CRPP Community Resilience Partnership Program

Annex 2.3:

Design Study: Project Concepts

25 July 2023

Contents

1. ABOUT THE ANNEX

This annex is part of the wider annex 2 on the design study of the Community Resilience Partnership Program (CRPP).[1] It presents a summary of the Asian Development Bank (ADB) projects that, while currently in their very early stages of conceptualization, are examples of large-scale interventions that could serve as vehicles for the delivery of the specific local adaptation solutions promoted by the CRPP, using IF resources provided by GCF. In line with the guidance provided for the submissions of programmes that is detailed in the GCF Programmatic Policy Approach paper [GCF/B.21/31/Rev.01], the CRPP is following a **"Case 3"** submission process. As such, multiple projects are included here with sufficient indicative information for compliance with GCF policies, but with the understanding that full project design studies are to be done in the future, and that these will include a detailed and comprehensive climate risk assessment that presents the climate rationale for the proposed interventions to be funded by the GCF. As the AE, ADB will undertake detailed due diligence on the proposed projects in the future and full appraisals will be carried out using the eligibility criteria presented in annex 2.4 when approved by the Board.

2. INTRODUCTION

The CRPP is a regional partnership program of the Asian Development Bank (ADB) which aims to help countries and communities in Asia and the Pacific region scale up investments in climate adaptation, especially investments at the community level, that explicitly target the nexus between climate change, poverty, and gender. The CRPP aims to contribute to transformational change by; (i) mobilizing large-scale public investments that support community level adaptation of poor and vulnerable people; (ii) developing national and local policies, plans, and programs that promote financing for community-led adaptation; and (iii) increasing the meaningful participation of poor women and men in resilience related decision-making. In doing so, the CRPP will address the points of procedural and distributive justice so that the people most vulnerable to the impacts of climate change can engage in a fair process and receive a fair share of the benefits of adaptation efforts.

The CRPP is operationalized through the Community Resilience Financing Partnership Facility (CRFPF) which was established by ADB in August 2021 and comprises two separate but interlinked components; the **CRPP Trust Fund (TF)** focusing on upstream support to strengthen the enabling environment required for implementing local adaptation measures at scale; and the **CRPP Investment Fund (IF)** focusing on the efficient roll-out of local adaptation measures through downstream investments.

The TF will provide technical assistance and grant resources financed by development partners and administered by ADB, to selected developing member countries (DMC) of the ADB to implement the following three outputs: (1) Knowledge and action research on climate risk informed pro-poor community-level solutions strengthened; (2) Institutional and community capacity to develop and deliver climate adaptation investments at community-level strengthened; and (3) Inclusive and pro-poor adaptation investment projects identified and prepared. The TF will include a dedicated Gender Window with funds earmarked specifically for providing technical assistance and grants for identifying, developing, and implementing investments that explicitly strengthen the resilience of women, particularly poor women, and/or adaptation investments led by women that have a specific focus on supporting women to build their resilience. The TF will have a budget of US$75 million with roughly 15% earmarked for the Gender Window. To date, Government of United Kingdom, the Nordic Development Fund,

[1] The other annexes under 2 include (i) Annex 2.1 Country Climate Risk Profiles (ii) Annex 2.2 Design Study, and (iii) Annex 2.4 Project Selection Approach and Criteria for CRPP IF projects.

and the French Development Agency has confirmed financial support for the TF, amounting to a total of ~ US$68 million. The TF will **not** be funded by GCF.

The IF will provide grant and loan financing to seven selected DMCs, namely, Cambodia, Indonesia, Lao PDR, Pakistan, PNG, Timor-Leste, and Vanuatu, to implement local adaptation measures as part of ADB financed projects that are targeted at the poor and vulnerable population. The IF will deliver three climate related **outputs** that are the focus of this annex (**4**) **information and systems** for delivering applied climate-risk informed local investments at scale improved; (**5**) climate resilient pro-poor **livelihoods** investments implemented; and (**6**) pro-poor climate adaptation **infrastructure** investments implemented. All projects financed by the IF will be implemented by the respective governments following ADB's procedures. The GCF is requested to provide US$100 million as grants and US$20 million as loan for the seven countries identified above (with each country receiving between USD 12 to 25 million) in support of the IF of this program, while the ADB will provide USD 555 million of grant and loan financing. The program will utilize GCF grant resources to co-finance at least 10-15 projects implemented under the IF only, for outputs 4, 5 and 6. The IF will be part of an ADB administered trust fund set up for GCF financed projects under the umbrella of the CRFPF.

3. PROJECT CONCEPTS

The project concepts presented in this annex have been shortlisted from ADB's Country Operations and Business Plans of the CRPP countries and do have the potential to meet the CRPP IF eligibility criteria described in annex 2.4. These concepts are examples of large-scale interventions that could serve as vehicles for the delivery of the local adaptation solutions targeted at the poor and vulnerable population, using the CRPP IF resources provided by GCF. Without grant financing from the IF, activities proposed under these projects that explicitly promote adaptation to climate change at the local level will not be implemented. The projects are at an advanced stage of development, however the outputs and activities described in this document are still indicative, pending confirmation based on further discussions with government agencies, including the National Designated Authorities (NDA); findings of detailed climate risk assessments to identify context-specific adaptation measures; and other due diligence required for all ADB investments. All concepts have however been subject to an initial review process that has required a strong climate adaptation case be made based on available peer reviewed scientific data. ADB is currently developing a larger pipeline of projects that are at an early stage of development. By identifying projects that are at the concept stage of development, it can be ensured that the rigorous criteria for the design of the CRPP investment projects can be applied from the very beginning of the project design, and national and local stakeholders, including the NDAs are involved and closely consulted from the outset.

The following projects are presented in this annex.

Lao PDR	Flood and Drought Mitigation and Management Project
Pakistan	Sindh Coastal Resilience Project
Timor-Leste	Agriculture Improvement and Water Harvesting Project

Due to the early stage of project design, the concepts can only provide indicative number of beneficiaries and the exact allocation of CRPP funds is yet to be confirmed based on the level of climate risk and local adaptation needs. However,

Table 1 below outlines some indicative figures in this regard.

Table 1: Indicative allocation of budget and estimated number of beneficiaries

Project	Indicative Budget	Beneficiaries[2]
LAO: Flood and Drought Mitigation and Management Project	$10 million USD	1.02 million (Total)
PAK: Sindh Coastal Resilience Project	$40 million USD	1.02 million (Total)
TIM: Agriculture Value Chain and Water Harvesting Project	$6 million USD	460,000 (Total)

[2] The beneficiaries presented here are not consistent with a clear breakdown according to direct and indirect; some projects have estimated only direct beneficiaries, others only total beneficiaries. The full breakdown of beneficiaries will be provided as part of the detailed project design and feasibility studies.

A. Lao People's Democratic Republic: Flood and Drought Mitigation and Management Project

Country: Lao People's PDR
Project location: Three central provinces of Bolikhamxai, Khammouan, and Vientiane Capital

Summary: Project alignment with CRPP overall program design			
CRPP Output	**CRPP Sub-activities**	**Link to CRPP Outcomes**	**Link to GCF Adaptation Result Areas**
Output 5: Climate resilient pro-poor livelihoods investments implemented	**5.3** Climate resilient agriculture supply chains.	**Outcome 3:** Food security of poor and vulnerable communities is increased. **Outcome 4:** Exposure of poor and vulnerable people to climate shocks and stresses is reduced.	**ARA1:** Most vulnerable people and communities. **ARA2:** Health and wellbeing, and food and water security. **ARA3:** Ecosystems and ecosystem services.
Output 6: Pro-poor climate adaptive-infrastructure investments implemented.	**6.1** Construction and installation of ecosystem-based green infrastructure.		

Project Summary

Lao (People's Democratic Republic) PDR is ranked 142nd out of 181 countries in the ND-GAIN Index, and as the 36th most vulnerable country globally. Rural areas in Lao PDR account for nearly 90% of the poor population, and rural poverty is almost three times higher than in urban areas. The poverty head count rate in the central provinces is some of the highest in the country and is showing the slowest rate of reduction. The combination of the monsoon climate, high variability, and the geographical terrain makes Lao PDR extremely vulnerable to weather related extremes, notably from floods, storms, landslide and droughts.[3] The whole country experiences regular flooding and there are also frequent storms: three of the five costliest events on record having taken place since 2009. Typhoon Ketsana in 2009 and Haima in 2011 caused damages of US$ 94 million and US$ 66 million respectively, and in 2018 a confluence of storm and flood disasters affected over 600,000 people and led to losses of US$ 371 million. There are also periodic droughts: in, 2015 a severe drought, driven by a strong El Niño event, damaged tens of thousands of hectares of rice, and fruit crops including in the central region. Historical damage data indicates that annual expected losses range between 3.3% and 4.1 percent of GDP.[4] Disasters disproportionate impact on the poor, and the rural poor are particularly vulnerable to ENSO-related shocks.[5] Rural areas experience widespread food insecurity due to the reliance on rain-fed agriculture, and these households have a high probability of falling into extreme poverty even when exposed to relatively low frequency flood and drought events.[6]

[3] UNDP (2010). National Risk Profile of Lao PDR. National Disaster Management Committee Government of Lao PDR / United Nationals Development Programme (UNDP) Lao PDR. November 2010
[4] The World Bank Group (2017). Lao PDR: Systematic Country Diagnostic. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/983001490107755004/lao-pdr-systematic-country-diagnostic-priorities-for-ending-poverty-and-boosting-shared-prosperity
[5] Sutton, W., et.al. 2019. Striking a balance: Managing El Niño and La Niña in Lao PDR's Agriculture. World Bank Group. https://www.worldbank.org/en/country/lao/publication/striking-a-balance-managing-el-nino-and-la-nina-in-lao-pdrs-agriculture
[6] Asian Development Bank (ADB). 2017. *Risk financing for rural climate resilience in the greater Mekong subregion. Greater Mekong Subregion Core Environment Program*. Asian Development Bank. Publication. P.30. 2017. URL: https://www.adb.org/sites/default/files/publication/306796/riskfinancing-rural-climate-resilience-gms.pdf

Recent observations show that the climate of Lao PDR is changing.[7] There is a clear warming trend, with 0.1 to 3°C per decade reported across the entire country. The patterns of annual rainfall trends are more uncertain, although there are trends of increasing variability and increasing extreme rainfall.[8,9] Future climate change will exacerbate existing risks. The projected temperature increases for Lao PDR indicates a further rise of broadly 1°C to 2°C by mid-century.[10,11] Projections also indicate that there will be an increase in temperature across seasons in particular during April and May and elevated night-time minimum temperatures.[12,13] It is difficult to model rainfall changes due to the influence of Monsoon dynamics, but most climate models project increases in annual rainfall by the mid-century (2050s) and there is more confidence that heavy precipitation events will increase. This is likely to result in changes in hydrology and water availability, and increase the flood risks across the country.[14] Modelling for the country's rivers – from northern watershed, through the central region, and in the Mekong - indicate higher discharge leading to increased floods with greater areas of land and more people at risk of flooding, and higher value at risk. [15, 16] Changes in preceipitation patterns can also result in soil organic matter transformation, increased soil erosion[17], and increased annual likelihood of drought. There are projected reductions in agricultural yields in Lao PDR, and these negative impacts on the rural agrarian population could be amplified by the possible increases in heat and humidity (including heatwaves) that will likely reduce labour productivity.

The Flood and Drought Mitigation and Management Project (FDMMP) aims to support sustainable and climate resilient livelihoods in Lao PDR through reducing the financial and economic losses from floods and droughts as a result of extreme weather events caused by climate change and improve the food and nutrition security of the rural poor through the promotion of crop and nutrition diversification. Most climate change adaptation in Lao PDR has been focused on urban areas, such as the GCF funded *Building resilience of urban populations with ecosystem-based solutions in Lao PDR* or in the Mekong river plains, leaving a large adaptation gap in the central regions. This leaves the large important agricultural areas in the central provinces that are highly climate sensitive vulnerable to the impacts of climate change. The FDMMP will address specific adaptation needs in the country and fill the current gaps in adaptation financing by focusing on managing the risk and impacts of more frequent and intensified floods and droughts on the lives of poor rural households in the three central provinces of Bolikhamxai, Khammouan and Vientiane Capital. The project is expected to improve water reliability by harnessing flood water for usage during dry season and droughts, reduce damages from floods, and provide modernized agrometeorological information systems.

The project contributes to Lao PDR's climate change priorities by aligning to the first target of the country's Nationally Determined Contributions (NDCs) through investing in improved vegetative cover of watersheds as a means of flood control and by promoting crop and nutrition diversification. It will also support post COVID-19 economic recovery and rural

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[7] The World Bank Group Climate Change Knowledge Portal (CCKP). Climate Data: Projections. 2019. URL: https://climateknowledge portal .worldbank.org/country/laos.
[8] Lao PDR (2013). Second National Communication to the UNFCCC. Lao PDR, 2013. https://unfccc.int/documents/116664
[9] Westra, S., et.al. *Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555.* 2014. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2014RG000464
[10] The World Band Group Climate Change Knowledge Portal (CCKP). Climate Data: Projections. 2020. https://climateknowledgeportal.worldbank.org/country/laos/climate-data-projections.
[11] World Bank / ADB (2021). Climate Country Profile. Lao PDR. Published by the World Bank and ADB
[12] Lao PDR Nationally Determined Contribution (2021).
[13] USAID. (2014). Climate Change in the Lower Mekong Basin: An Analysis of Economic Values at Risk.
[14] Lao PDR Nationally Determined Contribution (2021).
[15] Try, S., Tanaka, S., Tanaka, K. *et al.* 2020. *Assessing the effects of climate change on flood inundation in the lower Mekong Basin using high-resolution AGCM outputs*. Prog Earth Planet Science. **7,** 34 (2020). DOI: https://doi.org/10.1186/s40645-020-00353-z
[16] USAID. (2014). Climate Change in the Lower Mekong Basin: An Analysis of Economic Values at Risk.
USAID Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC). Published by USAID, 2014.
[17] World Bank / ADB (2021). Climate Country Profile. Lao PDR. Published by the World Bank and ADB

resilience by (i) generating rural employment through construction; (ii) increasing incomes through the reduction of flood damages and losses, and (iii) diversification into high value crops.

SECTION 1: PROJECT CONTEXT AND CLIMATE RATIONALE

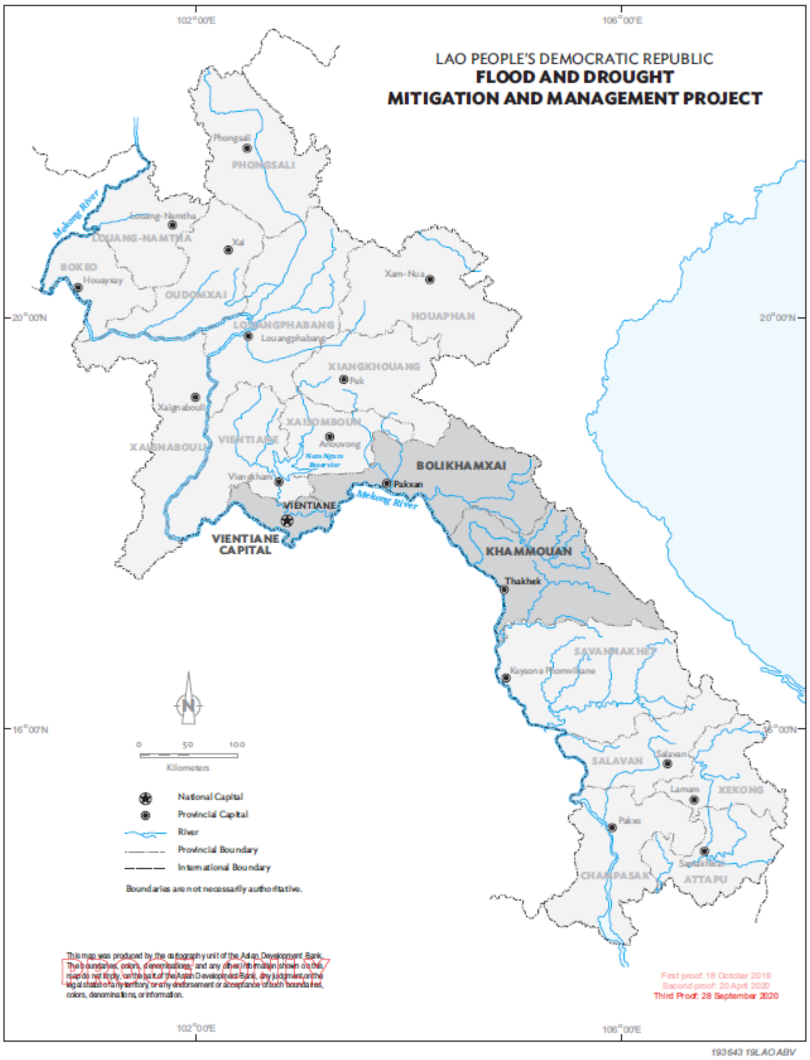
Vulnerability characteristics of the proposed intervention zone

Lao PDR's gross domestic product (GDP) growth averaged 7.7% during 2010–2019, but its Human Development Index ranking remains low. Over 65% of the population live in rural areas, where the poverty rate is 23.8% compared to 7.0% in urban areas.[18] The three economic subsectors contributing to the country's GDP include the service (46.8%), industry (35.5%) and agriculture (17.7%) sectors.[19] The share of employment in the country shows a shift from agricultural towards the service and industry sectors, at around 3% in a span of 5 years. Nonetheless, agriculture remains the dominant employer, accounting for 65.2% of the labor force in 2015[20]. In 2017, rice was the major crop, accounting for 50% of national agricultural value-added.[21] About 960,000 hectares (ha) of wet season rice is grown, mostly for subsistence. Other major crops include maize, cassava, banana, and coffee, along with livestock production, which are used for both subsistence and commercial purposes.

