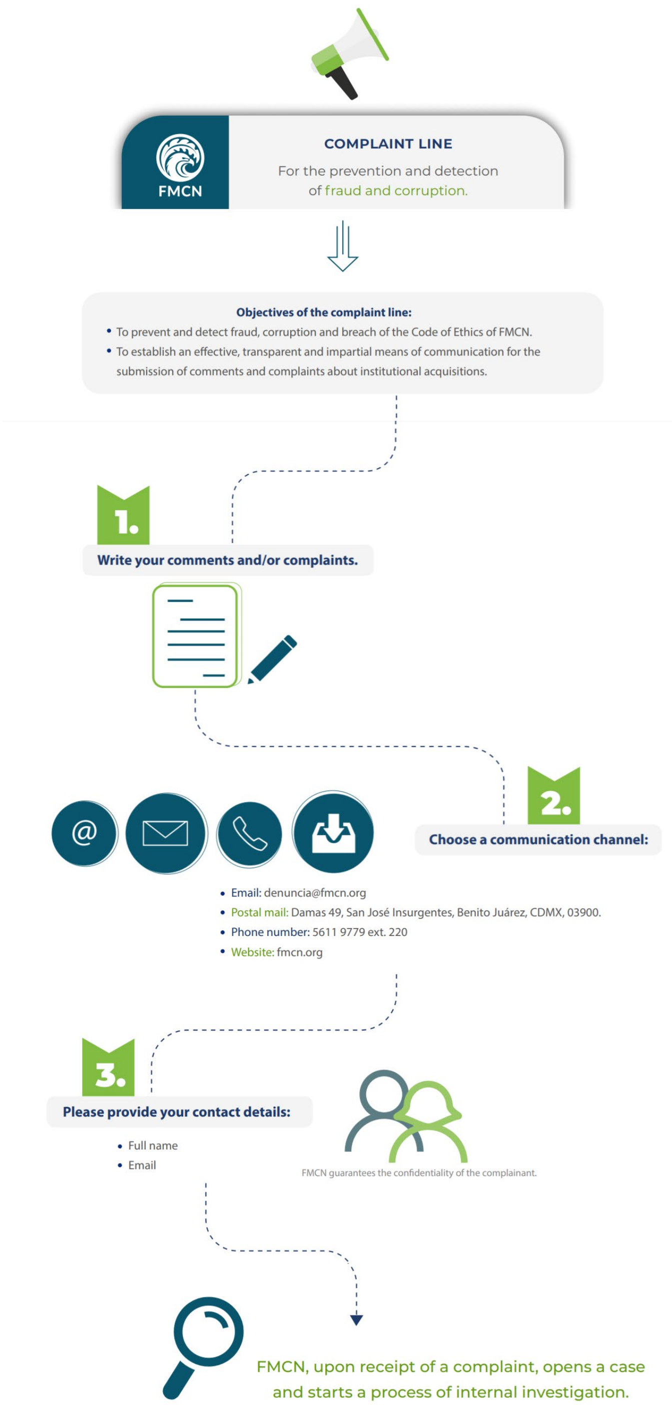

Figure 5.5. FMCN´s complaint line.

RIOS grievance redress mechanism

FMCN´s grievance procedures will be the starting point for implementing a project level grievance redress mechanism (GRM), which shall be accessible, inclusive, agile, fast, effective, transparent, and culturally appropriate to all affected and interested parties directly related to the implementation of the RIOS project, without cost or retribution.

The GRM for RIOS will follow the same procedure as FMCN´s grievance mechanism and its operation will fall on the instances described on 5,2 and meet the following procedures.

a) GRM procedure

The grievances may be submitted by any person, group, party, or community, who considers that the project RIOS negatively affects their interests, well-being or lifestyle, or who have queries or want to offer feedback for improvement of the project.

The procedure for filing a complaint or query and its follow-up is (Table 5.10 and Figure 5.7):

1. The organization, community or affected person may contact directly the RF.
2. The RF will be the first instance of attention to possible claims or queries. The RF will receive, record, classify, report, and process complaints and consultations related to the project. If required, the RF may use a translator of indigenous languages for the formulation of the complaint or provide support to write it. The RF shall record the contact details of the appellant to ensure the communication with the person or organization in question. The RF will investigate grievances for confirming their validity. The RF may undertake interviews and dialogue with relevant stakeholders and, when necessary, collect additional information to deliberate on and address the grievance. The RF will develop reports outlining the result of its verification and recommend actions. Where relevant, the RF will make contact with the complainant at the earliest opportunity, and invite him/her/them to participate in the process to resolve. Dialogue with the grievance raiser will be maintained throughout the process to ensure accountability for the fair conduct of the grievance process. When appropriate, the RF shall respect and use the traditional community grievance redress mechanisms and procedures to promote conflict resolution (e.g. community assembly, the consultation instruments with traditional authorities). The RF will be responsible for documenting and drafting external communications, including response letter to grievance raisers. The RF will also maintain an up-to-date grievance list containing details of all grievances handled following this procedure. The status of each claim will be submitted to the TC in its regular meetings.
3. The RF will have 10 working days to emit a written response to the complainant. The reply will inform if the grievance was considered as merited or not and the details. If appropriate, the RF will indicate the process the complaint will follow either for resolving (if it is within the competence of the RF) or if it was elevated to the next level of governance of the project. In the latter case, the maximum period to resolve the grievance will be 30 working days, always trying to reply in the shortest possible time.

4. If within the 10 days, the grievance or consultation cannot be resolute satisfactorily or if the RF cannot address it, then the grievance will be sent directly to the next instance in the hierarchy of the project. This also applies whenever the claim submitted is directly related to the performance of the RF.
5. If the RF can solve the grievance or query, the claim or consultation will be presented to the TC. The TC, as the highest authority of the project, can act as a mediator in cases requiring it and/or convene the relevant authorities to resolve issues of greater severity. The TC will have up to 30 days to respond and propose a solution.
6. The description of this procedure, the respective contact data, and channels to direct complaints or queries is included in FMCN´s Operation Manual and will also be available on the website and other communication platforms use to inform the project´s beneficiaries, stakeholders, and affected parties (e.g. meetings of the Learning Community). The RF will permanently provide information on the GRMM once the project begins to operate, through all areas of outreach, communication, and exchange of experiences among beneficiaries, affected and interested parties.
7. If the complaint submitted is directly related to the performance of INECC or other governmental agencies, the RF shall inform the affected parties that each of these federal institutions has an internal control body where they can deliver their complaints.

