ANNEX 2 FEASIBILITY STUDY
COMMUNITY-BASED AGRICULTURE SUPPORT PROGRAMME 'PLUS'

CHAPTER I: CLIMATE CHANGE IMPACTS AND CLIMATE VULNERABILITY ANALYSIS[1]

The thorough climate and environmental analysis in Tajikistan is presented in this document and in the EO4SD's Atlas (CASP+ Annex 16 and Annex 16a). This document presents the main historical climatic and environmental analysis, the projected climate scenarios, the future climate change's impacts on natural and agricultural systems and the potential actions to respond to them in the framework of CASP+. In addition, the document presents the geographic vulnerability analysis based on the previous mentioned findings.

[1] This document is an appendix to CASP+' SECAP - Social Environment and Climate Assessment (required Annex of the Project Design Report for IFAD financing) and included here to provide a full set of information in the Feasibility Study for GCF financing.

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Chapter 1: climate change impacts and climate vulnerability analysis[2]

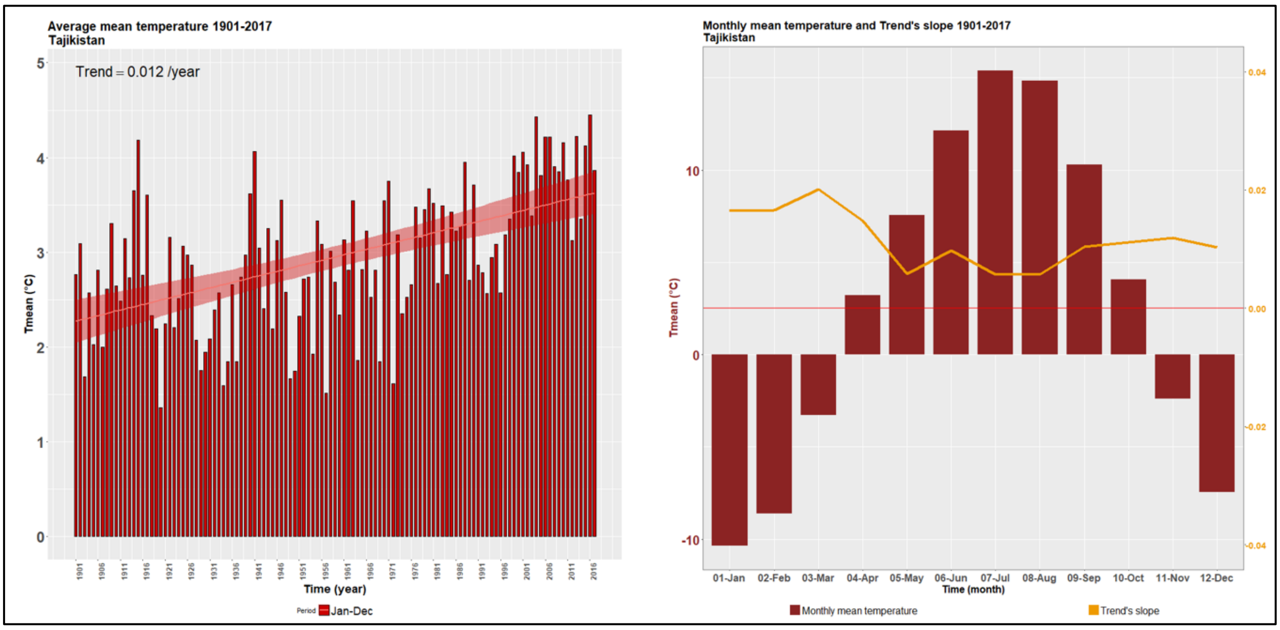
I. Historical and current climate

1. Tajikistan's climate is classified as continental, but its vast mountainous terrain means there are wide climatic variations; ridges and elevation changes affect the range of temperature, humidity, and precipitation. Aridity, high temperatures and significant inter-annual variability of almost all climatic elements are predominant characteristics of Tajikistan's climate[3].

A. Temperature

2. The country has experienced a considerable warming of its climate over the past half century. Our temperature analysis uses data from the Climatic Research Unit – University of East Anglia (CRU) at national level covering the 1901-2017 period (Figure 1). It shows that the mean temperature rose at an average rate of 0.12 ºC per decade for the full period and, for the period 1970-2017, the positive trend was even higher with an increase of 0.28 ºC per decade compared to 0.01 ºC per decade for the period 1901-1969. The monthly mean temperature positive rise trend is higher during winter months with an impact on glacier and snow extent during that period as presented in Figure 9.

Figure 1 - Average mean temperature in Tajikistan for the period 1901-2017
Source: Climatic Research Unit – University of East Anglia (CRU)



3. A similar trend is observed at regional levels with remote sensing data as presented in the Annex 16 pp. 94-106. Indeed, all regions experienced an increase in temperature varying from 0.3 to up to 1.8 degrees, for both the climate reference period (1986-2005) and the current decade (2010-2019). The highest increase in temperature is seen in South Khatlon.

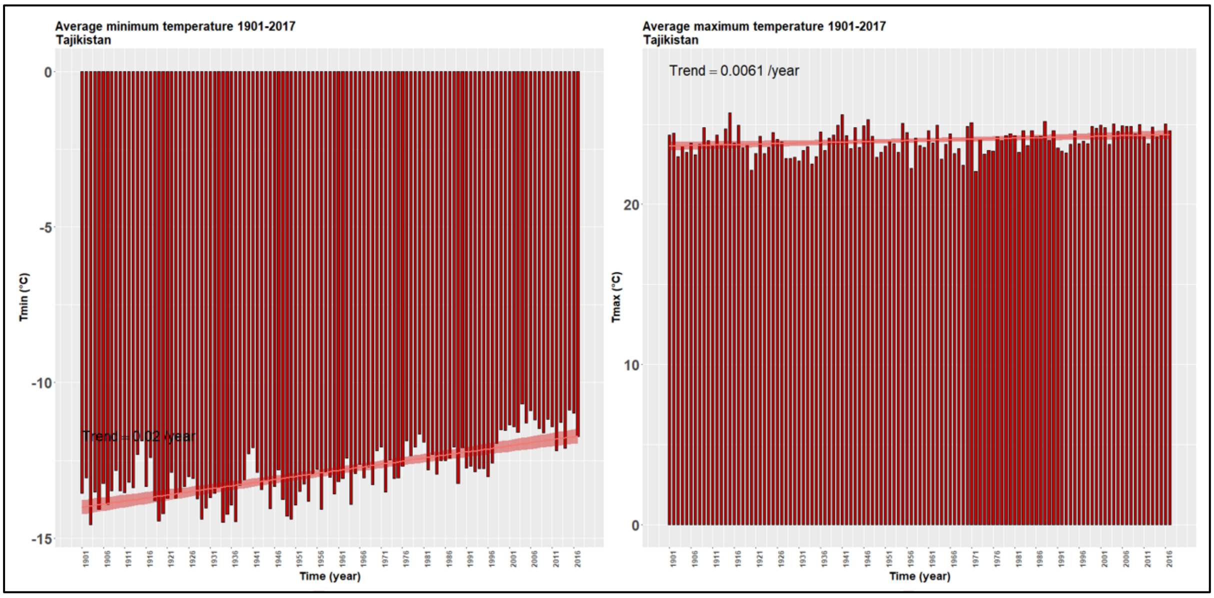
4. Higher changes are observed for the annual minimum temperature at an average rate of 0.2 ºC per decade for the period 1901-2017. Similarly, daily minimum temperatures are increasing at district levels as presented in Annex 16 pp. 120-132, with higher increases for the June to September period compared to the rest of the year; the trend increases even more since 2015.

[2] This document is an appendix to CASP+' SECAP - Social Environment and Climate Assessment in the IFAD PDR but is included here due to the GCF format and structure which indicates that it is more appropriate to include it in the Feasibility Study.
[3] The Government of the Republic of Tajikistan. Second National Communication of the Republic of Tajikistan under the United Nations Framework Convention on Climate Change. 2008.

Most of the country experiences a minimum temperature rise of up to 6 degrees difference between the average daily minimum temperatures for the climate reference period (1986-2005) and the current decade (2010-2019) except for localized areas in Eastern Khatlon, Districts of Republican Subordination (DRS), Sughd and Gorno-Badakhshan Autonomous Region (GBAO) and Eastern Sughd.

5. The annual number of frost days declined for the period 1986-2019 for all regions as presented in the Annex 16 pp. 86-93. The comparison between the reference period (1986-2005) and the current decade (2010-2019) presents East Khatlon, West DRS and South Sughd as the most affected areas in the country.

Figure 2 - Average minimum and maximum temperature in Tajikistan for the period 1901-2017.
Source: Climatic Research Unit – University of East Anglia (CRU)



6. Changes are observed for the annual maximum temperature at an average rate of 0.06 ºC per decade for the period 1901-2017 (Figure 2). Daily maximum temperatures are increasing at district level as presented in the Annex 16 pp. 107-119, but with differences in sub-regional areas. Northern GBAO and Eastern DRS experienced lower daily maximum temperature (i.e. 4°C decrease) for the current decade (2010-2019) compared to the climate reference period (1986-2005). For the same comparison, Central and Eastern Khatlon, and Western DRS and Sughd experienced an increase up to 3°C in several areas.

7. These trends and averages at national level do reflect the trends and averages found when analysing available weather stations' data. The analysis focused on 9 weather stations (see Figure 3 below) out of 51 available. The selection of the weather stations was done in order to cover the different agro-ecological zones in the country and use the more complete set of data in time.

Figure 3 - Location of the local weather stations used for the analysis of CASP+ design in Tajikistan
Source: NASA SRTM & http://www.pogodaiklimat.ru/history.php?id=tj

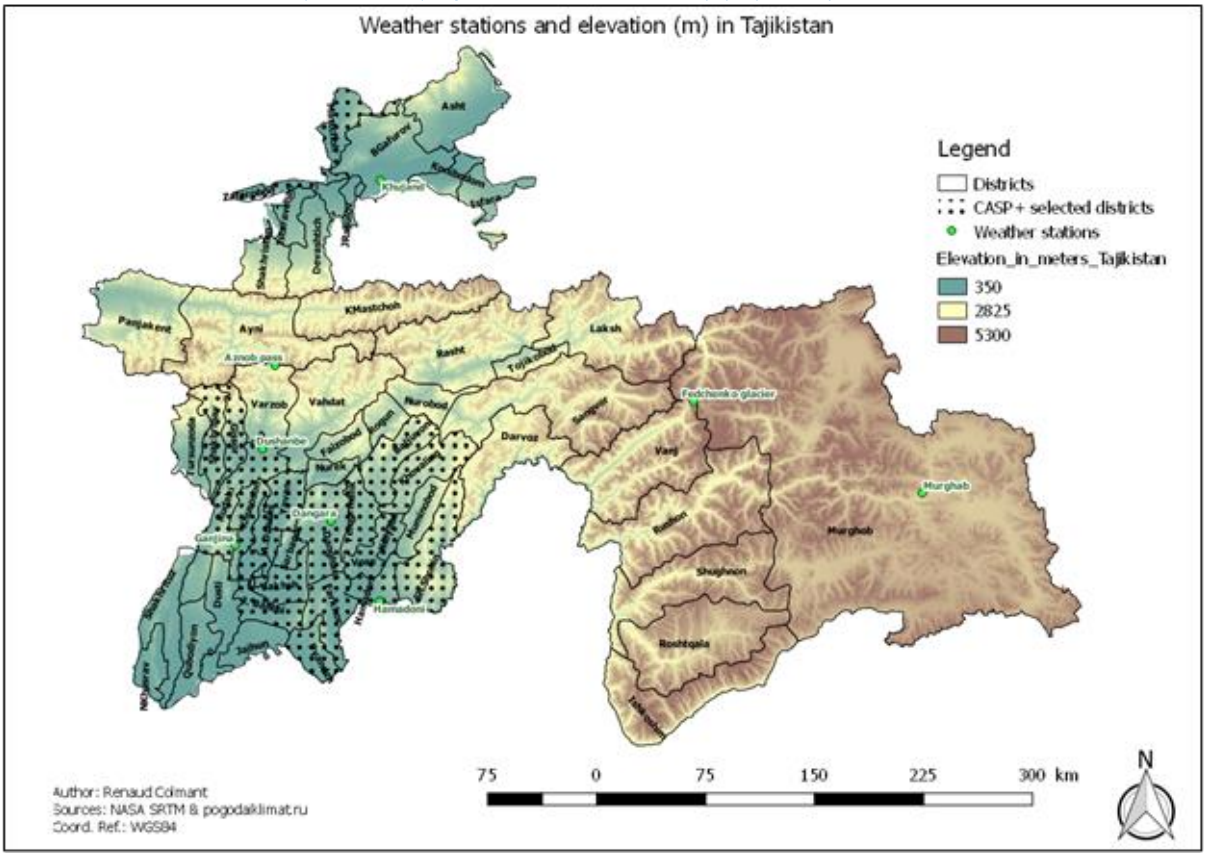
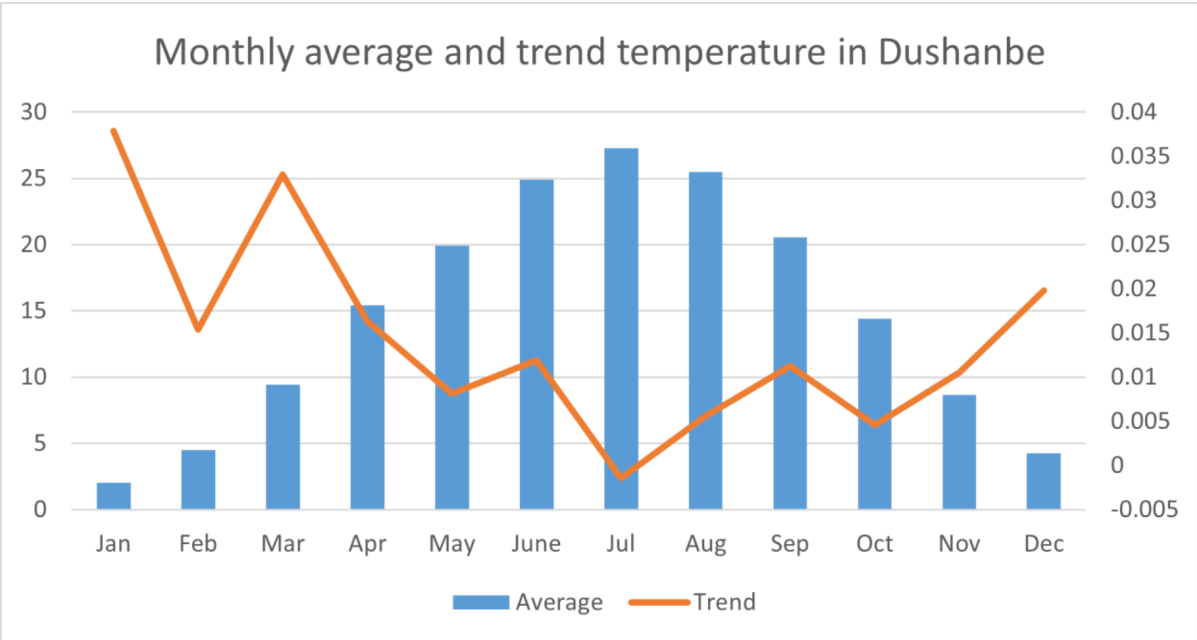


Figure 4 - Montly average and trend in Dushanbe weather station (lat: 38.55; long: 68.78)
Source: http://www.pogodaiklimat.ru/history.php?id=tj

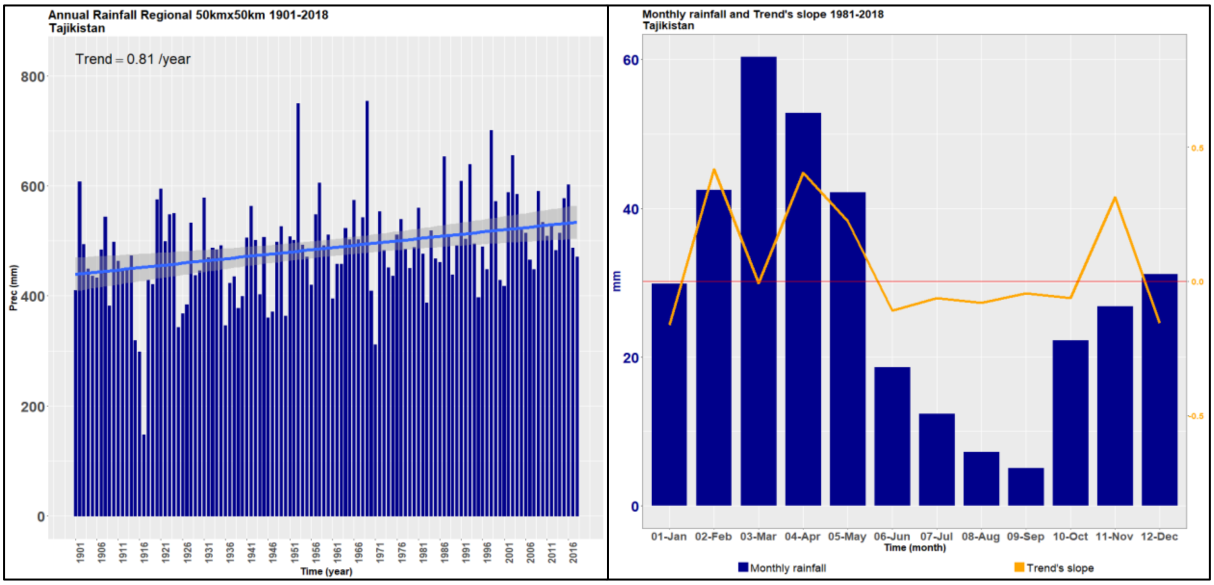


B. Precipitation

8. Precipitation is not evenly distributed geographically in the country (Figure 6). Indeed, the Central and North-West areas of the country receive an average of 700-900 mm per year compared to the Northern Sughd Region, Eastern GBAO Region and Southern Khatlon Region which receive around 100-300 mm per year for the 1981-2018 period. At national level, annual precipitation rose significantly by 15-20% during the 1901-2018 period. The increase in precipitation is concentrated during the February-May season as shown in Figure 5; the June-October season experienced a significant decrease of 4 mm/decade for the period 1981-2018.

Figure 5 - Annual precipitation (1901-2018) (left) and Monthly rainfall and trend (1981-2018) (right) in Tajikistan.

Source : Climatic Research Unit – University of East Anglia (CRU) and Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), respectively.



9. It is observed that significant increases in precipitation occurred in the western part of Tajikistan during the November-May season (1981-2018) and, apart from isolated spots, significant decrease across the whole country occurred during the June-October season (see Figure 5).

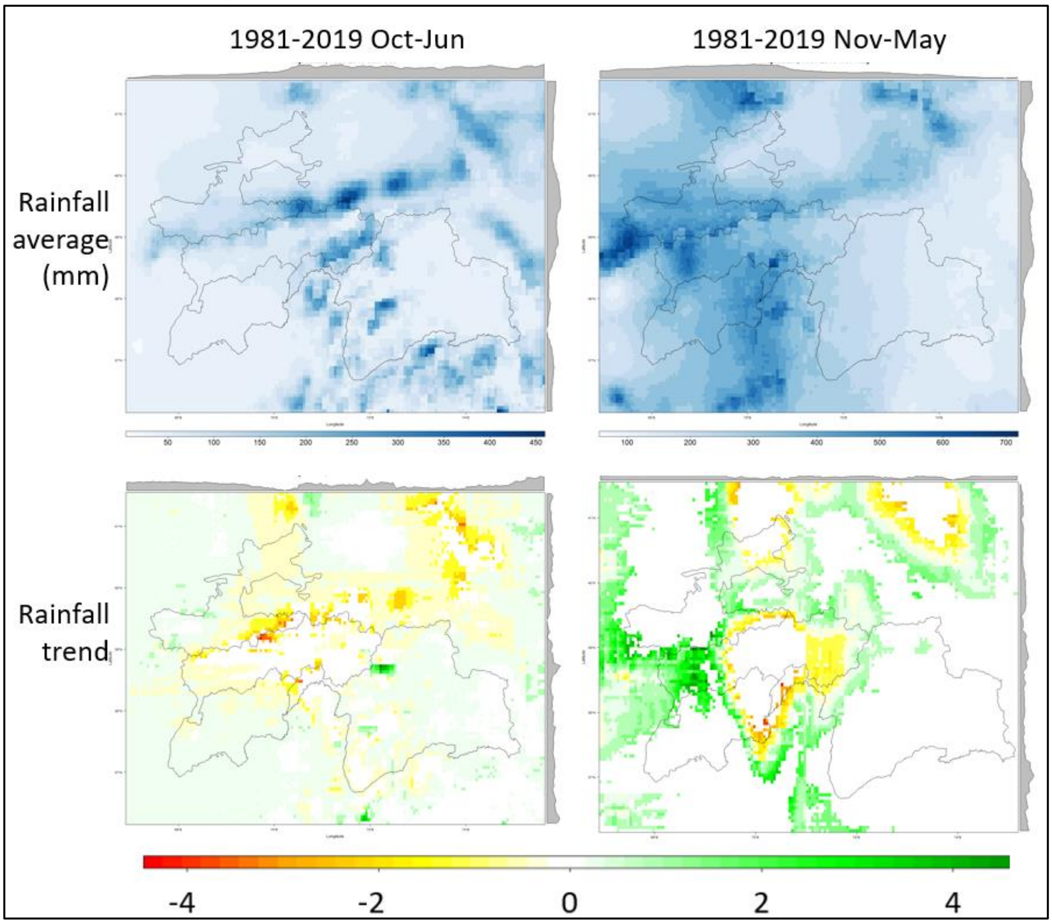
10. The analysis of the 1-day maximum rainfall since 1986 does not show significant change at district level as presented in Annex 16 pp. 61-73. A small decrease up to -4.2 mm in average 1-day maximum rainfall for the current decade (2010-2019) versus the climate reference period (1986-2005) is observed in Central DRS and Northern Khatlon while an increase up to 0.8mm is apparent in Eastern GBOA.

11. Divergent trends in accumulated 5-day rainfall have been observed across Tajikistan, ranging from a decrease of -51 mm to an increase of 31 mm (Annex 16 pp. 74-86). Around one third of the country has experienced an increase in accumulated precipitation, notably in Southern Khatlon and Central and Eastern GBAO, with the largest increase along the East-West belt in Southern Sughd region (+15 to +31 mm). Overall, this increase is generally more moderate than the decrease in accumulated rainfall observed in the wettest areas. A decrease of -20 to -51 mm has been observed across almost all the DRS, as well as in Western GBAO and Central and Northern Khatlon.

12. A conclusion can be drawn from the precipitation analysis. There is a clear shift in the precipitation pattern and an increase in precipitation intensity, with less precipitation during summer months and more precipitation in certain areas of the country during the winter rainy months. This shift has a major impact on water availability, deepening the gap between the end

of the rainy season in May and the beginning of it in November-December. This gap is increasing the vulnerability of the ecosystem to drought.

Figure 6 - Seasonal rainfall average and trend (1981-2018) in Tajikistan.
Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)



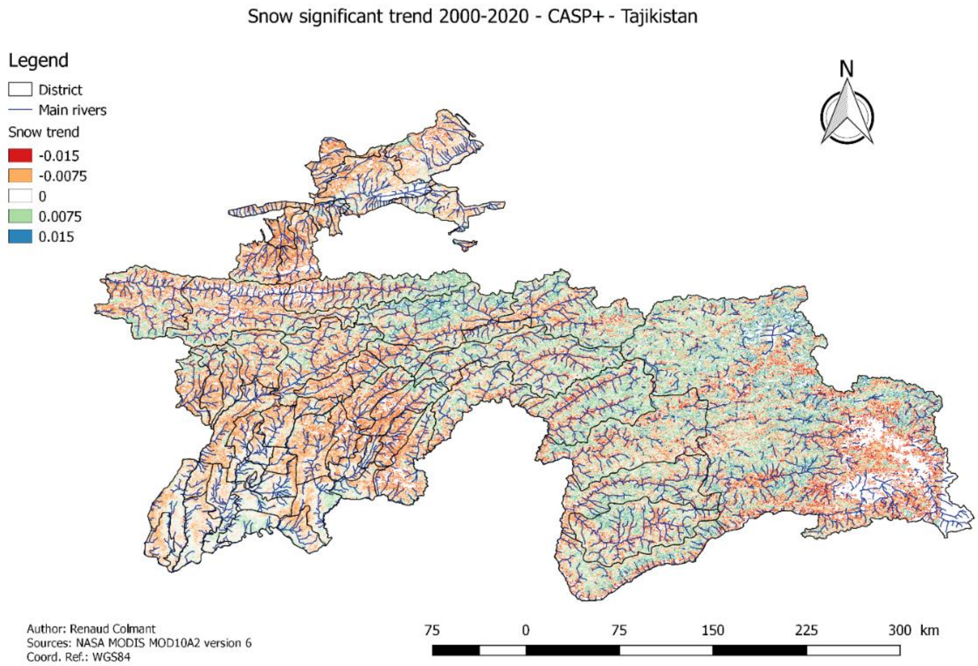
II. Impacts of historical climate change

A. Snow extent and water availability

13. According to the World Bank Climate Change Knowledge Portal[4], around 20 percent of Tajikistan's glaciers have retreated, and some have already disappeared. The analysis of the NASA Snow satellite imagery since 2005 in Tajikistan presents a significant decrease in the snow extent in around 51% of the whole territory of Tajikistan against a significant increase in 36% and no significant change in 13% (see Figure 7)[6]. Negative trends in snow presence are found in the plains, around the glaciers in the slopes of medium to high mountain rangelands and around the main rivers.

14. Considering that the main source of water of the Tajikistan's rivers are glaciers, glacial melt over the medium and long terms reduces water flow into the country's rivers. Indeed, the decrease in snow occurrence in these areas could have a direct impact on water flow in rivers in spring as less water is stored during winter. Furthermore, water is released faster when snow melts because of high temperature which can increase the risk of floods, erosion, and droughts.