The central provinces (see figure F-L1) have seen the smallest decline in their poverty head count rates, only decreasing from 23.5% in 2012/13 to 21.5% in 2018/19. By targeted province, Bolikhamxai has a poverty rate of 20.6%, Khammouan of 25.5% and Vientiane of only 5.3% in 2018/19. While Bolikhamxai and Vientiane saw a reduction of about 6% compared to 2013, the rate in Khammouan virtually remained at the same level.[22] Furthermore, Khammouan and Bolikhamxai have experienced the sharpest decline in both urban and rural jobs, driven by declining manufacturing and trail trade activities.[23] The large section of the rural population in these areas that are engaged in agriculture are particularly vulnerable to the impacts of natural hazards due to their large dependence on subsistence agriculture production and inadequate social protection systems.

Figure 1: Flood and Drought Mitigation and Management Project Location

[18] Lao Statistic Bureau. 2020. Poverty in Lao PDR: Key findings from the Lao Expenditure and Consumption Survey, 2018-2019. Vientiane.
[19] Laos Statistical Information Service. *GDP and economic subsectors*. Department of Economic Statistics, LSB, MPI, Vientiane, Laos. 2020.
[20] Ministry of Planning and Investment. *8th Five-Year National Socioeconomic Development Plan (2016–2020)*. VIIIth National Assembly's Inaugural Session, 20–23 April 2016, Vientiane. Laos. 2016. URL: https://laopdr.un.org/sites/default/files/2019-08/2016_8th%20NSEDP_2016-2020_English.pdf
[21] Bank of Lao PDR. 2017. Annual Economic Report. Vientiane.
[22] Ibid footnote No. 74.
[23] World Bank Group. 2020. Lao People's Democratic Republic Poverty Assessment 2020. Catching up and falling behind.



Climate baseline and justification for adaptation intervention

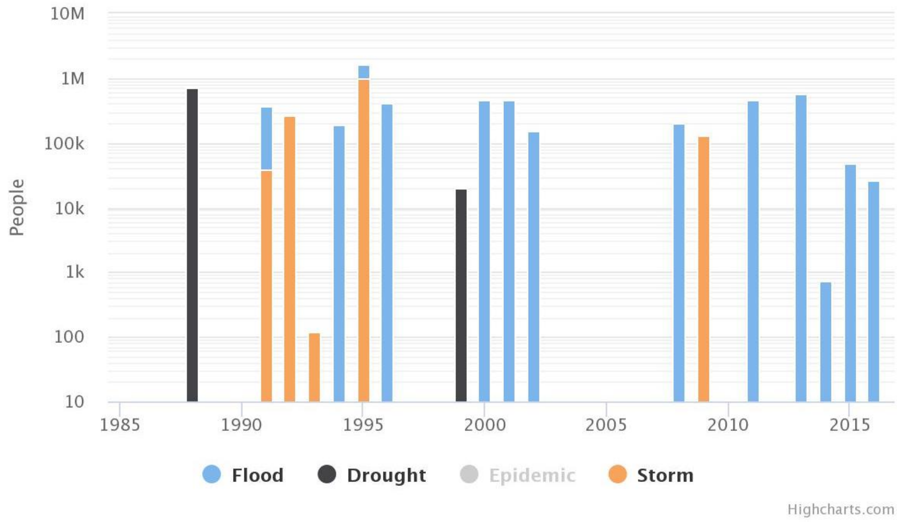
The combination of the monsoon climate, high variability, and the geographical terrain makes Lao extremely vulnerable to weather related extremes, notably from floods, storms, landslide and droughts (UNDP, 2010[24]). Historical damage data indicates that annual expected losses range between 3.3% and 4.1 percent of GDP (World Bank, 2017[25]). The whole country experiences regular flooding and there are also frequent storms: three of the five costliest events on record having taken place since 2009 (EM-DAT, 2021[26]: DESINVENTAR, 2021[27]). Typhoon Ketsana in 2009 and Haima in 2011 caused damages of US$ 94 million and US$ 66 million respectively, and in 2018 a confluence of storm and flood disasters affected over 600,000 people and led to losses of US$ 371 million (UNDRR 2019[28]). 57% of the losses were in the agriculture sector. In 2022 alone, tropical storms such as Mulan, Ma-on, and Noru affected 16 provinces across the country, damaging towns and farmland, causing floods, and destroying crops and

[24] UNDP (2010). National Risk Profile of Lao PDR. National Disaster Management Committee Government of Lao PDR / United Nationals Development Programme (UNDP) Lao PDR. November 2010.
[25] The World Bank Group (2017). Lao PDR: Systematic Country Diagnostic. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/983001490107755004/lao-pdr-systematic-country-diagnostic-priorities-for-ending-poverty-and-boosting-shared-prosperity
[26] EM-DAT (2021). The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, https://emdat.be/
[27] DESINVENTAR (2021). Disaster loss data for Sustainable Development Goals and Sendai Framework Monitoring System. https://www.desinventar.net/
[28] UNDRR (2019). Disaster Risk Reduction in Lao PDR. Status Report 2019. https://www.undrr.org/publication/disaster-risk-reduction-lao-pdr

infrastructure.[29] In 2022, extreme weather events such as floods and droughts cost Lao economy over US$ 77 million. There are also periodic droughts: in, 2015 a severe drought, driven by a strong El Niño event, damaged tens of thousands of hectares of rice, and fruit crops (Sutton et al., 2019)[30]. Shortly after the 2018 storms, an extensive drought caused delays in planting of over 800,000 ha of rice. [31] Droughts can occur anywhere in the country but are most common in the central region.

Disasters disproportionate impact on the poor, and the rural poor are particularly vulnerable to ENSO-related shocks (Sutton et al., 2019)[32]. The repeated patterns of disaster events can be seen below in **Figure 2**.

Figure 2: Number of people affected, 1985–2018



Source: World Bank Climate Portal.

As shown in Figure 3 the three central regions that are the focus of this study are some of most heavily affected by floods. In 2010, UNDP undertook a disaster risk hazard mapping exercise in Lao PDR[33]. This included flood hazard assessments in eight priority river basins. The analysis found high flood related hazards for various flood return periods in the three central areas that are the focus of this project. It also identified landslide risk which includes high risk areas in these areas. Finally, the analysis looked at drought risk - while droughts can occur anywhere in the country, they are most common in the central region, which is the focus of the project (see Figure 11).

Lao PDR also regularly experiences high temperatures, with an average monthly maximum of around 28°C and an average maximum of 31°C for May (warmest month). The current median probability of a heat wave (defined as a period of three or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 3% (CCKP, 2019).

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[29] The Laotian Times. Natural Disasters Cost Laos Economy Over USD 77 Million in 2022. Vientiane. Feb. 2023

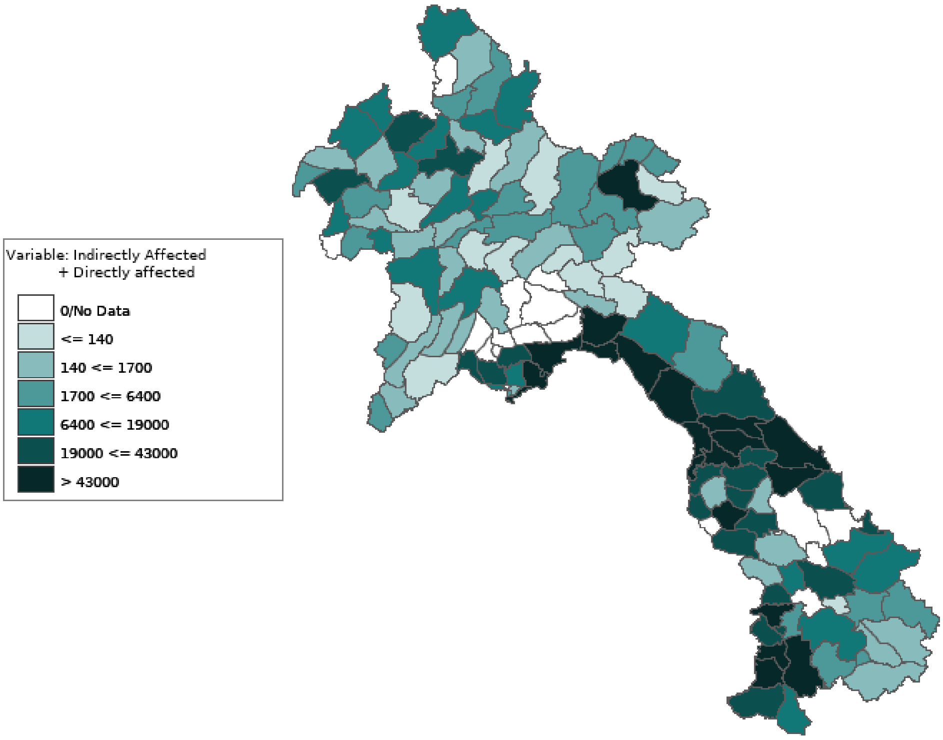
[30] Sutton, W., et.al. 2019. *Striking a balance: Managing El Niño and La Niña in Lao PDR's Agriculture*. World Bank Group. https://www.worldbank.org/en/country/lao/publication/striking-a-balance-managing-el-nino-and-la-nina-in-lao-pdrs-agriculture

[31] Government of Lao PDR. 2018. Post-Disaster Needs Assessment 2018 Floods.

[32] Sutton, W., et.al. 2019. Striking a balance: Managing El Niño and La Niña in Lao PDR's Agriculture. World Bank Group. https://www.worldbank.org/en/country/lao/publication/striking-a-balance-managing-el-nino-and-la-nina-in-lao-pdrs-agriculture

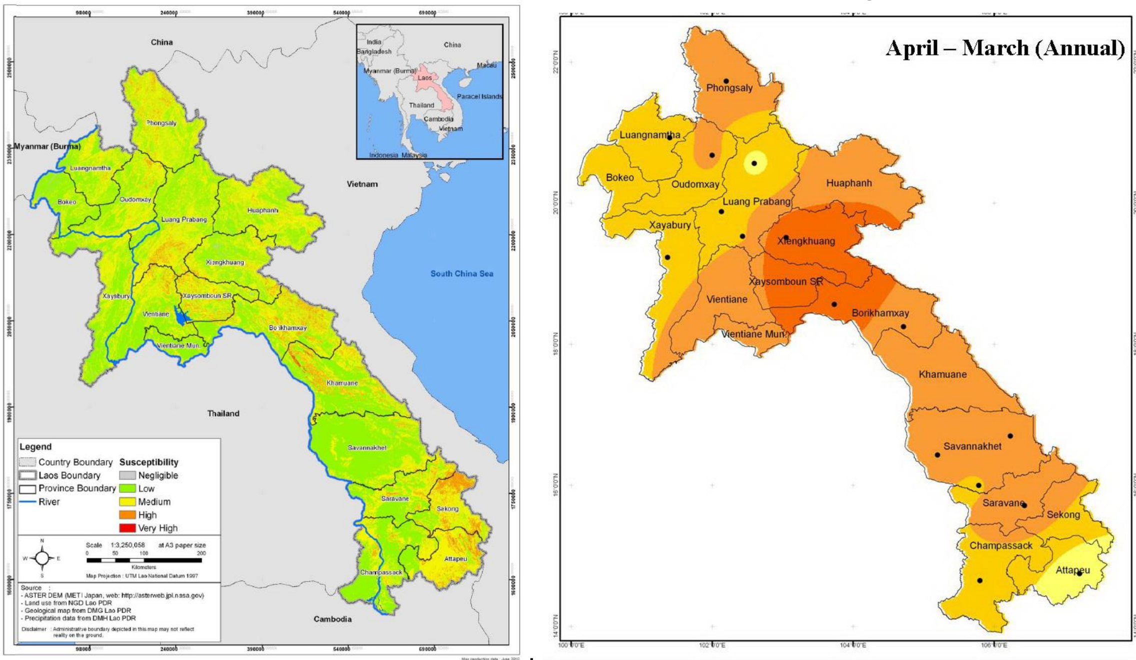
[33] UNDP (2010). DEVELOPING A NATIONAL RISK PROFILE OF LAO PDR. Lao PDR. Part 1: Hazard Assessment 2010 Disaster Management Committee Government of Lao PDR and United Nationals Development Programme (UNDP) Lao PDR

Figure 3: Number of people affected by Flood (directly and indirectly)



Source: DESINVENTAR (2021). Disaster loss data for Sustainable Development Goals and Sendai Framework Monitoring System. https://www.desinventar.net/.

Figure 4: Landslide hazard map and annual moderate to extreme drought risks for Lao PDR



Source: UNDP, 2010.

The information on future impacts resulting from climate change are set out below.

Floods: Lao PDR's 2nd National Communication to United Nations Framework Convention on Climate Change (UNFCCC)[34] reports a transition in the country's precipitation regime towards more intense precipitation periods, with the frequency of months with more than 600 mm rainfall increasing. Also, the Coupled Model Inter-comparison Project Phase 5 (CMIP5) show a trend of consistent warming and an increase in the intensity of heavy precipitation periods and extreme events. Most of the models anticipate increases in annual precipitation rates, with larger changes under higher emissions pathways. The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia and are already documented in Lao PDR.[35]

Using the World Resources Institute's AQUEDUCT Global Flood Analyzer to establish a baseline level of river flood exposure,[36] and assuming protection for up to a 1 in 25-year event (as of 2010), the population annually affected by flooding in Lao PDR is estimated at 48,000 people and the expected annual damages is $159 million. Climate change is expected to increase the affected population by 40,000 people and the damages by $295 million, under the RCP8.5 emissions pathway by the 2030s (AQUEDUCT Scenario B).

Even under lower emissions pathways coherent with the Paris Climate Agreement, almost all Asian countries face an increase in the frequency of extreme river flows.[37] What would historically have been a 1 in 100-year flow, could become a 1 in 50-year or 1 in 25-year event in most of South, Southeast, and East Asia. Further, the model ensemble project an increase of up to 23% under the highest emissions pathway in the amount of rainfall accumulated during extreme rainfall events. This phenomenon may increase the risk of flash or surface flooding, and associated issues such as landslides.

Drought. Two primary types of drought may affect Lao PDR, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). At present, Lao PDR faces an annual median probability of severe meteorological drought of around 4%, as defined by a standardized precipitation evaporation index (SPEI) of less than -2.22.[38] Naumann et al. (2018) provide a global overview of changes in drought conditions under different warming scenarios.[39] Projections for Southeast Asia suggest that the return periods of 12-month droughts could be reduced. This trend is less significant under lower levels of global warming, but once warming reaches 2- 3ºC, events that presently occur only once every hundred years may return at frequencies greater than once in every fifty years. The projections of the CCKP model ensemble on meteorological drought hold some uncertainty, but generally point towards an increased annual likelihood of drought (**Figure 5**). The rise in drought probability appears not to correlate with emissions in a linear fashion.

[34] UNFCCC. 2010. National Capacity Self-Assessments

[35] Westra, S., Fowler, H. J., Evans, J. P., Alexander, L. V., Berg, P., Johnson, F., Kendon, E. J., Lenderink, G., Roberts, N. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2014RG000464.

[36] World Resources Institute (WRI). *AQUEDUCT Gobal Flood Analyzer.* 2018. URL: https://floods.wri.org/#

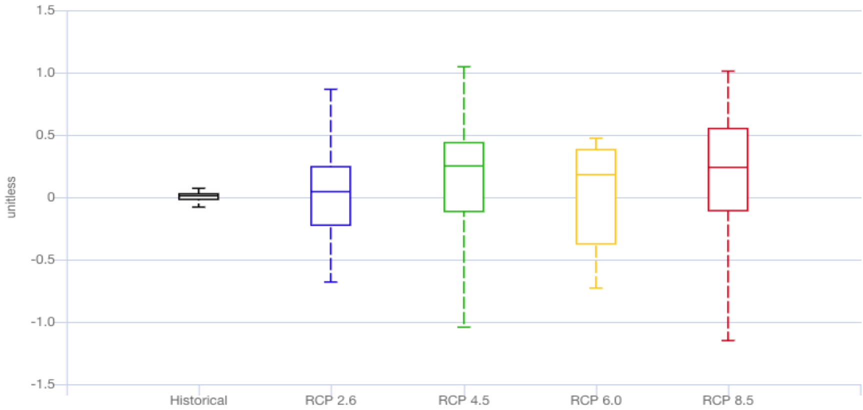
[37] Paltan, H., et.al. *Global implications of 1.5°C and 2°C warmer worlds on extreme river flows Global implications of 1.5°C and 2°C warmer worlds on extreme river flows*. Environmental Research Letters, 13. 2018. URL:https://doi.org/10.1088/1748-9326/aad985.