Table 5.10. Procedures to follow for grievances on the project.

Complaint	Procedure to follow
1. I have a complaint related to other members of my community concerning project activities.	Address the complaint to the RF by calling to the Regional Project Coordinator (-phone number-), sending an e-mail (-mail-) or a WhatsApp (-number-), or delivering written grievance by postal mail (-address-), so the Regional Project Coordinator may support the community to solve the conflict through the traditional authorities or the proper forums for participation.
2. I have a complaint related to any of the institutions participating in the project (INECC, FMCN).	Address the complaint to the RF by calling to the Regional Project Coordinator (-phone number-), sending an e-mail (-mail-) or a WhatsApp (-number-), or delivering written grievance by postal mail (-address-).
3. I have a complaint related to the lack of coordination with other institutions in the project areas.	Call the Regional Project Coordinator (-phone number-), send an e-mail (-mail-), or deliver written grievance by postal mail (-address-).
4. I have a complaint related to the Regional Project Coordinator.	Contact the Technical Committee´s institutional representatives (e.g. INECC and FMCN) by phone (-phone number-), send an e-mail (-mail-), or deliver written grievance by postal mail (-address-).

5. I have a complaint about a public server related to project activities.	Call the Regional Project Coordinator (-phone number-) or send an e-mail (-mail-) for guidance regarding the internal control body of the institution involved.

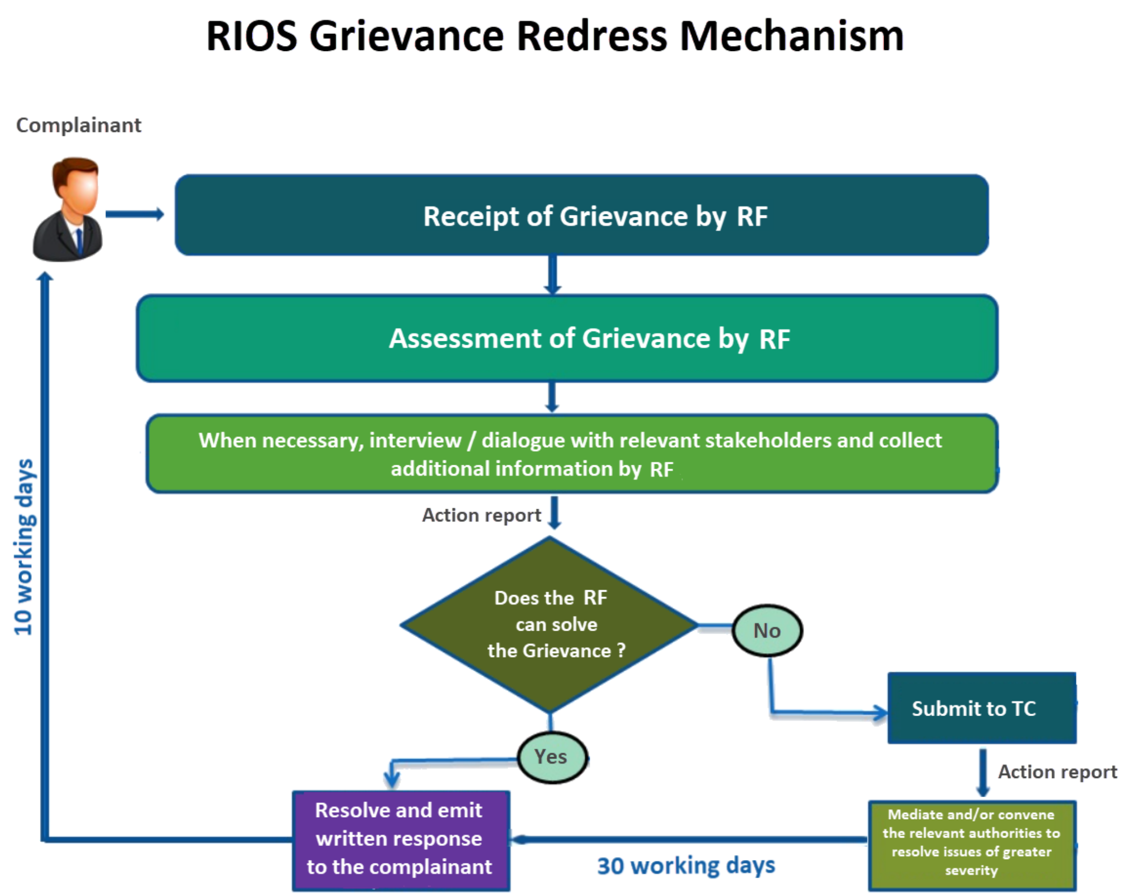

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Figure 5.7. Process of the grievance redress mechanism.

The RIOS GRM will apply throughout the project cycle; especially in those components which involve population affected or potentially affected by its activities. Furthermore, for serious or severe grievances, RIOS will rely on FMCN´s additional instruments to complement the GRM, such as:

- Environmental, Social, and Gender Safeguards

  https://www.dropbox.com/s/sgcx78zrbc4n1ux/20191119%20MOAC%202020.pdf?dl=0

- Complaint line

  https://www.fmcn.org/uploads/privacies/file/pdf/HOVb9YcpKmX5EoSYT0dgag0SSi2FeH9nqePMUnVj.pdf

- Protection Policy for Complainants

  https://www.fmcn.org/uploads/privacies/file/pdf/kCBiQKgqPPYRGosMY25JioQ2q9BXg4n3LjKVAIKy.pdf

- Policy for the Resolution of Procurement Disputes

  https://www.fmcn.org/uploads/privacies/file/pdf/bXaReWrkPJEHBfhoxvcsX547Axv7TpSsgq1Q5wFl.pdf

- Protection Policy against Sexual Exploitation, Sexual Abuse, and Sexual Harassment

  https://www.fmcn.org/uploads/privacies/file/pdf/ulAFMaxOx8HCqSSYfas8NrYVu4WgMNB9Im2qASXW.pdf

INECC INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO GREEN CLIMATE FUND FONDO MEXICANO PARA LA CONSERVACIÓN DE LA NATURALEZA, A.C. FMCN INSTITUCIÓN PRIVADA

References

Ahmed, S.A., N.D. Diffenbaugh, and T. Hertel. 2009. Climate volatility deepens poverty vulnerability in developing countries. *Environmental Research Letters*, 4(3), 034004, doi:10.1088/1748-9326/4/3/034004.