Figure 7 - Snow occurrence's trend 2000-2020 in Tajikistan
Source: NASA MODIS MOD10A2 500m 8days V.6 & IFAD



15. The analysis of the snow extent at national level shows that the total snow cover extent has decreased by more than 56 square kilometres by year on average for the period 2000-2020 (see Figure 8).

16. Furthermore, the monthly analysis by region gives a clear understanding of the dynamics of snow extent by months (January to December) in Figure 9. The trend of occurrence of snow cover is decreasing in the four regions for the whole year except in DRS and Sughd during a short period in early October. The main negative trend occurs in winter for the four regions.

[4] World Bank Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/tajikistan/impacts-agriculture (visited in November 2020)
[5] Hall, D. K. and G. A. Riggs. 2016. MODIS/Terra Snow Cover 8-Day L3 Global 500m SIN Grid, Version 6. [2000-2020]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/MODIS/MOD10A2.006. [November 2020].
[6] The analysis is considering the seasonality and the 8 days data collecting time step with the function TrendRaster of R.

Figure 8 - Snow extent in square kilometers at nationa level in Tajikistan 2000-2020
Source: NASA MODIS MOD10A2 V.6 & IFAD

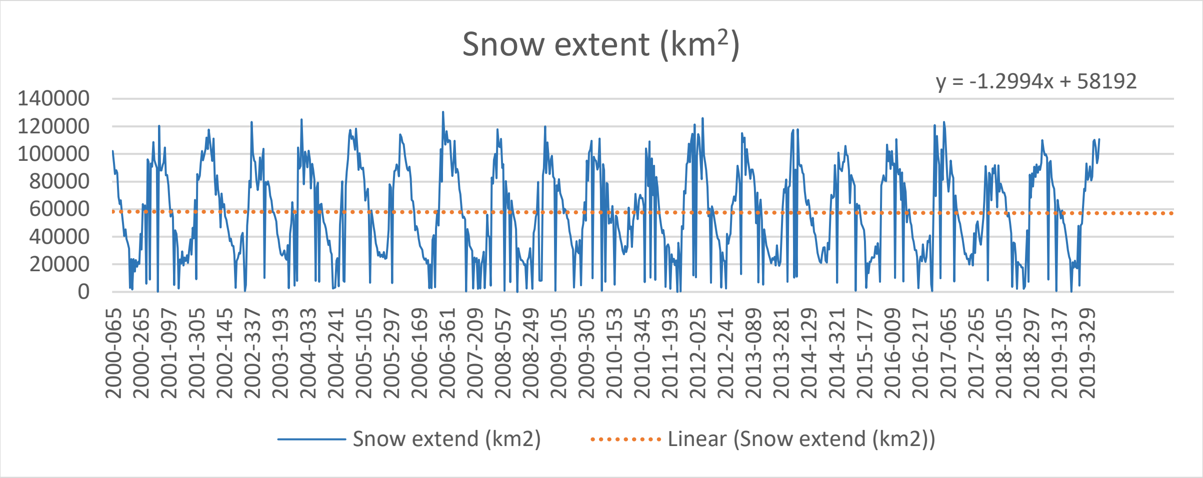
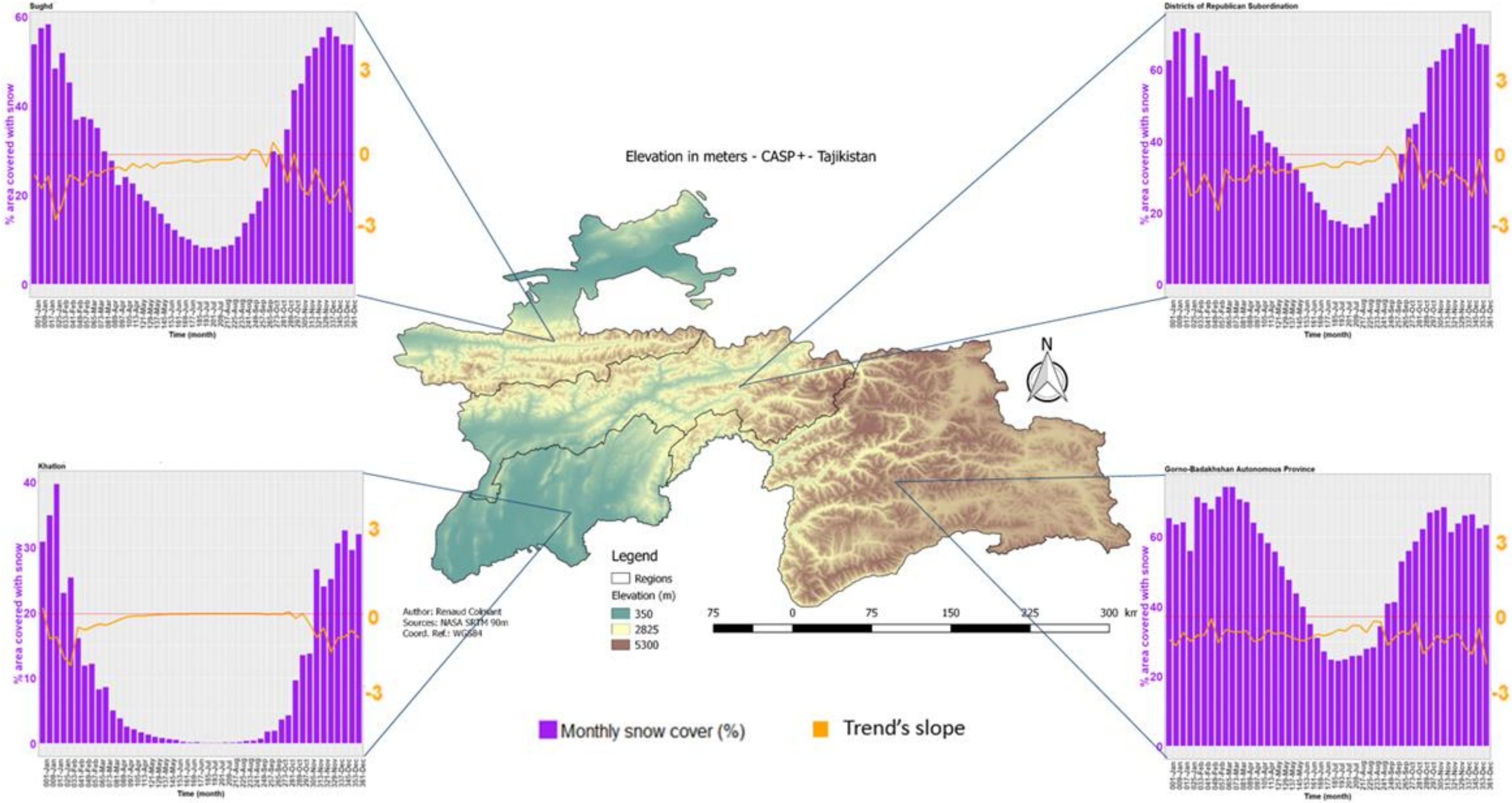


Figure 9 - Snow extent's average and trend 2000-2020 in Tajikistan by region and elevation in meters.
Source: NASA MODIS MOD10A2 V.6 – NASA Shuttle Radar Topography Mission 90m

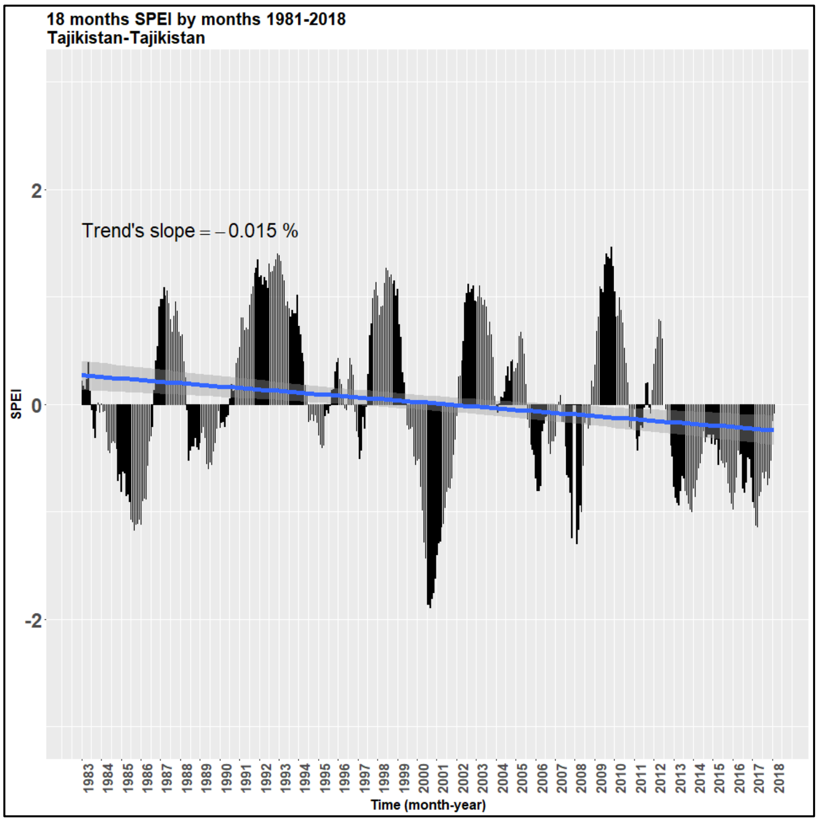


B. Droughts

17. An extensive analysis of drought is presented in Annex 16 pp. 134-197. Drought is analysed at national level through the Standardised Precipitation-Evapotranspiration Index (SPEI)[7] with the time steps of 6-, 9-, 12- and 18-months accumulation period for the period 1980 to 2019. The monthly average SPEI values for all time steps present negative values during the whole year except for the 6 months accumulation time for DRS and GBAO in February. At national level, the trend for the 1981-2018 period is significantly negative, indicating a clear increase in long term droughts. Furthermore, the SPEI for the 18-month time step has been negative since 2013 (Figure 10). Events such as the 2000-2001 drought are highlighted and coincide with higher temperature and low precipitation (see above sections).

Figure 10 - SPEI in Tajikistan 1981-2018

Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) and IFAD.



C. Erosion

18. Much of the agriculture land in Tajikistan is exposed to land degradation and erosion of fertile topsoil. Available data indicate that about 82.3% of all land and 97.9% of agricultural land in Tajikistan suffers some level of erosion – of this 88.7% suffer high and medium level of erosion[8]. The remote sensing analysis of soil erosion validates these data in Tajikistan where land degradation is a serious issue[9]. The soil erosion is caused by both natural and anthropogenic factors and is visible across the country, especially in the North-West and in the Centre. Erosion

[7] SPEI is a multiscale drought index based on climatic data (precipitation, evapotranspiration) allowing the index to account for the effect of temperature on drought development through a basic water balance calculation. SPEI has an intensity scale in which both positive and negative values (-5,5) are calculated, identifying wet and dry events. It can be calculated for time steps of as little as 1 month up to 48 months or more, with longer period deeper layer of soil can be analysed. Source: Copernicus Climate Change Service ERA5 reanalysis.

[8] The Economics of Land Degradation for the Agriculture Sector in Tajikistan – A Scoping Study. 2012. UNEP & UNDP

[9] Annex 16 Climate Patterns & Trends atlas of Tajikistan pp. 19-41

follows the precipitation patterns and depends on the vegetation and soil conservation practices (forest, agroforestry, physical infrastructure) put in place.

19. The erosion analysis is done through the Revised Universal Soil Loss Equation (RUSLE)[10]. The analysis provides an estimate of the rate of soil loss (tonnes per hectare per year) due to water erosion in Tajikistan at 100m for the periods 2001-2005 (high precipitation period) and 2015-2019 (current) (Annex 16 pp. 20-42). Approximately 50% of Tajikistan experiences a low rate of soil loss (< 5 tn/ha/yr), notably in Northern Sughd region, Southeast GBAO, and Southern Khatlon. The highest rate of soil loss is along the East-West belt in Southern Sughd (>100 tn/ha/yr).

20. Most of Tajikistan has experienced a low amount of change in the rate of soil loss (+/- 10 tn/ha/yr), with more surface area experiencing lower, rather than higher, soil loss. Notably, areas that experience the highest soil loss rates (Southern Sughd and Northern GBAO) have observed the largest reduction in the rate of soil loss between the two observation periods (up to -25 to -67 tn/ha/yr). The largest increase in the rate of soil loss is recorded in the Centre of the country (+25 to +67 tn/ha/yr) and in Northwest GBAO.

21. The erosion at national level has increased in area (%) in the category of medium-high erosion level by 5.1% (severe erosion decreased by 1.2% and low erosion decreased by 3.9%) which is worrisome since more than half of the country is experiencing more than 5 t/ha/yr loss in superficial soil for the period 2016-2020.

Table 1 - Distribution of soil loss in Tajikistan during the period 2000-2004 and 2016-2020

Soil loss (t/ha/yr)	% Tajikistan 2000-2004	% Tajikistan 2016-2020
Non-applicable	9.68%	9.77%
0-1	12.28%	10.81%
1.01-3	18.66%	16.6%
3.01-5	12.49%	12.09%
5.01-10	17.01%	18.09%
10.01-20	11.64%	14.85%
20.01-50	12.3%	13.04%
50.01-100	3.34%	2.76%
>100	2.6%	1.99%

22. The erosion is higher in grasslands than in other land cover types because of the lack of vegetation. Indeed, the areas covered by forest is the land cover type with less erosion in Tajikistan. Grassland accounts for a larger share of land cover than cropland in Tajikistan, predominating across GBAO region, in Western Khatlon region, in Southern and parts of Northern Sughd region, as well as in patches across the DRS region. The rate of soil erosion predominantly ranges 3 to 20 tn/ha/yr, with the lowest rates observed in the grasslands of Eastern GBAO. The highest rates (more than 200 tn/ha/yr) are observed in in Southern Sughd region, including along the border with the DRS, and Eastern GBAO.

D. Floods

23. According to the European Commission, Joint Research Centre (JRC - Flood hazard map of the World - 100-year return period), flood events occur in several areas of the country (Annex 16 pp.18). In Sughd Region, fluvial flood depth peaks along the upper Zeravshan River channel. Water depth up to 24m is also observed along the Syr Darya river channel downstream of the Kairakkum Reservoir, whereas lower flood depths (up to 6m) and are observed upstream. High flood depths are also observed in Gorno Badakhshan along the Gunt and Bartang rivers, and on

[10] RUSLE maintains the same empirically based equation as USLE to compute sheet and rill erosion as follows: A=RKLSCP where A is computed soil loss, R is the rainfall-runoff erosivity factor, K is a soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is a cover management factor, and P is a supporting practices factor (https://fargo.nserl.purdue.edu/rusle2_dataweb/)

the Vanch river on the border with Afghanistan. In the Districts of Republican Subordination, high flood depths (up to 30m) are observed along the upper Vakhsh and Obikhingou rivers each of which supply the Nurek Reservoir in Khatlon. In Khatlon region, flood depths up to 6m are observed along the lower Kofarnihon river north of the Afghanistan border, as well as along the Vakhsh river downstream of Nurek reservoir and along the Panj River, bordering Afghanistan.

E. Vegetation

24. The analysis of the Normalized Difference Vegetation Index (NDVI)[11] shows that there is a clear East-West divergence in the level of the vegetation index across Tajikistan. In GBAO and Eastern DRS, NDVI averages are lower than 0.2, consistent with the grassland habitat that predominates in this region, with large area of zero vegetation growth. NDVI ranges from 0.4 to 0.7 in Khatlon and the DRS, however peaking in Central areas of the latter region. Whilst most of Sughd Region observes NDVI from 0.4 to 0.6, consistent with extensive crop growing in the region, low (<0.1) NDVI is recorded at higher elevations of Sughd Region.

25. Most of Tajikistan has experienced no significant difference in average NDVI (-0.05 to +0.05) between 2001-2005 and 2015-2019. The largest increases in NDVI (up to +0.4) are observed in cropland areas with high NDVI (e.g. Central Khatlon and Central Sughd regions). Conversely, patches of significant decreases (up to -0.4) in NDVI are observed in Central and Northern Sughd region and central Districts of Republic Subordination, as well as in the vicinity of Dushanbe.

26. The deterioration of vegetation health during the period 2015-2019 is analysed in Annex 16 pp.12-14. Vegetation includes forests, shrublands and rangelands. Deterioration in vegetation health is caused by drought, disease, or forest clearing. Severe degradation is observed in Central and West Khatlon. Minor degradation is observed in clusters throughout the DRS, South-Central Sughd region, Northwest GBAO, and Central Khatlon. A significant increase in severely degraded vegetation in most notable in Central and West Khatlon region, with small clusters also present on along the border between DRS and North-West GBAO. Areas of minor degradation have been observed in the same areas, however there are more numerous clusters of minor degradation throughout Central Khatlon and DRS.

27. The vegetation vulnerability to increasing temperatures in natural vegetation for the period 2001 – 2019 (Annex 16 pp.16) presents a moderate vulnerability in Eastern and Central DRS and Western GBAO. In line with these results and according to the World Bank[12], Tajikistan’s forest density has also decreased by 20% in 2007 as compared to 1990.

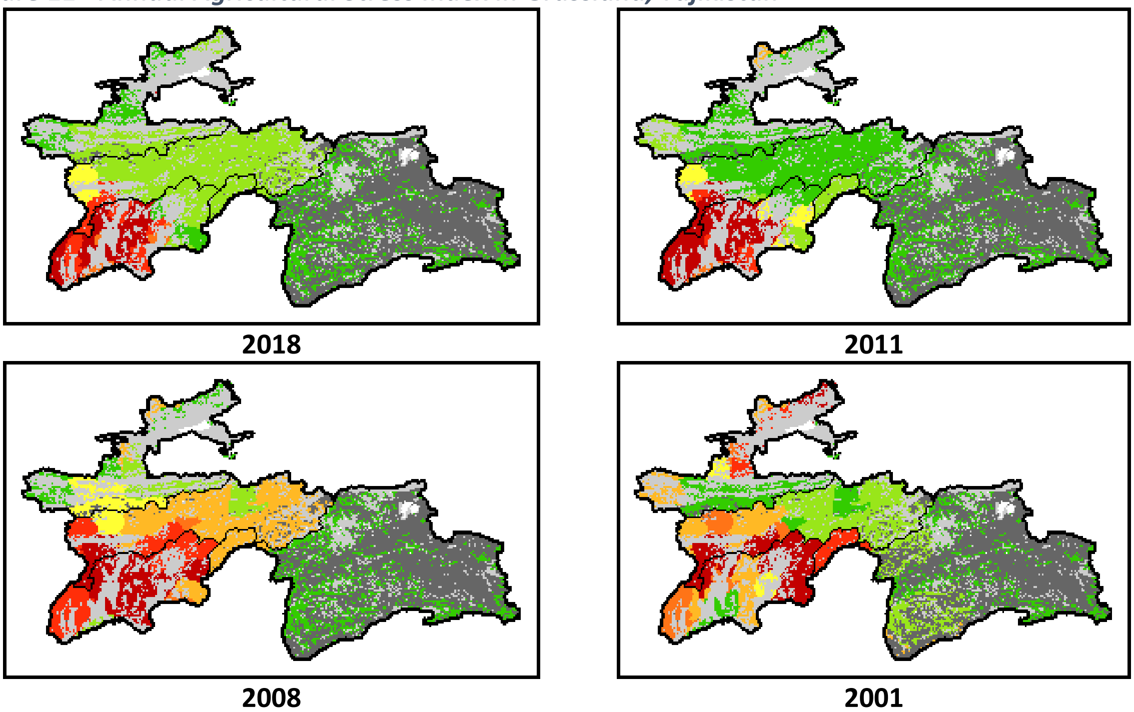
[11] The Normalized Difference Vegetation Index (NDVI) is an indicator of the greenness of the biomes. The mathematical formula for NDVI is: NDVI = (NIR - VIS)/(NIR + VIS), where NIR is near-infrared radiation and VIS is visible wavelength radiation. The value range of the NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).

[12] World Bank Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/tajikistan/impacts-agriculture (visited in November 2020)

F. Grassland & Cropland

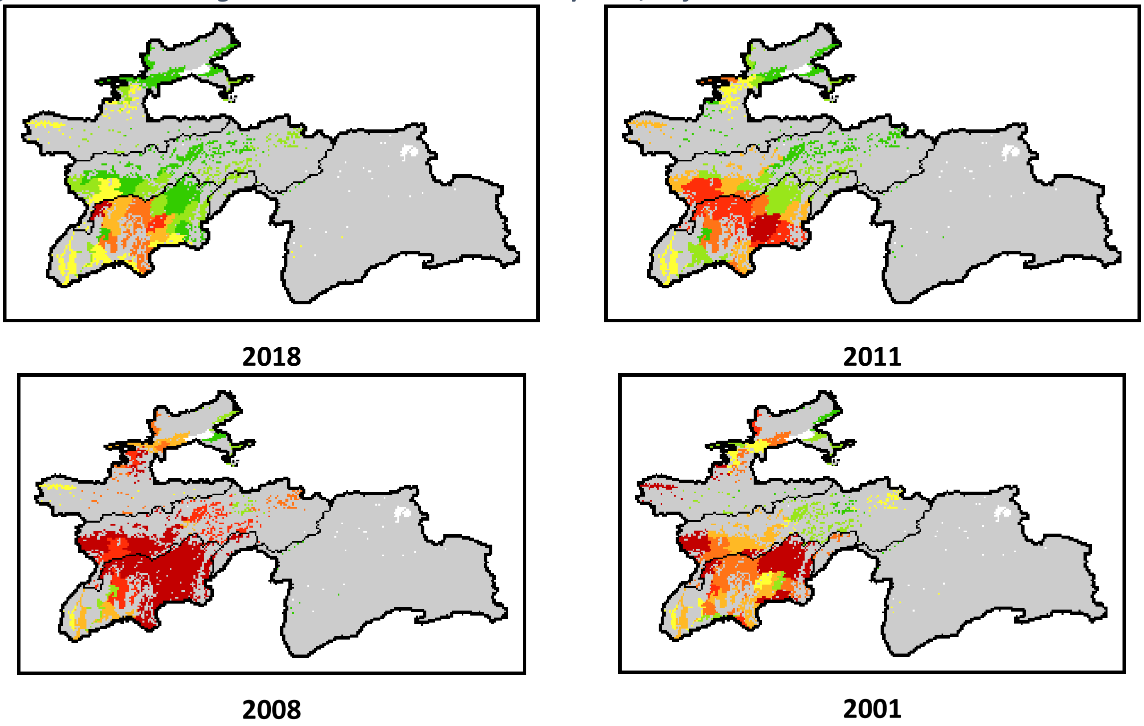
28. The Food and Agriculture Organization of the United Nations (FAO) has developed a country-level Agricultural Stress Index System (ASIS)[13] tool to help countries monitor agricultural drought and manage its risks, using satellite data to detect cropped land that could be affected by drought. The tool uses satellite data to detect agricultural areas (farmland) in which crops might be affected by drought. The country-specific version of the Tool is based on the general methodological principles of the global Agricultural Stress Index System (ASIS), which is used at FAO Headquarters to support the Global Information and Early Warning System on Food and Agriculture (GIEWS). The analysis presented in Figure 11 and Figure 12 below shows that grassland has suffered from stress during the past 20 years, specifically in Khatlon, Western and Nothern Sughd, and Western DRS. The same conclusion can be drawn for croplands. The combination of indexes to build the ASI is showing a negative trend for both grassland and cropland with variations geographically, in time and in intensity. The main differences between them can be seen where cropland is benefitting from irrigation and additionally, possibly from use of drought resistant species. The grassland suffers greatly from climate change and extreme events. Furthermore, the situation of grassland is made worse by low management and low adaptive practices.

Figure 11 - Annual Agricultural Stress Index in Grassland, Tajikistan



[13] http://www.fao.org/giews/earthobservation/country/index.jsp?lang=en&type=11111&code=TJK#
The Agricultural Stress Index (ASI) is a quick-look indicator that facilitates the early identification of cropped land with a high likelihood of water stress (drought). The Index is based on the integration of the Vegetation Health Index (VHI) in two dimensions that are critical in the assessment of a drought event in agriculture: temporal and spatial. The first step of the ASI calculation is a temporal averaging of the VHI, assessing the intensity and duration of dry periods occurring during the crop cycle at the pixel level; this calculation includes the use of crop coefficients, which introduces sensitivity of a crop to water stress during each phenological phase. The second step determines the spatial extent of drought events by calculating the percentage of pixels in arable areas with a VHI value below 35 percent (this value was identified as a critical threshold in assessing the extent of drought in previous research by Kogan, 1995).

Figure 12 - Annual Agricultural Stress Index in Cropland, Tajikistan



G. Impacts of Natural hazards

29. The country is prone to frequent natural disasters including floods, mudflows, landslides, droughts and water scarcity that have a non-negligible impact on people, people's livelihood and the economy[14,15,16]. Climate change is recognized to have a significant impact on disaster management efforts and poses a significant threat to the efforts to meet the growing needs of the most vulnerable populations[17].

30. Environmental shocks and stresses affect the rural poor population who has limited resources and capacities to adapt. The main natural shocks are presented below and reported in the table by region. The charts below provide an overview of the most frequent natural disasters in Tajikistan and allow to understand the impacts of those disasters on human populations. Floods, extreme temperatures, earthquakes, landslides, drought, storms, and epidemics are the key natural hazards identified for the period 1985-2018 (Figure 13). The last decade was specifically marked by floods, extreme temperatures, and earthquakes. Since 1900, the natural hazards with the most occurrence are floods, earthquakes, landslides, epidemics, extreme temperatures, and drought (Figure 14).