[38] The World Bank Group Climate Change Knowledge Portal (CCKP*). Interactive Climate Indicator Dashboard.* 2019. URL: https://climatedata.worldbank. org / CRMePortal/web/water/land-use-/-watershed-management?country=LAO&period=2080-2099.

[39] Naumann, G., et.al.*Global Changes in Drought Conditions Under Different Levels of Warming*. Geophysical Research Letters, 45(7), 3285–3296. 2018. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2017GL076521

Overall, it is likely that future drought patterns will depend on the influence of climate change on monsoon and ENSO patterns,[40] though further research is required to constrain this impact.

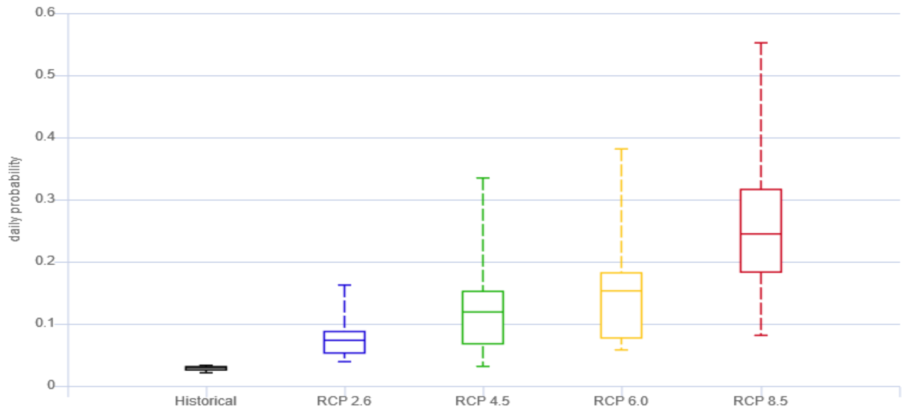
Figure 5: Annual probability of experiencing a 'severe drought' in Lao PDR (-2 SPEI index) in 2080-2099 under four emissions pathways



Source: WBG Climate Change Knowledge Portal. 2019. Interactive Climate Indicator Dashboard. 2019. URL: https://climatedata.worldbank. org / CRMePortal/web/water/land-use-/-watershed-management?country=LAO&period=2080-2099.

Heat waves. As shown in the CCKP model ensemble, there are significant increases in the annual probability of a heat wave under the different emissions pathways (Figure 6). General warming and increased climate variability are both almost certain to increase the probability of heat waves compared with the historical baseline (1986-2005). The increase in the number of days in which temperatures exceed 35°C is projected to increase from approximately 40 days to 50-110 days depending on emissions pathway and climate model, suggesting a transition to a chronically heat stressed environment.[41]

Figure 6: Projected change in the probability of observing a heat wave in Lao PDR, 2080-2099[42]



Source: WBG Climate Change Knowledge Portal. 2019. Interactive Climate Indicator Dashboard. 2019.

Description of adaptation needs

It is clear that climate change will have a major impact on Lao PDR. The ND-GAIN ranking highlights Lao is due to a combination of political, geographic, and social factors, Lao PDR is recognized as very vulnerable to climate change impacts, and is ranked 142th out of 181

[40] Adamson, P. and J. Bird. *The Mekong: a drought-prone tropical environment?* International Journal of Water Resources Development, 26(4), pp.579-594. 2010. URL: https://www.tandfonline.com/doi/abs/10.1080/07900627.2010.519632
[41] WBG Climate Change Knowledge Portal. 2019. Interactive Climate Indicator Dashboard. 2019.
[42] WBG Climate Change Knowledge Portal. 2019. Interactive Climate Indicator Dashboard. 2019.

countries in the ND-GAIN Index.[43] Floods and droughts constrain crop yield, limiting production and revenues, and thus availability and access to food, and nutritional variety, exacerbating existing high levels of malnutrition and leaving many young rural people stunted due to poor nutritional variety and dietary options, which is worsened by lack of awareness.

The frequency of inundation constrains agriculture development through repeated damages to productive rural infrastructure, crop losses, and limited market chain development. Flood-plain irrigation systems adjacent to rivers face additional risks from regional flooding of major rivers such as the Mekong River and more localized flooding due to the poorly regulated operations of hydro-power reservoirs. With projected increase in temperature and intensified precipitation, livelihoods and agricultural yields will be greatly impacted in the targeted provinces due to damage to rural infrastructure by floods, increased crop evapotranspiration in the dry season with associated higher demand for water, more frequent land inundation and consequently crop losses during floods, loss of livestock due to water shortage or by destructive floods.

The Lao PDR has a total irrigated area of over 515,000 ha, including approximately 100,000 ha planted with rice as well as those areas planted with other crops such as vegetables.[44] Rice thus remains a staple of household food security in Lao PDR. Changes in the onset, duration and intensity of the rainy season, increased drought frequency, and increased incidence of heat wave, if coinciding with key phases towards the start and end of the cropping cycle, may have strong negative implications for total rice production, as well as its reliability as a source of income and calories.[45] Rice is particularly vulnerable to elevated night time minimum temperatures.[46] Minimum temperatures are expected to rise much faster than average temperatures in Lao PDR. One study has suggested that the influence of climate change on temperature and rainfall patterns could depress local rice yields by around 5- 20% by the 2040s, with losses typically larger on higher emissions pathways.[47]

Inequalities have been widening in Lao PDR since the turn of the 21st century.[48] An income gap between rural and urban areas of 18.6% had opened by 2013, and both real and absolute income growth has accrued proportionately more to the rich than to the poor.[49] The growth in inequality in Lao PDR is in affect slowing progress in tackling poverty, which remains high at 23% in 2012. Moreover, the poor intensely depend on biodiversity and natural resources for livelihoods. Thus, climate change is likely to pose formidable threats to the economy and society at large.[50] With agriculture as main sector employing the Lao PDR population, direct impacts of climate change could put the livelihoods of the people in jeopardy, potentially increasing the proportion of the country's population back into poverty. In addition, the majority of rural citizens in Lao PDR have problems with land ownership and tenure is extremely

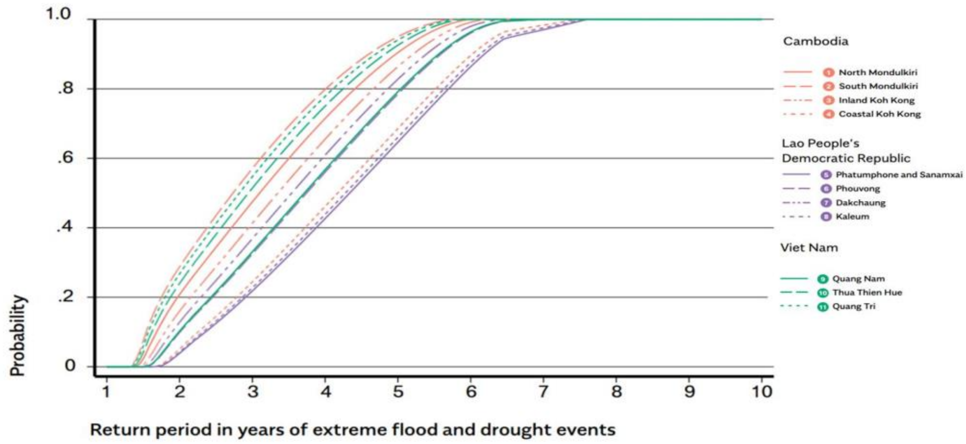
[43] University of Notre Dame. *Notre Dame Global Adaptation Initiative.* 2019. URL: https://gain.nd.edu/our-work/country-index/
[44] Government of Lao PDR. *National Biodiversity Strategy to 2020 and Action Plan to 2010.* 2004. URL: https://www.cbd .int/doc/world/la/la-nbsap-01-en.pdf
[45] Laing, A. M., et.al. *Mechanized dry seeding is an adaptation strategy for managing climate risks and reducing labor costs in rainfed rice production in lowland Lao PDR.* Field Crops Research, 225(May), 32–46. 2018. URL:https://doi.org/10.1016/j.fcr.2018.05.020.
[46] Welch, J. R., et.al. *Rice yields in tropical/subtropical Asia exhibit large but opposing sensitivities to minimum and maximum temperatures.* Proceedings of the National Academy of Sciences, 107(33), 14562–14567.2010. URL: https://www.pnas.org/content/pnas/107/33/14562.full.pdf
[47] Li, S., Q. Wang, & J.A. Chun. *Impact assessment of climate change on rice productivity in the Indochinese Peninsula using a regional-scale crop model*. International Journal of Climatology, 37(April). 2017. URL: https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/joc.5072
[48] Tselios, V., & E.L.Tompkins. *What causes nations to recover from disasters? An inquiry into the role of wealth, income inequality, and social welfare provisioning.* International Journal of Disaster Risk Reduction, 33, 162–180. 2019. URL: https://www.sciencedirect.com/science/article/pii/ S221242091830712X?via%3Dihub
[49] United Nations. *SDG 10: Inequalities. Lao PDR*. 2019. URL: http://www.la.one.un.org/sdgs/sdg-10-inequalities.
[50] Government of Lao PDR. *Strategy on Climate Change of the Lao PDR*. 2010. URL: https://mirror.unhabitat.org/downloads/docs /12679_1_595432 .pdf

insecure. This marginalizing access issue leaves millions of forest-dependent communities vulnerable to land expropriation.[51]

Many of the climate changes projected are likely to disproportionately affect the poorest groups in society. Flooding and extreme heat stand out as key threats, as heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress.[52] Poorer businesses are least able to afford air conditioning, an increasing need given the projected increase in cooling days. Poorer farmers and communities are least able to afford disaster insurance, local water storage, irrigation infrastructure, and technologies for adaptation. Recent events elicit this low adaptive capacity as more than 200 families living in Laos' Bokeo province have suffered because of sudden increases in the height of the river, threatening their livelihoods.[53]

The ADB has highlighted that many households in Lao PDR have a high probability of falling into extreme poverty even when exposed to relatively high frequency flood and drought events.[54] For example, an event occurring once in every five years has approximately a 50% chance of pushing a household into extreme poverty (Figure 7). This highlights the precarious nature of life in Lao PDR for many households under current conditions.

Figure 7: Probability of falling into extreme poverty by return period of combined flood and drought events[55]



Source: Asian Development Bank (ADB). 2017. *Risk financing for rural climate resilience in the greater Mekong subregion*. Greater Mekong Subregion Core Environment Program. Asian Development Bank. P. 30,d. URL: https://www.adb.org/sites/default/files/publication/306796/riskfinancing- rural-climate-resilience-gms.pdf

Women participation in Lao PDR shows another dimension of the probably impacts of climate change. A gender report published in 2012, women's work is considered largely informal, 73% of women (compared to 78% for men) contribute to the country's labor force, 70% is engaged in agriculture related activities. Further, women and girls constitute over 70% of unpaid family workers, but only 32% are identified as 'own account workers'. This suggests that women are

[51] Saunders, J., A. Flanagan, & N. Basik. *Forest Conversion in Lao PDR: Implications and Impacts of Expanding Land Investments*. Forest Trends and Policy Briefs. Forest Governance, Markets and Climate Program, DFID. 2014.

[52] Kjellstrom, T., et.al. *Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts.* Annual Review of Public Health: 37: 97-112. 2016. URL: https://www.annualreviews.org/doi/pdf/10.1146/annurev-publhealth-032315-021740

[53] Whong, E. *Livelihood of locals in Laos & Thailand are affected by the sudden water releases of Chinese dams.* Radio Free Asia. July 6, 2019.

[54] Asian Development Bank (ADB). *Risk financing for rural climate resilience in the greater Mekong subregion*. Greater Mekong Subregion Core Environment Program, Asian Development Bank. 2017. URL:https://www.adb.org/sites/default/files/publication/306796/riskfinancing-rural-climate-resilience-gms.pdf

[55] Asian Development Bank (ADB). 2017. *Risk financing for rural climate resilience in the greater Mekong subregion*. Greater Mekong Subregion Core Environment Program. Asian Development Bank. P. 30,d. URL: https://www.adb.org/sites/default/files/publication/306796/riskfinancing- rural-climate-resilience-gms.pdf

less likely engaged in productive work with income that they control. Clearly, gender wage gaps are present,[56] not only the undervalued significant work of women in the agriculture sector but also the fact that they work longer hours than men as they spend 7 hours per day on productive and reproductive tasks, compared to the 5.7 hours spent by men.[57]

In the three target provinces, diversification from rice to high value crops (HVCs) and adapting to new cropping system can not only improve farmers' income and nutritional status but can also enhance climate resilience. Depending on the agroecological zone and the climate profile, the switch from rice to other crops can reduce water requirements and improve flood and drought tolerance of specific crops. Focus will also be given to local species and native crops with specific nutritional and climate resilient properties. This switch does not only address adaptation needs but also mitigation. Most emissions of methane from crop production are related to methanogenic bacteria living in flooded soils under rice cultivation which can be avoided by applying improved agricultural practices (i.e. alternate wet and dry paddy) or crop diversification. As the climate changes, agriculture production strategies must change too.

The current water management infrastructure reflects a lack of hydrological skills and tools for assessing and managing flood risks. For example, in the Nam Ngum catchment in Vientiane Capital, the Mekong flood pulse in the 2018 flood was much higher than average, which was further exacerbated by the release of reservoir surplus water. Given the likely increase in extreme flooding events due to climate change, this is a specific gap that needs addressing to protect rural livelihoods.

The agrometeorological information systems are unable to produce adequate and timely data for modelling impacts and forecasting extreme weather events. Government agencies do not have the necessary skills and decision support tools to plan and guide investment for mitigation of, or adaption to, climate risks. The 2018 flood event, for example, destroyed some of the existing monitoring systems, including crucial flood water monitoring stations in Bolikhamxai and Khammouan provinces, urgently requiring replacement.

Lastly, the Bolikhamxai province uplands use gravity-fed irrigation, and although command areas are smaller, they play an important role in local food security and economic growth, especially among ethnic communities. A key benefit of securing irrigation for two seasons of cropping in Bolikhamxai is incentivizing dry season HVCs that are in demand in neighboring Viet Nam and domestically.

Proposed project solution

The project will (i) improve the climate resilience of floodwater and irrigation infrastructure; (ii) improve the delivery efficiency of irrigation water; (iii) introduce climate adapted farming practices to enhance soil health and conservation; and (iv) improve rural incomes through a market-led diversification into higher value dry season cropping. The proposed outputs will lead to the intended project outcome which is climate resilience and livelihoods of agricultural communities improved.

The project will help the government to implement the National Water Management Strategy and Action Plan 2030 (NWMS), which is being elaborated with ADB support. In this strategy, the government recognizes that floods and drought have to be tackled simultaneously in order to increase water supply for crop diversification, and limit the destructive impact of flooding,

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[56] UN Women Regional Office for Asia and the Pacific. 2018. URL: https://asiapacific.unwomen.org/-/media/field%20office%20eseasia/docs/ publications /2018/08/factsheetunwomeninlaopdrrevisedversion2f08compressed.pdf?la=en&vs=1124

[57] ADB and World Bank. *Country Gender Assessment for Lao PDR-Reducing Vulnerability and Increasing Opportunity: Lao PDR*. 2012. URL: https://www.adb.org/sites/default/files/institutional-document/33755/files/cag-lao-pdr.pdf

and to ultimately improve nutrition. The project will: (i) improve vegetative cover to prolong water discharge from catchments and improve disaster preparedness; (ii) invest in irrigation scheme modernization; (iii) develop climate resilient cropping systems that will increase food security and farm household income; (iv) reduce the impact of climate variability through timely and concise information availability for decision-making (both on farm, as well as at government level); and (v) improve the livelihoods, disaster preparedness and nutrition awareness of farming communities.

The sustainable management, conservation and restoration of ecosystems can contribute to climate change adaptation by providing protection from extreme events through their natural ability to regulate changes and absorb the impacts of hazards such as floods and droughts.[58] Scaling-up approaches that rehabilitate natural systems using ecosystem-based adaptation (Eba) can not only mitigate the impacts of natural hazards and climate change but they can also contribute to sustainable livelihoods as well as generating additional environmental, economic, and social benefits and thus build resilience[59]. Well-integrated ecosystem-based adaptation interventions are often referred to as low regrets or no-regrets options as they can generate benefits regardless of uncertainties in climate projections as well as often being more cost effective and sustainable than non-integrated physical engineering approaches[60]. The evidence base continues to grow on the feasibility and effectiveness of natural flood risk management in river systems through resotring and protecting riparian vegetation to address the impact of increased rainfall intensity, reducing flood damage and increasing water security.[61] This has led to increasing confidence in approaches which have been shown to work leading to further expansion in some countries.