Altamirano, J.C., E. Ortiz Sánchez, J. Rissman, K. Ross, T. Fransen, C. Brown Solá, & J. Martinez. 2016. *Achieving Mexico's Climate Goals: An Eight-Point Action Plan.* Working Paper. Washington, DC: World Resources Institute. Available online at http://www.wri.org/publication/achieving-mexicos-goals

Anguiano, J. M., Aguirre, J., & Palma, J. M. 2013. Secuestro de carbono en la biomasa aérea de un sistema agrosilvopastoril de Cocos nucifera, Leucaena leucocephala Var. Cunningham y Pennisetum purpureum Cuba CT-115. *Avances en Investigación Agropecuaria*, 17(1), 149-160.

Arora, K., S.K. Mickelson, M.J. Helmers, and J.L. Baker. 2010. Review of pesticide retention processes occurring in buffer strips receiving agricultural runoff. *JAWRA* 46(3): 618–647.

Arreguín-Cortés, F.I., and C.E. Cervantes-Jaimes. 2017. Flood Risk Management in Mexico. Available from: https://www.intechopen.com/books/flood-risk-management/flood-risk-management-in-mexico#B21

Averchenkova A. & S.L. Guzmán. 2018. Mexico´s General Law on Climate Change: Key achievements ad challenges ahead. Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy. London School of Economics and Political Science. London. 30 p.

Azuara-Morales, I., López-Ortiz, S., Jarillo-Rodríguez, J., Pérez-Hernández, P., Ortega-Jiménez, E., & Castillo-Gallegos, E. 2020. Forage availability in a silvopastoral system having different densities of Leucaena leucocephala under Voisin grazing management. Agroforestry Systems. doi:10.1007/s10457-020-00487-5

Baig, S. P., Rizvi, A., Josella, M., & Palanca-Tan, R. 2016. *Cost and benefits of ecosystem based adaptation: the case of the Philippines.* IUCN, Gland, Switzerland.

Barrios, E., G.W. Sileshi, K. Shepherd, and F. Sinclair. 2012. Agroforestry and soil health: Linking trees, soil biota, and ecosystem services. In: Wall, D.H., R.D. Bardgett, V. Behan-Pelletier, J.E. Herrick, H. Jones, K. Ritz, J. Six, D.R. Strong, W.H. van der Putten. 2012*. Soil ecology and ecosystem services.* First edition. Oxford University Press. Chapter 5. pp. 315- 330.

Beck, R., McNeely, R., Thomas, M., & Bailey, C. 2007. Seasonal and Yearlong Grazing in the Northern Chihuahuan Desert. New Mexico State University.

Bentrup, G., Cernusca, I., & Gold, M. 2018. Supporting US agricultural landscapes under changing conditions with agroforestry: An annotated bibliography. Bibliographies and Literature of Agriculture 137. Washington, DC: US Department of Agriculture Forest Service. 63 p., 137.

Bentrup, G., Cernusca, I., & Gold, M. 2018. *Supporting US agricultural landscapes under changing conditions with agroforestry: An annotated bibliography.* Bibliographies and Literature of Agriculture 137. Washington, DC: US Department of Agriculture Forest Service. 63 p., 137.

Briske, D. D., Derner, J. D., Brown, J. R., Fuhlendorf, S. D., Teague, W. R., Havstad, K. M., . . . Willms, W. D. 2008. Rotational Grazing on Rangelands: Reconciliation of Perception and Experimental Evidence. Rangeland Ecology & Management, 61(1), 3-17. doi:https://doi.org/10.2111/06-159R.1

Briske, D. D., Sayre, N. F., Huntsinger, L., Fernandez-Gimenez, M., Budd, B., & Derner, J. D. 2011. Origin, Persistence, and Resolution of the Rotational Grazing Debate: Integrating Human Dimensions Into Rangeland Research. Rangeland Ecology & Management, 64(4), 325-334. doi:https://doi.org/10.2111/REM-D-10-00084.1

Brito, L., & A. Pedrozo. 2015. Inundaciones, heladas e incendios forestales. En: Cavazos, T. 2015. Conviviendo con la naturaleza. ILCSA. México. pp. 80-113.

Buechler, S., 2009: Gender,water, and climate change in Sonora, Mexico: implications for policies and programmes o

Cámara de Diputados. 2019. *Plan Nacional de Desarrollo.* Gaceta Parlamentaria Número 5266-XVIII. Año XXII. Anexo XVIII-Bis. 225 p.

Carabias, J., L. Ruiz & A. Rabasa. 2016. El marco legal de la restauración de ecosistemas forestales en México. En: Ceccon, E. & C. Martínez (Coords.). 2016. *Experiencias mexicanas en la restauración de los ecosistemas.* Universidad Nacional Autónoma de México, Centro Regional de Investigaciones Multidisciplinarias, Universidad Autónoma del Estado de Morelos y Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México. pp. 49-78.

Carabias, J., R. Landa, J. Collado y P. Martínez. 2005. *Agua, medio ambiente y sociedad: hacia la gestión integral de los recursos hídricos en México.* Universidad Nacional Autónoma de México–El Colegio de México–Fundación Gonzalo Río Arronte, México.