[14] Climate risks and food security in Tajikistan. A Review of Evidence and Priorities for Adaptation Strategies. April 2017. WFP.
[15] Tajikistan: Country situation assessment Working paper, 2015. CARECECO, PRISE.
[16] Tajikistan - Autonomous Adaptation to Climate Change: Economic Opportunities and Institutional Constraints for Farming Households. World Bank. 2014. Washington, DC.
[17] World Bank Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/tajikistan/impacts-agriculture (visited in November 2020)

Figure 13 - Key Hazard Statistics for 1985-2018 in Tajikistan.
Source: World Bank Climate Change Knowledge Portal

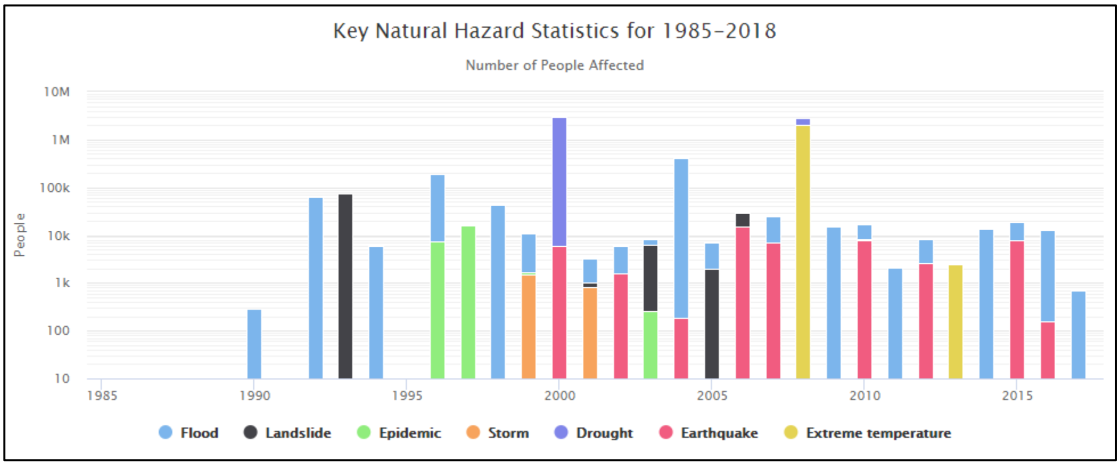


Figure 14 - Average annual natural hazard occurrence for 1900-2018.
Source: World Bank Climate Change Knowledge Portal

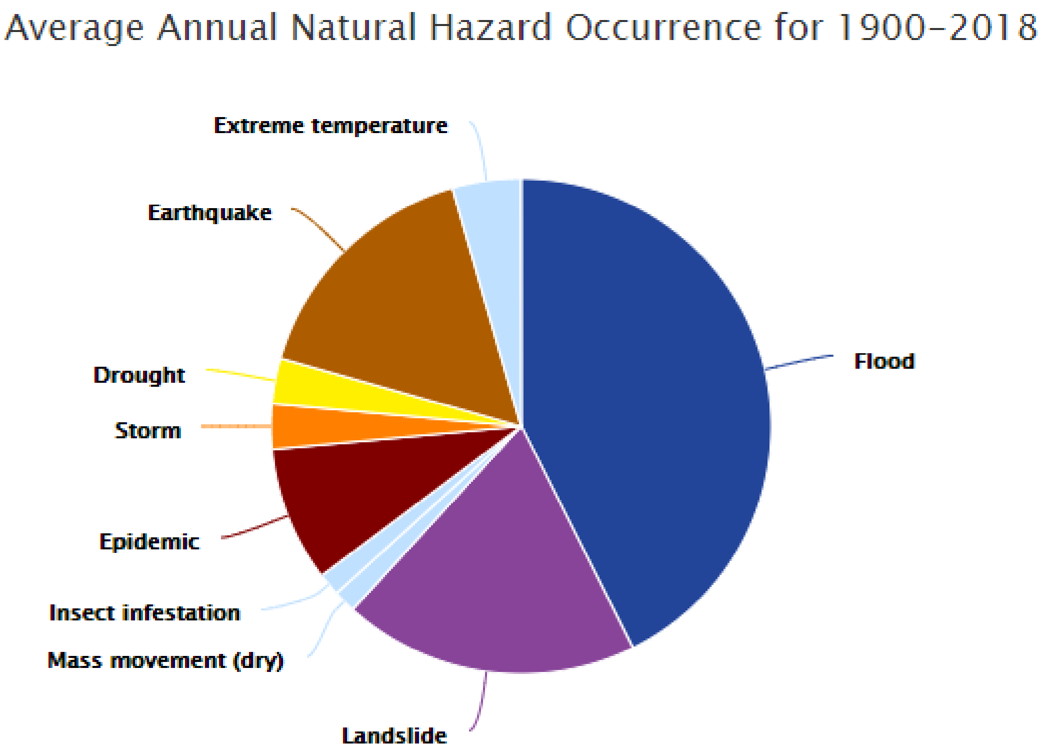


Table 2 - Natural hazards and impacts at national level and by region in Tajikistan

Sources: Tajikistan's Third National Communication on Climate Change to the UNFCCC, 2014, Climate risks and food security in Tajikistan. A Review of Evidence and Priorities for Adaptation Strategies. April 2017. WFP, Tajikistan: Country situation assessment Working paper, 2015. CARECECO, PRISE, Tajikistan - Autonomous Adaptation to Climate Change: Economic Opportunities and Institutional Constraints for Farming Households. World Bank. 2014. Washington, DC. and OCHA (Office for the Coordination of Humanitarian Affairs). 2015. Caucasus, Central Asia and Ukraine: regional humanitarian snapshot (January - June 2015). (also available at http://reliefweb.int/sites/reliefweb.int/files/resources/ROCCA_00024_HSRC_20150716_ENG.pdf).

Area	Natural hazards
National	The 2000/01 drought substantially impacted Tajikistan at an estimated 5% of its GDP. More than 3 million people (or half of the countries' population at that time) were affected. Over the last twenty years, natural disasters have resulted in more than 2,000 deaths and an economic damage exceeding 160 million USD in Tajikistan. The mudflows and floods in 1998, 1999, 2005 and 2010 were the most devastating. In 2003, heavy periods of rainfall destroyed 185 km of forest roads, damaged 50,000 planting stocks of forest nurseries, 9,000 fruit and forest trees were damaged with total yield loss of the harvest, constituting almost 70%, due to extreme weather events, causing very high economic losses.
Sughd Region	In Sughd Province, the districts of Pandjakent, Asht and Isfara are those that experienced the highest number of natural shocks and associated casualties. Asht district saw the highest frequency of mudflows. Data on casualties from the Committee of Emergency Situations and Civil Defence (CoES), reports the deaths of more than 30 people in two events in 1999 and 2007. In Panjakent and Isfara district floods and mudflows between 1998 and 2011 killed 12 inhabitants and caused damage to more than 900 houses, 30 percent of which were destroyed. A frost at the end of March 2015 in Tajikistan impacted 225 000 people and resulted in significant damage and losses to crops and orchards in the region.
Districts of Republican Subordination (DRS)	In the DRS region, Jirgatol, Rasht and Tojikobod districts experienced the highest frequency of floods and mudflows in comparison with other districts and saw the highest number of causalities. In Rasht, 32 people were killed in natural disasters between 1998 and 2011, in Tojikobod 30 people died, and in Jirgatol 18 people died from natural disasters during this period.
Khatlon Region	The western part of Khatlon, the areas that are most vulnerable to flooding are settlements along the river Kafirnigan, and irrigated areas in the Shaartuz and Qabodiyon districts. Recently, due to the failure of the drainage network and intensive irrigation activities, the level of groundwater is rising in many areas of Khatlon, leading to serious salinization of cultivated land. A lack of, and poor-quality flood protection works such as drainage diversion, small dams or riverbank reinforcement works, exacerbate the risk posed by floods in the Khuroson and Jomi, Temurmalik, Vose, Farkhor, Panj and Muminobod districts. The highest number of floods registered was in Farkhor and Kubodien districts, with the most damage registered in Temurmalik, Jomi, Vose and Kubodien districts.
Gorno-Badakhshan Autonomous Region (GBAO)	In GBAO, Ishkoshim district recorded the highest number of floods and mudflows between 1998 and 2011. The highest number of casualties from natural disasters between 1998 and 2011 were registered in Roshtaqala district. Roshtqala and Ishkoshim districts also saw high levels of damage between 1998 and 2011 as compared to other districts of the GBAO province.

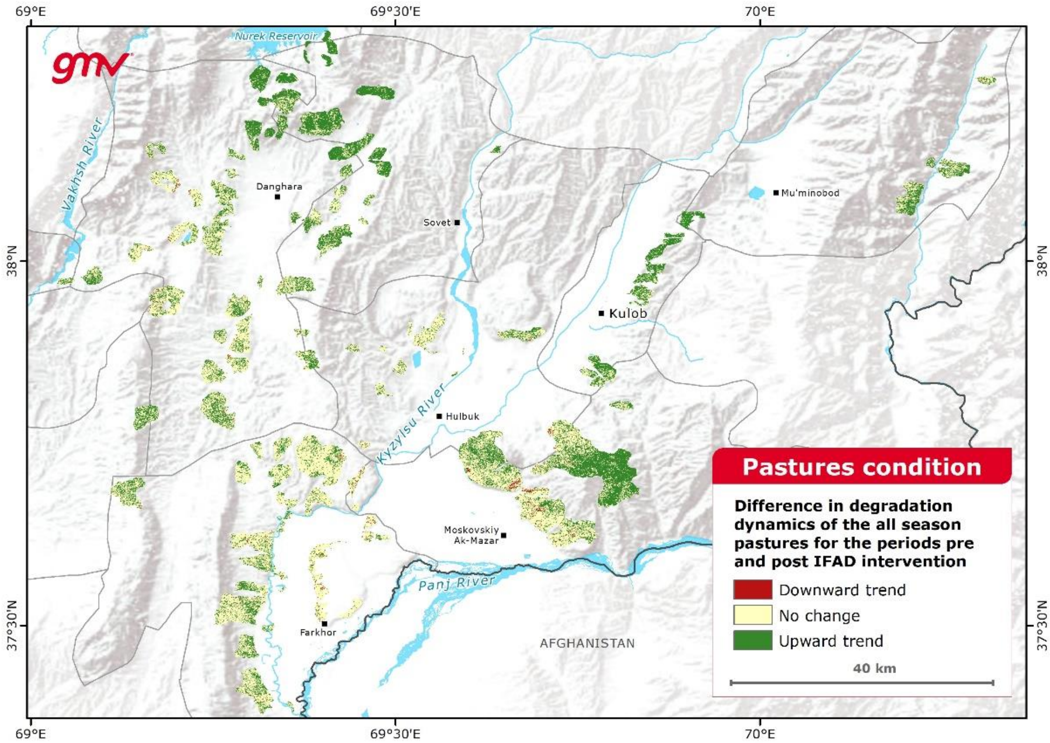
H. Pasture Degradation: Rapid assessment in IFAD-funded project areas

31. A detailed analysis of the the evolution of pasture degradation in IFAD-funded project Livestock and Pasture Development Programme Phase II (LPDP II[18]) area was carried out and is reported in CASP+ **Annex 16a**.[19] The analysis shows how – taking into account only pasture areas of the villages beneficiaries of LPDP II, comparing the degradation level during the 2016-2020 period (before IFAD intervention) to the level of degradation during the 2020-2021 period (after IFAD intervention), the following can be observed (Figure 15):

- **Generalized lower degradation patterns**: Most of the pastures presented a less intense degradation trend post IFAD intervention, especially in all seasons, spring, summer, and winter pastures.
- **No change or slight degradation on autumn pastures**: The IFAD intervention seems to have had a smaller effect on autumn pastures, as large portion of autumn pasture area did not show any difference in their degradation trends post and pre-IFAD intervention.
- **Isolated cases of degradation in spring pasture**: The only case were the degradation trend appeared as worsening was in small patches of spring pastures.

Figure 15 – difference in degradation dynamics for the period pre and post IFAD intervention – All-seasons pastures

Source: GMV



[18] https://www.ifad.org/en/web/operations/-/project/2000000977

[19] CASP+ **Annex 16a**. Rapid assessment of pasture conditions in IFAD-funded project in Khatlon region

III Future climate

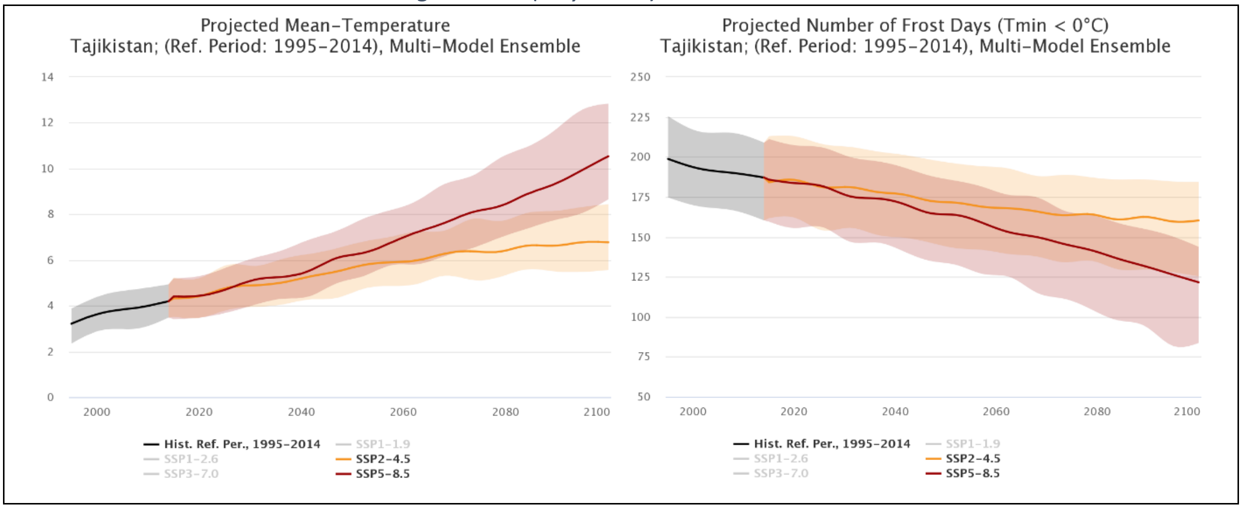
A. Climatic change projections

32. In this section, except if stated otherwise, the trends and anomalies presented were calculated based on 11 models[20] included in the Coupled Model Intercomparison Project, Phase 6 (CMIP6) produced in view of the IPCC's Sixth Assessment Report (AR6). We will present the results from the median model derived from these 11 projections, under two scenarios (RCP4.5, the intermediate emission scenario; and RCP8.5, the worse-case emission scenario), focussing on the 2040-2059 horizon, using the period 1995-2014 as a reference period.

33. Climate change projections appear to follow the same trends than historical data. The mean annual temperatures by 2040-2059 is expected to be warmer that the reference period by 1.8°C on average under the RCP4.5 scenario and by 2.4°C on average under the RCP8.5 scenario. This general increase in annual temperature is also reported in the Tajikistan's Third National Communication on Climate Change to the UNFCCC. The months of August to November are likely to see the largest warming under both scenarios. During the same period, annually accumulated frost days are projected to decrease by 19.6 days on average under the RCP4.5 scenario, and by 28.1 days on average under the RCP8.5 scenario.

Figure 16 – Time Series of the projected mean temperature and annually accumulated frost days in Tajikistan under the RCP4.5 and RCP8.5 scenarios

Source: World Bank Climate Change Portal (July 2022).



34. The mean annual precipitation is projected to remain stable (increase of only 1.1% on average under the RCP4.5 scenario, and only 1.3% on average under the RCP8.5 scenario). However, the maximum number of consecutive dry days is projected to increase by 4 to 10 days (depending on the region) under the RCP4.5 scenario, and by 6 to 11 days (depending on the region) under the RCP8.5 scenario.

35. During the same period, more intense precipitation events are expected, as the precipitation amount during the wettest days increases (+4.5 mm on average under the RCP4.5 scenario, and +5.3 mm on average under the RCP8.5 scenario). This increase is also reported in Tajikistan's Third National Communication on Climate Change to the UNFCCC.

36. The SPEI drought index is an indicator of the duration and/or severity of droughts. When the SPEI decreases, the duration and/or severity of droughts increases. During the study period, the 18f]

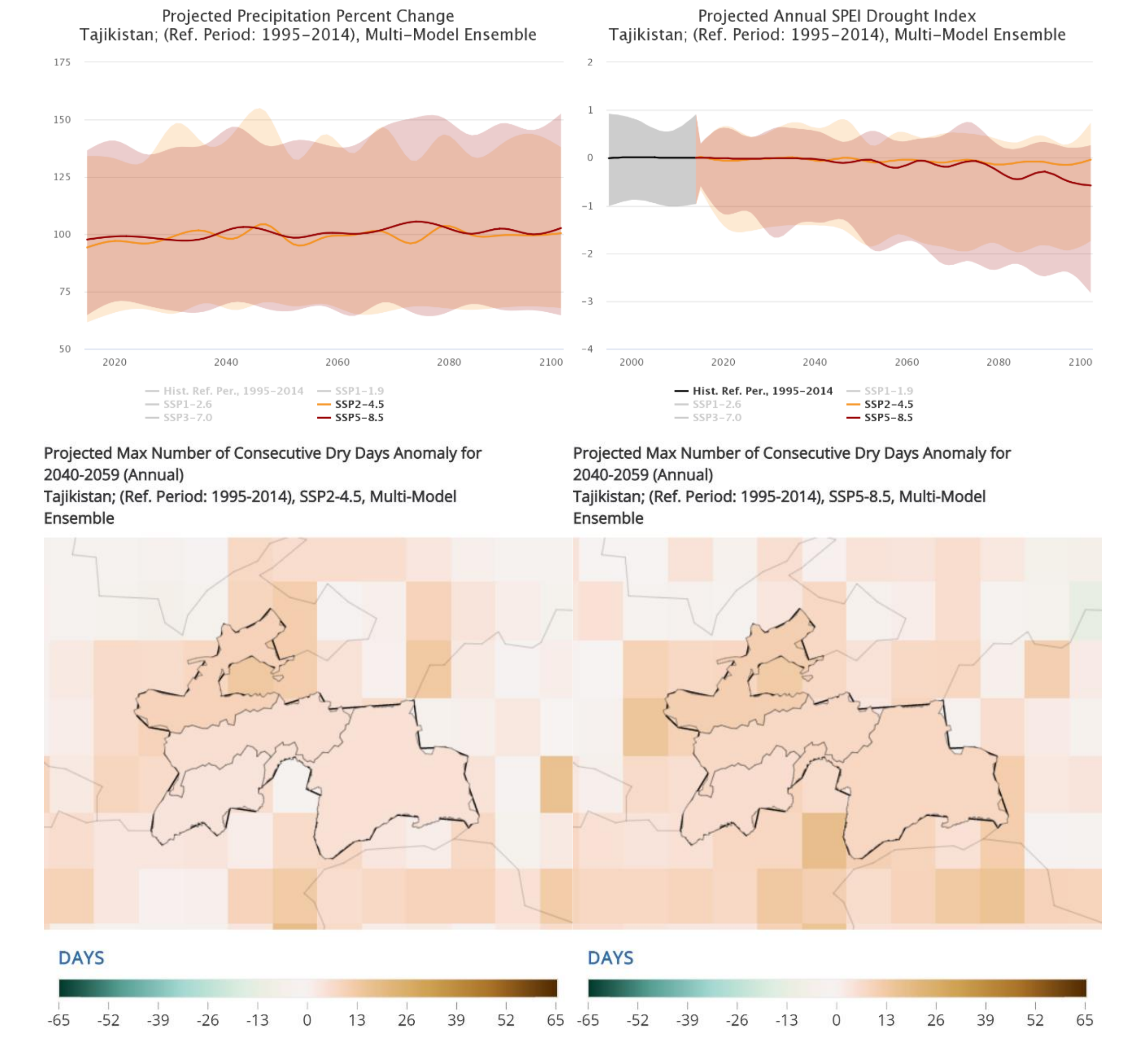
[20] The ensemble includes the following models: cams-csm1-0, canesm5, cnrm-esm2-1, ec-earth3-veg, fgoals-g3, gfdl-esm4, ipsl-cm6a-lr, miroc-es2l, miroc6, mri-esm2-0 and ukesm1-0-ll

37. SPEI drought index is expected to decrease in all regions, especially in the Khatlon region under both scenario (Sughd: RCP4.5: +0, RCP8.5: -0.33; GBAO: RCP4.5: +0, RCP8.5: -0.05; DRS: RCP4.5: -0.04, RCP8.5: -0.26; Khatlon: RCP4.5: -0.13, RCP8.5: -0.42), implying and increase in the duration and/or severity of droughts.

38. The growing season length is the number of days where crops can be grown, assuming that crops start growing when at least 6 consecutive days presents a daily mean temperature of 5°C or more. In Tajikistan it is expected to increase under both scenarios (Sughd: RCP4.5: +17, RCP8.5: +23; GBAO: RCP4.5: +19, RCP8.5: +23; DRS: RCP4.5: +21, RCP8.5: 28; Khatlon: RCP4.5: +22, RCP8.5: 26). Changes in the length of the growing season can have both positive and negative effects on the crop production. If the temperatures increase is not compensated by sufficient water availability, as is it expected in Tajikistan, the increasing growing season length might have negative effect on crops.

Figure 17 – Time series of the projected precipitation percent change and projected annual SPEI Drought index, and maps of the projected maximum number of consecutive dry days anomaly in Tajikistan under the RCP4.5 and RCP8.5 scenarios.

Source: World Bank Climate Change Portal (July 2022)



39. According to the Tajikistan's Third National Communication on Climate Change to the UNFCCC, it is expected that the nature of precipitation will change with the amount of rainfall increasing and snowfall decreasing.

40. Scenarios and conclusions proposed in the Second National Communications on climate change of all countries of Central Asia indicate that in the case of warming, the main river regimes can change, and by the end of 21st century water resources could reduce by 10-20% or more.

41. According to the World Bank[21], projected increases in temperature in Tajikistan could result in an increase in the frequency or intensity of heat waves, and, together with higher evaporation, could lead to increased drought, with subsequent loss of crops and pastures, and the expansion of desert areas.

42. Under these projections, glacier will continue retreating in Tajikistan and, by 2050, up to 30 percent or more are likely to retreat or disappear[21]. According to Tajikistan's Third National Communication on Climate Change to the UNFCCC, extreme high temperatures will also cause glaciers to melt, which could lead to flooding in some areas and shortage of fresh water in other areas, posing threats to food security and the environment and aggravate conflicts over water resources. Indeed, increase of water turbidity in rivers is expected, which can result in large depositions and drifts in the irrigation channels, basins, pump stations and sedimentation basins. Groundwater levels are also likely to be impacted. The increase in intensity of precipitation will aggravate mudflows, landslides, and avalanches. Finally, more frequent and severe droughts may aggravate soil degradation and salinization of areas of Central Asia as a result of poorly managed agricultural irrigation, clearing of forests, overgrazing, and unsustainable agricultural practices.

B. Climate Change's impacts on agricultural systems using CARD

43. With more than 70% of the population living in rural areas[22], and 58% of the total labour engaged in Agriculture (2015)[23]. Climate has always been an important factor determining the incomes and lives of the rural population, as they are dependent on land for their livelihoods and food. Climate change, environmental shocks and stresses affect agriculture, and by extension, rural poor population who has limited resources and capacities to adapt. Tajikistan's 2019 National Strategy of Adaptation to Climate Change of the Republic of Tajikistan for the Period Until 2030 states that by 2050, the population living in climatically vulnerable areas will increase by 77.2%, and some parts of Tajikistan may experience a fall in agricultural yields by 30% by the end of this century. Understanding the dynamics and impacts of climate change is key to adapt to its effects.

CARD (projection)

44. The Climate Adaptation in Rural Development (CARD)[24] assessment tool enables easy access to peer-reviewed modelling results for crop yields under climate change stresses. It has been developed by the West and Central Africa Division of the International Fund for Agricultural Development (IFAD) with funding from Phase II of the Adaptation for Smallholder Agriculture Programme (ASAP2).

45. The CARD tool allows a choice between three risk settings, which impacts the way the underlying crop-climate models are analysed:

- Median: This setting reflects a "best guess" of the uncertainties reflected in the models. The models are aggregated using the median model.

[21] World Bank Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/tajikistan/impacts-agriculture (visited in November 2020)
[22] Data World Bank. 2019: https://data.worldbank.org/
[23] FAO. 2018. Policy analysis of nationally determined contributions (NDC) in Europe and Central Asia. Budapest, 84 pp.
[24] https://www.ifad.org/documents/38714170/41085512/Card_usermanual_W.pdf/e867a16c-e581-8038-aa6f-1767a10629a3

- Pessimistic: This setting reflects a pessimistic consideration of the uncertainties reflected in the models. The models are aggregated using the 10th percentile of all underlying crop yield projections (i.e. close to the model with the largest decline, or smallest increase, in crop yields).
- Optimistic: This setting reflects an optimistic consideration of the uncertainties reflected in the models. The models are aggregated using the 90th percentile of all underlying crop yield predictions (i.e. close to the model with the least decline, or largest increase, in crop yields).

46. To circumvent the issue of complexity associated with climate models, scenarios and data, the developers of the CARD tool decided to simplify as much as possible the outputs available in the tool. Therefore, only one climate change scenario (Representative Concentration Pathway, RCP), the RCP8.5 scenario, was selected. The RCP8.5 scenario is the scenario from the Intergovernmental Panel on Climate Change projecting the highest concentration in greenhouse gases (GHGs), and hence the highest global warming. The figures from Figure 18 to Figure 23 present the results for Tajikistan by main crops from 2020 to 2050.