Opportunities for on-farm diversification such as cultivating different crop varieties, crop species, integrating crop-fish/ livestock systems, etc. can improve resilience by buffering production from the effects of greater climate variability and extreme events, and by reducing pest and disease outbreaks[62]. Cultivar improvements and agricultural diversification, as well as community-based adaptation approaches have been identified by the IPCC as feasible and effective options at reducing climate impacts in different socio-cultural, economic and geographical contexts.[63] Studies show that households that diversify what they choose to produce, as well as to sell, are pursuing key livelihood strategies that make them more food secure, and more able to take up new agricultural practices to deal with changing circumstances[64]. In Lao PDR, crop diversification has already been found to be an effective

[58] Klein, R.J.T. et al. *Adaptation opportunities, constraints, and limits.* In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 899–943. 2014.

[59] Monty, F., Murti, R., Miththapala, S., Buyck, C., . *Ecosystems protecting infrastructure and communities: lessons learned.* IUCN, International Union for Conservation of Nature. 2017. URL:https://doi. org/10.2305/IUCN.CH..2017.14.en

[60] Organisation for Economic Co-operation and Development (OECD). 2019. *Implementing adaptation policies: towards sustainable development.* URL: https://www.oecd.org/g20/summits/osaka/OECD-G20%20Paper-Adaptation-and-resilient-infrastructure.pdf.

[61] Parmesan, C., M.D. Morecroft, Y. Trisurat, R. Adrian, G.Z. Anshari, A. Arneth, Q. Gao, P. Gonzalez, R. Harris, J. Price, N. Stevens, and G.H. Talukdarr, 2022: Terrestrial and Freshwater Ecosystems and their Services. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

[62] Green Climate Fund. 2021. *Sectoral Guide on Agriculture and Food Security.* [Online] available at https://www.greenclimate.fund/sites/default/files/document/agriculture-and-food-security-sectoral-guide.pdf

[63] Bezner Kerr, R., T. Hasegawa, R. Lasco, I. Bhatt, D. Deryng, A. Farrell, H. Gurney-Smith, H. Ju, S. Lluch-Cota, F. Meza, G. Nelson, H. Neufeldt, and P. Thornton, 2022: Food, Fibre, and Other Ecosystem Products. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

[64] Wright H, Kristjanson P, Bhatta G. 2012. *Understanding Adaptive Capacity: Sustainable Livelihoods and Food Security in Coastal Bangladesh.* CCAFS Working Paper No. 32. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.

strategy to deal with climate risks and the uncertainties associated climate change, while also contributing to improved livelihoods for smallholder farmers[65].

SECTION 2: PROJECT DESCRIPTION

Project outcomes: Climate resilience and livelihoods of agricultural communities improved.

Project outputs:

Output 1: Improved flood water management to reduce damages.
Output 2: Improved water reliability during droughts to reduce losses.
Output 3: Agrometeorological information systems modernized.

Project activities:

- Output 1: The climate change assessments for the area suggest a "hotter and wetter" scenario for Lao PDR. An integrated flood risk management approach as recommended by the Intergovernmental Panel on Climate Change (IPCC) will be adopted in which all three key components of hazard, exposure, and vulnerability are holistically addressed. Hazards (or climate risks) such as high intensity rainfalls and exposure to hazards are addressed by adoption of more climate resilient infrastructure including upgrade of headworks and spillways to withstand extreme weather events, provision of removable solar pumps on floating pontoons that can be shifted away from floodwaters during the wet-season, installation of solar panels above flood levels, and promotion of flood tolerant rice varieties that can survive extended periods of inundation. Vulnerability, or the ability of communities to prepare for, respond to, and recover from climate-related threats is addressed through better access to weather information through the Lao Climate Services for Agriculture (LaCSA) system (Output 3) as well as improved weather and hydrological monitoring systems, capacity building activities to strengthen preparedness and response capacity for flood, and capacity building for improved agriculture and water management practices.
- Output 2 will improve resiliency of the agricultural systems to climate change impacts especially droughts. The projected "hotter and wetter" scenario (footnote 3) is leading to increasingly lower rice yields in the dry season due to declining water availability, higher crop water requirements, and poor soil health. Farmers in the project area will be supported to transition from a monoculture of rice to a more diversified cropping pattern which becomes possible through construction of irrigation schemes that supply the right amount of water to the right place at the right time. Dry-season irrigation water will be supplied with less energy costs by involving solar powered pumping and more effective water delivery systems. Water user groups will be empowered to improve the management and operation of their schemes. A 2–3 year transitional extension program will be adopted for farmers to help in their diversification to high value crops (HVCs) using climate-resilient farming practices that lead into less greenhouse gas emissions. Pilot farm plots will be introduced early in the project to demonstrate management and operation of HVC climate-resilient farming supported by market-led strategies. The private sector will be engaged to conduct the extension services under the overall supervision of the MAF. Additionally, with application of the LaCSA system (Output 3), farmers will have access to reliable and easy-to-use climate data for planning crop calendars.
- In addition, in connection with the designated subprojects, upland degraded forest areas will be assisted to regenerate through natural reforestation and community plantation initiatives to improve the water retention capacity of the upper catchments.

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[65] Vernooy, R. 2015. *Effective implementation of crop diversification strategies for Cambodia, Lao PDR and Vietnam: Insights from past experiences and ideas for new research*. https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Effective_implementation_of_crop_diversification_strategies_for_Cambodia__Lao_PDR_and_Vietnam_1874.pdf

Community livelihood schemes will be implemented in communities impacted by the consequent loss of access to forestry areas, including assistance with house-level irrigation and garden systems, livestock raising, non-timber forest products, agro-forestry and improved post-harvest capability.

- Output 3 will develop a climate and disaster information system to provide periodic information to communities for better decision-making about climate-sensitive farming as well as issuance of emergency flood early warning systems to vulnerable communities. Project investment in an agro-meteorological system will include both hard infrastructure (i.e. weather stations or flood monitoring stations) and soft infrastructure (data base, collection, and analytical tools, etc).

Use of GCF funds

GCF will directly fund climate adaptation activities under outputs 1 and 2 of the FDMMSP, and indirectly strengthen output 2. The exact activities will be identified based on detailedsurveys and consultations during the early stages of implementation.

GCF funding under project Output 1: GCF will fund activities under output 1 of the FDMMP that are related to the expansion and conservation of ecosystems and natural resources by communities through increasing vegetative cover (natural reforestation and application of bioengineering) in order to regulate the impacts of changing precipitation patterns and the likely increase in flooding, resulting from intense periods of rainfall. Expanding vegetation and foliage through green infrastructure investments will not only reduce flood peaks, but also function as a carbon sink and provide communities with non-wood forest products and additional income.

GCF funding under project Output 2: The interventions funded by GCF under output 2 will specifically focus on (i) natural reforestation and community plantation of upland degraded forest areas; and (ii) production and post-harvest technologies to ensure proper handling of crops and livestock and reduction of post-harvest losses due to extreme climate events. GCF funds will be used to procure upland degarded forests. Within these areas, community agreement to plant permanent tree crops and natural regeneration of steep lands will be prerequisites for the incentive packages that improve adaptability of the impacted communities in the long-term. These initiatives will not only reduce greenhouse gas emissions, but also impact microcliamte by helping moderate temperature rise and provide protection to more frequent and intense flooding, but also substantially increase ecosystem services. Provision of small-scale innovative technologies and equipment (e.g. solar irrigation pumping, solar drying, green houses, digital soil and water metering) will increase adaptive capacity and further strengthen farmers ability to meet the demand for high quality agricultural products, thus increasing income potential. While ADB will invest in irrigation infrastructure, GCF will support farmers to adopt climate-smart and regenerative agricultural strategies within the irrigation schemes to increase farmer returns, as well as incentives to stop and reverse land conversion into cassava production, thus minimizing practices that increase climate risk.

Justification for GCF grant financing

A key element for upscaling regenerative climate-smart technologies will be building locally robust farming systems that can respond to climate change. GCF funds will be used to promote on-farm resilience to climate change by applying climate-smart and water-saving agricultural practices leading to increased productivity and resilience as well as diversification to HVCs. Coupled with investments in higher soil fertility and crop diversification, this will ultimately lead to increased income generation for poor rural households. Field schools, and farmer to farmer extension processes will allow farmers and farmer groups to experiment and learn new farming methods that increase their resilience.

In the long-term, upland watershed management is vital to the reliability of the watercourses on which the lowland irrigation schemes depend. Investment in the establishment and management of upland forests, as well as the impacted communities, will secure the long-term returns made in the targeted subprojects.

Ecosystem-based solutions such as reforestation and community climate adaptation can address a large part of the identified climate risks in a sustainable way with significant environmental and social co-benefits, opportunities for scalability, and often more cost effectively than traditional solutions. However, such measures have a limited ability to generate revenue in the short to medium term through their operation, and thus repaying a capital investment on increasing vegetative cover is not feasible. The non-revenue aspect of ecosystem-based solutions do not provide justification for the government to undergo further in debt and therefore GCF funds will be provided as grant that primarily promotes application of ecosystem-based solutions and community climate adaptation solutions.

Implementation arrangements

The National Steering Committee will be the oversight body of FDMMP and will be chaired by the Minister of MAF or his delegate. Each of the three target provinces will establish a provincial steering committee chaired by its governor. The governor's offices of these provinces will be the implementing agencies and will assign the Provincial Agriculture and Forestry Offices to undertake local procurement, finance and administration and subproject design and approval. The project governance team already established under DOI will supervise and backstop provincial staff.

Flow of funds

The mechanism for flow of GCF funds will be established in detail during the initial stages of implementation and prior to any disbusrement. Tentatively the approach below is proposed.

All competitive procurement will be conducted in accordance with ADB's Procurement Policy (2017), and will be defined in an updated procurement plan. For payments to communities/farmer groups for land, materials and equipment, a framework of grants will be used based on priorities defined by such groups. Grant guidelines will be developed and approved by ADB prior to any disbursement. Disbursements will be by direct payment from ADB for larger contracts, and through an advance account held at the Ministry of Finance, and sub-accounts held by each PAFO for smaller contracts.

SECTION 3: PROJECT ALIGNMENT WITH GCF AND CRPP INVESTMENT CRITERIA

Paradigm Shift: The following factors are expected to catalyze the impact of the project beyond the initial investment.

The long-term benefits in terms of climate change adaptation will be three-fold:

a. **Scalability and replicability:** the project will equip farmers and communities with appropriate farming techniques, equipment, and knowledge to better withstand extreme weather events, such as floods and drought. HVCs will be promoted to further diversify farmers' income and make them more resilient to external shocks. Findings from farmer trainings, pilot sites and farmer field schools can also be used as a blueprint for communities outside the targeted provinces. Therefore, using best practices and lessons learned have the potential for replication in other provinces and the possibility for scaling up of proposed activities.

b. **Sustainability of outcomes:** After project completion, sustainability of both ADB project investments, as well as the GCF funds, will be ensured in multiple ways: (i) by ensuring improved and consistent financial returns for the farmers as a result of the implementation of proven adaptation strategies and technologies, adoption of climate change resilient farming systems will be continued by farmers; (ii) conducting a rigorous financial management assessment of the relevant government agencies to ensure sufficient operation & maintenance (O&M) funds are set aside; and (iii) improving skills and knowledge – the project will include a series of capacity building activities, training and skill development on climate-smart agricultural practices, crop diversification and improved community livelihoods and nutritional knowledge that will engage a wide variety of people, ranging from poor and vulnerable, to women and minority groups. This will ensure a wide adaptation and use of the acquired skills even after the project has ended.

Sustainable development potential

The following positive economic, social and environmental co-benefits have been identified:

a. **Environmental co-benefits:** water resource protection by improved irrigation water use efficiency; conservation of aquatic biodiversity through construction of fish passage on flood control and irrigation infrastructures; and forest regeneration.
b. **Social co-benefits:** the community development and nutrition component funded by GCF will improve livelihoods and make communities better prepared to meet climate adaptation challenges and introduce major nutritional benefits for young people, especially girls and women. The commercial opportunities available in HVCs in the dry season will deter people from seeking off-farm employment and help to maintain family cohesion.
c. **Economic co-benefits:** Through the ADB project and use of the GCF funds, crop production will occur in both the wet and dry season. This will increase household food securty and income. It will also provide the opportunity for women during the dry season to lead the production of commercial fruit and vegetables, and market these crops at local and national retail markets. It has been shown that these opportunities can have a significant impact on time-poverty issues.

The following positive co-benefits according to the sustainable development goals have been identified:

a. **SDG 1.4:** By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance
b. **SDG 2.4:** By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality
c. **SDG 5.5:** Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life
d. **SDG 6.5:** By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
e. **SDG 10.1:** By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average
f. **SDG 12.2:** By 2030, achieve the sustainable management and efficient use of natural resources.

Needs of the recipient

Almost 1 in 4 people in the central provinces live below the national poverty line in 2019, with most of the poor living in rural areas. Bolikhamxai and Vientiane have seen a poverty reduction of around 6% between 2013 and 2019, while the rate in Khammouan virtually remained at the same level[66]. In terms of access to safe and nutritious food, the prevalence of food insecurity remains the highest in the central provinces at 25%, compared to the northern and southern provinces of about 20% in 2018/19.

The impact of climate change though increased floods, droughts and temperature extremes is further hampering the economic and social development of rural communities in the targeted provinces. With no proper coping an adaption measures in place, farming households are being disproportionately affected by severe weather events, lowering their incomes and livelihoods even further. Over 60% of the losses during the 2018 flood incurred in the agriculture sector, devastating crops, livestock and productive equipment and infrastructure. Climate change is expected to exacerbate these issues.

Country Ownership

Lao PDR's Agricultural Development Strategy to 2025 and Vision to 2030 prioritizes irrigation development to support the production of both wet and dry season crops.[67] The government prioritizes interventions in agriculture and rural development by: (i) improving agrometeorological information and coverage to reach target users; (ii) increasing forest and vegetative land cover; (iii) developing water management infrastructure for flood control and irrigation; and (iv) modernizing irrigation technologies and practices. Vientiane Capital and Khammouan flood plains are government priorities for securing two season production, including dry season high value crops. Bolikhamxai is a priority province for year-round cultivation to increase trade with Viet Nam.

The project contributes to Lao PDR's climate change priorities by aligning to the first target of the country's Nationally Determined Contributions (NDCs) through investing in improved vegetative cover of watersheds as a mean of flood control and by promoting crop and nutrition diversification.

The project also will provide support to Lao PDR to operationalize the National Water Management Strategy and Action Plan 2030 (NWMS), which is being elaborated with the support of ADB. Relevant priorities from the NWMS include (i) reducing the fiscal and household losses from floods and droughts; and (ii) developing the major flood plains to produce two irrigated crops per year.

Moreover, the project is in line with the 2010 National Strategy on Climate Change (NSCC)[68] which is a Framework Document that has identified seven priorities areas for Adaptation and Mitigation: 1. Agriculture and Food Security, 2. Forestry and Land Use Change, 3. Water Resources, 4. Energy and Transport, 5. Industry, 6. Urban Development, and 7. Public Health.

Lastly, the project also aligns well with GCF country programme 2019[69] which has the following main priorities:

a) Short term priorities (2019-2021):

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[66] Ibid footnote No. 74.
[67] Ministry of Agriculture and Forestry. 2015. Agriculture Development Strategy to 2025 and Vision to the Year 2030. Vientiane.
[68] Government of Lao PDR, Ministry of Natural Resources and Environment, National Strategy on Climate Change, 2010, Vientiane
[69] Government of Lao PDR, Ministry of Natural Resources and Environment, Department of Climate Change, Lao PDR GCF Country Programme, 2019, Vientiane.

a. Increase and maintain national forest cover
b. Increase the resilience of urban areas to water impact, in particular to floods
c. Increase the resilience of rural areas to climate induced droughts and floods
d. Enhance resilience of smallholder farming communities in vulnerable areas
e. Climate friendly agribusiness value chain

b) Medium to long term priorities (2022-2030):
   a) Promote energy efficiency measures
   b) Increase renewable energy supply
   c) Implement low carbon transport measures
   d) Increase the resilience of the health system (infrastructure and population)
   e) Enhance the resilience of urban infrastructure.