CBD . Global Biodiversity Outlook 4. Secretariat of the Convention on Biological Diversity; Montreal, QB, Canada: 2014

CENAPRED. 2018. *Desastres en México – Impacto social y económico*. Infografía. Centro Nacional de Prevención de Desastres. México.

Chará, J., Murgueitio, E., Zuluaga, A., & Giraldo, C. 2011. Ganadería colombiana sostenible. Mainstreaming Biodiversity in sustainable cattle ranching. Fundación CIPAV.

Chará, J., Rivera, J., Barahona, R., Murgueitio, E., Calle, Z., & Giraldo, C. 2019. Intensive silvopastoral systems with Leucaena leucocephala in Latin America. Tropical Grasslands-Forrajes Tropicales, 7(4), 259-266.

CICC. 2007. *Estrategia Nacional de Cambio Climático.* Comisión Intersecretarial de Cambio Climático. SEMARNAT. México. 161 p.

CONAFOR. 2017. *Iniciativa de Reducción de Emisiones* (IRE). http://www.conafor.gob.mx:8080/documentos/docs/51/7523Documento%20de%20la%20Iniciativa%20de%20Reducci%C3%B3n%20de%20Emisiones.pdf

CONAFOR. 2018. *Reporte Semanal de Resultados de Incendios Forestales 2018*. Del 01 de enero al 20 de septiembre de 2018. Programa Nacional de Prevención de Incendios Forestales. Centro Nacional de control de Incendios Forestales. https://www.gob.mx/cms/uploads/attachment/file/392529/Reporte_del_01_de_enero_ al_20_de_septiembre_de_2018.pdf

CONAGUA .2017. Sistema Nacional de Información del Agua. http: //sina.conagua.gob.mx/sina/index.php

CONAGUA 2010. Statistics onWater in Mexico, 2010 Edition [Ministry of Environment and Natural Resources (ed.)]. NationalWater Commission of Mexico [Comisión Nacional del Agua (CONAGUA)], Mexico City, DF, Mexico, 249 pp.

CONAGUA. 2010. *Statistics on Water in Mexico,* 2010 Edition [Ministry of Environment and Natural Resources (ed.)]. NationalWater Commission of Mexico [Comisión Nacional del Agua (CONAGUA)], Mexico City, DF, Mexico, 249 pp.

CONAGUA. 2014*. Determinación de la disponibilidad de agua en el acuífero Cotaxtla (3008),* Estado de Veracruz. Diario Oficial de la Federación. 20 de abril de 2015. Comisión Nacional del Agua.

CONAGUA. 2017. *Sistema Nacional de Información del Agua.* http: //sina.conagua.gob.mx/sina/index.php

CONAGUA. 2017. *Sistema Nacional de Información del Agua.* http: //sina.conagua.gob.mx/sina/index.php

CONAGUA. 2017. *Statistics on Water in Mexico*. Ministry of Environment and Natural Resources and National Water Commission. Mexico. 291 p.

CONAGUA. 2018. *Actualización de la disponibilidad media anual de agua en el acuífero Cotaxtla (3008),* Estado de Veracruz. Comisión Nacional del Agua.

CONAGUA. 2018. *Servicio Meteorológico Nacional, Ciclones tropicales - Información histórica*. Consultado en http://smn.cna.gob.mx/es/ciclones-tropicales/informacion-historica, 19/04/2018.

CONAPO. 2010. *Índice de Marginación por localidad 2010.* Consejo Nacional de Población. México.

CONEVAL. 2010. *Índice de Rezago Social 2010 a nivel municipal.* Consejo Nacional de Evaluación de la Política de Desarrollo Social. México.

CONEVAL. 2010. *Pobreza a nivel municipio 2010.* Consejo Nacional de Evaluación de la Política de Desarrollo Social. México.

Daigneault, A., Brown, P., & Gawith, D. 2016. Dredging versus hedging: Comparing hard infrastructure to ecosystem-based adaptation to flooding. *Ecological Economics* 122: 25–35.

DeRamus, H. A., Clement, T. C., Giampola, D. D., & Dickison, P. C. 2003. Methane emissions of beef cattle on forages: efficiency of grazing management systems. Journal of environmental quality, 32(1), 269-277.

Diaz, D. D. 2010. Engaging Western Landowners in Climate Change Mitigation: A Guide to Carbon-Oriented Forest and Range Management and Carbon Market Opportunities: DIANE Publishing.

DOF. 1917. *Constitución Política de los Estados Unidos Mexicanos*. México. 319 p.

DOF. 1992. *Ley de Aguas Nacionales.* México. 112 p.

DOF. 1994. *NOM-060-SEMARNAT-1994*. México. 10 p.

DOF. 1998. *Ley General del Equilibrio Ecológico y Protección al Ambiente*. México. 135 p.

DOF. 2000. *Ley General de Vida Silvestre.* México.72 p.

DOF. 2001. *Ley de Desarrollo Rural Sustentable*. México. 71 p.

DOF. 2003. *NOM-022-SEMARNAT-2003.* México. 22 p.

DOF. 2006. *NOM-152-SEMARNAT-2006*. México. 24 p.

DOF. 2010. *Ley Estatal de Mitigación y Adaptación ante los Efectos del Cambio Climático*. Veracruz. México. 12 p.

DOF. 2012. *Ley General de Cambio Climático*. México. 58 p.

DOF. 2015. *Ley para la Acción ante el Cambio Climático del Estado de Jalisco.* Jalisco. México. 51

DOF. 2016. *Acuerdo por el que se actualiza la disponibilidad media anual de las aguas nacionales superficiales de las 757 cuencas hidrológicas que comprenden las 37 regiones hidrológicas en que se encuentra dividido los Estados Unidos Mexicanos.* Diario Oficial de la Federación. 7 de julio de 2016.

DOF. 2016. *Ley General de Cambio Climático.* Diario Oficial de la Federación. Cámara de Diputados del H. Congreso de la Unión. México. 52 p..

DOF. 2018. *Ley General de Desarrollo Forestal Sustentable*. México. 69 p.