Figure 18 - Main crops yield with full irrigation under future climatic scenario RCP 8.5 with risk setting Median from 2020 to 2050 in Tajikistan

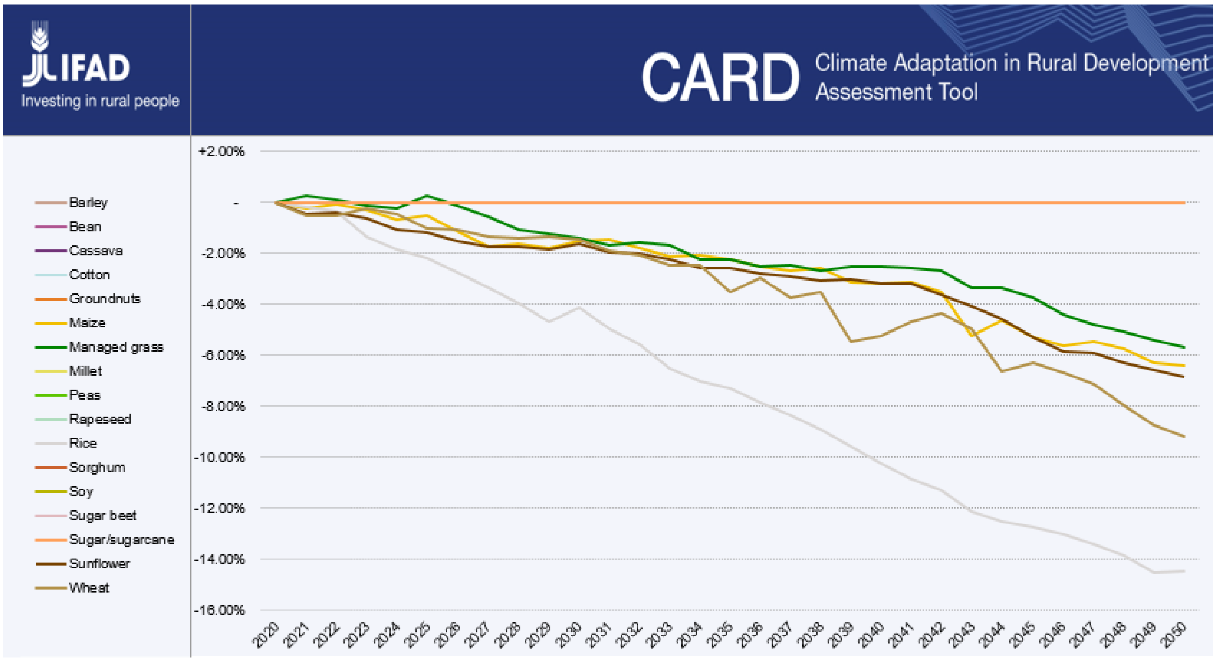


Figure 19 - Main crops yield <u>without irrigation</u> under future climatic scenario RCP 8.<u>5 with risk setting Median</u> from 2020 to 2050 in Tajikistan

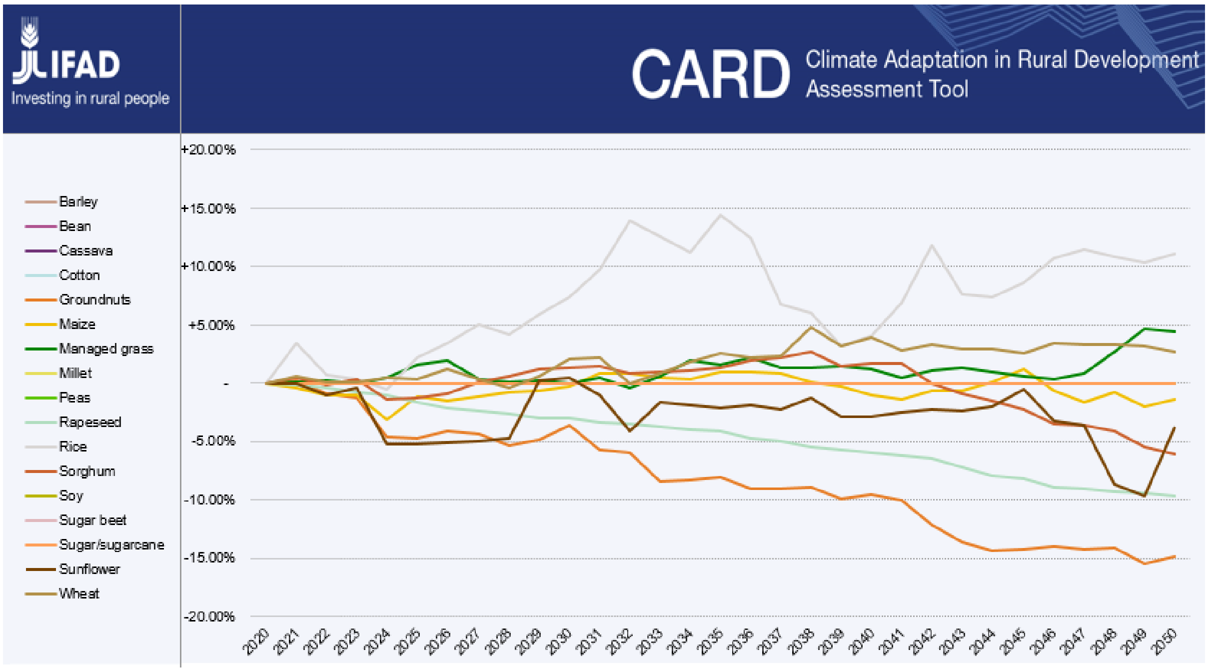


Figure 20 - Main crops* yield *<u>with full irrigation</u> under future climatic scenario RCP 8.5 <u>with risk setting Pessimistic</u> from 2020 to 2050 in Tajikistan

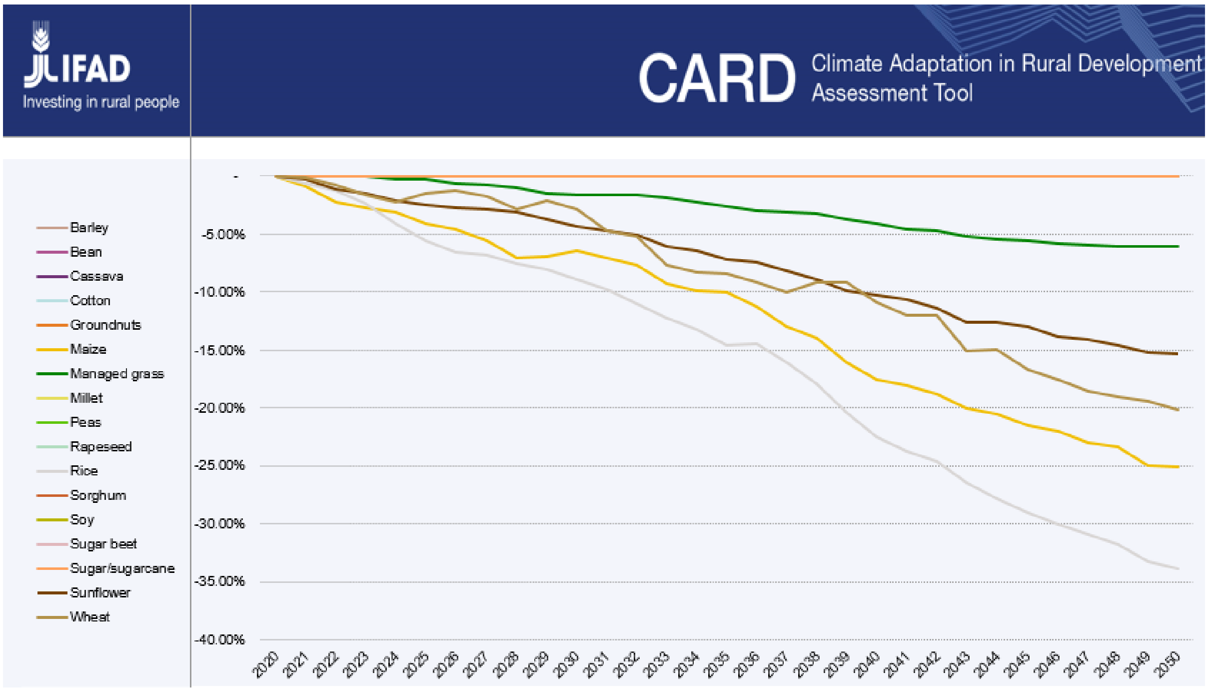


Figure 21 - Main crops yield <u>without irrigation</u> under future climatic scenario RCP 8.5 <u>with risk setting Pessimistic</u> from 2020 to 2050 in Tajikistan

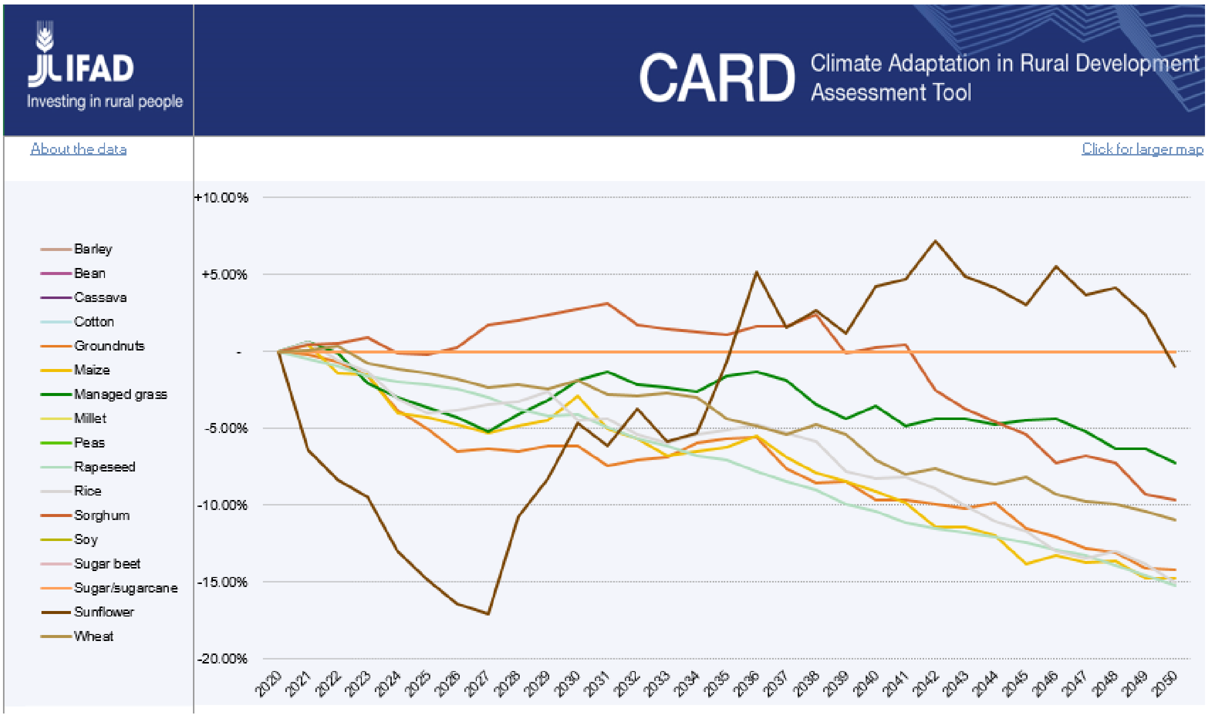


Figure 22 - Main crops yield <u>without irrigation</u> under future climatic scenario RCP 8.<u>5 with risk setting Median</u> from 2020 to 2050 on steep terrain AEZ in Tajikistan

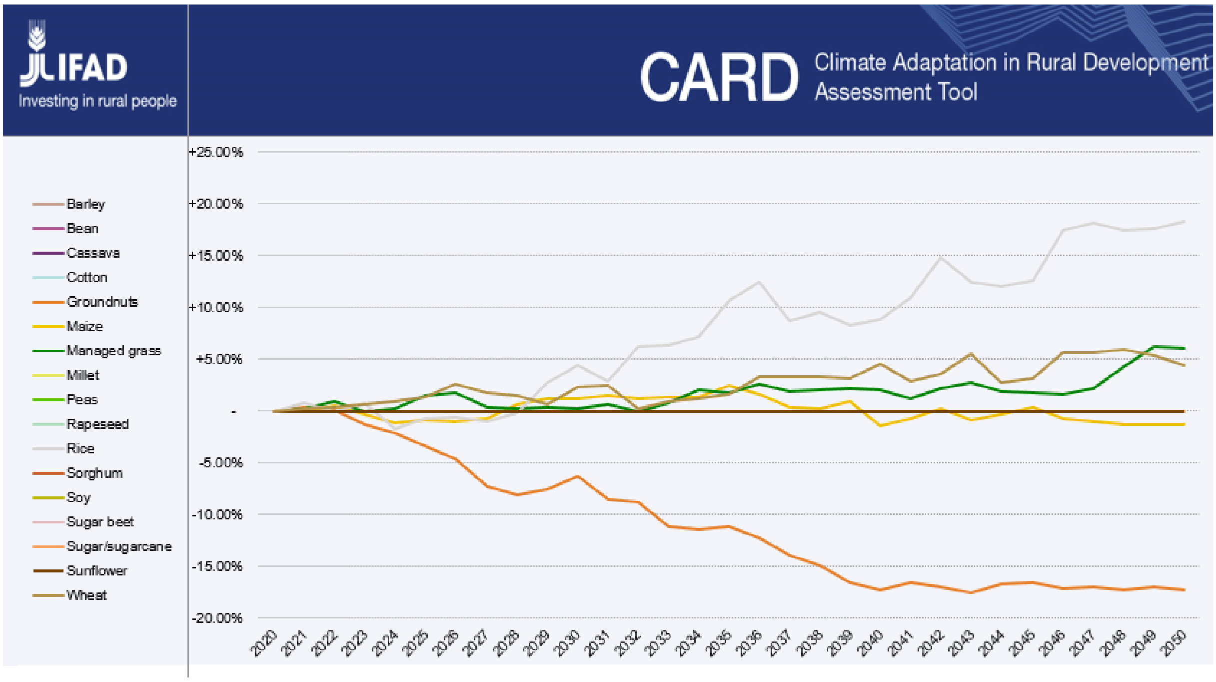


Figure 23 - Main crops yield <u>without irrigation</u> under future climatic scenario RCP 8.5 <u>with risk setting Pessimistic</u> from 2020 to 2050 on steep terrain AEZ in Tajikistan.

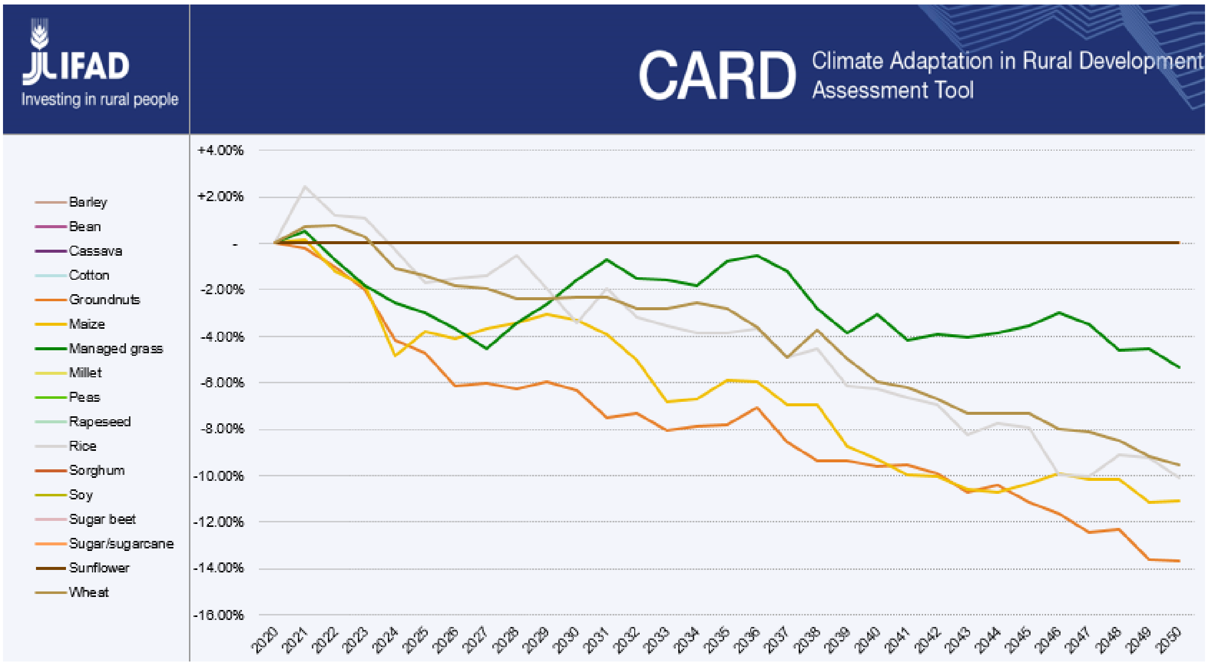


Figure 24 - Agro-ecological zones (AEZ) in Tajikistan. CARD

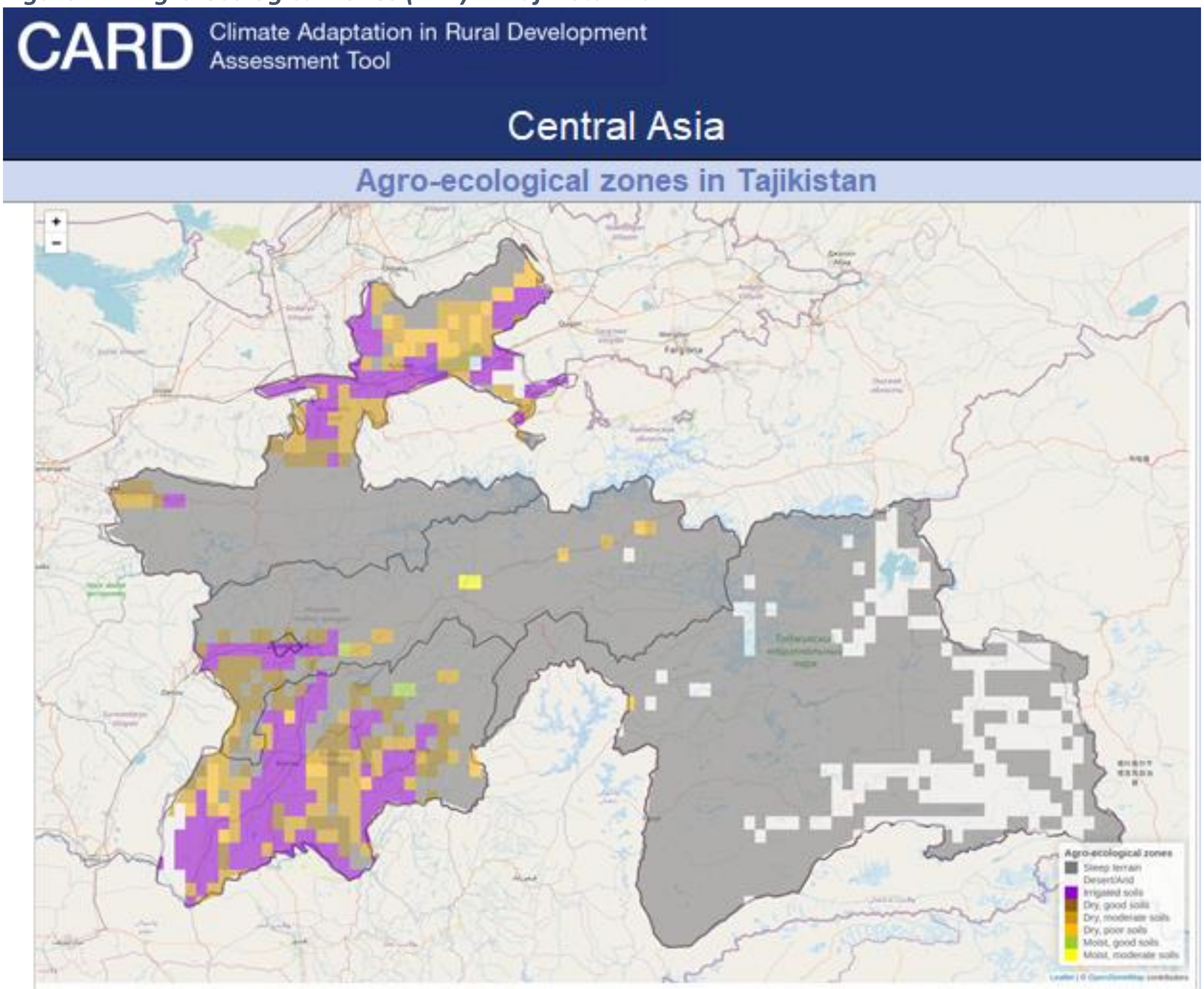


Table 3 - CARD Main crops yield trend with no irrigation under future climatic scenario RCP 8.5 with risk setting Pessimistic from 2020 to 2050 in Tajikistan

Sources: Crop yield data courtesy of the ISIMIP project (https://www.isimip.org), for terms of use see https://www.isimip.org/protocol/terms-of-use/#licences-for-isimip-fast-track-simulation-data.
Country shapes courtesy of GADM (https://gadm.org). IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy. Accessed on October 2, 2020, on http://www.gaez.iiasa.ac.at/, Menu item "Land Resources / Soil Resources / Agro-ecological zones".

Crops	2021	2022	2023	2024	2025	2030	2040	2050
Groundnuts	-0.3%	-0.7%	-1.6%	-3.9%	-5.0%	-6.2%	-9.7%	-14.2%
Maize	+0.4%	-1.5%	-1.5%	-4.0%	-4.3%	-2.9%	-9.1%	-14.8%
Managed grass	+0.7%	-0.1%	-2.1%	-3.0%	-3.6%	-1.9%	-3.6%	-7.3%
Rapeseed	-0.5%	-0.9%	-1.6%	-2.0%	-2.2%	-4.1%	-10.4%	-15.2%
Rice	+0.6%	-0.6%	-1.3%	-3.1%	-4.0%	-4.5%	-8.2%	-15.1%
Sorghum	+0.4%	+0.6%	+0.9%	-0.2%	-0.2%	+2.7%	+0.3%	-9.7%
Sunflower	-6.5%	-8.4%	-9.5%	-13.0%	-14.9%	-4.6%	+4.2%	-1.1%
Wheat	+0.1%	+0.3%	-0.8%	-1.2%	-1.4%	-1.9%	-7.1%	-11.0%

Main findings

47. Without irrigation, yields are more volatile and rely entirely on climatic variability and hazards. Climate change affects both systems - with and without irrigation - and under the Pessimistic risk setting all crops' yield are projected to decrease. Additionally, the CARD analysis presents the following findings:

- All the main crops presented in the CARD analysis for Tajikistan with full irrigation under future climatic scenario RCP 8.5 with risk settings at Median and Pessimistic are projected to see their yield decrease by up to 14% and 34%, respectively, by 2050. Rice production will be most affected, after wheat and sunflower.
- The yield of rice, wheat and managed grasslands with no irrigation under future climatic scenario RCP 8.5 with risk setting at Median, are projected to increase by around 10%, 3% and 5%, respectively, by 2050. The other crops are projected to see their yield decrease by 1% to 15%.
- All the main crops with no irrigation under future climatic scenario RCP 8.5 with risk setting at Pessimistic are projected to see their yield decrease by 1% to more than 15% by 2050. Sorghum yield is projected to remain stable until 2040 but will eventually decrease by 2050. Sunflower yield is projected to decrease in the near future and then increase between 2035 and 2049 up to 7% but will eventually decrease by 2050.

48. Specifically on steep terrain agro-ecological zones, the yield of managed grassland is foreseen to increase by 6% in a Median risk setting and decrease by 6% in a Pessimistic risk setting. Extreme climate events are indeed having negative impacts on managed grasslands, in line with what is already seen in certain areas of the country under high temperature and drought.

Use of historical and projected impacts of climate in the Economic and Financial Analysis

49. The use of historical and projected impacts the Economic and Financial Analysis (EFA) will give more confidence to the models developed under the CASP+ design. From the above analysis, overall, without adaptive practices, the main crops presented in the CARD are foreseen to experience a decrease in yield under the RCP 8.5 and Pessimistic risk setting.

50. From this analysis and the historical analysis in section "Impacts of historical climate change" the trends in extreme weather events is 1 every 5 years (drought and floods mainly). These events

are projected to happen more often in the future to be 1 every 3 years by 2050. This increase in extreme will be reflected in the EFA along the 20 years period. The projections in yield in the CARD tool are also integrating extreme events.

51. As presented above, all the main crops presented in the CARD analysis for Tajikistan with full irrigation under future climatic scenario RCP 8.5 with risk settings at Median and Pessimistic are projected to see their yield decrease by up to 14% and 34%, respectively, by 2050. From Table 2 - Natural hazards and impacts at national level and by region in Tajikistan, historical losses from floods and droughts were between 5 and 70%. Based on this, it was decided to take an average of 20% losses every 5 years in 2020 with an increase in the occurrence in time for the 20 years period for the EFA models.

IV. Climate Vulnerability analysis in Tajikistan for geographic targeting

52. IFAD adopted a methodology to analyse Tajikistan's vulnerability to climate change. Vulnerability refers to the propensity of exposed elements to suffer adverse effects when impacted by hazard events. The analysis is based on official statistics and data[25], improved with additional remote sensed data[26] and analyses to increase the evidence base and knowledge on how climate change affects rural populations. Climate vulnerability is defined as a function of exposure, sensitivity, and adaptive capacity:

- **Exposure** is typically conceptualized as the type and intensity of the hazard event affecting a system.
- **Sensitivity** is the predisposition of a system to suffer harm, loss, or damage as a consequence of a hazard event.
- **Adaptive capacity** is defined as "the ability of a system (human or natural) to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (Intergovernmental Panel on Climate Change (IPCC) Working Group 2, 2001.)

53. Climate vulnerability and the size of affected populations is location specific and derives from unique interactions of different biophysical and socioeconomic variables so that different levels of vulnerability characterize different places.

54. At the concept note design stage, the climate vulnerability analysis had only considered exposure and sensitivity (potential impacts). The data for adaptive capacity have been integrate at the second level of analysis as more data were available to the design team to avoid excluding pockets of poverty (i.e. IFAD target group) and had indicators better fitting the activities and context. The adaptive capacity indicators were used to target specific Jamoats[27] within the pre-identified districts.