Stakeholder consultation and engagement

As part of the project preparation, comprehensive consultations have been held with relevant national government ministries, state departments, development partners, civil society organizations, beneficiaries and nongovernment organizations. At all levels, project stakeholders were invited and encouraged to provide suggestions on design, scope, implementing arrangements, opportunities for collaboration and partnerships, and lessons learned from other community-based development projects. Views of stakeholders, including women, men, and youth, were also incorporated into the design and implementation arrangements. Furthermore, ADB has coordinated with development partners such as the Food and Agriculture Organization of the United Nations, the International Fund for Agricultural Development, the Japan International Cooperation Agency, and the World Bank, to ensure complementarity and avoid duplication of effort.

Efficiency and effectiveness

Economic analyses have been carried out on three representative subprojects, and have proven to be economically viable. It is expected that the remaining additional subprojects will yield similar results, as indicated by the table below.

Table 2: Project Economic Benefits

Project Output	Economic benefits
Output 1: Improved flood water management to reduce damages.	Flood infrastructure typically found to have high benefit to cost ratios (averaging 5:1). [70, 71] Economic benefits from avoided losses, but additional benefits associated with green infrastructure from avoided GHG emissions and wider socio-economic benefits.
Output 2: Improved water reliability during droughts to reduce losses	Disaster preparedness found to have high benefit to cost ratios (~10:1)[72] with economic benefits delivered through reduction in damages (avoided losses). Community schemes have positive distributional and gender elements.
Output 3: Agrometeorological information systems modernized	Early warning systems have high benefit to cost ratios (averaging 9:1)[73] from avoided losses. More widely, high benefits from weather and climate services from the value of information (improved decisions that reduced losses or increase gains) associated with

[70] Mechler, R. Nat Hazards (2016) 81: 2121. https://doi.org/10.1007/s11069-016-2170-y
[71] ECONADAPT. Assessing the economic case for adaptation to extreme events at different scales. Deliverable 5.1 https://econadapt.eu/sites/default/files/docs/Deliverable%205-1%20approved%20for%20publishing_1.pdf
[72] Shreve, C.M., & Kelman, I. (2014) 'Does mitigation save? Reviewing cost-benefit analyses of disaster risk reduction', International Journal of Disaster Risk Reduction, 10(A), 213–235. https://doi.org/10.1016/j.ijdrr.2014.08.004
[73] Global Commission on Adaptation (2019). Adapt Now. Available online at ww.gca.org.

Project Output	Economic benefits
	hydromet[74] and for agriculture[75]. High economic benefits are reported community-based schemes.[76]

SECTION 4: SAFEGUARDS AND OTHER REQUIREMENTS

Environment and Social Impact

The ADB investment project and GCF funds are not expected to involve any major resettlement as interventions for flood and drought management are mostly moderate (such as embankments, solar-operated pumps, improved vegetation) and modernized irrigation schemes will be promoted. Upland degarded forest areas are expected to be acquired, but only with the full consent of the affected communities and accompanied by livelihood imporvmnent programs.

During project preparation safeguard assessments concluded that, of the three representative subprojects, one is classified as Category B and the other two as category C for both environmental and social safeguards. The environmental and social safeguards of all future additional subprojects will continue to be assessed as part of the detailed project design in line with ADB and GCF policies and the CRPP Environmental and Social Safeguards approach outlined in Annex 6.

Gender-sensitive development impact.

A gender analysis has been carried out as part of the project preparation to assess women's and men's contribution to farming, decision making, workload and household income, among others, and a gender action plan has been developed accordingly. The project will promote a gender balance for participating farming households. This will allow women to participate on equal terms with their husbands in information and decision-making meetings, training, demonstration sessions, and extension services; according to their interests. There will also be potential for offering women and poor farmers short-term benefits from employment and entrepreneurship opportunities during the project's construction and implementation of period.

[74] World Bank (2012). A Cost Effective Solution to Reduce Disaster Losses in Developing Countries: Hydro-Meteorological Services, Early Warning, and Evacuation. Stéphane Hallegatte. Policy Research Working Paper 6058.

[75] Clements, J et al (2013). The Value of Climate Services Across Economic and Public Sectors. Report to the United States Agency for International Development (USAID). Available at http://www.climate-services.org/sites/default/files/CCRD-Climate-Services-Value-Report_FINAL.pdf

[76] White, B. and M. Rorick (2010). Cost---Benefit Analysis for Community---Based Disaster Risk Reduction in Kailali, Nepal. Mercy Corps Nepal.

B. Pakistan: Sindh Coastal Resilience Project

Country: Islamic Republic of Pakistan
Project Location: Thatta, Sujawal, and Badin districts, in Sindh Province

Summary: Project alignment with CRPP overall program design			
CRPP Output	**CRPP Sub-activities**	**Contribution to CRPP Outcomes**	**Link to GCF Adaptation Result Areas**
Output 4: Improved information and systems for delivering applied climate-risk informed investments at scale.	**4.1** Climate information services for key sectors to meet local adaptation needs.	**Outcome 3:** Food security of poor and vulnerable communities is increased. **Outcome 4:** Exposure of poor and vulnerable people to climate shocks and stresses is reduced.	**ARA1:** Most vulnerable people and communities. **ARA2:** Health and wellbeing, and food and water security. **ARA4:** Ecosystems and ecosystems services.
Output 6. Climate adaptive pro-poor infrastructure investment implemented.	**6.1** Ecosystem green infrastructure. **6.2** Flood and landslide protection infrastructure		

Project Summary

Pakistan faces some of the highest climate related risk levels in the world.[77] Sindh province, particularly in the coastal area, faces its own unique pressures and challenges exacerbated by climate change. Conditions in the coastal area districts have seen significantly degraded by a confluence of environmental factors. The negative effects have been driven largely by reduced freshwater availability, water pollution upstream, and poor or uncontrolled development. These are now expected to be exacerbated further by rising temperatures, extreme weather events, and sea level rise under climate change. Reduced discharge below Kotri Barrage in recent decades and poor surface water drainage connectivity have reduced freshwater availability and sediment load on the coast, thereby enhancing natural subsidence and increasing saline intrusion, which in turn has caused a loss of agricultural production, vegetation, and land. Flooding is an acute risk in the region, including riverine floods, flash flooding, waterlogging, urban flooding, and storm surges, which are expected to increase in future under climate change.

This, in turn, has caused a severe degradation of the quality of life and livelihoods in already poor socio-economic circumstances: poverty rates are high, education and literacy rates are low, there is poor access to services and basic amenities. Communities are reliant on agriculture and fisheries and are thereby exposed to the natural hazards associated with climate change and man-made environmental impacts. With few alternatives, communities are using increasingly saline groundwater for human consumption and agriculture, which is detrimental to their health and degrades the soil. Water pollution, loss of mangrove habitats and poor fishing practices have depleted fish stocks. The area has seen increased migration to urban areas as the environmental conditions become less tenable for development.

The proposed Sindh Coastal Resilience Project, targeted for board approval in 2025, will support the development of a prosperous and resilient coastal region. The project will strengthen the “building blocks of resilience”: the underlying physical and non-physical elements that support protection, improved health and food security, and sustainable development of the communities in the coastal areas.

[77] https://www.adb.org/sites/default/files/publication/700916/climate-risk-country-profile-pakistan.pdf

The project comprises four core outputs as described below (further details provided below under Project Description), outputs 1 and 2 are to be co-financed by GCF. ADB is currently under discussion with International Fund for Agricultural Development (IFAD) for a parallel co-financing arrangement for Output 3. IFAD would prepare and implement Output 3 independently under a common project monitoring framework.

- Output 1: Integrated water resources, drainage and flood risk management schemes developed (ADB administered). This output will strengthen coastal region water resources management, drainage, and flood risk infrastructure in the coastal districts, and support longer-term climate change resilience. It will reduce impacts of coastal flooding and intrusion, water logging, improve freshwater availability, support agricultural production, and improve transport and connectivity. The component will support construction or upgrading of coastal and river control systems, bunds, weirs, and gates. It is expected to establish or upgrade drainage infrastructure, channels, and culverts and support revival of natural waterways (*dhoras*) and depressions (*dhands*)
- Output 2: Natural protection buffers restored (ADB administered). This output will support strengthening of nature-based protective buffers in the coastal region. It will support planting and protection of mangrove, riverine forests, and salt tolerant species for shoreline and soil stabilisation. The component will support biodiversity net gain thereby provide improved habitat and ecosystem services, increase carbon sequestration, reduced temperatures and impact of heatwaves, reduce flooding (improve drainage and evaporation), prevent erosion and increase soil stability, and increase commercial and private asset value.
- Output 3: Livelihood and economic transformation enhanced (IFAD administered). This output targets the poor and vulnerable households primarily focusing on youth and women. It will be modelled (and adapted) on the earlier IFAD Gwadar-Lasbela Livelihood Support Project in Balochistan. Project interventions will include asset creation, vocational/entrepreneurship training, establishing commercially viable producers' organizations and producers-public-private partnerships ("4Ps") with a focus on fisheries and nature-based solution for saline agriculture.
- Output 4: Strategic action planning for the coastal region strengthened (ADB administered TA). This output will support and build capacity in key departments and stakeholders for higher-level integrated and strategic planning for the coastal region, including on climate change resilience. It will support the development of a strategic action plan and coastal zone management action plans. It will help improve scientific understanding of the region thereby enabling engineering solutions backed by a solid evidence base.

The project outcome is expected to be livelihoods, land and freshwater protected from reoccurring damage in the coastal region.

SECTION 1: PROJECT CONTEXT AND CLIMATE RATIONALE

Vulnerability context

Pakistan faces some of the highest disaster risk levels in the world, ranked 18 out of 191 countries by the 2020 Inform Risk Index[78]. This risk ranking is driven particularly by the nation's exposure to earthquakes, but Pakistan also has high exposure to flooding (ranked jointly 8th), including, riverine, flash, and coastal, as well as some exposure to tropical cyclones and their associated hazards (ranked jointly 40th) and drought (ranked jointly 43rd) and heat waves. Disaster risk in Pakistan is also driven by its social vulnerability. Pakistan's vulnerability ranking (37th) is driven by its high rates of multidimensional poverty. Pakistan scores slightly

[78] https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk

better in terms of its coping capacity (ranked 59th). The National Disaster Management Authority (NDMA) shows that extreme climate events between 1994 and 2013 have resulted in an average national annual economic loss of almost US$4 billion.

The Indus Delta is the 5th largest in the world and also a hotspot for storm surge, soil erosion and cyclones[79,80]. The delta covers an area of about 41,440 km^2 and the seaward extent is approximately 210 km across. The delta is extremely low-lying and near flat in gradient, with around 4,750 km^2 (circa 10%) below 2m above mean sea-level. Around 5 million people in Pakistan live in this low-lying coastal area, but because of population growth, it is projected that the population could increase six-fold to reach 30 million people by 2060. The coastal provinces of Sindh and Balochistan, in which Pakistan's 990km coastline is located, have the highest rural poverty rates among Pakistan's provinces and the highest urban-rural poverty gaps.[81]

The delta is a combination of variety of ecosystems such as mangrove forests, mudflats, wetlands (freshwater and brackish lakes) and irrigated landscape. It is characterized by 17 distinct inactive creeks, and the Indus River is now limited to the single outlet from Khobar Creek/ Jangh River (Overeem and Syvitski, 2009; Syvitski and Brakenridge, 2013). Sediment deposition behind the various dams and barrages has further blocked the natural flow of the river and restricted the movement of the freshwater and sediments (Renaud et al., 2013). As a result of subsistence, seawater intrusion, and 94% less sediment flowing into the delta than one century ago, the delta has eroded to one fifth of its' size since 1932 (Giosan et al., 2014).

The Indus Delta holds the 7th largest mangrove forest system, yet is unique in holding the world's largest area of arid climate mangrove forest therefore highly resistant to extreme temperatures, seawater salinity and low precipitation. The delta constitutes 97% of the total mangrove forests found in Pakistan. In terms of the total area of mangrove forest, varied figures have been published by different organizations in different times viz. 347,000 hectares (FAO 2005), 86,727 hectares (IUCN Pakistan 2005), 283,280 hectares (SFD 2015) and 108,058 hectares (MFF Pakistan 2014). However, current figures range from 85,000 to 95,000 hectares (FAO, 2016). Due to low precipitation and aridity the mangrove forest ecosystem of Indus Delta is highly dependent on the freshwater and sediment flow from the Indus Delta (Hecht, 1999; Hamid et al., 2000; Ismail et al. 2014; Siyal, A.A. 2018).

Since the 1980s, the mangroves have suffered extensive deforestation (WWF, 2018). Studies suggest that mangrove forests in the Indus Delta historically covered about 2,230–2,500 km^2 (223,000 – 250,000 hectres). According to a Space and Upper Atmosphere Research Commission (SUPARCO) study conducted through satellite images in 1988-89, the mangroves in Pakistan covered 160,000 hectares. This cover was reduced by half (80,000 hectares) when WWF Pakistan surveyed the mangroves in 2002. The rate of degradation of mangrove forests in the delta was estimated to be 6% per year between 1980 and 1995 and only a small percentage were considered to be healthy (WWF-Pakistan, 2007). Mangrove ecosystem services include fisheries, timber, fuelwood, fodder, construction and tourism – if not managed sustainably these services are lost along with the livelihoods for the coastal community. The valuation study of 10,600 ha mangrove plantations established under Sindh Coastal Community Development project, 2013, estimated yearly benefits of PRs3.27 billion (US$32.7 million equivalent) from the mangrove planting under the project for the 3 coastal talukas (IUCN, 2013). The economic analysis of the study reveals a benefit cost ratio of 3.56

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[79] and WWF, 2022 https://wwf.panda.org/discover/knowledge_hub/where_we_work/indus_delta/

[80] Kanwal, S.; Ding, X.; Sajjad, M.; Abbas, S. Three Decades of Coastal Changes in Sindh, Pakistan (1989–2018): A Geospatial Assessment. Remote Sens. 2020, 12, 8. https://doi.org/10.3390/rs12010008

[81] Redaelli, Silvia. 2019. *Pakistan@100 From Poverty to Equity* . World Bank Group Policy Note. March 2019. URL: http://documents1.worldbank.org/curated/ar/868741552632296526/pdf/135319-WP-P163618-14-3-2019-20-44-35-PakPNFromPovertytoEquityFinal.pdf

and an internal rate of return IRR 25 %.

The Indus Delta's rich flora and fauna supports the livelihoods of local fishermen, herdsmen of grazing animals, and hunting/gathering activities. From overall fish productivity point of view, the mangroves forest ecosystem maintains a higher yield (365 – 780 gC/m^2/year) than the coastal waters' fishing yield (50 – 200 gC/m^2/year) (Amajd et al., 2018). Keti Bunder, for example, lies about 200 km southeast of Karachi, one of the most seaward townships in Pakistan and important fishing hub within the Indus Delta. The settlements are built on the mudflats between the channels/ creeks. The location of Keti Bunder has changed three times in 70 years as an adaptation measure to the ever more saline soil and water. The natural resource reduced, most notably due to a decline in freshwater flows due to anthropogenic activities (dams, irrigation, pumping), so that the community is now almost totally reliant on sea fishing and poverty remains high despite some infrastructure development (Asian Development Bank, 2008).

Threats to fish fauna include reduced wetland ecosystem health and freshwater flow, over exploitation of fish resources, use of harmful fishing methods, lack of skilled human resource, inadequate data, pollution, lack of infrastructure and post-harvest losses. All these threats have resulted in reduced production of commercially important species such as river shad 'Palla', barramundi 'dangri' and Indian threadfin 'rawans' during the past four decades. The annual fishing production has reduced from 5000 tons in 1951 to just 500 tons (WWF-Pakistan, 2008). Major threats to the birds of Indus Delta are hunting and poaching, degradation of mangrove forests and associated vegetation, presence of feral dogs and cats, and an excessive use of pesticides on agricultural land (WWF-Pakistan, 2008).

The coastal area is a particular hot spot for the risks of storm surges, erosion and cyclones. In Thatta district 0.5 million hectares of fertile land (12% of the entire cultivated area of the province) is affected by sea intrusion. This threatens the lives of about 400,000 fishermen families. Between 1995-2000, Thatta districts lost an estimated 263,272 ha of land in 3 talukas (Keti Bunder, Kharo Chan and Shah Bunder). According to estimates more than 100,000 people have been displaced due to loss of livelihood resulting from sea intrusion (Sindh Board of Revenue Department, Thatta).

Coastal communities are dependent on the mangroves for their livelihoods, with the poor being the most dependent. Degradation of the mangroves therefore further exposes the poorest members of society who have no alternative income sources. Factors affecting mangroves include increased variability of air temperature, precipitation and sea surface temperature, extreme weather events such as cyclones and storms and sea level rise which leads to sea intrusion and erosion. Challenges include a lack of awareness among local people, politicians and general public and lack management plans for mangrove forests (MCC, 2018) and failure to enforce forestry regulations (ADB, 2016). The loss of these habitats results in less food availability and ever increasing salinity, as well as increasing hazards exposure. This combination of risk and hazards will increase the vulnerability of the coastal community.