Domínguez, S. J. y Castillo, P. E. 2018. Las organizaciones comunitarias del agua en el estado de Veracruz. Análisis a la luz de la experiencia latinoamericana. *Estudios Demográficos u Urbanos* Vol. 33, núm. 2(98). mayo-agosto, 2018, pp 469-503.

Dugdale, S.J., I.A. Malcolm, K. Kantola, and D.M. Hannah. 2018. Stream temperature under contrasting riparian forest cover: Understanding thermal dynamics and heat exchange processes. *Science of the Total Environment* 610-611(2018): 1375-1389.

ENCC. 2013. *Estrategia Nacional de Cambio Climático. Visión 20-20-40.* Gobierno de la República. México. 62 p.

Evans, D.M., C.E. Zipper, J.A. Burger, B.D. Strahm, and A.M. Villamagna. 2013. Reforestation practice for enhancement of ecosystem services on a compacted surface mine: Path toward ecosystem recovery. *Ecological Engineering* 51: 16-23.

Fernandez, M.R., P. Segurado, E. Jauch, and M.T. Ferreira. 2016. Riparian responses to extreme climate and land-use change scenarios. *Science of the Total Environment* 569-570(2016):145-158.

FIRA. 2016. Paquetes tecnológicos ganadería. Retrieved from Mexico:

FONCET. 2020. Diagnóstico ambiental y socioeconómico para la implementación de procesos de ganadería regenerativa en Chiapas. FMCN, Mexico.

Fondo Golfo de México A.C. 2020. Diagnóstico ambiental y socioeconómico para la implementación de procesos de ganadería regenerativa en Veracruz. FMCN.

FONNOR. 2020. Diagnóstico ambiental y socioeconómico para la implementación de procesos de ganadería regenerativa en Jalisco. FMCN.

Fuentes, T. y Paré, L. 2012. El Comité de cuenca del río Pixquiac: ensayos para crear una plataforma social de cogestión y su instrumento de financiamiento. En: *Al filo del agua: cogestión de la subcuenca del río Pixquiac, Veracruz*. México. pp 191-218.

Garbach, K., J.C. Milder, M. Montenegro, D.S. Karp, and F.A.J. DeClerck. 2014. Biodiversity and ecosystem services in agroecosystems. *Encyclopedia of Agriculture and Food Systems*. Volume 2. Academic Press Oxford. pp. 21-40.

García-González, M. L., Carvajal-Escobar Y. y Jiménez-Escobar, H. 2007. La gestión integrada de los recursos hídricos como estrategia de adaptación al cambio climático. *Ingeniería y Competitividad*. Volumen 9(1): 19-29

Garner, G., I.A. Malcolm, J.P. Sadler, and D.M. Hannah. 2017. The role of riparian vegetation density, channel orientation and water velocity in determining river temperature dynamics. J*ournal of Hydrology* 553(2017): 471-485.

Garnett, T. 2009. Livestock-related greenhouse gas emissions: impacts and options for policy makers. Environmental Science & Policy, 12(4), 491-503. doi:https://doi.org/10.1016/j.envsci.2009.01.006

Gerritsen, P., & van der Ploeg, J. D. 2006. Dinámica espacial y temporal de la ganadería extensiva: estudio de caso de la Sierra de Manantlán en la costa sur de Jalisco. Relaciones. Estudios de historia y sociedad, 27(108), 165-191.

GOM. 2014*. Intended Nationally Determined Contribution- Mexico*. Government of Mexico. Mexico. 21 p.

GOM. 2015. *Intended Nationally Determined Contribution*. Government of Mexico. Mexico. 20 p.

Guhathakurta, P., & Saji, E. 2013. Detecting changes in rainfall pattern and seasonality index vis-à-vis increasing water scarcity in Maharashtra. Journal of Earth System Science, 122(3), 639–649. https://doi.org/10.1007/s12040-013-0294-y

H. Ayuntamiento Constitucional de Puerto Vallarta. 2020. *Programa Municipal de Cambio Climático de Puerto Vallarta, Jalisco 2020-2030.* Gaceta Municipal de Puerto Vallarta Número 12. Año 2. 104 p.

Hawkins, H.-J. 2017. A global assessment of Holistic Planned Grazing™ compared with season-long, continuous grazing: meta-analysis findings. African journal of range & forage science, 34(2), 65-75.

Herbel, C. H. 1982. Grazing management on rangelands. Journal of Soil and Water Conservation, 37(2), 77-79.

Hernandez Trujillo, J. A. 2013. Acompañamiento en la ejecución del proyecto "incrementar la productividad de las fincas ganaderas mediante la implementación de procesos de producción modernos, rentables, socialmente justos y ambientalmente sostenibles" en las veredas poblazon y samanga del municipio de popayán.

Hernández, A., B. Domínguez, P. Cervantes, S. Muñoz-Melgarejo, S. Salazar-Lizán, and A.Tejeda-Martínez, 2011. Temperature-humidity index (THI) 1917-2008 and future scenarios of livestock comfort in Veracruz, México. *Atmósfera,* 24(1), 89-102.

Hernández, A., B. Domínguez, P. Cervantes, S. Muñoz-Melgarejo, S. Salazar-Lizán, and A.Tejeda-Martínez, 2011:Temperature-humidity index (THI) 1917-2008 and future scenarios of livestock comfort in Veracruz, México. Atmósfera, 24(1), 89-102.

Hoffmann, I. 2014. Ecosystem services provided by livestock species and breeds, with special consideration to the contributions of small-scale livestock keepers and pastoralists. Background Study Paper No. 66. Food and Agriculture Organization of the United Nations. 158 p.

Hudson, P.F., D.A. Hendrickson, A.C. Benke, A. Varela-Romero, R. Rodiles-Hernández, W. Minckley. 2005 Rivers of Mexico. In: BENKE, A.C. and C.E. Cushing (Eds.). 2005. *Rivers of North America*. Academic Press. pp.1030-1084.

Iacob, O., Rowan, J. S., Brown, I., & Ellis, C. 2014. Evaluating wider benefits of natural flood management strategies: an ecosystem-based adaptation perspective. *Hydrology Research* 45(6): 774–787.