55. The indicators of exposure, sensitivity and adaptive capacity were chosen on the basis of the socio-economic, climatic and environmental analysis presented in the above sections and in the SECAP. These indicators are presented in the below table:

EXPOSURE	SENSITIVITY	ADAPTIVE CAPACITY
• Rainfall significant trend summer • Daily heavy rains (number of events; >10mm, 1981-2019) • Drought-SPEI (18 months) average and trend 1981-2019 • Max temperature (trend) 1958-2019	• Erosion RUSLE 2015-2019 • Land degradation (rangelands and forests) • Population rural total (<250 hab/km2) • Poverty rate (%)	• Presence of irrigation (2019) • Youth population (2020) • Proximity to main roads

[25] Committee on emergency, PPRC, NDC, IPCC
[26] Remote sensing analysis undertook by IFAD and EO4SD Atlas in Annex 16.
[27] The jamoats of Tajikistan are the third-level administrative divisions, similar to communes or municipalities

Exposure

Figure 25 - Significant Precipitation Trend. Dry season (Jun-Oct). Period: 1981-2019.
Data source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) - https://www.chc.ucsb.edu/data/chirps

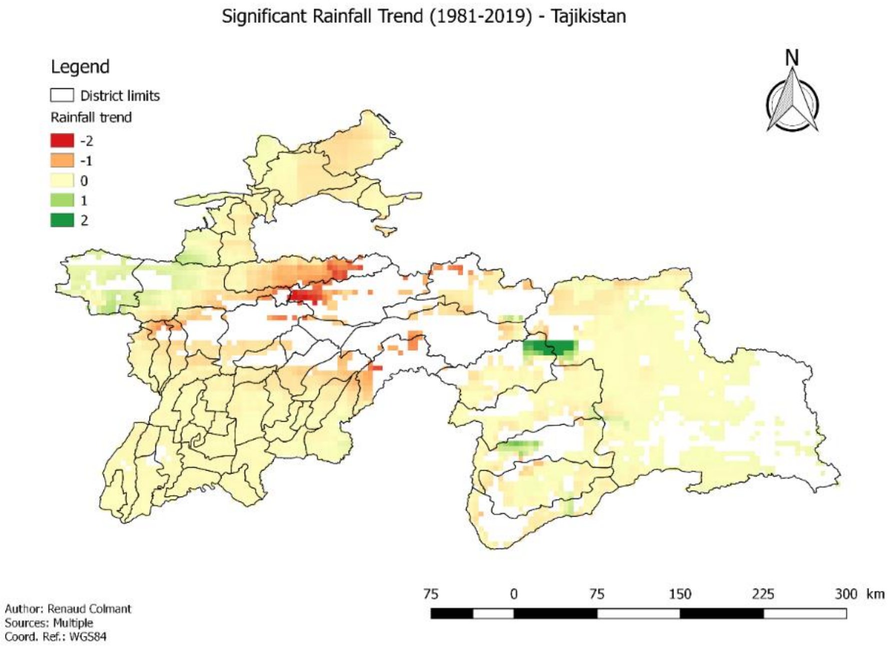


Figure 26 - Heavy rainfall events > 10 mm/d. Period: 1981-2019.
Data source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) - https://www.chc.ucsb.edu/data/chirps

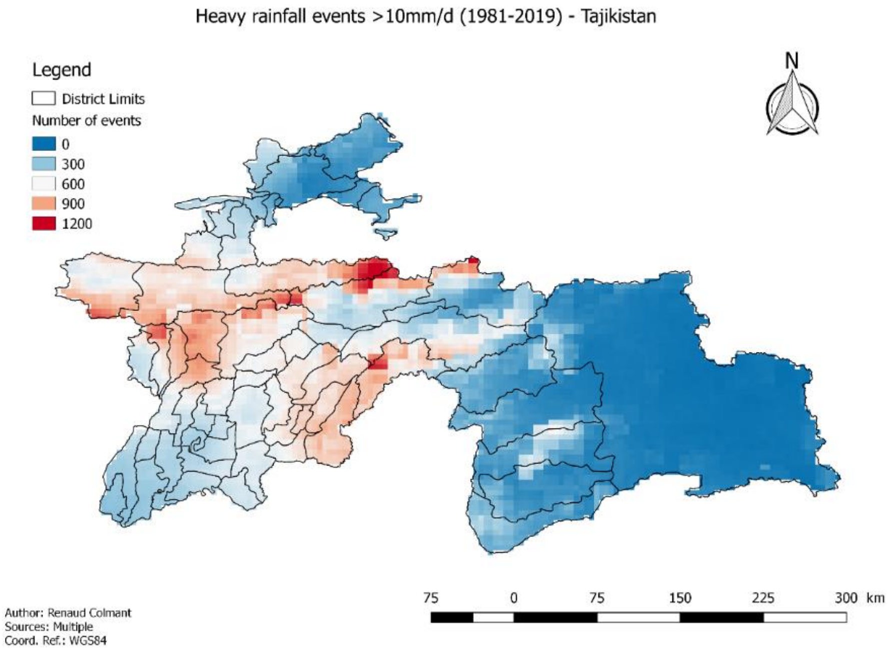


Figure 27 - Trend of the Standardised Precipitation Evapotranspiration Index (SPEI). Period: 1981-2019.
Data sources: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) - https://www.chc.ucsb.edu/data/chirps & Terraclimate - http://www.climatologylab.org/terraclimate.html

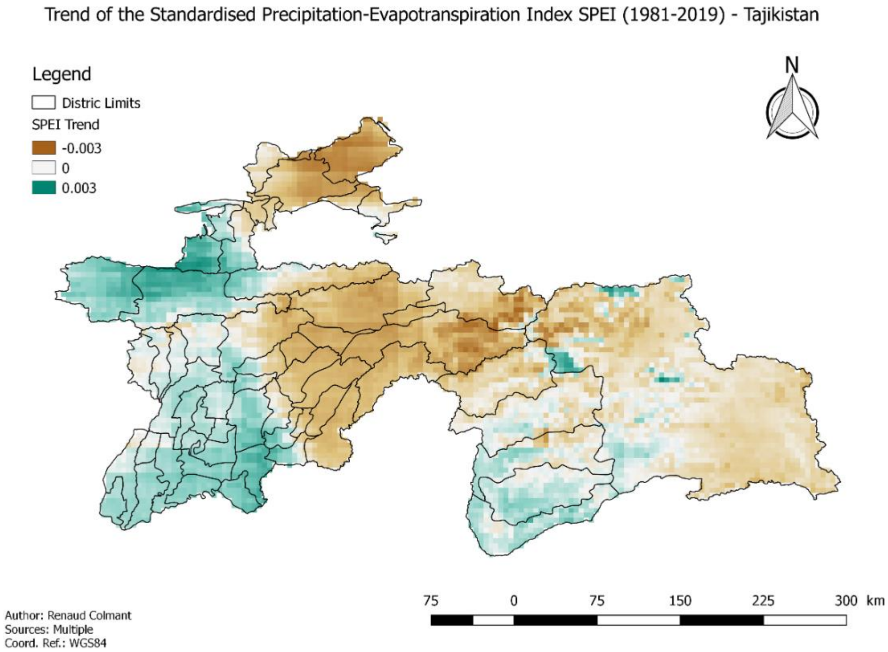


Figure 28 - Average Standardised Precipitation Evapotranspiration Index (SPEI). Period: 1981-2019.
Data sources: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) - https://www.chc.ucsb.edu/data/chirps & Terraclimate - http://www.climatologylab.org/terraclimate.html

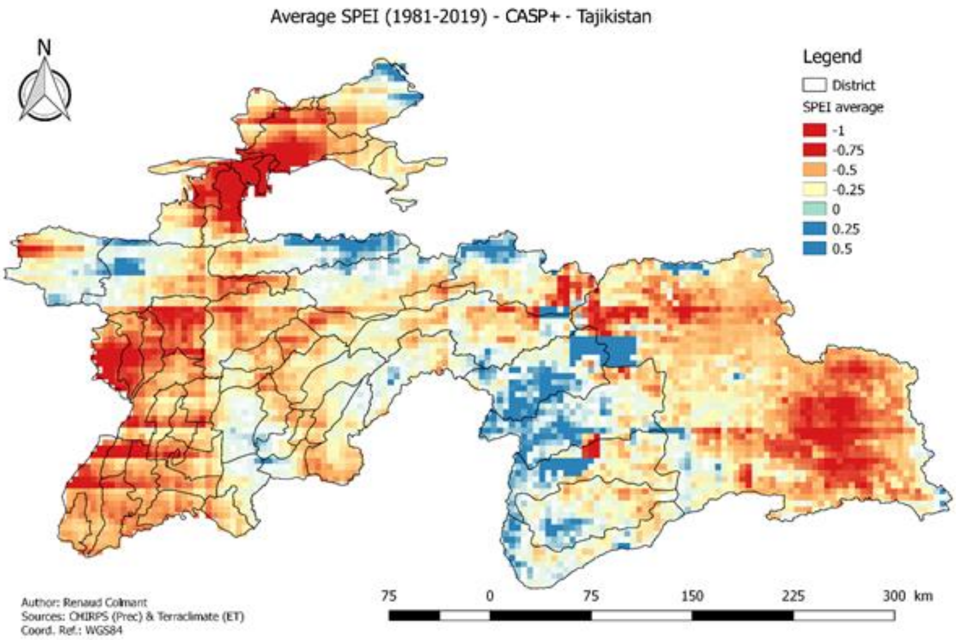


Figure 29 - Trend of the maximum temperature for the warm season April-September. Period: 1958-2019

Data source: Terraclimate - http://www.climatologylab.org/terraclimate.html

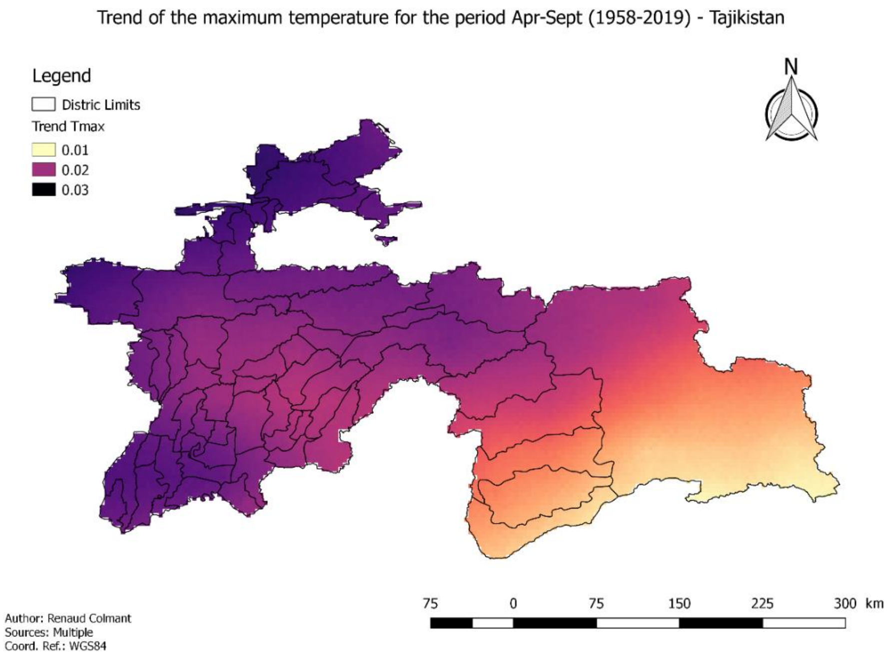
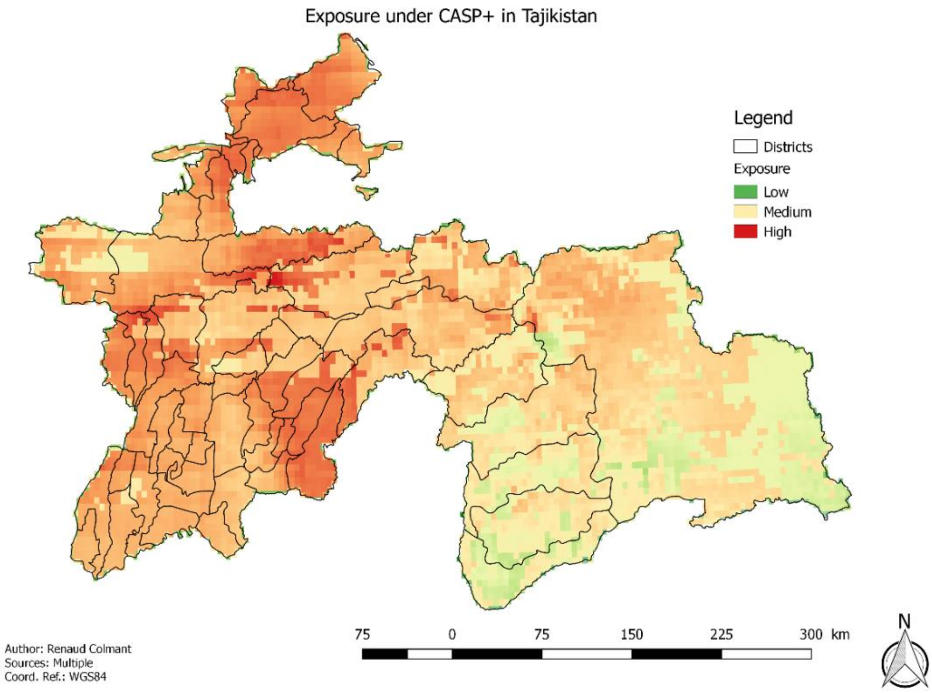


Figure 30 - Exposure in Tajikistan



Sensitivity

Figure 31 - Average Revised Universal Soil Loss Equation (RUSLE). Period: 2015-2019

Data Sources: Climate Hazards Center InfraRed Precipitation with Station data (CHIRPS) (2015 – 2019) & MODIS Vegetation Index (NDVI) (2015 – 2019) & Copernicus Dynamic Global Land Cover layer at 100m 2015 & SoilGrids, ISRIC 2019 & SRTM Digital Elevation Model, NASA.

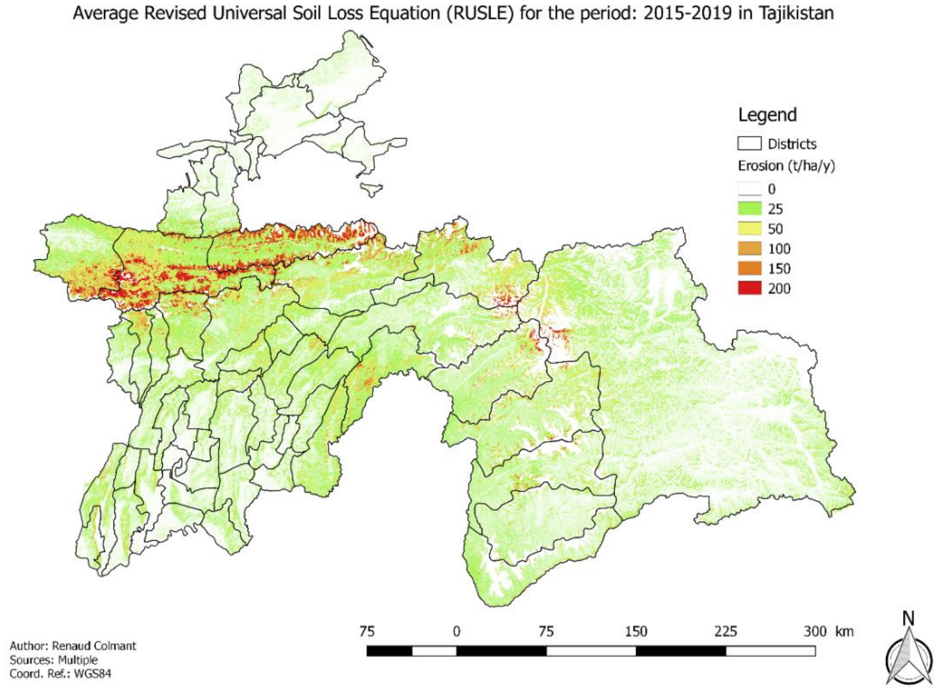


Figure 32 - Rural population 2018 (<250 pp/km^2)

Data Source: WorldPop - www.worldpop.org

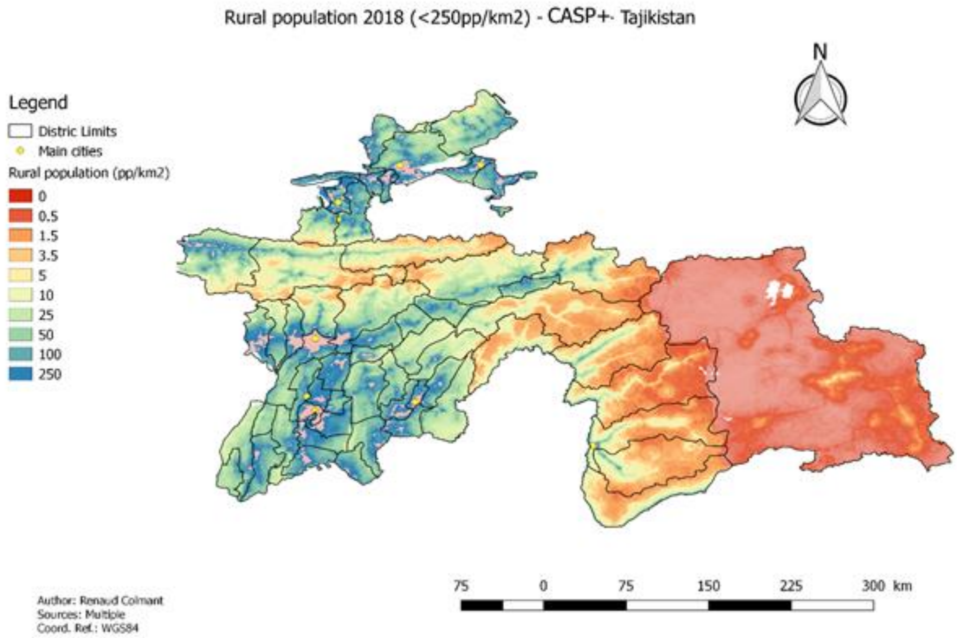


Figure 33 - Degradation in natural vegetation for 2015-2019
Data Sources: ESA Climate Change Initiative Land Cover at 300m & MODIS Vegetation Index Products at 250m & MODIS Surface reflectance (bands 01, 02 and 06) at 250 m & LAI Copernicus at 300 m.

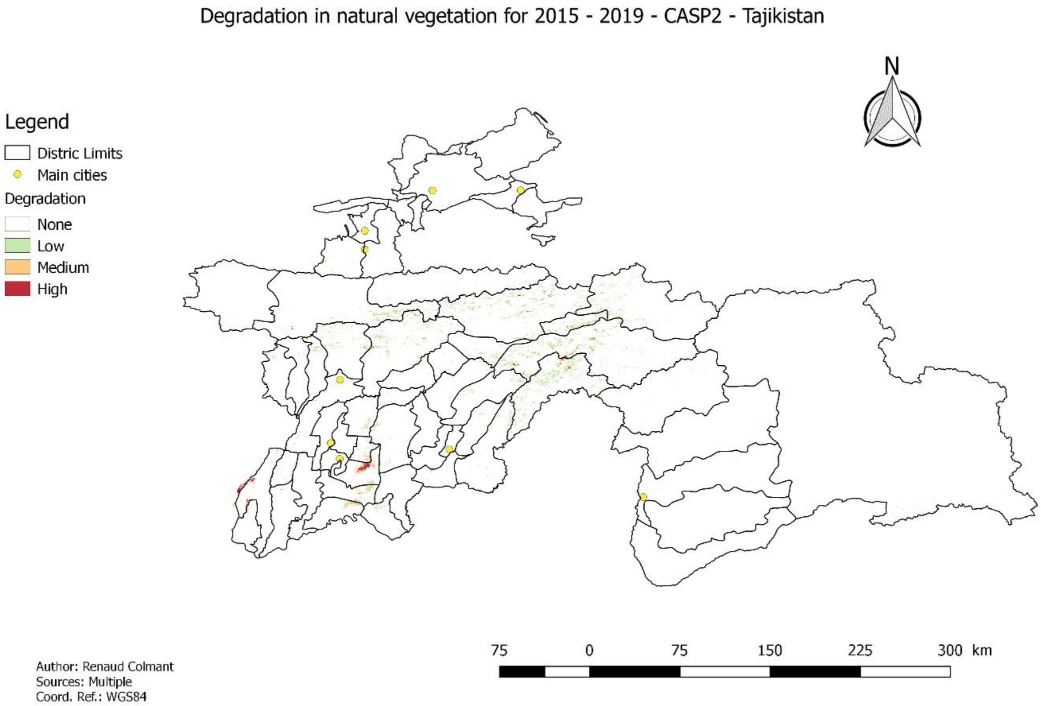


Figure 34 - Population poverty % at district level. Period: 2020.
Data Source: Government of Tajikistan.

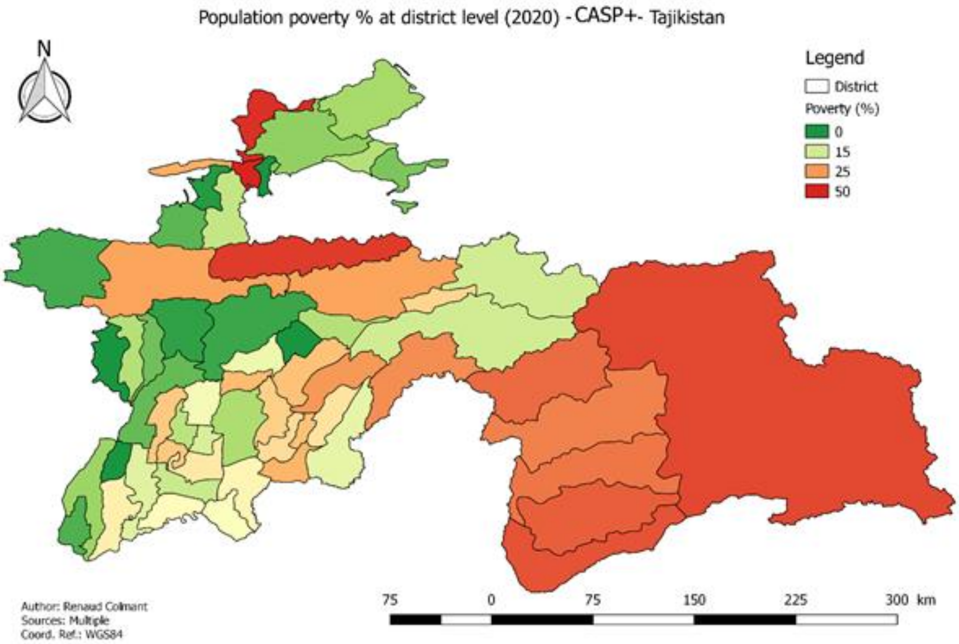
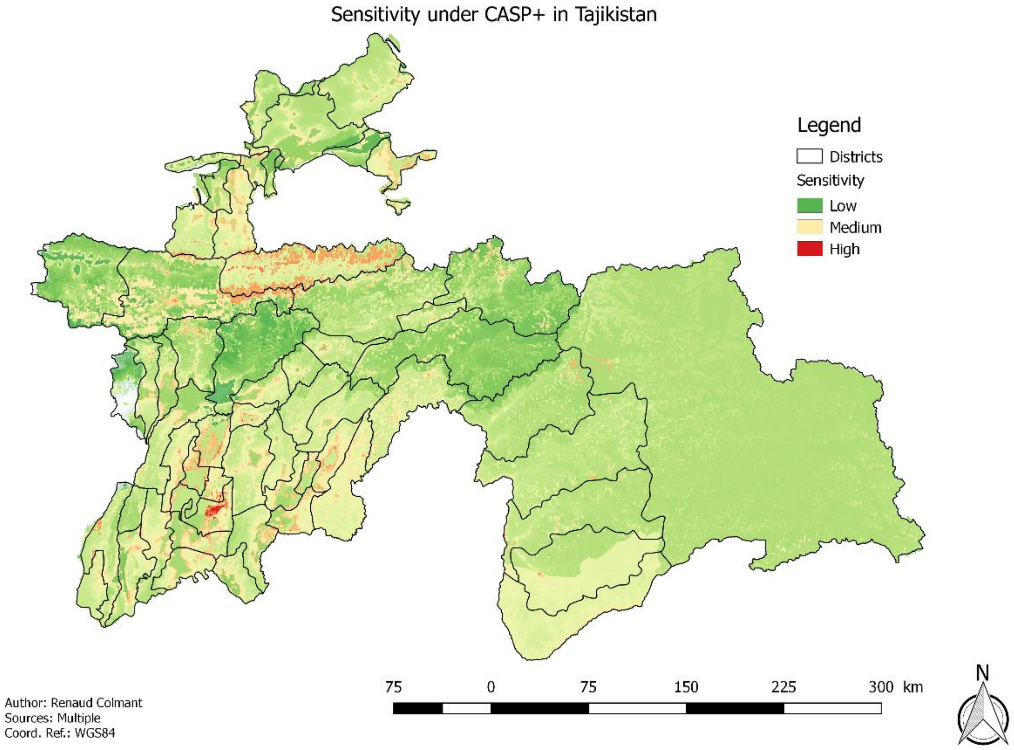


Figure 35 - Sensitivity in Tajikistan



Adaptive Capacity

Figure 36 - Presence of irrigation in Tajikistan
Source: CCI/ESA 2019

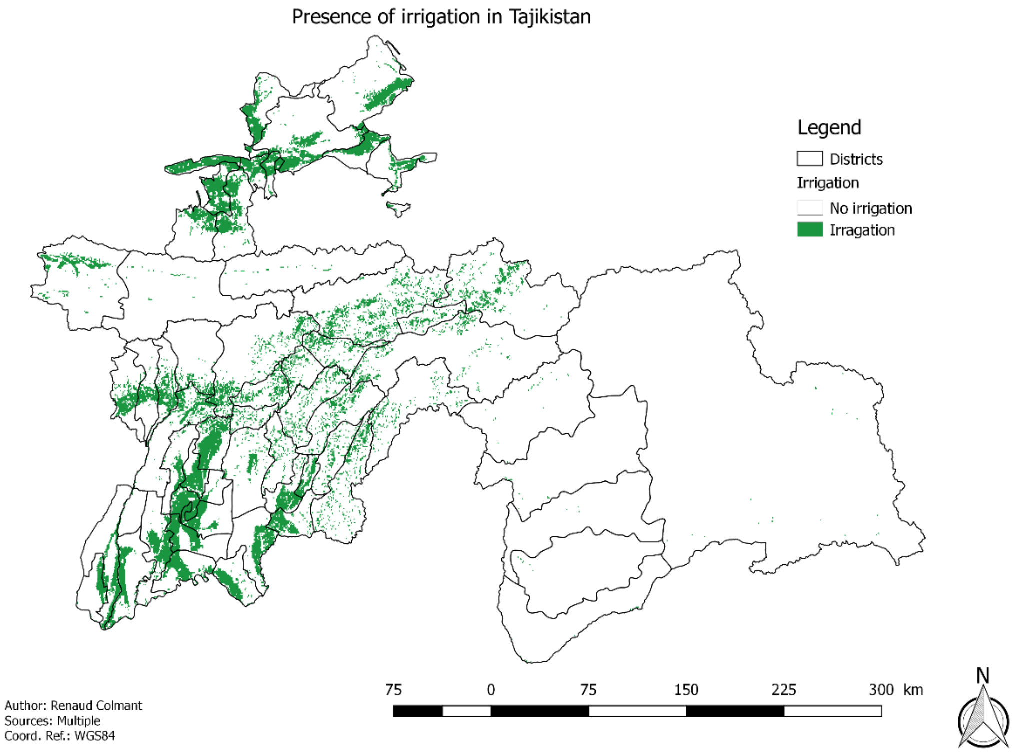


Figure 37 - Main roads in Tajikistan.
Source: gROADSv1[28]