Salik *et al* (2015) explored climate change induced socio-economic vulnerability of mangrove-dependent communities in Keti Bundar using the Composite Vulnerability Index (CVI). The data for three CVI components (exposure, sensitivity and adaptive capacity) were collected at household level through a questionnaire-based survey in six villages, along with secondary data related to 'exposure'. The assessment shows that the coastal communities are exposed and highly sensitive to climate change driven threats. Moreover, lack of access to basic facilities, inadequate income diversification, and low education levels are negatively affecting the adaptive capacity of the entire local population. However, the communities' nature of dwelling, their strong family networks, and their ability to migrate contribute positively to their adaptive capacity. Migrations in Keti Bundar were recorded as high, depicting high adaptive capacity of the community, given that people were capable enough to migrate at the times of natural disasters to seek shelter and job opportunities elsewhere.

The coastal communities of Sindh are highly vulnerable (Salik et al, 2015[82]). Agriculture employs 42.3% of the Pakistan's workforce and contributes 21% to gross domestic product (GDP). The Delta coastal belt has a rural agricultural and fisheries focus with a vast irrigation system. The present rural population of the rural delta area is approximately 1.4 million people. Above 71% of the population lives below poverty line (MDC, 2012). The population in and around mangrove forests on the coast of Pakistan is estimated to be about 1.2 million (around 900,000 people or 140,000 households in the Indus Delta, and 300,000 people or 30,000 households in the Baluchistan Coast). A population of about 210,000 is directly dependent on coastal resources (MCC, 2018). According to Chaudry (2017), 135,000 people depend directly on the mangrove for their livelihood in the Indus Delta. Mangrove are the dominant habitat and service provider for commodities such as fuel, construction material, protein and asset protection. Coastal communities are highly dependent on mangrove for their livelihoods, with the poor being the most dependent. Degradation of the mangroves therefore further exposes the poorest members of society who have no alternative income sources.

In Sindh, extreme climate events have significant impact on the agricultural sector. A major flood in 2010 led to an estimated 2.4 million hectares of unharvested crops being lost, worth approximately $5.1 billion. Droughts can be equally devastating to rural livelihoods, from 1999–2002, droughts in the Sindh and Baluchistan provinces killed two million livestock and emergency relief was required for the farming communities.

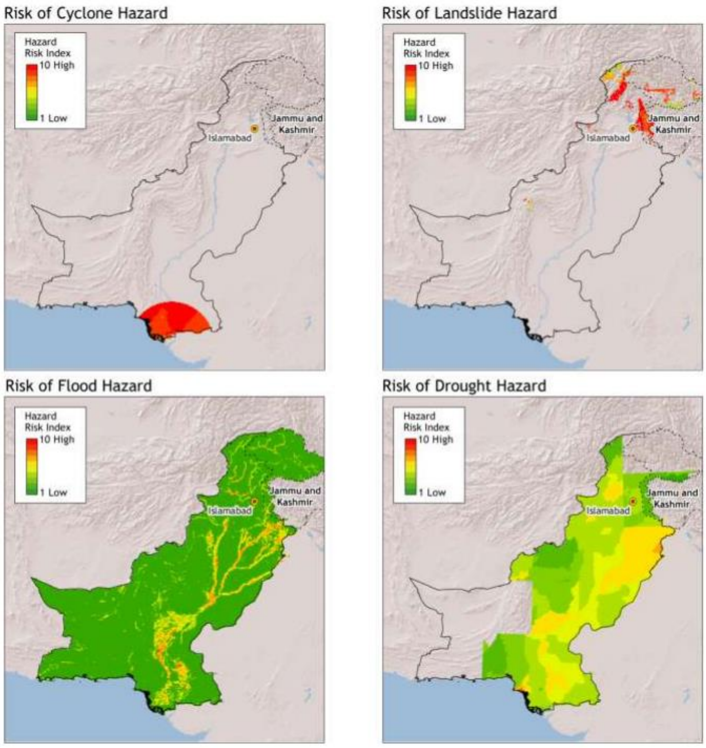
Climate baseline

Mangrove forest being the biggest ecological system of Indus Delta will also be affected by reduction in its cover, biodiversity and other natural resources. Decline in the mangrove forest is already happening, which will further be enhanced due to reduced freshwater availability, increased salinity, increased rate of coastal erosion, and increase in extreme weather patterns under climate change.

Sindh province, particularly the coastal area, faces its own unique pressures and challenges. As shown in Figure 8, cyclone and floods are of particular concern.

[82] Salik, Shif Majeed, Sehrish Jahangir, Waheed ul Zafar Zahdi, Shabeh ul Hasson(2015). Climate change vulnerability and adaptation options for the coastal communities of Pakistan, Ocean & Coastal Management, Volume 112, 2015, Pages 61-73, ISSN 0964-5691, https://doi.org/10.1016/j.ocecoaman.2015.05.006.

Figure 8: Exposure to climate-related hazards across Pakistan



Source: GFDRR. 2011. Climate Risk and Adaptation Country Profile: Pakistan. http://www.gripweb.org/.

The coastal areas of Pakistan are experiencing mean sea level change, the tidal observations at Karachi Port indicate a 1 mm/yr increase in mean sea level during the 20th century. Coastal and in-land floods and drainage issues to date are described in a number of recent reports produced for ADB[83].

Mirpur Sakro is located in Thatta district immediately to the south of Karachi. The largest population center near the coast is Mirpur Sakro town, with an estimated population of 20,000. Fluvial hazard is significant, and relative to coastal flood, about 2.5 times the number of people are impacted in an average year compared to coastal flood[84]. A recent event causing flooding in this area is Tropical Cyclone Phet which made landfall on 6 June 2010 along Sindh coast between Karachi and Keti bunder. Heavy rainfall with high winds caused flash floods and infrastructure damage[85]. According to the Pakistan Meteorological Department coastal areas were impacted by a storm surge around 3.7 – 4.3m high[86], though the source of this estimate and the location at which this occurred is not clear. The tropical cyclone tracked south of Karachi and thus the storm surge recorded at Karachi tide gauge – the only observational data set in the study area - is relatively small, with a maximum surge residual of 0.26m. Flooding was particularly severe in the northern and central parts of Thatta, reducing in magnitude to the south towards the Indus. In the coastal zone the analysis struggles to assess the difference between the regular tidal inundation and flood waters.

The flood risk characteristics of Badin and Tando Bago appear to have similar characteristics. Badin City is the main and capital city of Badin province, with a population (2017) of about

[83] Akhtar Ali (2013) Indus Basin Floods. Mechanisms, Impacts, and Management. https://www.adb.org/sites/default/files/publication/30431/indus-basin-floods.pdf

[84] ADB, 2022, Flood Risk Assessment for Sindh Province. Produced by Landell Mills, in association with JBA.

[85] The International Charter Space and Major Disasters, 2010, Tropical cyclone Sindh Coast of Karachi. https://disasterscharter.org/web/guest/activations/-/article/tropical-cyclone-sindh-coast-of-karac-4

[86] Pakistan Meteorological Department, Tropical Cyclone Warning Center, http://www.pmd.gov.pk/Tcyclone-video/admin/Historyadd.php

112,000[87] and has the highest density of flood risk in the district. With an elevation of 10 to 15m above mean sea level, there is no coastal flood risk in Badin or Tando Bago. Surface water flood hazard lies to the south and east of Badin, however the main flood hazard to the city itself is fluvial. There is a complex network of Indus River relic channels (Dhoras) and brackish lakes (Dhands).

Both Badin and Tando Bago lie in the foot of the Nagarparkar Igneous Complex, the elevated geological formation to the east. Precipitation in this area is the highest than in any other part of the Thar desert. Most of the water flows to the low lying Runn of Kutch, after filling the water table in eastern Sindh. This recharge through rainwater runs for 4 to 5 months after monsoon and is used as water supply for communities, agriculture and livestock[88].

As mentioned above, the lowland plains of Sindh and Baluchistan, which include the urban regions of Karachi and Hyderabad, are vulnerable to the impacts of tropical storms and the occasional cyclone. While the Arabian Sea is comparatively less prone to cyclonic storms than the Bay of Bengal, and cyclones do not commonly make landfall .

A marked decrease in storm genesis from the late 1970s has been documented, gradually returning to a level reflective of what can be perceived as the longer term mean by the late 2000s (Evan and Camargo, 2011). The interdecadal variability and trends in the frequency of occurrence of significant storms in the Arabian Sea may therefore have had a tangible impact of risk perception.

The annual distribution of monthly total cyclonic storm days over the Arabian Sea is bimodal, with peaks in activity occurring from May to June and then from October to December, with decreased tropical cyclone activity during the peak of the Indian monsoon (July to September). The very severe and super cyclonic storms form during the months of May, June and November. In May 1999, a category 3 storm made landfall near Keti Bandar in the Indus Delta, resulting in 231 fatalities[89]. The 1999 cyclone season was particularly active, which may have contributed to a perception of increasing intensity with respect to cyclone activity. Major storms recorded in 2004, 2007 and 2010 affected the project area. In 2007, storm surge caused by Cyclone Yemyin had significant impacts on lives (730) and property ($2.1 billion in Pakistan and India). Storm Phet in 2010 moved inland near Karachi, where several neighborhood's were flooded and power outages lasted over 12 hours. The storm killed 16 people in Sindh, and left $81 million in damage. Losses are mainly documented as being associated with flooding and wind.

Saline intrusion[90] and soil erosion continue to be major challenges in the coastal zone, degrading land quality and agricultural yields.[91] Declining discharge from Kotri Barrage on the Indus River and poor surface water connectivity in-land have reduced or prevented freshwater and sediment load reaching the coast. Enhanced subsidence, coastal erosion, and saline intrusion issues result. The effects on agriculture-based livelihoods has caused severe degradation to the quality of life in already poor socio-economic circumstances: the poverty rates in the coastal areas are among the highest in the country, education and literacy rates are extremely low with notable gender bias, and there is poor access to services and basic amenities.[92] With few alternatives, communities are increasing pumping groundwater for

[87] City Population, https://www.citypopulation.de/en/pakistan/cities/sindh/ (based on Pakistan Bureau of Statistics)
[88] Government of Sindh, Mines and Mineral Development Department, Granites of Sindh. http://www.smd.gov.pk/Portals/0/GraniteofSindh.pdf
[89] EM-DAT: The Emergency Events Database - Université catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be Brussels, Belgium.
[90] Zeng, L. & M.C. Shannon. *Salinity effects on seedling growth and yield components of rice*. Crop Sci. 40, 996–1003. 2000.
[91] Letey, J. & A. Dinar. *Simulated crop-water production functions for several crops when irrigated with saline waters.* Hilgardia. 54, 1–32. 1986.
[92] Government of Sindh. 2016. Multidimensional Poverty in Pakistan. Islamabad; Mangroves for the Future Pakistan. 2019. Gender Analysis – Coastal Villages of Keti Bunder, Sindh. Karachi.

human consumption and agriculture. Groundwater in Sindh is becoming increasingly more saline therefore detrimental to health and soil quality. Coastal areas have seen cultivated land decrease by up to 60% in the period 1998 to 2018.[93] This is the result of pumping saline water onto the land, with evaporation leaving salts behind within a few years the land becomes unusable. Additionally, water reduction, water pollution, loss of the mangrove habitats as nursery grounds, and poor fishing practices have depleted fish stocks. The area has seen increased migration to urban areas as the environmental conditions become less tenable for development.[94]

The Indus delta contains the majority of mangrove forest of Pakistan. As well as being a critical habitat and breeding ground for aquatic life and migratory birds, mangrove forests provide ecosystem service benefits to human populations. The provisioning ranges from physical buffering of cyclones and storm surge to sediment stability and coastal asset protection, whilst supporting livelihoods in communities far inland. As a vast buffer for coastal flood risk, the Indus mangroves have capacity to protect against storm waves and surge. The latter requires the geographical scale of the forest to be maintained and improved where the condition is poor or absent. The extent required is several kilometers in width, as is the case in northwestern delta, where mangroves presently extend 10 to 30 kilometers inland. Mangrove reacts well to sea level rise and will migrate if given space. Therefore, the buffer and benefits can migrate too overtime. Hence, mangrove is respected as one of the best eco-engineers to adapt to climate change.

Estimates of historical mangrove coverage vary widely. Four species of mangrove are found within the delta, whereas eight species of mangroves once existed. More recently tools such as the Global Mangrove Watch, allow us to see land use and coverage change overtime from satellite images. Mangrove coverage in the Indus Delta has reduced in the late 20th century and continues in the 21st century. Various reasons have been cited for this decline, including pollution, low freshwater flow and less sediment and nutrient supply, and overharvesting for firewood or grazing animals. In 2010, the Sindh government issued a notification declaring mangroves as protected forests. Since then, restoration and reforestation initiatives involving communities have supported the replantation and custodianship of tens of thousands of hectares. Development threatens the delicate forest and its ability to adapt to climate change, as competition for space and barriers to the mangrove migration consequently result in coastal squeeze. This restriction of the natural habitat will result in lowering effectiveness, unless the delta system is well understood and managed by removing the barriers to migration.

Potential climate change and impacts

Recent observations show that the climate of Pakistan and Sindh region are changing already and many of the issues described above are likely to intensify due to climate change, affecting many marginal and deprived communities. There is a clear warming trend, which has accelerated since the 1960s (with reported 0.5 to 1°C of warming), and higher numbers of heatwaves and hot days.[95,96,97,98,99] Data from the World Bank downscaled analysis shows that

[93] Mahar and Zaigham. 2019. Spatio-temporal assessment of agriculture & mangroves and its impact on socio-economy of people in Indus delta. Pakistan Journal of Botany 51 (1): 377-383.
[94] Salik, K.M. et al. 2015. Climate change vulnerability and adaptation options for the coastal communities of Pakistan. Ocean & Coastal Management. 112: 61-73.
[95] Pakistan's Second National Communication On Climate Change To United Nations. Framework Convention On Climate Change (UNFCCC). Ministry Of Climate Change, Government Of Pakistan (2018).
[96] USAID (2018). Climate Change Risk Profile. Pakistan
[97] GERICS (2015). Climate-Fact-Sheet Pakistan. Climate Service Center Germany
[98] Del Río, S., et.al. Recent mean temperature trends in Pakistan and links with teleconnection patterns. International Journal of Climatology, 33, 277–290. 2013.
[99] Dehlavi, A., A. Gorst, B. Groom, F. Zaman. Climate change adaptation in the Indus ecoregion: A microeconomic study of the determinants, impacts and cost effectiveness of adaptation strategies. WWF-Pakistan. 2015.

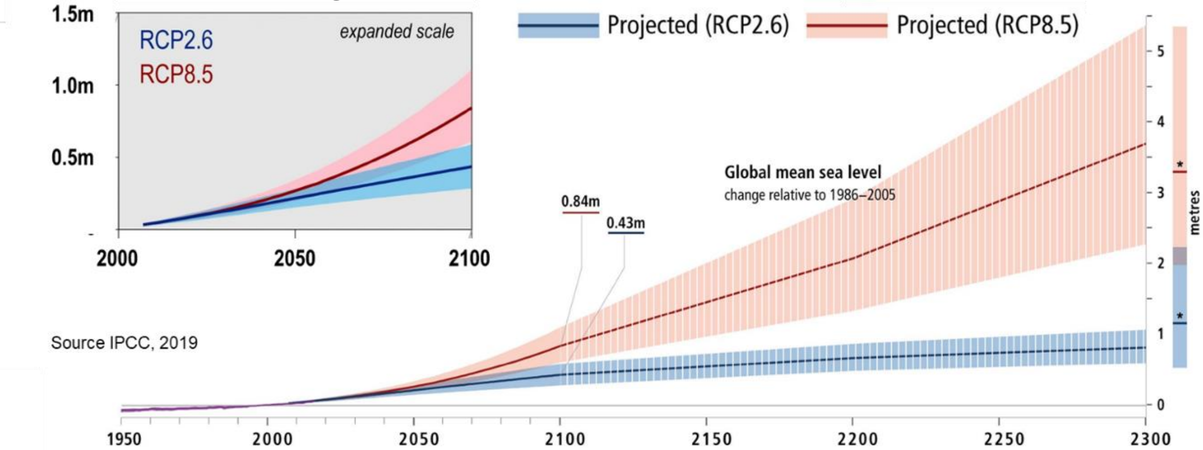
the projected temperature increases for Pakistan will be above the global average.[100] By mid-century (2050s) a further rise of 1.5°C to 2.5°C (central estimate), relative to a baseline 1986-2005 period is projected. There are also projected increases in hot and very hot days based on heat index.[101] Multiple sources report that rainfall in the coastal area has declined by 10 – 15% since the1960s. However, heavy rainfall events have increased, with the heaviest rain intensities recorded over the last decade.[102,103] Changes in the seasonality, regularity, and extremes of precipitation highlights the risk of increased frequency and intensity of flood and drought events.[104] The projections of sea level rise are a particular concern for the low-lying coastal delta and likely to increase coastal flood risk. Sea level rise will lead to saline intrusion via overland and groundwater mechanisms, degrading water and soil quality and thereby agricultural yields. These effects are projected to be exacerbated by increases in the frequency and intensity of storms, increased precipitation and riverine flooding events that may combine with related storm surge.