IIED. 2019. Assessing climate adaptation in Mexico. International Institute for Environment and Development. In: https://www.iied.org/assessing-climate-adaptation-mexico

INECC-FGM, 2018. *Plan de Acción de Manejo Integrado de Cuencas Hídricas del Río Jamapa.* Proyecto: Conservación de Cuencas Costeras en el Contexto de Cambio Climático. 151 pp.

INECC, 2018b. Actualización de la información del sistema de consulta de las cuencas hidrográficas de México. Instituto Nacional de Ecología y Cambio Climático.

INECC,. 2019b. Atlas nacional de vulnerabilidad al cambio climático (D. I. Terrazas González, A. Vermonden, R. T. Montes Rojas, Y. S. Nava Assad, F. López Díaz, F. Gress Carrasco, M. Rojas Barajas, M. A. Linares Munguía, J. Machorro Reyes, & C. Enríquez Guadarrama (Eds.); Primera ed). Instituto Nacional de Ecología y Cambio Climático. https://atlasvulnerabilidad.inecc.gob.mx/page/fichas/ANVCC_LibroDigital.pdf

INEGI. 2007. *Censo Ejidal 2007*. Instituto Nacional de Estadística, Geografía e Informática. México.

INEGI. 2010. *Censo de Población y Vivienda 2010.* Instituto Nacional de Estadística, Geografía e Informática. México.

INEGI. 2014. *Uso de suelo y vegetación de México. Serie VI. 2014-2017.* Escala 1:250 000. Instituto Nacional de Estadística, Geografía e Informática. México.

INIFAP. 2012. Establecimiento y manejo de praderas inducidas con gramíneas perennes. In A. y. P. Instituto Nacional de Investigaciones Forestales (Ed.).

IPCC. 2014. Climate Change 2014: Impacts, adaptations and Vulnerability, Summary for Policymakers. http://ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgll_spm_en.pdf

Jones, G. 2008. *Social and economic value of riparian environments*. In: Finch, Deborah M. Rocky Mountain Riparian Digest. Rocky Mountain Riparian Digest. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 3-4.

Jones, G. 2008. Social and economic value of riparian environments. In: Finch, Deborah M. Rocky Mountain Riparian Digest. Rocky Mountain Riparian Digest. Fort

Jose. S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforest Syst* 76: 1-10.

Kirshen P, Ruth M, Anderson W. 2008. Interdependencies of urban climate change impacts and adaptation strategies: a case study of Metropolitan Boston USA. *Climate Change* 86:105–122

Kuhling, I., and D. Trauts. 2013. The role of organic farming in providing ecosystem services. *International Journal of Environmental and Rural Development* (2013) 4-1.

Lago, M. 2014. *Inventory of river restoration measures: effects, costs and benefits* (FP7 REFORM).

Lago, Manuel. 2014. Inventory of river restoration measures: effects, costs and benefits (FP7 REFORM).

Liu, Y., BA. Engel, D.C. Flanagan, M.W. Gitaua, S.K. McMillan, and I. Chaubey. 2017. A review on effectiveness of best management practices in improving hydrology and water quality: Needs and opportunities. *Science of the Total Environment* 601-602(2017): 580-593.

Maldonado, G. A. L., González, G. E. J. y Cruz, S. G. E. 2017. Una aproximación a la representación del cambio climático en habitantes de dos cuencas del estado de Veracruz, México. *Revista Pueblos y Fronteras digital* 12(23). Pp 149-174

Martínez-Austria, P y Patiño-Gómez, C. 2012. Efectos del cambio climático en la disponibilidad de agua en México. *Tecnología y Ciencias del Agua,* vol. III, núm. 1, enero-marzo de 2012, pp. 5-20.

Martínez, A. 2019. *Ecosystems of Banderas Bay vs Climate Change.* Vallarta Tribune. Available from: https://vallartatribune.com/ecosystems-of-banderas-bay-vs-climate-change/

Mathur, V.N., A.D.F. Price &S. Austin. 2008. Conceptualizing stakeholder engagement in the context of sustainability and its assessment. *Construction Management and Economics* 26(6): 601-609.

McKergow, L. A., Weaver, D. M., Prosser, I. P., Grayson, R. B., & Reed, A. E. 2003. Before and after riparian management: sediment and nutrient exports from a small agricultural catchment, Western Australia. *Journal of Hydrology*, 270(3-4), 253-272.

McKergow, L. A., Weaver, D. M., Prosser, I. P., Grayson, R. B., & Reed, A. E. 2003. Before and after riparian management: sediment and nutrient exports from a small agricultural catchment, Western Australia. Journal of Hydrology, 270(3-4), 253-272.

Mekonnen, M. 2016. Ecological benefits of trees as windbreaks and shelterbelts. *International Journal of Ecosystem* 6(1): 10-13.

Meli, P., L. Ruiz, R. Aguilar, A. Rabasa, J.M. Rey-Benayas & J. Carabias. 2017. Bosques ribereños del trópico húmedo de México: un caso de estudio y aspectos críticos para una restauración exitosa. *Maderas y Bosques* 23(1): 181-193.

Michel, S., & Graizbord, C. 2002. *Los rios urbanos de Tecate y Tijuana: estrategias para ciudades sustentables.* San Diego: Institute for Regional Studies of the Californias, San Diego State University.

Michel, S., & Graizbord, C. 2002. Los RIOS urbanos de Tecate y Tijuana: estrategias para ciudades sustentables. San Diego: Institute for Regional Studies of the Californias, San Diego State University.

Morales-Nieto, C. R. 2018. Sistemas de pastoreo, origen y desarollo. Mexico: Universidad Autónoma de Chihuahua.

Moreno-Casasola, P., Aguirre F. L., Campos, A., Carral. M. C., Cejudo, E. Gonzalez, M., Hernandez, M. E., Mata, D., Lazos R. A., López, R. Hugo., Neri F. I., Pelaez L. A., Medina, K., Sánchez-Higueredo, L., Sánchez-García, E., Sánchez-Luna, O., Vázquez-González, C., Benavides, J. 2019. Humedales costeros de agua dulce y bases para su gobernanza. En: *Gobernanza y manejo de las costas y mares ante la incertidumbre. Una guía para la toma de decisiones*. Pp 427.