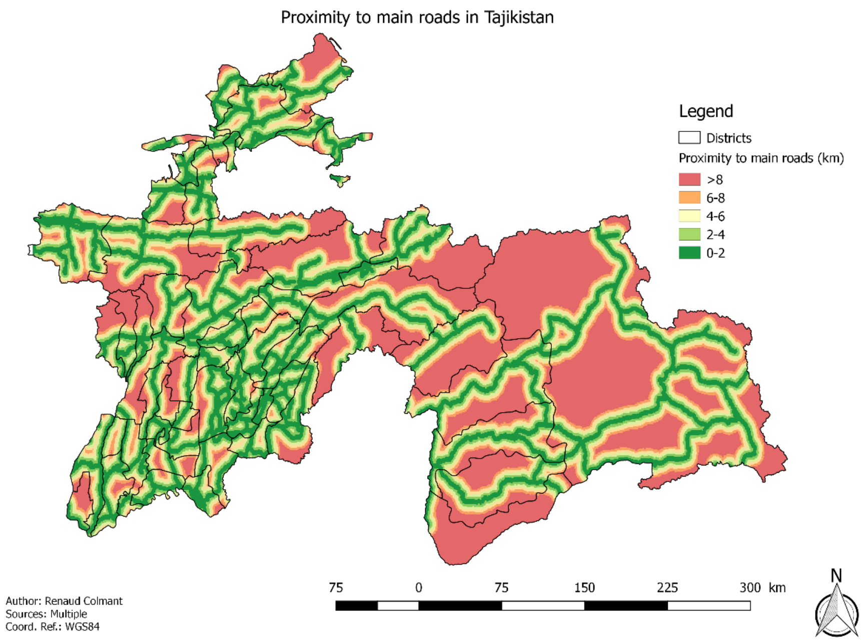
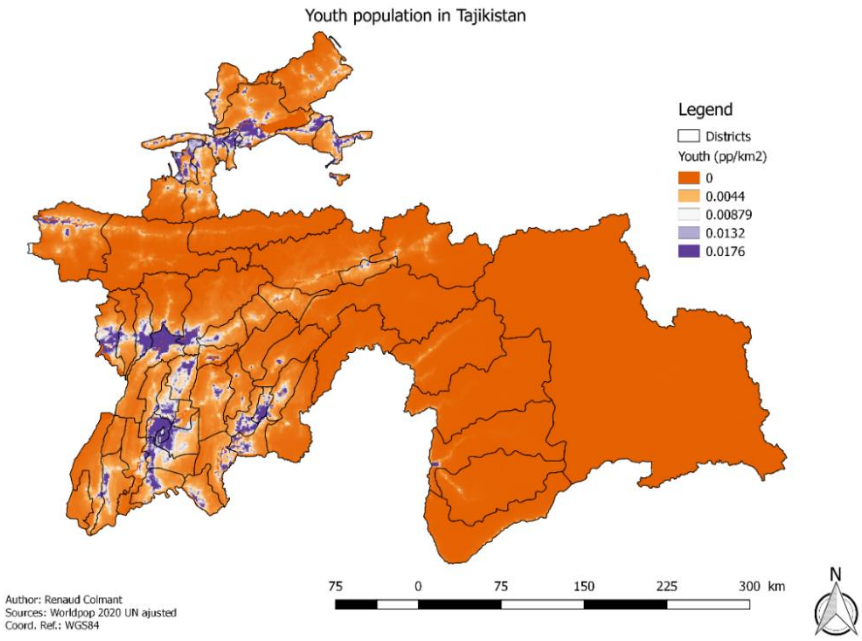
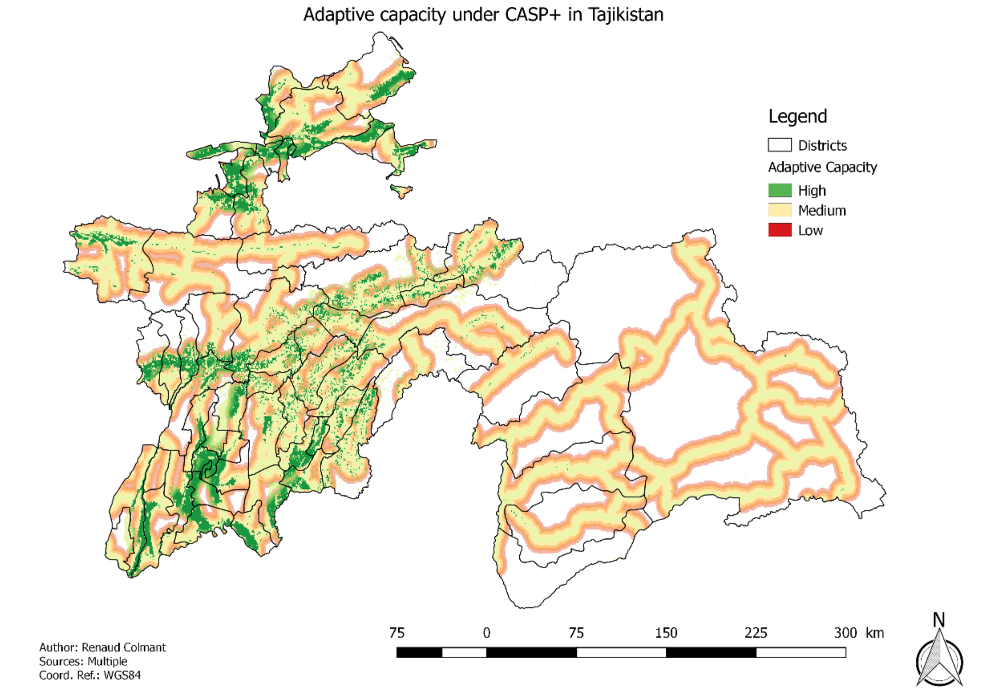


Figure 38 - Youth population in Tajikistan
Data Source: WorldPop - www.worldpop.org



[28] The Global Roads Open Access Data Set, Version 1 (gROADSv1) was developed under the auspices of the CODATA Global Roads Data Development Task Group. The data set combines the best available public domain roads data by country into a global roads coverage, using the UN Spatial Data Infrastructure Transport (UNSDI-T) version 2 as a common data model.

Figure 39 - Adaptive Capacity in Tajikistan



Vulnerability

Figure 40 - Vulnerability index in Tajikistan

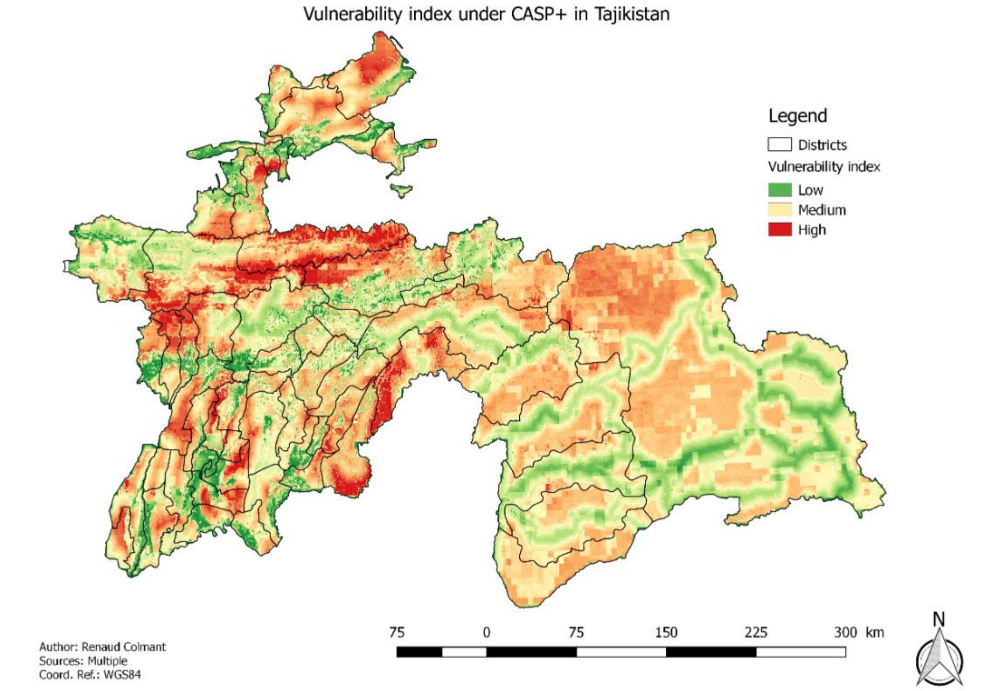
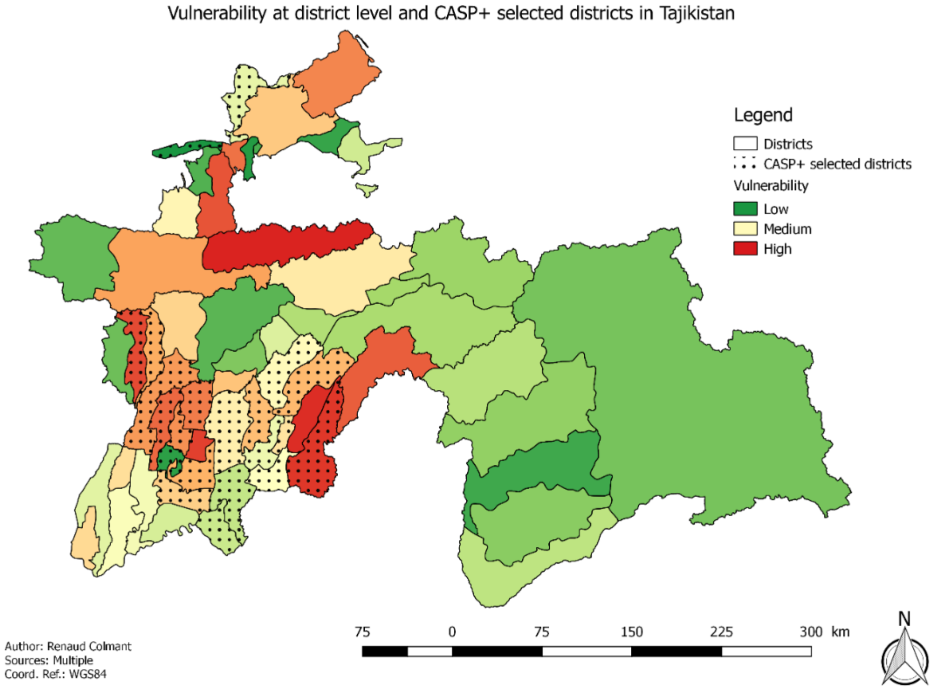


Figure 41 - Selected districts and Vulnerability at district level



56. The climate vulnerability index analysis shows that higher vulnerability to climate is seen in the Eastern and Central Khatlon and in the South East of Sughd. The main reason for this particular location is not only associated with adverse impacts of climate change but also with weak capacity of the population to cope with climate risks, low quality of life and insufficient income. These findings complement the observations and assessments of previous studies[29,30] and reported in the Tajikistan's Third National Communication on Climate Change to the UNFCCC.

57. The project area is situated in 21 districts, 16 in Khatlon region, 3 in RRS region and 2 in the Sughd region. The selected districts vary considerably in their elevation, from high mountains in the South-East of Khatlon (Sh.Sholin, Khovaling and Baljuvon districts) and in the West of RRS (Gissor and Shakrinav districts) with mountains up to more than 4000 meters high, to the medium and low lands in the rest of the districts with elevation down to less than 400 meters high. The selection of the districts was based on a vulnerability index including social, environmental and climatic and infrastructure parameters.[31] The average vulnerability index of the project area is higher than the national average. The area has suffered repeated long-term droughts[32] in recent years (excluding Farkhor and Danghara). The districts also experienced heavy precipitation events, specifically in Sh.Sholin, Khovaling, Baljuvon, Gissor and Shakrinav districts in Khatlon. Most of the project districts are also situated in the area where the average maximum temperature is the highest in the country (except high mountain areas). The districts include the following.

Table 4 - List of selected Districts in CASP+ in Tajikistan

REGION	DISTRICT
Khatlon	Bokhtar/Kushoniyon

[29] United Nations Development Program (UNDP). 2012. Capacity for climate resiliency in Tajikistan: Stocktaking and Institutional Assessment.
[30] Climate risks and food security in Tajikistan. A Review of Evidence and Priorities for Adaptation Strategies. April 2017. WFP.
[31] Climate vulnerability index of Tajikistan, IFAD 2021.
[32] Standardized Precipitation Evapotranspiration Index (SPEI) on 18 months. Climate vulnerability index of Tajikistan, IFAD 2021.

RRS	Gissor
Khatlon	J. Balkhi
Khatlon	Khuroson
Sugd	Mastchoh
RRS	Rudaki
RRS	Shakhrinav
Khatlon	Vakhsh
Sugd	Zafarobod
Khatlon	A. Jomi
Khatlon	Baljuvon
Khatlon	Dangara
Khatlon	Farkhor
Khatlon	Hamadoni
Khatlon	Khovaling
Khatlon	Kulob
Khatlon	Panj
Khatlon	Sh. Shohin
Khatlon	Temurmalik
Khatlon	Vose
Khatlon	Yovon

58. The project area represents a bit more than 15% of the total country area and includes 47% of the national population[33]. Poverty rates in the area are much higher than the national average with a high degree of variation from 8% in Gissor District to 43% in Mastchoh district. With more than 50% of the total livestock heads at national level, it has around 27% of the total pasture area, most of which is highly degraded. The project area is situated in a high agricultural production zone with a bit less than 50% of rainfed and irrigated crops. Only 8% of the actual forest land is situated in the project area, however it includes more than 21% of the potential area for reforestation of the country.[34]

59. By combining the Exposure to climate change variables, the Sensitivity and the Adaptive Capacity, the analysis allowed to create a vulnerability map, that represented the entry point for the selection of the districts. **Main criteria** for geographic targeting therefore included (i) the vulnerability to climate change (including for what concerns natural resources such as rangelands and forests) and (ii) the socio-economic variables (poverty incidence). Additional criteria were used such as: (iii) the overlaying of district area with sub- catchments basins boundaries; (iv) adjacency of selected districts to facilitate implementation; (v) inclusion of upstream and downstream communities highly affected by climate change. The presence and proximity to peri-urban and urban areas, relevant to ensure market access for smallholder producers, will be a sub-criterion to define the potential of livelihoods diversification and enhanced agri-food value chain activities.

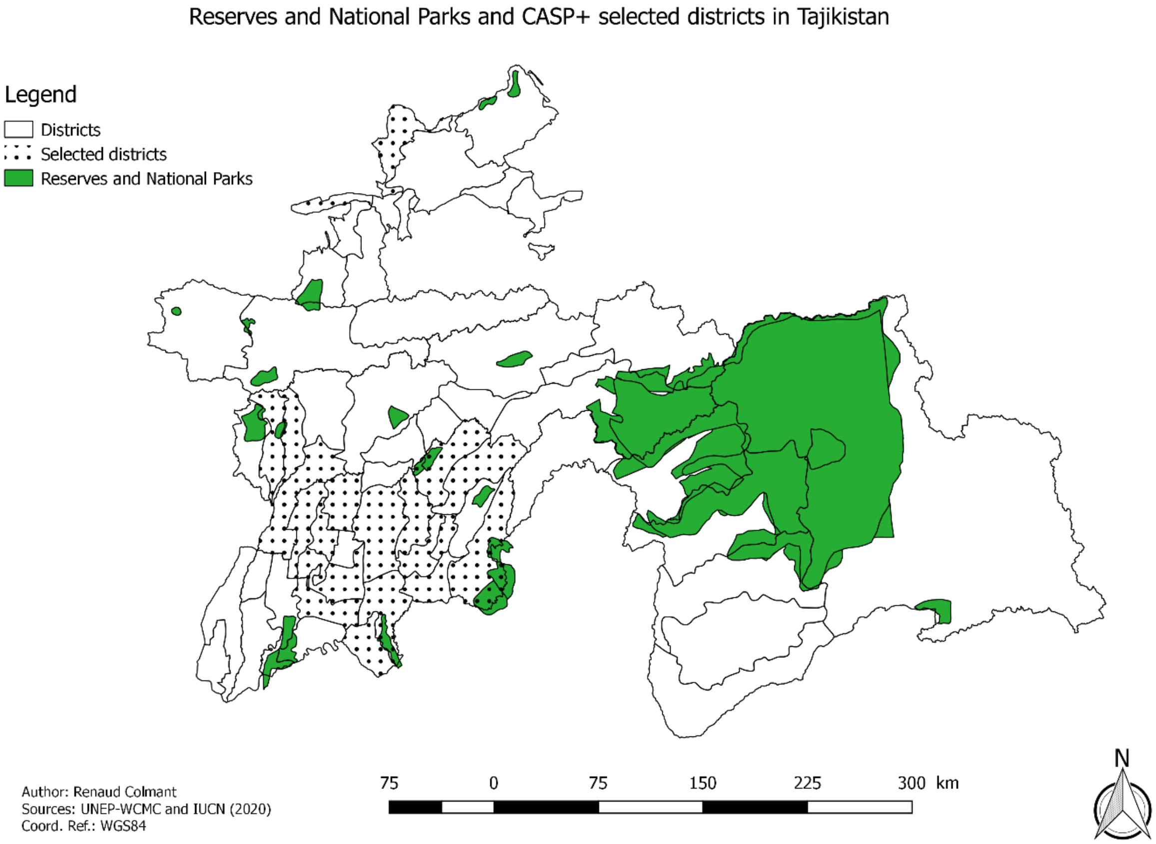
60. As specific selection of intervention areas and scope, CASP+ will intervene in vulnerable areas prone to climate-induced hazards such as river floods, heavy rainfall events, flash floods, mudslides, heat stress in summer, droughts. While addressing the climate vulnerability of targeted rural populations, with climate sensitive investments at community level, the project will tackle inappropriate forest-rangeland management practices causing land degradation that is further exacerbated by climate change.

[33] Tajstat 2020
[34] Based on the analysis of IFAD (2020) using dataset from Bastin et al. 2019 on potential reforestation in the world.

61. Increasing pressure of the livestock on the ecosystem, over-grazing of pastures and forests and pollution of waters are issues that should be tackle by the project at landscape scale. Landscape management practices have a direct impact on agriculture and landscape productivity and on the level of provision of ecosystem services.

62. CASP+ will avoid working in protected areas but will allow reforestation/plantation in buffer areas accompanied by in-depth Environmental and Social Impact Assessment (ESIA). The reserves and national parks of Tajikistan are presented in the map below.

Figure 42 - Reserves and National Parks, Tajikistan.
Sources: UNEP-WCMC and IUCN (2020), Protected Planet: The World Database on Protected Areas (WDPA) [Online], September 2020, Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.



Water sub-catchments basins approach for selection of villages

63. After selecting the district, a water sub-catchments basins approach was used to identify the most vulnerable villages, grouped in cluster in each basin, in each district. The vulnerability criteria was calculated at sub-catchment level and the pre-selected villages (see targeting strategy criteria) were geo-referenced by SEPMU and CEP and the data was shared with the design team. Each village was assigned a vulnerability index depending on its localization. A draft master table with the prioritization of villages was created and will be used and revised at Start-up. The table is available here:

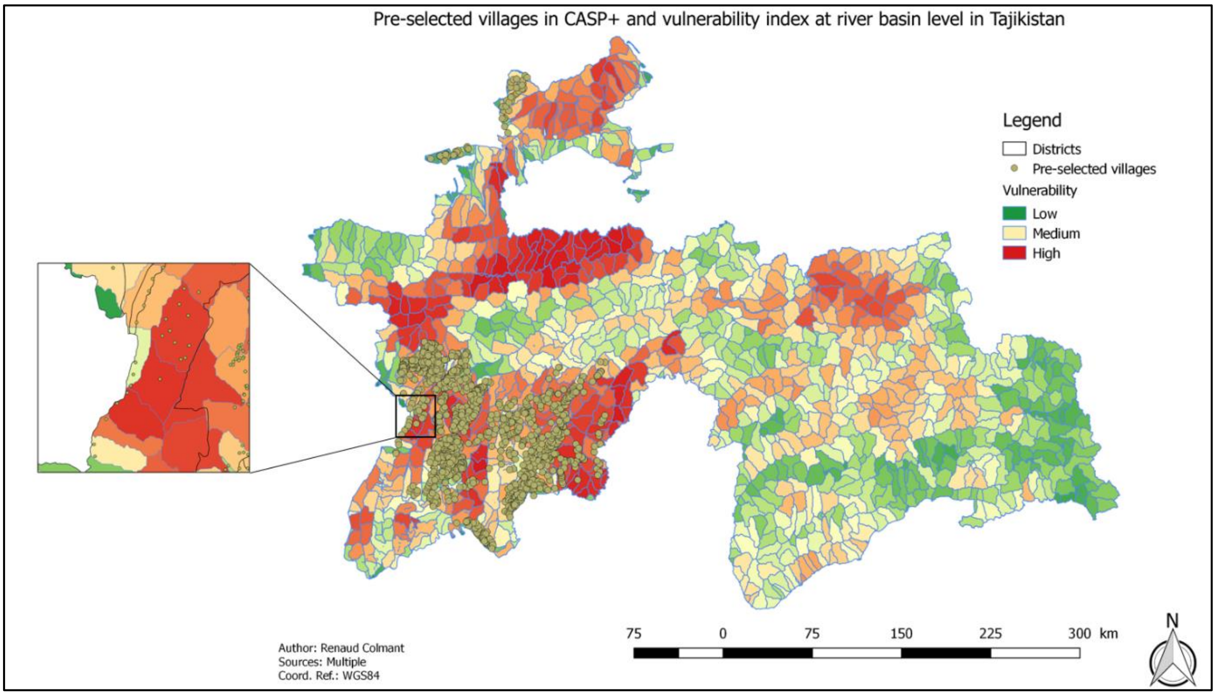
CASP+_Geographic_targeting_villages_river

64. The table allow the implementers to group the most vulnerable villages at water sub-catchment basin level in order to apply a landscape approach (through the CsCAPs mainly). A picture of the table is presented below as well as the vulnerability index at water sub-catchment basin level and the position of the pre-selected villages.

Table 5 - Example of the villages' priorization table based on the vulnerability index

Olast	District	Jamoat	Village	Pop.	HH nr	latitude	longitude	Vulnerability Index
Khatlon	A.Jomi	Dusti	Arkhu	974	223	38°09'14,8099"	68°50'06,0311"	0.283799111
Khatlon	A.Jomi	Dusti	.Hiloli	2903	491	38°08'26,6963"	68°50'52,9977"	0.283799111
Khatlon	A.Jomi	Dusti	Navahor	4300	1071	38°07'32,2543"	68°50'12,2110"	0.283799111
Khatlon	A.Jomi	Q. Giyosov	Navdi	3215	350	38°00'38,4518"	68°48'22,6354"	0.256368342
Khatlon	A.Jomi	Q. Giyosov	Aral	3022	401	38°00'29,6873"	68°49'36,7931"	0.256368342
Khatlon	A.Jomi	Q. Giyosov	ahoriston	1984	221	38°00'49,8938"	68°49'56,8775"	0.256368342
Khatlon	A.Jomi	Q. Giyosov	Fayzor	1687	169	38°00'18,9749"	68°50'38,5912"	0.256368342
Khatlon	A.Jomi	Q. Giyosov	Ozodi Sharq	1731	209	38°00'08,2620"	68°51'18,1420"	0.256368342
Khatlon	A.Jomi	Q. Giyosov	Rudaki	288	52	37°59'41,5803"	68°49'13,8729"	0.256368342
Khatlon	A.Jomi	Kalenin	Tut	1871	208	37°59'13,1079"	68°50'15,8804"	0.256368342
Khatlon	A.Jomi	Kalenin	Chashmasor	1400	362	38°00'07,1019"	68°51'10,5563"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	1-May	3999	566	37°56'40,0617"	68°52'12,0454"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Sayro	2550	367	37°57'07,8388"	68°52'47,5793"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Sayod	624	113	37°55'51,0791"	68°52'59,6299"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Zarnisor	3317	435	37°58'09,4742"	68°52'48,8152"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Vahdat	3001	440	37°58'30,2430"	68°51'10,2627"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Yosuman	1225	208	37°56'52,8337"	68°52'13,5903"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Pakhtakor	748	101	37°58'37,4282"	68°51'55,8388"	0.256368342
Khatlon	A.Jomi	50-solagii Tojikiston	Sunula	2773	458	37°59'28,5717"	68°51'30,5016"	0.256368342
Khatlon	A.Jomi	Dusti	Surkho	690	119	38°03'40,0198"	68°50'23,9526"	0.256368342
Khatlon	A.Jomi	Dusti	Galaa	4893	961	38°04'13,5910"	68°48'29,9351"	0.256368342
Khatlon	A.Jomi	Dusti	Guliston	1090	281	38°04'05,3202"	68°49'59,5423"	0.256368342
Khatlon	A.Jomi	Yakatut	Lohuti	1094	346	37°57'43,3383"	68°57'43,3383"	0.24308218
Khatlon	A.Jomi	Iftikhor	Navood	7720	865	37°36'51,1060"	68°25'57,9284"	0.241535947

Figure 43 - Vulnerabilty Index at Water Sub-Catchments Basins and pre-selected villages in CASP+ in Tajikistan



Preliminary Biodiversity analysis in CASP+ with B-INTACT

65. CASP+ is piloting the new biodiversity assessment tool developed by FAO called B-INTACT. A preliminary analysis based on a number of assumptions has been undertaken on four watersheds in Rudaki, Mastchoh, Sh. Sholin and Dangara to assess the impact the project interventions will have on biodiversity. As information on specific land use changes resulting from project interventions become available, the analysis will be updated and refined. During project implementation, B-INTACT can be used as a participatory decision-making tool to identify areas where the positive impact on biodiversity would be greatest. Overall, the preliminary analysis has shown that the impact on biodiversity in the four watersheds identified is positive with the level of biodiversity intactness increasing in all case studies.