Although there is a degree of uncertainty over the future patterns of tropical cyclones, recent analysis has also indicated that climate change has had a major role in increasing cyclone activity in the Arabian sea.[105] The IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC,2019[106]) projects that the average intensity of tropical cyclones, the proportion of Category 4 and 5 tropical cyclones and the associated average precipitation rates are projected to increase for a 2°C global temperature rise above any baseline period (medium confidence). This, combined with rising mean sea levels will contribute to higher extreme sea levels associated with tropical cyclones (very high confidence). Coastal hazards will also be exacerbated by an increase in the average intensity, magnitude of storm surge and precipitation rates of tropical cyclones, likely resulting in increased frequency and severity of coastal flooding in low-lying areas and coastal erosion along sandy coasts. Increasing saline intrusion can also degrade land quality and agricultural yields on the coastal zone affecting marginal and deprived communities.[107,108]

More recently, the IPCC SROCC report has reassessed the likely levels of future sea level rise (Figure 9).[109] This includes the addition of ice sheet contributions and projects much higher sea level rise globally. It reports a higher upper range, with 0.6 to 1.1 meters likely by 2100 under a high-emission scenario, due to the increased ice loss from the Greenland and Antarctic ice sheets. Even under low emission scenarios, it is likely that the coastal areas will experience at least a meter of sea level rise by 2100.

[100] World Bank Climate Change Knowledge Portal (CCKP). Climate Data: Historical. URL: https://climateportal.worldbank.org. 2018
[101] *Climate Change Profile of Pakistan.* The World Bank Group and the Asian Development Bank. *URL: https://www.adb.org/publications/climate-change- profile-Pakistan*
[102] Climate Change Profile of Pakistan. The World Bank Group and the Asian Development Bank. 2017.
[103] USAID (2018). Climate Change Risk Profile. Pakistan
[104] Amin, A., et.al. Regional climate assessment of precipitation and temperature in Southern Punjab (Pakistan) using SimCLIM climate model for different temporal scales. Theoretical and Applied Climatology: 131: 121–131. 2018.
[105] Murakami, H., Vecchi, G.A. & Underwood, S. Increasing frequency of extremely severe cyclonic storms over the Arabian Sea. Nature Clim Change 7, 885–889 (2017). https://doi.org/10.1038/s41558-017-0008-6
[106] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
[107] Climate Change Profile of Pakistan. The World Bank Group and the Asian Development Bank. 2017.
[108] *Zeng, L. & M.C. Shannon. Salinity effects on seedling growth and yield components of rice. Crop Sci. 40, 996–1003. 2000*
[109] Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari, 2019: Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.

Figure 9: Projected global sea level rise



Source: IPCC SROCC (2019).

Sea-level rise is one of the main threats to the proposed project area. As mentioned above, coastal erosion and storm surge waves are already threatening towns and farms situated along the coast. Work by the UK Met Office (2014) estimated that without adaptation, around one million people in Pakistan will face coastal flooding annually by the period 2070–2100.[110] These issues are likely to intensify (Tables 3 and 4), affecting many marginal and deprived communities. Taking the 'business as usual' scenario (RCP8.5) where failure to reduce or further increase global greenhouse gas emissions, then we will see a rise of between 0.98 m to 2.47 m (average 1.84 m) by year 2100, compared to mean levels around year 2000. With calculated adaptation and strategic action, the number of people in harm's way can be reduce by several orders of magnitude.

Table 3: Estimates of global mean sea-level rise by rate and total rise compared to 1986-2005 including likely range shown in brackets, data from Chapter 13 of the IPCC's Fifth Assessment Report with upper-end estimates based on higher levels of Antarctic ice-s sheet loss from Le Bars et al. (2017)

Scenario	Rate of global mean sea-level rise in 2100	Global mean sea-level rise in 2100 compared to 1986-2005
RCP2.6	4.4 mm/yr (2.0-6.8)	0.44 m (0.28-0.61)
RCP4.5	6.1 mm/yr (3.5-8.8)	0.53 m (0.36-0.71)
RCP6.0	7.4 mm/yr (4.7-10.3)	0.55 m (0.38-0.73)
RCP8.5	11.2 mm/yr (7.5-15.7)	0.74 m (0.52-0.98)
Estimate inclusive of high-end Antarctic ice-sheet loss		1.84m (0.98-2.47)

Source: Le Bars, D., S. Drijhout, & H. de Vries. *A high-end sea level rise probabilistic projection including rapid Antarctic ice sheet mass loss.* Environmental Research Letters: 12:4. 2017.

Table 4: The average number of people experiencing flooding per year in the coastal zone in the period 2070–2100 under different emissions pathways (assumed medium ice-melt scenario) and adaptation scenarios for Pakistan (UK Met Office, 2014)

Scenario	Without adaptation	with adaptation
RCP2.6	950,300	1,040
RCP8.5	1,207,740	2,190

Source: UK Met Office. 2014. Human dynamics of climate change: Technical Report. Met Office, UK Government.

There is a high level of certainty that sea levels will rise through the coming decades. However, how climate change may affect coastal flood risk at an individual country-level is less certain. Pakistan has been cited as lacking reliable research on MSL rise considering the significance of the exposed population (Hauer et al., 2019).

This indicated sea level rise of 2.8mm/year since 1993 across the study area. This more recent rate is similar to, although slightly lower than, the global average from altimeter records

[110] Syvitski, J. P. M.,et.al. *Sinking deltas due to human activities.* Nature Geoscience, 2(10), 681–686. 2009.

(approximately 3.1mm/year between 1993 and 2015; World Climate Research Program Global Sea Level Budget Group, 2018). Similarly, a linear trend of 3.7mm/year of MSL rise was estimated based on the Karachi Manora tide gauge observations (available between 2007 and 2016), which is also higher than the historical linear trend (1915 to 2016)[111] from the same tide gauge station. Uncertainties exist in these estimates due to discontinuities in the data, possible datum changes and the influences of the Metonic cycle. However, these data are consistent with an acceleration in MSL rise rates in the study area. This most recent trend is also consistent with a global MSL rise of 3.6mm/year over a similar period (2005-2015; Oppenheimer et al 2019).

Recent publications[112,113] raise the possibility of higher increases under high-emission scenarios, with conceivably 2 meters by 2100. Sea level will continue to rise for centuries, even if the Paris agreement to limit global temperature rise to 1.5^{o}C is achieved, due to the thermal inertia of the oceans (the 'commitment to sea-level rise'). Extreme sea level rise scenarios report potential population migration in Asia by the end of the century due to coastal flooding[114], which could affect coastal regions of Pakistan. As sea level rises, there is an increased risk of riverbanks being overtopped and of flooding of adjacent land further up the estuaries. Without intervention, saltwater will penetrate further upstream and inland. Key issue for livelihoods is thus the potential increase in saltwater intrusion affecting water availability and supplies, coupled with broader issues of water availability from the changes due to climate change and demand increases, heat stress, land availability and soil quality, affecting agricultural yields and rural agrarian livelihoods, in a country where Agriculture employs 42.3% of the Pakistan's workforce and contributes 21% to gross domestic product (GDP). Of the 24.3% of population below the national poverty line, over 80% are in rural areas, and comprise a large proportion of small-scale farmers (20%), landless farmers (10%) and agricultural laborers (12%).[115] The Second National Communication from GoP (2018) reports that the Sindh area will suffer the most from water logging and salinity because of poor drainage systems. Similarly, increase in compound / concurrent events will impact ecosystems, health, crops yield, labour productivity resulting in decline in living standards across the country in particular Sindh province being the worst affected.[116]

Description of adaptation needs

The Government of Sindh has already sought to counter the issues described above and reduce risks through both engineering and non-engineering measures. They have supported rural development through livelihood development, capacity building, and small-scale infrastructure projects. The National Climate Change Policy (2012), Framework for Implementation of Climate Change Policy (2013), updated Nationally Determined Contribution (NDC) to the Paris Agreement (2021), and Sindh Climate Change Policy (2021) identify the Indus River delta and coastal region as priority areas in need of (i) improved climate risk assessment, planning, and emergency response; (ii) enhanced water resources and coastal zone management; (iii) climate-resilient protective infrastructure; and (iv) restoration of ecosystems. The Nationally Determined Contribution estimates the cost of Pakistan's total adaptation need to be between \$7 and \$14 billion per year.[117] The National Disaster Risk Management Plan (2012) totaling about \$1.0 billion and National Flood Protection Plan IV

[111] Permanent Service for Mean Sea Level, Karachi Manora Station (ID:204). https://www.psmsl.org/data/obtaining/stations/204.php
[112] Garner, A.J., Weiss, J.L., Parris, A., Kopp, R.E., Horton, R.M., Overpeck, J.T. and Horton, B.P. (2018): Evolution of 21st Century Sea Level Rise Projections. Earth's Future, 6(11), 1603-1615, doi:10.1029/2018ef000991.
[113] Bamber, J.L., Oppenheimer, M., Kopp, R.E., Aspinall, W.P. and Cooke, R.M. (2019): Ice sheet contributions to future sea-level rise from structured expert judgment. Proceedings of the National Academy of Sciences, 116(23), 11195, doi:10.1073/pnas.1817205116.
[114] COACCH (2019). The Economic Cost of Climate Change: Synthesis Report on COACCH Interim Results. Analysis by Lincke et al. using the DIVA model. www.coacch.eu
[115] FAO 2020
[116] Climate Change Profile of Pakistan. The World Bank Group and the Asian Development Bank. 2017.
[117] Government of Pakistan. 2016. *Pakistan's Intended Nationally Determined Contribution (PAK-INDC).* Islamabad.

(2017) totaling about $2.0 billion include structural and non-structural investments to improve resilience and reduce the impact of natural hazards such as floods in the coastal areas.[118] However, to-date, Pakistan's climate change adaptation and disaster risk management has suffered from delayed implementation of the plans.

Ecosystem-based management is an interdisciplinary approach. It balances ecological, social and governance principles at appropriate temporal and spatial scales in a distinct geographical area. To achieve sustainable resource use, scientific knowledge and effective monitoring are used to acknowledge the connections, integrity and biodiversity within an ecosystem along with its dynamic nature and associated uncertainties. The approach recognizes coupled social-ecological systems with stakeholders involved in an integrated and adaptive management process where decisions reflect societal choice. Adaptation in coastal management is essential in a low-lying, highly dynamic and variable delta system, as the land adjusts at the shoreline and recedes, in response to the predicted relative sea level changes. This approach is responsive to measured observed changes and through learning what works and what does not, communities are empowered to better manage their environments.

Further capacity in developing a strategic action plan (SAP) for the coastal delta system which includes water resources and combating water scarcity, drainage under flooding, consideration for groundwater recharge opportunities, and improved data collection, analysis and interpretation, as well as livelihood support. The approach in land-use planning through zonation, as well as leaning to shoreline management plan type approaches, using an adaptation pathway[119] with well described triggers will support decision-making as sea level changes. The overarching SAP will need to be supported by a greater investment in observations and monitoring to inform models and forecasting tools, and to trigger alert changes.

Various empirical data has documented the capacity of mangroves to absorb energy in the coastal zone. Energy from both surface waves and storm surge are attenuated through mangroves, although the rate is highly site dependent, varying with the cross-shore distance of the mangrove, species type, the maturity of the mangroves and topographic characteristics. One synthesis of the available data (McIvor et al., 2012) listed storm surge attenuation magnitudes to be between 4 and 15cm for every horizontal kilometer of mangrove forest, based on several observations in Louisiana, USA. However, attenuation rates are not considered to be linear with distance, with decreasing rates with distance evaluated based on modelled attenuation rates (World Bank (2016).

Using natural options to slow the flow of water through the landscape has been championed internationally to a) give communities affected by flooding more time to prepare and b) to reduce peak water levels of rivers and streams. These natural options in flood engineering are known as nature-based solutions to reduce flooding. These can be effective on their own, or used alongside engineered solutions such as flood barriers, as part of a whole catchment approach to reduce the risk for communities that flood regularly. Examples of nature-based solutions are planting trees and vegetation to increase water absorption, catch rainfall and slow down surface water run-off, improve soil cover with plants to reduce water pollution and run-off, divert high water flows and create areas to store water, create leaky barriers to slow water flow in streams and ditches, and restore wetlands where mangrove, mudflats and saltmarshes thrive.

Nature-based solutions (NbS) provide ecosystem services – these are the benefits and co-benefits human receive from nature – in this case for flood risk management. This includes

[118] Government of Pakistan. 2012. *National Disaster Management Plan.* Islamabad; and Government of Pakistan. 2017. National Flood Protection Plan-IV. Islamabad.
[119] Ranger, N et al (2013) Addressing 'deep' uncertainty over long-term climate in major infrastructure projects: four innovations of the Thames Estuary 2100 Project. Access: https://link.springer.com/article/10.1007/s40070-013-0014-5

helping the communities that live within a catchment to become more resilient to the effects of climate change, such as increased flooding. NbS are effective for low level flooding in smaller catchments that flood regularly, in slowing the flow of rainwater through the landscape into streams and rivers, and reduce flooding from tidal waters on the coast. Wider co-benefits to using NbS in addition to reducing flooding, includes ability to increase the variety and availability of wildlife in rivers and streams by restoring natural habitats, improve water quality in rivers and streams by reducing soil erosion, and store carbon to help reduce global warming.

The ecosystem services provided by NbS, particularly mangrove, wetlands and seaweed, supports the ability for adaptation to climate change. The buffer zone can migrate inland with sea level rise. Literature also suggests that in natural environments mangroves capture sediment at a rate which keeps apace with MSL rise. However, in the context of Sindh, which is starved of sediment through anthropogenic influences further up the Indus system combined with general subsidence, this may not be the case. Saintilan et al (2020) determined that it was very likely that mangroves would not be able to initiate sustained accretion when relative MSL rise exceeds 6mm/year. The lack of sediment supply to the lower Delta suggests that this process may be further inhibited in the area of interest.

Since 1983 several studies have been conducted to assess the mangrove forest cover in Pakistan. These include assessments by SUPARCO 1983, FSMP 1992, WWF-Pakistan 2003, IUCN 2003, SUPARCO and Sindh Forest Department 2005, WWF-Pakistan 2005, and USPCAS-W 2018. The Sindh Forest and Wildlife Department has signed a 30-year agreement with Indus Delta Capital Ltd (UK) to replant 353,000 hectares of mangroves and develop mangrove forest carbon credits for sale on the international market. The ambition is that all mangrove plantations in the future generate carbon credit revenue for the province. The project started in 2015 and to date has established stewardship agreements with the communities to manage grazing, which threatens the mangroves, and is supporting communities with health care facilities and job creation. The project is initially focusing on three pilot fishing villages in the project area east of Karachi.

Proposed interventions

The complexity and multitude of pressures facing the coastal region warrants an integrated approach to climate change risk management. The project will focus on the key areas of physical and environmental risks to livelihoods and infrastructure in the coastal area. The interventions will comprise both structural and non-structural measures, incorporating best practices from around the world. The project focuses on the ‘building blocks’ of resilience, supporting integrated coastal zone management schemes which can provide the foundation for safer, more resilient, and sustainable economic development under future climate change. These combine flood risk management schemes that provide protection from in-land flooding and improve management of surface water (including storage) and strengthening of natural coastal protection in the form of restoring mangrove and other saline tolerant species.

The project challenges are numerous and the natural system dauntingly complex, however the project aims to simplify through providing an integrated, focused, and defined nature-based solutions to engineer out these complexities and challenges. Returning to a more natural-based management approach lessens the long-term burden on operations and maintenance requirements, and lower the risk of failures to critical infrastructure if not well maintained.

In the short-term, the natural protection buffer restoration will improve lives of those working in the forestry department system. These benefits will have a flow down impact from the local households to the surrounding communities and benefit small localities. In the long term, with the ecosystem functioning at a productive rate, that recovery will see improvement for agriculture, fisheries, and potential opportunities for aquaculture and mariculture. Wider opportunities for national tourism and ecotourism are further down the line, with the rehabilitation of the sandy coastal regions, mangrove creeks, and Ramsar designated wetlands.

The project proposes an emphasis on nature-based solutions to flood risk management. Under output 1, flood risk management schemes will include the restoration of natural waterways that provide drainage of surface water in the very low-gradient environment but have been obstructed through unplanned or improper development. Under output 2, coastal mangroves and riverine forestry provide an engineering intervention for flood and coastal erosion risk management and disaster risk or hazard reduction. An integrated approach to coastal planning and management will take the specific socio-economic needs of the community into consideration, along with the cost: benefit assessment as it engages stakeholders from the outset.