Muñoz-González, J. C., Huerta-Bravo, M., Lara Bueno, A., Rangel Santos, R., & Arana, R. 2016. Producción de materia seca de forrajes en condiciones de Trópico Húmedo en México. Revista mexicana de ciencias agrícolas, 7(SPE16), 3329-3341.

Murgueitio, E., Chará, J., Barahona, R., Cuartas, C., & Naranjo, J. 2014. Los sistemas silvopastoriles intensivos (ISPS), herramienta de mitigación y adaptación al cambio climático. Tropical and subtropical agroecosystems, 17(3), 501-507.

Neri-Flores, I., Moreno-Casasola, P. Peralta-Peláez, L.A. and Monroy, R. 2019. Groundwater and River Flooding: The Importance of Wetlands in Coastal Zones. *Journal of Coastal Research*, 92(sp1): 44-54.

Norman, L.M. 2020. Ecosystem services of riparian restoration: A review of rock detention structures in the Madrean Archipielago Ecoregion. *Air, Soil and Water Research* 12: 1-13.

Ortega, M., C. Carmona & A. Lorea. 2018. *Spinning the web: The cobenefits approach to an integrated implemetation of the 2030 Agenda and the Paris Agreement in Mexico*. Executive Summary. GIZ. 58 p.

Ortiz, L. J. A. 2013. *Modificación en la provisión de los servicios ambientales por efecto del cambio climático en la heterogeneidad ambiental en la Cuenca del Río Jamapa, Veracruz, México.* Tesis de Maestría. Instituto de Ciencias Marinas y Pesquerías. Maestría en Ecología y Pesquerías. Universidad Veracruzana. 152 pag.

Palmer, M. A., Lettenmaier, D. P., Poff, N. L., Postel, S. L., Richter, B., & Warner, R. 2009. Climate change and river ecosystems: protection and adaptation options. *Environmental management*, 44(6), 1053-1068.Parker, H., & Oates, N. 2016. *How do healthy rivers benefit society. A Review of the Evidence*. London: ODI and WWF. http://er.uwpress.org/content/27/3/330.full.pdf+html

Palmer, M. A., Lettenmaier, D. P., Poff, N. L., Postel, S. L., Richter, B., & Warner, R. 2009. Climate change and river ecosystems: protection and adaptation options. Environmental management, 44(6), 1053-1068.

Parker, H., & Oates, N. 2016. How do healthy rivers benefit society. A Review of the Evidence. London: ODI and WWF.

Pedroli, B., G. De Blust, K. Van Looy y S. Van Rooij, 200. Setting targets in strategies for river restoration. *Landscape* Ecology 17(1): 5-18.

Pezo, D., Ney RIOS, M. I., & Gómez, M. 2018. Silvopastoral Systems for Intensifying Cattle Production and Enhancing Forest Cover: The Case of Costa Rica.

Pronatura Noreste 2020. Diagnóstico ambiental y socioeconómico para la implementación de procesos de ganadería regenerativa en Chihuahua. FMCN.

Red Temática de Sistemas Agroforestales de México and SEMARNAT. 2019. *Experiencias de agroforestería en México*. SEMARNAT. Mexico.

Riis, T., M. Kelly-Quinn, F.C. Aguiar, P. Manolaki, D. Bruno, M.D. Bejarano, N. Clerici, M.R. Fernandes, J.C. Franco, N. Pettit, A.P. Portela, O. Tammeorg, P. Tammeorg, PM. Rodríguez-González, and S. Dufour. 2020. Global overview of ecosystem services provided by riparian vegetation. *BioScience* 70(6): 501-514.

Romero-Lankao, P., J.B. Smith, D.J. Davidson, N.S. Diffenbaugh, P.L. Kinney, P. Kirshen, P. Kovacs, and L. Villers Ruiz. 2014. North America. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1439-1498.

Romero, C. J.A. Delgado, J. Téllez and F.M. Carrillo. 2013. Análisis socioeconómico de la Cuenca del Rio Cuale, Jalisco, México: Una contribución para la Declaración del Área Natural Protegida Reserva de la Biosfera El Cuale. *Observatorio Iberoamericano del Desarrollo Local y la Economía Social* Número 14 Año 7.

SADER. (2019a). Bovino carne y leche, población ganadera 2009-2018, cabezas. from Servicio de Información Agroalimentaria y Pesquera (SIAP) https://www.gob.mx/cms/uploads/attachment/file/516353/Inventario_2018_Bovinos.pdf

SADER. 2019b. Cierre pecuario. from Servicio de Información Agroalimentaria y Pesquera (SIAP) https://nube.siap.gob.mx/cierre_pecuario/

Sarukhán, J., J. Carabias, P. Koleff, T. Urquiza-Haas. 2012. *Capital natural de México: Acciones estratégicas para su valoración, preservación y recuperación*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México.

Seavy, N, T. Gardali, G. Golet, F. Griggs, C. Howell, R. Kelsey, S. Small-Lorenz, J. Viers, J. Weigand. 2009. Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research. *Ecological Restoration* 27 (3): 330-338.

SEGOB, S. de G. (2020). Fideicomiso Fondo de Desastres Naturales (FONDEN). 1999-2020. https://www.gob.mx/segob/documentos/fideicomiso-fondo-de-desastres-naturales-fonden

SEMARNAT-INECC. 2011. *Fourth National Communication of Mexico to the United Nations Framework Convention on Climate Change*. Ministry of Environment and Natural Resources (SEMARNAT) and National Institute of Ecology and Climate Change (INECC). Mexico. 262 p.

SEMARNAT-INECC. 2016. *Mexico´s Climate Change Mid-Century Strategy*. Ministry of Environment and Natural Resources (SEMARNAT) and National Institute of Ecology and Climate Change (INECC). Mexico. 106 p.