Rudaki watershed results

66. In the case of the watershed in Rudaki, the level of biodiversity intactness would increase from a mean species abundance (MSA) of 0.31 to 0.47 with the project.[35] This is principally thanks to land use changes – MSA(LU) - resulting in the restoration of pastures, afforestation and Joint Forest Management (JFM), as well as a reduction in habitat fragmentation, MSA(F) leading to a higher level of biodiversity intactness.

Figure 44 – Land use in the water basin of Rudaki CASP+ selected district in Tajikistan

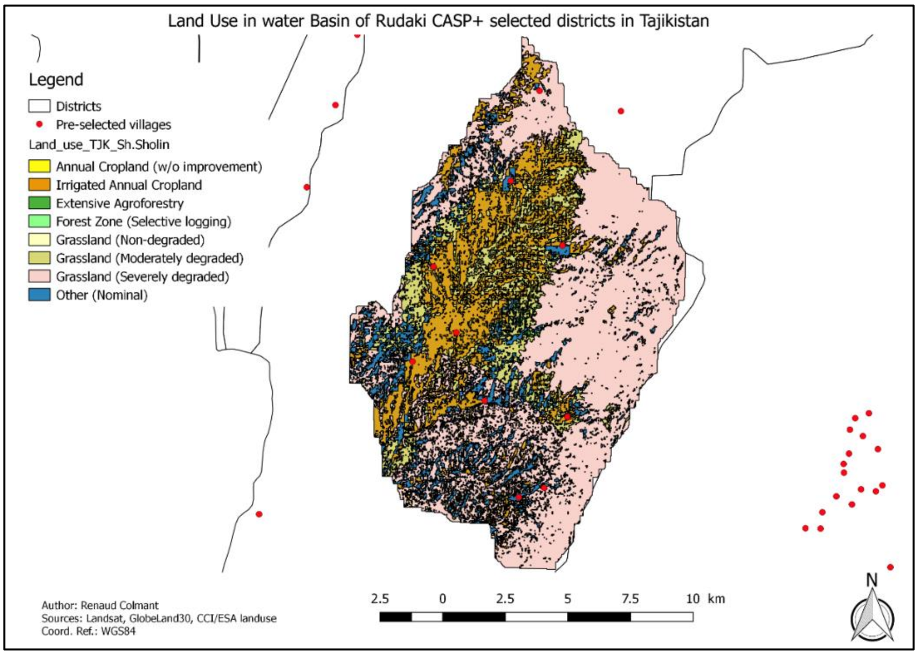
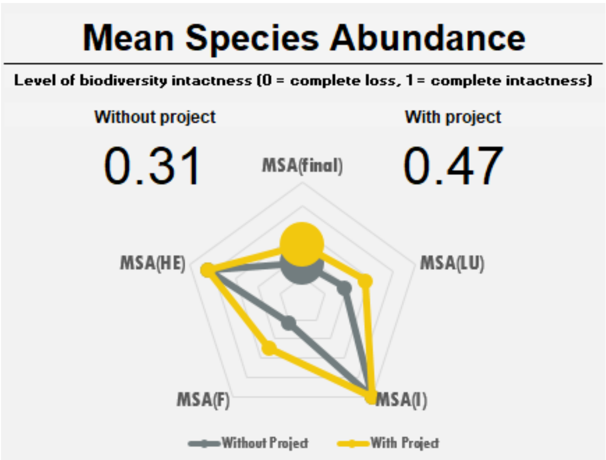


Figure 45 – Level of biodiversity intactness in the water basin of Rudaki CASP+ selected district in Tajikistan



	Without	With Project
MSA(final)	0.31	0.47
MSA(LU)	0.37	0.55
MSA(I)	1.00	1.00
MSA(F)	0.22	0.49
MSA(HE)	0.85	0.85

[35] MSA acts as an indicator of the degree to which an ecosystem is intact, and varies between 0 and 1, with 0 representing a destroyed ecosystem with no original species left and 1 representing an undisturbed ecosystem where all original species remain.

Dangara watershed results

67. In the case of the watershed in Dangara, the level of biodiversity intactness would increase from a mean species abundance (MSA) of 0.32 to 0.43 with the project. As in the case of Rudaki, this is principally thanks to land use changes – MSA(LU) - resulting in the restoration of pastures, afforestation and Joint Forest Management (JFM), as well as a reduction in habitat fragmentation, MSA(F) leading to a higher level of biodiversity intactness.

Figure 46 - Land use in the water basin of Rudaki CASP+ selected district in Tajikistan

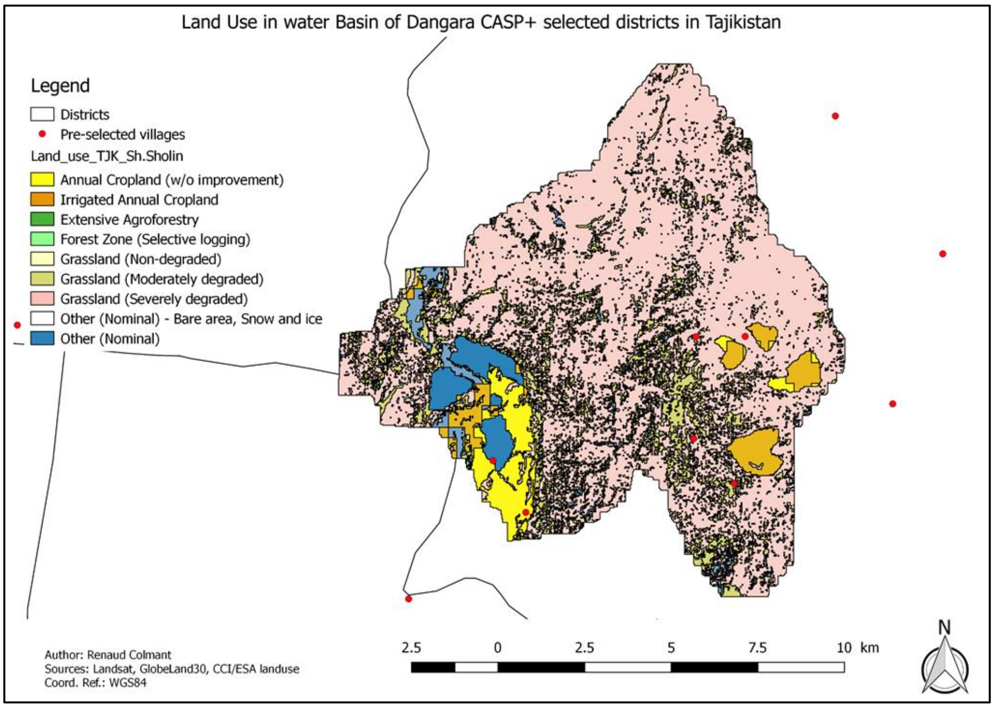
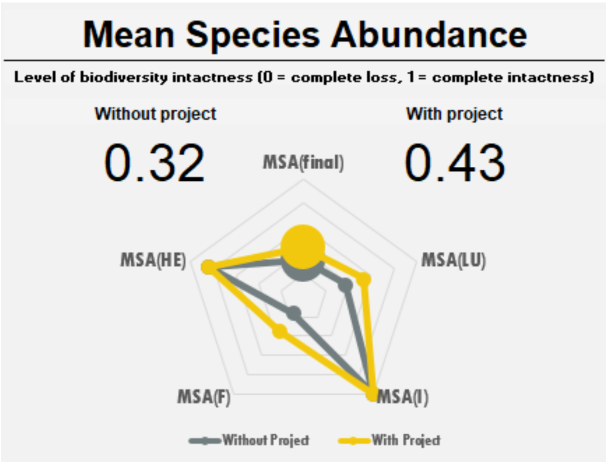


Figure 47 - Level of biodiversity intactness in the water basin of Rudaki CASP+ selected district in Tajikistan



	Without	With Project
MSA(final)	0.32	0.43
MSA(LU)	0.37	0.53
MSA(I)	1.00	1.00
MSA(F)	0.16	0.35
MSA(HE)	0.85	0.85

Mastchoh watershed results

68. In the case of the watershed in Mastchoh, the level of biodiversity intactness would increase from a mean species abundance (MSA) of 0.37 to 0.42 with the project. This is principally thanks to land use changes – MSA(LU) - resulting in the restoration of pastures, afforestation and Joint Forest Management (JFM). Unlike in the two cases above, habitat fragmentation does not play a role in increasing the biodiversity intactness. During project implementation, however, pastures and other areas for afforestation and forest management that would reduce habitat fragmentation could be identified.

Figure 48 - Land use in the water basin of Mastchoh CASP+ selected district in Tajikistan

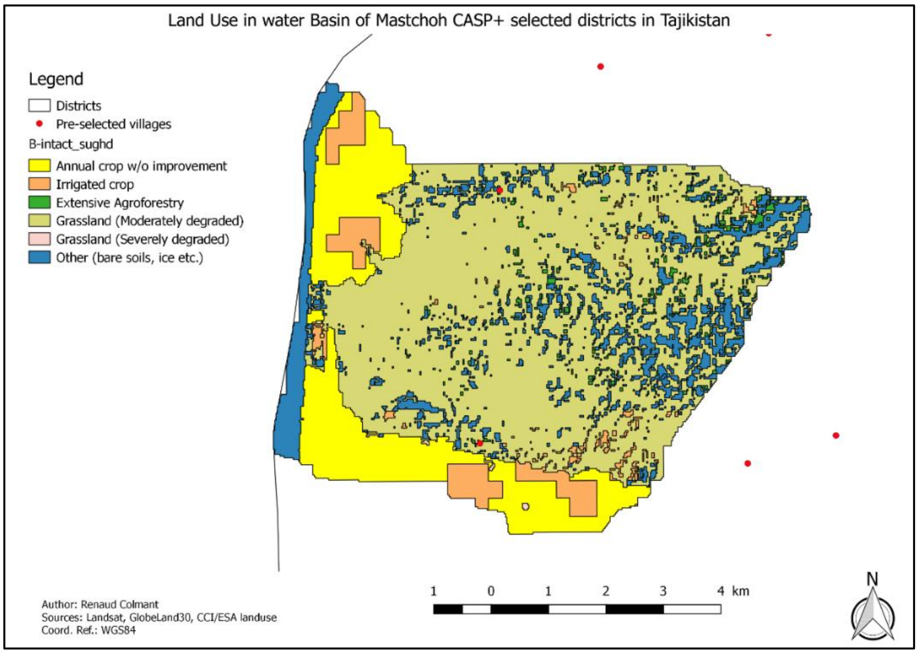
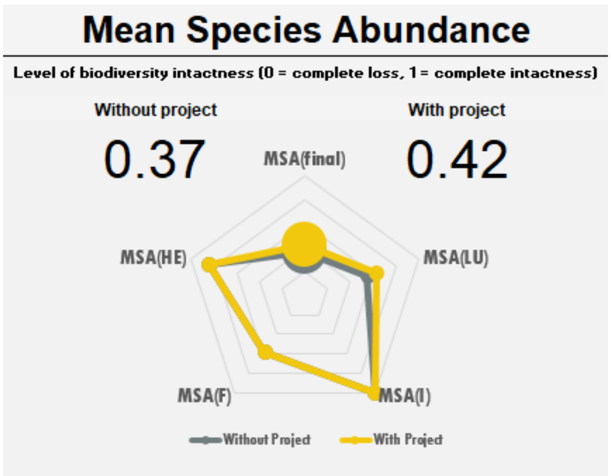


Figure 49 - Level of biodiversity intactness in the water basin of Mastchoh CASP+ selected district in Tajikistan



	Without	With Project
MSA(final)	0.37	0.42
MSA(LU)	0.55	0.63
MSA(I)	1.00	1.00
MSA(F)	0.58	0.58
MSA(HE)	0.85	0.85

Sh. Sholin watershed results

69. In the case of the watershed in Sh. Sholin, the level of biodiversity intactness would increase from a mean species abundance (MSA) of 0.34 to 0.42 with the project. This is principally thanks to a reduction in habitat fragmentation and land use changes – MSA(LU) - resulting in the restoration of pastures, afforestation and Joint Forest Management (JFM).

Figure 50 - Land use in the water basin of Sh. Sholin CASP+ selected district in Tajikistan

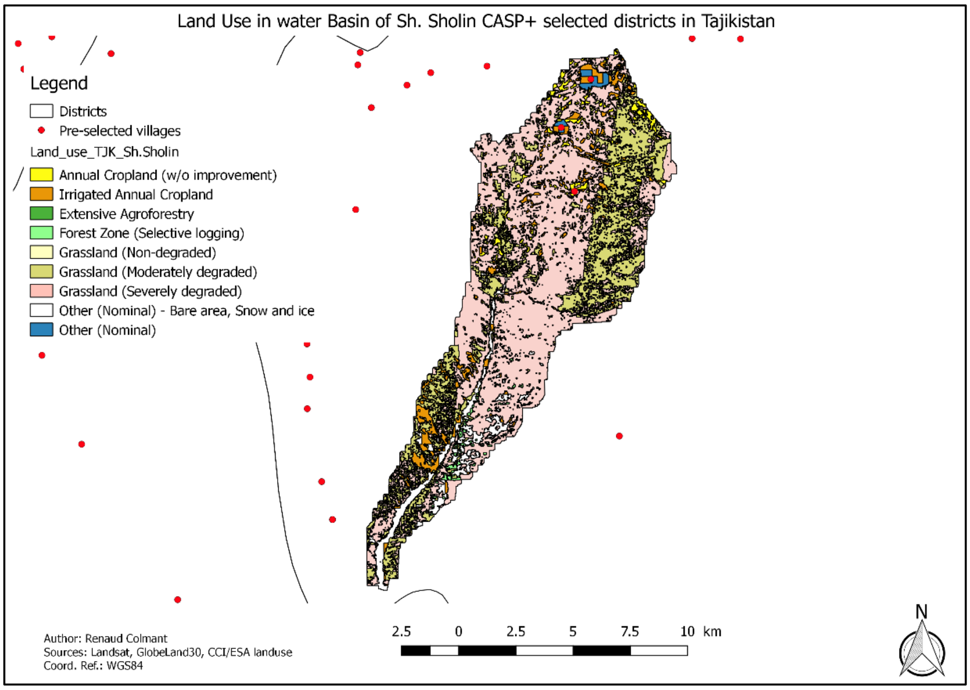
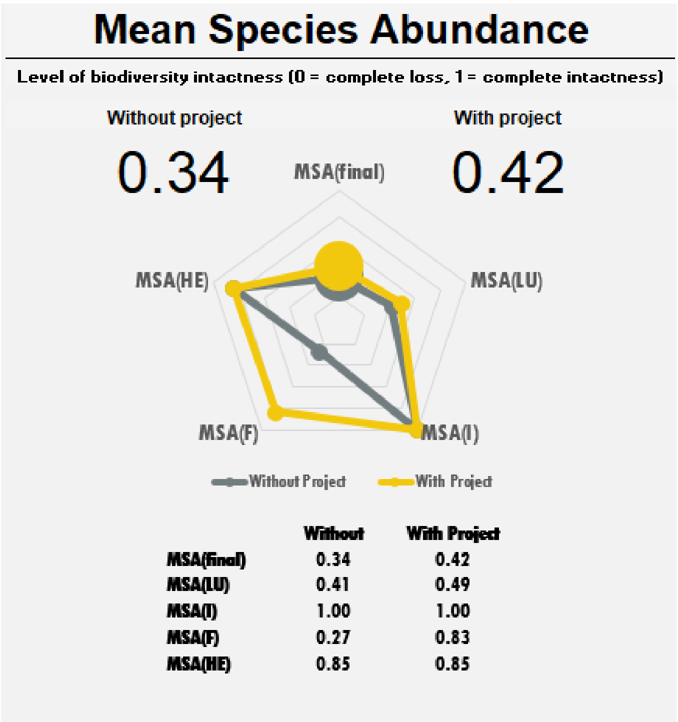


Figure 51 - Level of biodiversity intactness in the water basin of Sh. Sholin CASP+ selected district in Tajikistan



V. Recommendations to enhance resilience to climate change in Tajikistan

70. According to the ND-GAIN Index which captures a country's vulnerability to climate change and other global challenges, and its readiness to improve resilience, Tajikistan is among the most vulnerable countries in Central Asia (ranked second)[36].

71. As indicated in Tajikistan's Third National Communication on Climate Change to the UNFCCC, the main directions for enhancing the resilience of macroeconomic, socio-economic and political spheres to climate change and the impact of extreme hydro-meteorological events include, among others:

- Ensure effective social protection for the population;
- Support the stable development of labour markets and the development of human capital;
- Ensure participation of all stakeholders in the planning and implementation of climate change measures;
- Improve water and food security; and
- Meet fuel and energy demands, achieve energy independence and improve energy security.

72. Also in line with Tajikistan's 2019 National Strategy of Adaptation to Climate Change of the Republic of Tajikistan for the Period Until 2030, CASP+ aligns its activities to respond to the challenge of climate change in Tajikistan and improve the resilience of the most vulnerable smallholders. This would not be possible without including local population in a participatory manner and have a market linkage. CASP+ would include communities and villages and support them to adopt sustainable use of their assets in time (natural resources, capital, access to services and institutions). In this regard, the project would support smallholders along the main value chains in an integrated manner while supporting diversification interventions—such as technical/ entrepreneurial training and productive investment grants to help households diversify their income sources and become more resilient to climate change. Diversification is a common risk reduction measure and should be done at two levels: (1) diversification of income sources to reduce financial risks; and (2) diversification of agricultural products to reduce the vulnerability of smallholders to climate change and extreme weather events.

73. CASP+ would, as a priority activity, aim at reducing climate change-related stress, especially of pastures and forests ecosystems through the rational management of water resources, forests and pastures using a landscape approach with sustainable practices such as agroforestry, agroecology, and others.

74. The combination of climate change adaptation and risk mitigation measures at the community level is key to both improve ecosystem and smallholders' resilience and reduce GHG emissions. CASP+ would rehabilitate degraded pasture, promote reforestation, and promote local genetic resources (local cultivars and wild relatives). In addition, the project might also support (depending on the needs) renewable energy (introduction of solar dryers, photovoltaic panels).

75. Forest planting is the most effective way of reforestation and forest management in Tajikistan[37]. Forests belong to the State Forest Agency and are managed at local level by Forest Enterprises (Leskhoz), with often limited budgets. The development of private and community-based forest management, reforestation and the expansion of forest shelter belts are promising areas of intervention (Joint Forest Management is recognized as the most effective practice to ensure involvement communities and institutions). The below sections describe the opportunities of action of CASP+ in forestry, livestock and horticulture systems with evident links between them.

[36] ND-GAIN, 2018: https://gain.nd.edu/our-work/country-index/rankings/
[37] Tajikistan's Third National Communication on Climate Change to the UNFCCC, 2014.

A. Opportunities for alignment with the updated NDCs

76. Based on the general analysis of the information received to prepare the updated NDC, the following adaptation measures have been formulated for the key sectors of the economy in Tajikistan[38]:

Agriculture

77. Tajikistan's agriculture is very vulnerable to climate change. Without substantial adaptation measures, food and nutrition security, poverty eradication and sustainable development may be adversely affected. Adaptation measures are of priority both for crop production (including cereals and leguminous crops, technical crops, vegetables and horticulture and viticulture) and livestock subsectors. Agricultural adaptation measures contribute to national policy objectives for agriculture, food and nutrition security, gender, disaster risk reduction, industrial development, and biodiversity conservation (e.g., National Biodiversity Strategy and Action Plan under the CBD), and thus contribute to multiple SDGs, the Sendai Framework and commitments under the CBD and the UNCCD. Giving high priority to agricultural adaptation enhances the NDC by maximizing synergies with other key development objectives:

- Introduction of "green" technologies and "green" infrastructure in agro-industrial production
- Improvement of livestock breeding,
- Development of agroforestry and conservation agriculture,
- Crop rotation, intercropping and crop diversity (resilience to droughts and pests),
- Enhancement of seeds,
- Promoting soil protection and integrated pest management,
- Improved management of irrigation and drainage systems,
- Improved pasture management,
- Raising awareness and increasing access to climate change information for rural populations, farmers and agricultural enterprisers.

Forestry

78. In forestry, adaptation measures (many of which also have strong mitigation benefits) include:

- reforestation/afforestation,
- natural and active/assisted regeneration,
- forest protection from cutting, grazing, fire, pests etc.,
- improved and sustainable management of existing forest,
- improved pasture productivity, promoting crosscutting actions: integrated land management, improving the regulatory framework, strengthening law enforcement, developing a sustainable financing system, conducting inventory and monitoring, and investing in science and innovation.

Cross-sector

79. Adaptation measures in cross-sectoral areas:

- creating an enabling environment for the introduction of new technologies for climate change mitigation and disaster risk management;
- taking gender-sensitive measures to enhance planning;
- management and communication of risks related to climate change; construction of new recreational zones within cities and around them when adjusting master plans;
- developing curricula for secondary schools, secondary vocational and higher educational institutions, including issues of climate change mitigation, adaptation and early warning of natural disasters;

[38] Updated Nationally Determined Contribution (NDC) towards the achievement of the global goal of the UN Framework Convention on Climate Change (UNFCCC) by the Republic of Tajikistan, 2021.

- strengthening mechanisms to organize a regular professional training of the employees of authorized bodies and government officials on climate change adaptation and governance;
- arranging media campaigns on climate change and disaster risk management.

80. The above assessment of adaptation opportunities in Tajikistan directed the design of CASP+ and the choice of activities as presented in the below sections.

B. Opportunities in afforestation/reforestation

81. Tajikistan has potential for reforestation and can, in the context of the country's risks presented above, respond to current challenges. Indeed, reforestation and afforestation are one of the best options to improve soil erosion management and water retention in soils. Besides, agro-silvo-pastoril systems can offer alternative and complementary ways of fodder production for livestock from fodder trees. These systems bring more biodiversity to a productive landscape.

82. Biodiversity is inherent to food production and crops productivity. According to Krishnan et al. (2020)[39], agricultural landscapes adjoining fragmented forests and natural areas benefit from pollinator services, and animal-pollinated crops therefore achieve higher fruit set. On the other hand, pollinators benefit from diverse natural habitats for forage and nesting, especially when these are limited in plant production systems. The extent of forests and other natural habitats in a landscape plays a role in determining the species composition of pollinators. Landscape and forest management practices can help ensure the continued availability of pollinators and thereby increase resilience and the productivity of forestry and agriculture.

83. In the context of the design of CASP+, an analysis of the potentiality of reforestation was done based on the more recent study undertook at global level from Bastin et al. (2019)[40].

84. To facilitate the pre-feasibility analysis of project's investment, based on the maps of tree restoration potential of the Earth at 1-km resolution41, of the SRTM at 90 m42 and of the rivers in Tajikistan43, thresholds were established for each type of reforestation and presented in Table 6. The maps below represent the potential of reforestation by forest type (Figure 52). The Table 7 presents the total potential at national level by forest type.

85. Each forest type is composed of more than one tree species. The species of trees in each forest type have been pre-selected after discussion with local experts and are local tree species[44]. They are the most adapted to the conditions of the country and further study will be made during implementation of CASP+ to identify the most suitable species by location in relation to the changing climate.

Table 6 - Thresholds were established for each type of reforestation in Tajikistan

Forest Type	Slopes	Altitudes	Adjacency to water	Priority if overlapping
Riparian	<15% and 15-30%	300 – 900m	Inside 200m buffer of the centre line of a river	1

[39] Krishnan, S., Wiederkehr Guerra, G., Bertrand, D., Wertz-Kanounnikoff, S. and Kettle, C.J. 2020. The pollination services of forests – A review of forest and landscape interventions to enhance their cross-sectoral benefits. Forestry Working Paper No. 15. Rome, FAO & Bioversity International.
[40] -Bastin, J-F. ;Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., Routh, D., Zohner, C. M., Crowther, T. W., The global tree restoration potential. Science 05 Jul 2019: Vol. 365, Issue 6448, pp. 76-79. DOI: 10.1126/science.aax0848
[41] Ibid.
[42] NASA's Shuttle Radar Topography Mission (SRTM) in 2000, released in 2015. https://www2.jpl.nasa.gov/srtm/
[43] HydroRivers: Lehner, B., Grill G. (2013): Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes, 27(15): 2171–2186. Data is available at www.hydrosheds.org
44 List of pre-selected tree species, among others: Turkestani maple (Acer tatarcium semenovii) with Tajik poplar (Populus tadshikistanica) admixture. Persian Walnut (Juglans regia) with Tajik poplar (Populus tadshikistanica) admixture. White saxaul (Haloxylon persicum) and black saxaul (Haloxylon aphyllum). Coniferous Forest (Juniperus zeravshanica, J.semiglobosa, J. turkestanica, J. sibirica) with Turkestan birch (Betula turkestanica), Tajik poplar (Populus tadshikistanica) and barberry (Berberis vulgaris). Pistachio (Pistacia vera) forests with Burkharian almond (Amygdalus bucharica). Sea buckthorn (Hippophae rhamnoides)

Fruit and nut	<15% and 15-30%	1000 - 2000m	N/A	2
Pistachio	<15% and 15-30%	1500 – 2500m	N/A	3
Juniper	<15% and 15-30%	900 to 3200 m	N/A	4

Figure 52 - Reforestation potential by forest's type, CASP+, Tajikistan.
Source: Bastin et al. (2019) and IFAD (2020)

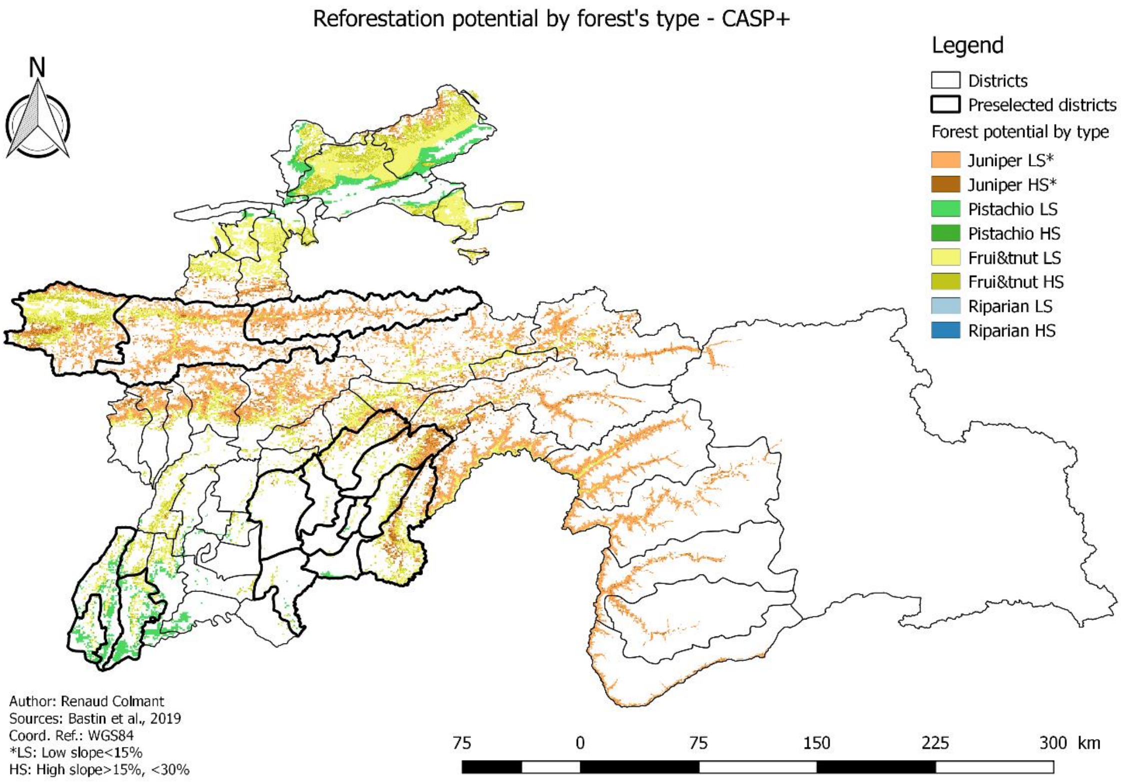


Table 7 - total potential at national level by forest type

Forest type (ha)	Total (ha)
Riparian low slope	233
Riparian high slope	2 802
Fruit & Nut low slope	317 001
Fruit & Nut high slope	821 884
Pist low slope	8 059
Pist high slope	83 951
Juniper low slope	142 629
Juniper high slope	554 540
Total (ha)	1 931 099

C. Opportunities in Livestock systems

86. Grazing systems emit greenhouse gases, which can, under specific agro-ecological conditions, be partly or entirely offset by soil carbon sequestration45. However, any sequestration is time-limited, reversible, and at a global level outweighed by emissions from grazing systems. Thus, grazing systems are globally a net contributor to climate change and the time scale of key processes needs to be factored into any mitigation efforts. Failing to do so leads to unrealistic expectations of soil carbon management in grazing systems as a mitigation strategy. Protecting the large carbon stocks in grazing lands is also essential in order to avoid further climate change from additional CO2 release. Despite the time-limited and reversible nature of soil carbon sequestration in grazing lands, sequestration should be promoted in cases where it delivers environmental and agronomic benefits as well as for its potential, particularly on degraded land.

87. The FAO report "Five practical actions towards low-carbon livestock"[46] proposed five actions which can be widely implemented for measurable and rapid impacts on livestock emissions:

- Action 1: Boosting efficiency of livestock production and resource use.
- Action 2: Intensifying recycling efforts and minimizing losses for a circular bioeconomy.
- Action 3: Capitalizing on nature-based solutions to ramp up carbon offsets.
- Action 4: Striving for healthy, sustainable diets and accounting for protein alternatives.
- Action 5: Developing policy measures to drive change

88. Shaping a sustainable future depends on understanding the diversity and complexity of livestock agrifood systems and the challenges stakeholders face during transformative change. CASP+, in this regard, will, where feasible, align its activities to these five practical actions[47].

89. Action 1 - Boosting efficiency of livestock production and resource use. Livestock production is responsible for substantial contributions to greenhouse gas emissions; however, healthier animals are more productive and generate lower emissions per weight of product. Technological innovations such as improved feeding, genetics, animal health, general husbandry and information technology are driving up productivity, making resource use more efficient with potential to reduce environmental impact[48].

90. Jointly with pasture management, manure management and improved feeding practices, animal health would be considered an integral part of climate change strategies of CASP+[49]. This would contribute to reducing the impacts of climate change on animal health.

IMPACT	DIRECT IMPACTS	INDIRECT IMPACTS
A changing climate can have devastating impacts on the health of animals. It can also affect disease patterns, making outbreaks harder to control. Livelihoods that depend on animals are becoming less secure as a result.	Climate-driven fluctuations in environmental conditions such as droughts, fires, floods, heat stress and unpredictable weather influence the physiological and immune responses in livestock.	Climate change affects incidence, spread and predictability of animal diseases.
The stress caused by these factors is difficult to control and can affect animal production and public health, the safety of foods, and disease burdens from bacteria, parasites, and their vectors.		

91. Reducing the impact of climate change on animal health and on the spread of infectious diseases would reduce greenhouse gas emissions from the livestock sector and enhance resilience of vulnerable communities to climate change.

[45] Godde, C.M., de Boer, I.J.M., Ermgassen, E.z. *et al.* Soil carbon sequestration in grazing systems: managing expectations. *Climatic Change* **161,** 385–391 (2020). https://doi.org/10.1007/s10584-020-02673-x
[46] FAO. 2019. Five practical actions towards low-carbon livestock. Rome Accessible at http://www.fao.org/3/ca7089en/ca7089en.pdf
[47] The specific feasibility will be analysed during the full design with livestock and pasture experts.
[48] Ibid.
[49] See CASP+ Working Paper on Animal Health, 2021

92. In parallel, the programme could support national efforts on the prevention, preparedness, early detection and early response to animal health threats and emergencies that could be triggered by climate change through:

- Strengthen animal health systems by investing in the public and private sector.
- Promote the progressive control and elimination of priority animal diseases.
- Promote One Health approaches to disease control – involving public, private, wildlife and environmental health sectors.
- Enhance animal health as part of the overall sanitary requirements for circular agri-food systems, facilitating recycling of different biomass streams.

93. Action 2 - Intensifying recycling efforts and minimizing losses for a circular bioeconomy. Promoting a circular bioeconomy involves recycling resources at every possible step in agri-food systems and closing systems to minimize the loss of resources and nutrients. Manure management fulfils both adaptation and mitigation objectives. The GHG emissions dimension associated with manure is complex[50]. Manure management – without bedding and water – have nutrients that are valuable for soil and grass' health and growth rates. The three most important nutrients N, P and K are present in the manure together with a few micronutrients. Manure also contains calcium, magnesium, sulphur, boron, copper, iron, manganese and zinc. Various options exist to modify GHG emissions in the production, storage and application of manure.

94. In extensive systems like in Tajikistan, manure has to be collected from the field, usually once it has dried and methane emissions are negligible[51]. Improved livestock diets and the use of certain feed additives can substantially reduce methane emissions from enteric fermentation and manure storage[52]. Unused crop residues, food waste, and agro-industrial by-products are lost opportunities to recycle and optimize resource use efficiency and can be repurposed for animal feed. Furthermore, manure and slaughterhouse waste can be used to generate fertilizer and biogas as a source of renewable energy.

95. In many regions of Tajikistan, annual pasture production is predicted to increase due to carbon dioxide fertilization and warmer temperatures during winter/spring; specifically in high mountain pastures, a temperature increase of 1.5-3°C could increase pasture productivity by 25-50%[53]. Production may decline, however, in regions with either reduced rainfall or severe flooding as expressed in the CARD analysis based on the RCP 8.5 climate scenario for managed grassland. Should this occur, as adaptive measures farmers could strategically use supplementary feed, reduce stocking rates, plant local and fodder trees, irrigate, or sow alternative plant species with greater drought tolerance.

96. Action 3 - Capitalizing on nature-based solutions to ramp up carbon offsets. Agriculture is the largest direct driver of deforestation globally but nature-based solutions like carbon sequestration can help offset emissions. When management practices that deplete soil carbon stocks are reversed, grassland ecosystem carbon stocks can be rebuilt, sequestering atmospheric CO2[54]. Healthy plants begin to grow earlier in the spring, become more productive throughout the summer, and continue to grow later into the fall. Healthy, properly managed pastures produce better quality and greater quantities of forage for animals and lengthens the grazing season, producing healthier animals and reducing costs. Soil carbon sequestration through regenerative grazing practices and restoring degraded land can help put carbon back in the ground and vegetation.

97. The analysis of the grassland[55] over time (2000-2004 compared with 2016-2000) permitted to locate hot spots where grassland present moderately and severely degraded evolution. These

[50] L. Lipper et al. (eds.), Climate Smart Agriculture, Natural Resource Management and Policy 52, FAO, 2018. DOI 10.1007/978-3-319-61194-5_17.
[51] P. Smith, D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, M. Howden, T. McAllister, G. Pan, V. Romanenkov, U. Schneider, S. Towprayoon, M. Wattenbach, J. Smith, (2008) Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences 363 (1492):789–813
[52] FAO. (2013). Climate smart agriculture sourcebook. FAO Rome.
[53] World Bank Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/tajikistan/impacts-agriculture (visited in November 2020)
[54] https://edis.ifas.ufl.edu/pdffiles/SS/SS57400.pdf
[55] Vegetation indices considered: NDVI, EVI, SAVI, MSAVI from Landsat 5 & 8 of NASA. https://www.usgs.gov/core-science-systems/nli/landsat/

hotspots have a direct relation to climate change as described above. Prioritization and adapted practices have been decided on this basis and the diagnostic at district level during implementation will give further details.

98. Grassland management practices that reduce emissions also enhance adaptation[56]. Well-managed grasslands provide multiple co-benefits that are critical to adaptation and is thereby a key adaptation and mitigation strategy for addressing climate change and variability. Lush pastures also conserve water and filter out manure or compost and nutrients, keeping them from entering nearby water bodies, protecting water quality, human health, and animal health. Indeed, the increasing organic matter content at the surface helps improve and stabilize soil aggregation at the soil surface resulting in increased water infiltration, and reduced runoff and erosion. These effects will be further amplified with the planting of fodder tree species in pastures. Keeping more water on fields reduces the threat of contamination of surface waters from runoff. The addition of manure by the grazing animals adds additional organic matter, which is rapidly incorporated into the soil matrix by earthworms and other soil organisms. In that sense, manure or compost application in remote pastures is also avoiding the concentration and infiltration in areas closed to residences and water sources. Furthermore, risks associated with prolonged drought periods and unreliable rains as presented in the climate analysis can be offset by the increased water infiltration and retention associated with organic matter accumulation in the soil. It will improve nutrient cycling and plant productivity and, at the same time, enhance the conservation and sustainable use of habitat and species diversity. Finally, livestock farms can contribute to renewable energy production through biogas, solar and wind power.

99. Potential investments under Action 4. Striving for healthy, sustainable diets and accounting for protein alternatives would be covered by the diversification in value chains in subcomponent 3.3 of the CASP+. Giving opportunity to farmers to develop alternative production to livestock.

100. For Action 5. Developing policy measures to drive change, CASP+ would establish strategic partnerships with institutions and development partners active in the climate sensitive dialogue and investment, complementing the efforts and contributing with evidence and lessons from the investment on the ground and from innovative climate change related monitoring platforms and tools (including remote sensing, carbon accounting tools as most prominent innovations). Specifically the project intends to (a) strengthen national capacities to plan, manage and monitor the natural resource base at central and decentralized levels; (b) propose relevant upgrades in evidence-based policy and regulatory framework improvements for improved climate sensitive evidence-based integrated natural resources management, focusing on forestry, pasture, animal husbandry/feed, animal health, water management, green agri-food value chains, energy; and (c) support an improved enabling environment for participation in selected value chains[57] of rural population in climate vulnerable areas (including public-private producers partnerships, rural alliances)[58], supporting farmers to organise transport and sale of agricultural products and guarantee better price.

101. The CASP+ project would support farmers in coping with climate change and climate variability by improving agricultural practices including sustainable crop and livestock production, animal reproduction and health, feed and pasture management, income diversification and vegetation regeneration activities (including reforestation). Small-scale infrastructure improvements (e.g. rural roads, irrigation, collection centres) would also be undertaken, to support farmers' activities.

102. The Project would address the effects of heat stress and droughts on livestock by improving livestock water supply systems and water points in the most vulnerable areas. The Project would also promote the improvement and maintenance of rural roads and collection centres.

[56] Richard T. Conant. Integrated Crop Management Vol. 9 - 2010 - Challenges and opportunities for carbon sequestration in grassland systems. FAO. pp. 66
[57] An assessment of the related agrifood value chain is ongoing and will be informing the final design of CASP+.
[58] **Public-private producers partnerships** (also referred to as 4Ps) involve cooperation between a government, business agents and small-scale producers, who agree to work together to facilitate access of producers to markets, technical assistance, knowledge, technology and capital. A **rural alliance** is a formal agreement between a group of organized farmers and a buyer, for the provision of a certain good, in a specified quantity and quality.

103. Rural roads will help improve transport and communications for the most vulnerable in rural areas. Improving mobility allows access to: (i) services (agriculture, education, health, finance); (ii) markets (inputs, agro-industry, wholesale trade, retail, export); (iii) income-generating activities; (iv) social, political and community activities; and (v) technology transfer. All the potential climate threats will be recognized under the CsCAP planning and design and design standards for rural roads - especially for drainage - need to be adjusted to avoid increased environmental damage. With climate change and the increased risks associated with climatic hazards, the period of recurrence of events will have to be increased, adapting installation of drainage works and river crossings.

104. The project will seek to align for minimal negative impact - when the project involves the realignment of an existing road, it will consider all the alternatives and choose the road that will have the least direct and indirect negative impacts, taking into account the soils, climate, geology, topography, hydrology, ecology, land tenure, existing uses and other socio-economic factors (via the participatory approach of the project). No physical resettlement or economic displacement will be expected. In addition, the project foresees the consultative design of road sites using local knowledge, and safety measures will be included in the design of road rehabilitation activities according to national law. The development of infrastructures will be linked to the needs expressed in the participatory approach. Design for road safety will accommodate all prospective users and will not exceed the national standard design speed for rural roads; and provide speed bumps (with accompanying warning signs) in highly populated areas such as villages, schools, markets and other centres. Road safety assessment will be done for each phase of the project and will monitor incidents and accidents and implement measures to resolve them, and prepare regular reports for this type of activity's monitoring.

105. In order to improve the adaptation of livestock farmers to climate change, the project would support activities on pasture management and waste management. Not using animal manure or efficiently transform it in compost can be a real loss for farmers. Almost anything on a livestock farm can be managed and utilised to achieve a more environmentally and sustainable way of producing while gaining more profit while reducing GHG emissions. Improving pasture management by using manure to increase pasture quality in the mountains could be spread through Pastoral / Farmers Field Schools (PFS/FFS). This practice is not well spread among farmers and could be improved with the support of CASP+.

106. To successfully achieve pasture management, the project would count on the creation and strengthening of Pasture Users Union which demonstrated positive results in previous MoA-implemented and IFAD-funded projects.

107. To support manure and compost transportation, it is recommended to support trailers for manure and compost transportation. The project could also promote use of renewable energy for storage facility units (e.g. solar photovoltaic panels)

Livestock/dairy	Seeds and other inputs	On-farm production	Harvesting-Storage-Processing	Product Marketing
Potential impacts of CC on farmers. **Main effects: Drought and high precipitation**	Poor access to inputs (transport, storage, etc.) Quality of pasture reduced, insufficient fodder, high cost of feed, fertility reduced, high cost of breeding	Lower milk production due to low animal feed. Increase pests and diseases due to poor feeding and low immunity.	Decrease access, increase operational costs (collecting milk and feed), increase milk spoilage	High operation costs incurred by milk traders; reduced market/marketing activities due to reduced milk production
Potential options to increase farmers' adaptive capacity under CASP+	• Strengthen and expand national platforms, policies, infrastructure, and tools to prevent, prepare and respond to animal health related emergencies triggered by climate change. • Support to select most suitable breeds for the area, following already approved plans, • feed conservation, • Inputs supply: involvement of pharmacist owners	• Strengthen and expand national platforms, infrastructure, and tools to prevent, prepare and respond to animal health-related emergencies triggered by climate change. • Develop capacity for epidemiological monitoring of diseases and their vectors. • Promote research to model and forecast the impact of climate change on the spread of infectious diseases • Promote partial forestation of pastures with local fodder tree species. • Support PUUs establishment and capacity strengthening to ensure sustainable pasture management and rehabilitation • Capacity building for improved composting and vermicomposting, soil conservation, improved composting and vermicomposting. • Use of manure and improved compost in pasture; spreading schedule agenda developed and replicated within all clusters. • Possible support to PUU for manure and compost transportation (e.g. trailers to remove the manure from congested residences).	• Exchange visits between similar clusters to improve capacity building and exchange of innovations. • Exchange visits between different clusters to trigger goods exchange, diversify input sources from local production and increase resilience. • Matching grants (e.g. milking machine) for milk collection centres, including possible support for renewable energy for storage facility units (e.g., solar photovoltaic panels); • Support from milk/dairy processing enterprises (to build capacities on improving the quality of milk, etc.)	• Cluster approach to organise transport and sale and guarantee better price. • rural roads rehabilitated/constructed to improve input and market access;

D. Opportunities in horticulture systems

108. According to available information, area under horticultural crops in Tajikistan has increased in the recent 10 years by 71,000 ha or 3.2% per year on average (CAGR[59]). For comparison, during the same period of time area under cereals has been declining 1.7% per year and area under fibre crops dropped by 24.3% per year on average. This suggests that horticultural crops have provided better returns on investments compared to other crops. Tajikistan's Horticultural Sector Strategy is directed to sustainable and reliable year-around supplier of high value unique horticultural products for local consumers and high-end diversified export markets.

109. Climate change will alter the growth patterns and capabilities for flowering and fruiting of many perennial and annual horticultural plants. Higher average temperatures and shifting precipitation patterns are causing plants to bloom earlier, creating unpredictable growing seasons. In some regions perennial fruit crops are likely to experience substantial difficulties because of altered seasonal conditions affecting dormancy, acclimation and subsequent flowering and fruiting. Vital resources such as water and nutrients may become scarce in some regions reducing opportunities for -growing -horticultural crops[60]. Some of the most problematic species, including potatoes, may thrive under new conditions and move into new areas. Important connections between pollinators, breeding birds, insects, and other wildlife and the plants they depend on will be disrupted. Pollinators such as bees may arrive either too early or too late to feed on the flowers on which they normally rely.

110. Climate smart solutions exists to alleviate the impacts of Climate Change on horticulture in Tajikistan. Access to water is the main parameter of production for horticulture and vegetable production in Tajikistan. CASP+ could support services to identify, analyze and adopt climate resilient production practices, focus on strengthening the capacity to adapt the production systems to become more resilient to changing climate conditions and in some cases identify opportunities to link to local markets. CASP+ should support activities aiming at reducing water consumption and increasing water use efficiency. For adaptation strategies the emphasis should be on development of production systems for improved water-use efficiency, rainwater harvesting and storage to adapt to the shift in precipitation pattern and hot conditions.

111. In order to improve the resilience of the most vulnerable people, the project should incorporate diverse native species where suitable and where there is market demand and high potential value. Potential partners on the field have already been approached and pre-identified. Caritas is working with women groups on neglected and underutilized crops and vegetables (NOC) with a direct link to WFP school cantines. Slow Food International and Women's non-governmental organization "Zan wa Zamin" are also present in Tajikistan working on NOC and agro-ecology and could support CASP+ in the implementation of community gardens and Farmer Field Schools (FFS) for knowledge transfer and capacity development system. This capacity development could be part of the Action Plan on Horticulture of the National Investment Plan (NIP): "Develop nationwide capacity development program for horticulture hiring recognized international experts with field demonstrations". Strategies like changing sowing or planting dates, adapting fertilizer application, providing irrigation during critical stages of the crop growth and conservation of soil moisture reserves by mulching with crop residues are the most important interventions and practices that should be disseminated.

112. The project could also support the greenhouse production and improve the energy efficiency by using renewable energy (e.g. solar energy) to support the production of tomatoes, cucumbers, eggplants, peppers and other products to replace imports.

113. Furthermore, the project could support the use of compost and production waste as part of the FFS. It has been demonstrated that the use of the improved compost and vermicompost is beneficial in horticulture production (results of AMMAR IFAD project, IFAD). Pilots of production with improved composting and vermicomposting could be installed and capacity building could be spread through FFS. Capacity building workshops would be given on the use of

[59] CAGR - Compound Annual Growth Rate.
[60] Dixon, G., R., Collier, R., H., Bhattacharya, I. An Assessment of the Effects of Climate Change on Horticulture. Horticulture: Plants for People and Places, Volume 2, 2014. ISBN : 978-94-017-8580-8

vermicomposting in fields. Furthermore, the project could organize exchange visits of small groups of farmers (considering the COVID-19 situation) to increase knowledge of farmers and trigger exchanges between different clusters.

114. In horticulture production, there is the opportunity to establish agroforestry systems. These systems can effectively leverage short-term cash-flow over time as it combines long-term yields with short-term returns from crops, livestock and other forest products. They can increase crop yields, help with energy savings, improve soil's condition, reduce erosion and sustain or even increase biodiversity[61].

115. The project could also promote the diversity of pollinating insects important for crop production, food security and livelihoods[62]. Small and large farmers can benefit greatly from enhanced pollination by using diversification techniques that promote pollinators and reduce need for pesticides. These methods include diversifying crops through polyculture and rotation, planting flower borders and maintaining patches of natural habitats. These methods have many co-benefits: soil fertility, pest/disease control, flood and erosion control, water quality, carbon storage and biodiversity[63]. Furthermore, the project could support beepeeking as part of its diversification strategy.

116. Storage - For small-scale farmers, horticulture production provides a better diet and higher income, but the storage of quality products entails significant costs of total cultivation costs. Temperature fluctuations and light exposure are the main causes of quality deterioration in storage. Better storage methods can therefore alleviate the problems associated with horticulture products in the mid-hills and mountain areas. Appropriate storage practices should not require farmers to make major changes to their existing practices and must be low-cost and easy to adopt. CASP+ could support through matching grants the use of renewable energy for storage facility units (e.g. solar photovoltaic panels for temperature and/or ventilation). This could also apply for other similar type of production.

117. In conclusion, five main actions for Climate Change adaptation for horticulture production can be considered for CASP+:

- Storage
- Local organic fertilizer/improved compost
- Improved management and agricultural practices (via capacity development)
- Access to water
- Rehabilitation of roads and infrastructure adaptive to extreme climate events to ensure access to areas of production, and access to inputs and market

[61] Rosenstock TS, Wilkes A, Jallo C et al (2019) Making trees count: measurement and reporting of agroforestry in UNFCCC national communications of non-Annex I countries. AgricEcosyst Environ 284:106569.
[62] Albrecht M, Kleijn D, Williams NM, Tschumi M, Blaauw BR, et al. 2020. The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yield: a quantitative synthesis. Ecol. Lett. 23(10):1488–98
[63] Kremen, C., Albrecht, M. & Ponisio, L. (2019). Restoring pollinator communities and pollination services in hedgerows in intensively managed agricultural landscapes. In The ecology of hedgerows and field margins. (ed Dover, J.W.). Routledge, New York, USA, pp. 163–185

Horticulture	Seeds and other inputs	On-farm production	Harvesting-Storage-Processing	Product Marketing
Potential impacts of CC on farmers. **Main effects: Drought and high precipitation**	Increased input costs due to limited access (poor rural road network); Incidence of planting seed spoilage during transportation; Poor seed quality due to pest infestation.	Deteriorated soil properties; Increase pest and disease incidences; increased need for irrigation; high production costs (labour & pest and disease control), low productivity.	Decreased harvest (in quantity and quality); Increased pest infestation during harvest and storage (lack of access to storage facilities); high transport costs (low economies of scale).	Low level of product supply, low farm gate prices due to poor quality and low quantity of produce.
Potential options to increase farmers' adaptive capacity under CASP+	• Support from Seed potato national biotechnical institution and experts to support farmers; • Rural roads rehabilitated/ constructed; • Matching grants for seeds.	• Technical support by input suppliers; • Permanent support to clusters from biotechnical institution; • Matching grants for mechanization; Water ponds for access to water. • Capacity building on horticulture production, composting and vermicompost uses. • Agroforestry systems to increase efficiency and productivity	• Cluster approach to organise harvest, storage and processing; • intra-cluster hand-on exchanges with mentor producer; • Matching grant for warehouse material. • Exchange visits between similar clusters to improve capacity building and exchange of innovations; • Exchange visits between different clusters to trigger goods exchange, diversify input sources from local production and increase resilience; • Matching grants of renewable energy for storage facility units (e.g. solar photovoltaic panels for temperature and/or ventilation).	• Cluster approach to organise transport and sale and guarantee better price. • rural roads rehabilitated/constructed to improve input and market access.

VI. Outstanding issues

118. Next steps towards implementation. The analysis above was carried out on a preliminary basis during the concept note design and full design and discussed with local counterparts. The analysis would benefit additional information source, including from the project-specific baseline survey to be carried out at early implementation phase. Among others, key elements that the full project design would complement include:

- Ex-Act, B-intact and Gleam-i analyses to be carried on during implementation.
- The analysis of the grassland over time (2000-2004 compared with 2016-2020) permitted to locate hot spots where grassland present moderately and severely degraded evolution. These hotspots would need to be confirmed during diagnostic at district level in accordance with national experts and visit on the field. In the same way, prioritization and adapted practices will be decided and be included in the CsCAPs.

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