SEMARNAT-INECC. 2018. *Sexta Comunicación Nacional y Segundo Reporte Bienal de Actualización ante la Convención Marco de las Naciones Unidas sobre Cambio Climático.* SEMARNAT, INECC, GEF, PNUD. México. 736 p.

SEMARNAT, 2014. *Special Program on Climate Change.* In: https://www.gob.mx/cms/uploads/attachment/file/166842/mexico_mcs_final_cop22nov16_red.pdf

SEMARNAT, 2014. *Special Program on Climate Change.* In: https://www.gob.mx/cms/uploads/attachment/file/166842/mexico_mcs_final_cop22nov16_red.pdf

SEMARNAT; 2020. Manifestación de impacto ambiental del proyecto CCC Dos Bocas II (descargado en: http://apps1.semarnat.gob.mx/dgiraDocs/documentos/ver/estudios/2020/30VE2020E0024.pdf).

SEMARNAT. (2018). Informe de la Situación del Medio Ambiente 2018, Compendio de Estadísticas Ambientales, Indicadores Clave, de Desempeño Ambiental y de Crecimiento Verde. Mexico Retrieved from https://apps1.semarnat.gob.mx:8443/dgeia/informe18/index.html

SEMARNAT. (2018). Informe de la Situación del Medio Ambiente 2018, Compendio de Estadísticas Ambientales, Indicadores Clave, de Desempeño Ambiental y de Crecimiento Verde. Mexico Retrieved from https://apps1.semarnat.gob.mx:8443/dgeia/informe18/index.html

SEMARNAT/INECC. (2018). México, Sexta Comunicación Nacional y Segundo Informe Bienal de Actualización ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático. Mexico: SEMARNAT Retrieved from http://cambioclimatico.gob.mx:8080/xmlui/handle/publicaciones/117

Shields F.D., C.M. Cooper Jr., Scott S. Knight, M.T. Moore. 2003. Stream corridor restoration research: A long and winding road. *Ecological Engineering* 20: 441–454.

Solorio, S. F. J., Wright, J., Franco, M. J. A., Basu, S. K., Sarabia, S. L., Ramírez, L., . . . Ku, V. J. C. (2017). Silvopastoral systems: Best agroecological practice for resilient production systems under dryland and drought conditions. In Quantification of Climate Variability, Adaptation and Mitigation for Agricultural Sustainability (pp. 233-250): Springer.

Soto Montes De Oca, G., A. Ramirez Fuentes. 2017. *The economic benefits of the Atoyac basin' s restoration in Puebla, Mexico*.

Soto, V.H. y Delgado, H. 2020. Dos años de observaciones de temperatura superficial del aire y del suelo en la vertiente norte del volcán Pico de Orizaba, México. *Acta Universitaria* 30. E2427 doi. http://doi.org/10.15174.au.2020.2427

Soto. V.H. 2014. *Glaciar del norte del Citlaltépetl y su relevancia hidrológica para las localidades de la parte alta de la Cuenca Jamapa-Cotaxtla.* Tesis de Maestría. Facultad de Ciencias Biológicas y Agropecuarias. Universidad Veracruzana, 109 pag.

Temática de Sistemas Agroforestales de México and SEMARNAT, (2019). Experiencias de agroforestería en México.SEMARNAT. Mexico.

Tovar, R., F.R. Vázquez, and S.A. Vázquez. 2015. Impactos y adaptación al cambio climático en el Puerto de Veracruz. *RUMBOS TS*, año X, número 12, pp. 119-129.

Tubiello, F. N., Cóndor-Golec, R. D., Salvatore, M., Piersante, A., Federici, S., Ferrara, A., . . . Biancalani, R. (2015). Estimación de emisiones de gases de efecto invernadero en la agricultura. Un manual para abordar los requisitos de los datos para los países en desarrollo. Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO), Roma.

Undersander, D. J., Albert, B., Cosgrove, D., Johnson, D., & Peterson, P. 2002. Pastures for profit: A guide to rotational grazing: Cooperative Extensiton Publications, University of Wisconsin-Extension.

UNEP. 2007. *Dams and Development of Relevant Practices for Improved Decision Making*. Nairobi, Kenya: United Nations Environment Programme

USFS. 2000. *Forest Service Manual, Title 2500, Watershed and Air Management. Section 2526.06.* USDA Forest Service. Washington, DC.

Van Vliet, M.T.H., W.H.P. Frassen, J.R. Yeatsley, F. Ludwig, I. Haddeland, D.P. Lettenmaier, and P. Kabat. 2013. Global river discharge and water temperature under climate change. *Global Environmental Change* 23(2): 450-464.

Villanueva Najarro, C., Casasola Coto, F., & Detlefsen Rivera, G. 2018. Potencial de los sistemas silvopastoriles en la mitigación al cambio climático y en la generación de múltiples beneficios en fincas ganaderas de Costa Rica (9977576823). Retrieved from

Welsh, R. C.M., Ochoa C.A. y Morales, M.A. 2010*. Estudio de los posibles impactos del cambio climático en zonas cercanas al volcán Citlaltépetl*. Fernández García, Felipe; Galán Gallego, Encarna; Cañana Torrecilla, Rosa (eds.). Barcelona: Serbal, 2010, p 485-496.

World Bank. (2017). Guidance note on shadow price of carbon in economic analysis. In.

Zamora Saenz, I., Mazari Hiriart, M., & Almeida Leñero, L. 2017. Sistema de indicadores para la recuperación de RIOS urbanos. El caso del río Magdalena, Ciudad de México. *Acta universitaria,* 27(6), 53-65.

Zerecero-Salazar, B. C., Ibarrarán-Viniegra, M. E., Gómez, G. A., Hernández-De la Rosa, P. González-Guillén, M., Escalona-Maurice, M. J., Sardiñas, G. O., Rivera, C. y Toruño, P. 2015. Modelo de indicadores de vulnerabilidad al cambio climático y su representación espacial en la región Centro-Golfo de México. *Revista Iberoamericana de Bioeconomía y Cambio Climático*. Vol. 1. pag. 149-184.