The project will also employ an innovative Connection-Restoration-Protection approach which ‘makes space for water’, detailed as follows;

- **a. Connection** of the hydrological system, through irrigation, drainage and waterways maintenance and monitoring. Connecting the freshwater and supporting the sediment supply for ecological function, and therefore urgent improvements for human and irrigation needs at the tail end of the Indus River supply. Additionally, connection between departments and organizations is encouraged for synergy and reaching common objectives. Strategic Action Planning as discussed in the previous sections, underpins the project’s physical activities with a coherent forward-looking approach. It will encompass strategy, policy, planning, monitoring, regulatory aspects, plus capacity building.
- b. **Restoration** of the natural and traditional engineering infrastructure assets, systems that have been poorly managed or neglected over time. The physical and ecological building blocks for development need an asset management style review to understand where problem hotspots for erosion or flooding are and a prioritization approach for maintenance or planting. ‘Work with nature’ to strengthen the natural protections of the coastal area by replanting mangrove and other tree species in strategic areas. This will provide protection against storm surge, coastal erosion, and saline intrusion, with indirect benefits for the environment and livelihoods. There are exciting opportunities with Natural Capital and carbon accounting initiatives.
- **c. Protection** of the coastal communities through natural and traditional coastal management interventions for improved resilience. The connection-restoration ecosystem adaptive management approach with mangrove and forestry will provide natural coastal protection, and where additional traditional coastal engineering interventions are required, they will be designed and implemented accordingly. Integrated flood risk management schemes will provide clear planning regarding where water is ‘allowed’ and given space to pool or be stored, and where it is ‘not allowed’ where townships are defended and/or raised. This clear delineation is a first step in land use management and towards adaptation. There are clear linkages with planning, policy and governance of land-use and waterway management plus Blue Economy initiatives.

Long-term resilience through a free-flowing, well-managed delta catchment along with a thriving 30 km deep mangrove belt to provide adaptive coastal defense. The belt will ameliorate wind-wave energy during storms, and help buffer the impacts of elevated sea levels during storm or cyclone related surge, tsunami, or climate related sea level rise. Natural drainage through restored gated or open channels and creeks will improve overtopping and sheet flow to be channeled from the land during high rainfall or river flooding events. Whilst traditional engineering for flood management and storage for drinking water, early warning systems and signposting to higher ground, will provide protection to coastal communities and improve resilience.

The evidence base continues to grow on the feasibility and effectiveness of re-establishing and protecting coastal mangroves forests for coastal storm and flood protection, coastal erosion control and salt water intrusion prevention that are likely to increase as a result of rising sea levels and increasing storm energy. This has the adaptation benefits of protecting coastal life property and livelihoods[120,121,122,123].

SECTION 2: PROJECT DESCRIPTION

Brief Description of the Project

The Sindh Coastal Resilience Project (SCRP) will support the development of a prosperous and resilient coastal region. Enhancing livelihood opportunities in the coastal region requires simultaneous improvement of the physical environment. SCRP will strengthen the “building blocks of resilience”: the underlying physical and non-physical elements that support the protection, improve health and food security, and enable sustainable development of the communities in the coastal areas.

The project outcome is expected to be improved protection and adaptive management of coastal area infrastructure and livelihoods. The project comprises four core components: (i) integrated water resources, drainage and flood risk management schemes; (ii) rebuilding natural buffers and livelihoods, (iii) livelihood and economic transformation support, and (iv) strategic action planning for the coastal region. The project is expected to be aligned with the GCF impact of *resilience of local communities to the adverse impacts of climate change enhanced*.

The project components are as follows:

Output 1: <u>Integrated water resources, drainage and flood risk management schemes developed</u> (ADB administered). The component will strengthen coastal region water resources management, drainage, and flood risk infrastructure in the coastal districts, and support longer-term climate change resilience. It will reduce impacts of coastal flooding and intrusion, water logging, improve freshwater availability, support agricultural production, and improve transport and connectivity. The project aligns a systems-based approach and follows the natural waterways and artificial catchments within the delta drainage system. Interventions will be prioritized, planned, and grouped along minor catchment areas in the coastal region (see Figure 1 map below), with a primary focus in coastal catchments (indicated as 1 through 5 in the figure). The engineering-based interventions will be harmonized with the nature-based solutions in Output 2 to ensure adequate synergies and enhanced benefits. The component will support construction or upgrading of coastal and river control systems, bunds, weirs, and gates. It is expected to establish or upgrade drainage infrastructure, channels, and culverts and support revival of natural waterways (*dhoras*) and depressions (*dhands*).

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[120] Parmesan, C., M.D. Morecroft, Y. Trisurat, R. Adrian, G.Z. Anshari, A. Arneth, Q. Gao, P. Gonzalez, R. Harris, J. Price, N. Stevens, and G.H. Talukdarr, 2022: Terrestrial and Freshwater Ecosystems and their Services. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.
[121] *IUCN. 2013. Valuation Study of Mangrove Plantations Established under Sindh Coastal Community Development Project (SCCDP). https://www.iucn.org/sites/dev/files/import/downloads/pk_sccdp_mf_final_report_mangrove_valuations.pdf*.
[122] *Kimball, S. et al., 2015: Cost-effective ecological restoration. Restoration Ecology, 23(6), 800–810, doi:10.1111/rec.12261.*
[123] *Bayraktarov, E. et al., 2016: The cost and feasibility of marine coastal restoration. Ecological Applications, 26(4), 1055–1074, doi:10.1890/15-1077.*

Output 2: Natural protection buffers restored (ADB). The component will support strengthening of nature-based protective buffers in the coastal region. It will support planting and protection of mangrove and salt tolerant species for shoreline and soil stabilisation and agricultural practices. The component will support biodiversity net gain thereby provide improved habitat and ecosystem services, increase carbon sequestration, reduced temperatures/ impact of heatwaves, reduce flooding (improve drainage and evaporation), prevent erosion/ increase soil stability, and increase commercial and private asset value. The project will support community engagement for sustainable management of the forest with opportunities for indirect livelihood benefits, entrepreneurial opportunities, and eco-tourism enhancement. It will support the development of a provincial forest carbon strategy and plan, to support long-term sustainable and self-funding development of the forest resources in Sindh.

Output 3: Livelihood and economic transformation enhanced ($100 million, IFAD administered). The component targets the poor and vulnerable households primarily focusing on youth and women. It will be modelled (and adapted) on the earlier IFAD Gwadar-Lasbela Livelihood Support Project in Balochistan. Project interventions will include asset creation, vocational/entrepreneurship training, establishing commercially viable producers' organizations and producers-public-private partnerships (4Ps) with a focus on fisheries and nature-based solution for saline agriculture. The project will integrate the relevant ongoing interventions of Government of Sindh particularly the rural growth hubs, enterprise development fund and skills development initiatives. At the field level implementation will be undertaken through the district implementation offices and partners organisations recruited through a competitive process. At least two types of implementing partners will be recruited i.e. (i) social mobilization partner(s) to assist in social mobilization of communities, identification of beneficiaries for assets transfer and training; and, (ii) business mobilization partner(s) to assist in setting up producers' organisations and 4Ps, conduct market studies, assist in preparation of viable business plans and implementation support to producer organizations and 4Ps.

Output 4: Strategic action planning for the coastal region strengthened (ADB administered TA). The component will support and build capacity in key departments and stakeholders for higher-level integrated and strategic planning for the coastal region, including on climate change resilience. It will support the development of a strategic action plan and coastal zone management action plans. It will help improve scientific understanding of the region thereby enabling engineering solutions backed by a solid evidence base. It will provide additional equipment for monitoring and mapping, data collection and sharing coordination, modelling systems, and early warning systems. As required it will provide additional capacity building and implementation support to implementing agencies.

Figure 10: Project area. The project will focus on initial subprojects within minor catchments 1 to 5. Source: Resilient Coasts.

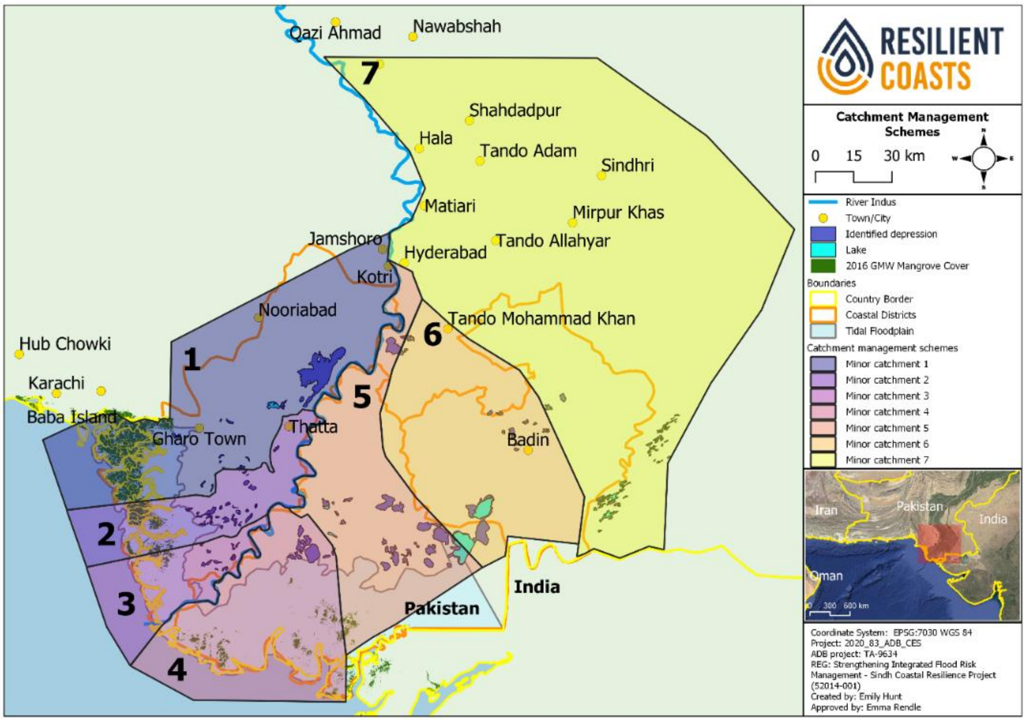


Table 5: Indicative Financing Plan

Source of Funds	Amount ($ million)
ADB loan	125
ADB TA grant	3
IFAD loan	60
GCF	40
Private/beneficiary contribution	10
Government	25
Total	**263**

ADB = Asian Development Bank; GCF = Green Climate Fund; IFAD = International Fund for Agricultural Development; OCR = ordinary capital resources; TA = technical assistance
Note: Detailed arrangements to be confirmed during project preparation.
Source: Asian Development Bank.

Implementation arrangements

The project is targeted for ADB Board consideration in 2025. Project period of implementation is 2025 to 2029.

Implementation arrangements will be finalized during preparation of the project. Planning and Development Board, Government of Sindh (GoS) is expected to be project executing agency. Implementation agencies are expected to be Irrigation Department, GoS (Output 1); Forestry and Wildlife Department, GoS (Output 2); Agriculture Department, Livestock and Fisheries Department, and Technical Education & Vocational Training Authority, GoS (Output 3); Sindh Coastal Development Authority, GoS and National Institute for Oceanography, Ministry of Science and Technology (Output 4).

It is envisaged that a Project Steering Committee will be established chaired by Chairman, P&DB for the start of project preparation. A project management and coordination unit (PMCU) is envisaged to be established within Sindh Coastal Development Authority to coordinate project implementation by project implementation units (PIUs) of respective agencies. Project implementation units (PIUs) are envisaged within Irrigation Department and Forestry and Wildlife Department for ADB-financed Components 1 and 2, with respective project directors (PDs).

Use of GCF funds

The GCF funds are envisaged to be used to support the establishment of integrated flood risk management solutions under output 1 and 2, combining grey and green infrastructure. The exact activities will be identified based on detailed climate risk assessments to be undertaken during project preparation.

The project aligns a systems-based approach and follows the natural waterways and artificial catchments within the delta drainage system. Formulation of multi-layered defences to achieve the ‘triple win’ effect from Nature based Solutions (NbS), that is environmental, social and economic uplift. Combined with traditional engineering solutions at appropriate locations to create Flood Risk Management (FRM) schemes, the NbS elements have the benefit of being community lead, maintained and managed. The FRM schemes utilizing the natural sand, forest and vegetation buffers, ditch-drain-embankments systems, raised platforms, identified ‘safe’ places within towns to retreat behind or onto natural asset. The emphasis on utilising nature-based solutions within communities has been widely discussed throughout this process and regular engagement with Government of Sindh since 2019.

Project preparatory work

Further feasibility study and detailed design will be required to prepare the project. Project preparation, feasibility, and readiness of the ADB-administered components will be supported through a transaction TA targeted to be approved in 2023. The transaction TA will conduct social, gender, and poverty; safeguards; and physical assessments and initial advanced feasibility studies. IFAD will prepare their component (Output 3) separately but in close coordination with the ADB team.

SECTION 3: PROJECT ALIGNMENT WITH GCF AND CRPP INVESTMENT CRITERIA

Paradigm shift potential

Innovative solutions and approaches. By providing an integrated, focused and defined nature-based solution, the approach to the project will engineer out the complexities and challenges commonly associated with such solutions. Forests can respond to sea-level rise by adjusting their position within a tidal frame that is transitioning landwards. This response is dependent upon a range of hydrological, sedimentological and ecological factors. The availability of accommodation space, defined as the lateral and vertical space in which mineral and organic sediments and organic material from *in situ* vegetation can accumulate, is increasingly proposed as a means of conceptualising the response of shorelines to sea-level rise. Where there is a lack of space, the issue of coastal squeeze results, leaving townships and assets vulnerable. By creating space and improving the opportunity for mangrove forests to be restored and migrate, the ecosystem services will be realised.

Moving from a system which is failing in terms of conservation, coastal defence and co-benefits, to a system where the forest is restored and the ecosystem is functioning for the benefit of coastal communities. Livelihoods which rely heavily on ecosystem services will be the primary beneficiaries, namely activities relating to fisheries and aquaculture, agriculture, forestry and firewood, and animal husbandry.

Scaling up and replication: The project will build on and align with earlier and planned investments in the area, by ADB, World Bank, and other development partners and civil society organizations. The skills and opportunities for training in local communities by design (teaching) and through demonstration (doing) in a learning on the job approach. The focus will be on scaling-up the mangrove efforts where it is successful and improving the restoration efforts in regions where mangrove is difficult to reforest (lack of freshwater, sediment supply and compacted soils).

Creation of enabling environment (and sustainability of outcomes). To support institutional development and long-term sustainability, the investments will be underpinned by support for strategic planning and assessment for coastal zone management and future coastal zone investments. The capacity and coordination of federal, provincial, and local institutions for coastal zone management and planning will be strengthened and underpinned by shoreline management plans. Community groups will be organized and mobilized for the (i) planning and development of the flood risk management schemes; and (ii) reforestation, monitoring, and long-term protection of the mangrove trees.

Sustainable development potential

Economic Co-benefits: Improvements to the local coastal economy through the opportunities that are born from the improved environmental and ecological stability. There are opportunities for both genders and inclusive of wide age range. These benefits will have a flow down impact from the larger towns to local households and benefit even very small townships and the migratory communities. In the longer-term, with the ecosystem functioning at a productive rate, overtime that recovery will see improvement for agriculture, fishers, aquaculture, and mariculture. Wider opportunities for national tourism and ecotourism, with the stabilization and rehabilitation of the sandy coastal regions, mangrove creeks, and Ramsar designated wetlands.

Impacts on coastal and marine ecosystem services should be factored into the appraisal of projects and investments, to support the sustainable development of coastal areas. This section provides an overview of mangrove ecosystem valuation studies undertaken in Pakistan, providing an indication of the economic significance of these services, which are lost if the mangroves are degraded or destroyed.

There have been several mangrove valuation studies undertaken in Pakistan, most notably: (i) a study by the Ministry and Climate Change (2018) in part preparation for the development of two potential mangrove payment for ecosystem services (PES) schemes, located near Korangi Harbor Area (Korangi and Phitti Creeks) in Sindh province and Miani Hor in Lasbela District of Balochistan province; (ii) Mangroves for the Future (MFF) study in Port Qasim Authority (PQA) of Indus Delta (2016); and, (iii) a study by IUCN in 2013[124] to estimate the value of mangrove plantations in Keti Bunder, Karo Chhan and Shah Bunder under the Sindh Coastal Community Development project.

The total value of the mangrove area is estimated at PKR 6.75 billion/year (USD 63.73 million/year) in which fish products (Fish, Shrimp and Crab) are the main source of income with a market value of PKR 6.39 billion/year (USD 60.34 million/year), Fuelwood contributes 0.323 billion/year (USD 3.05 million/year), fodder PKR 3.11 million/year (USD 0.294 million/year). Though the area has tourism potential only Khalifa Jat Paro has existing tourism activities valued at PKR 4.59 million /year (USD 43,319/year). Overall, mangrove products and service are estimated at US$ 1,363 /ha/year.

[124] IUCN. 2013. Valuation Study of Mangrove Plantations Established under Sindh Coastal Community Development Project (SCCDP). https://www.iucn.org/sites/dev/files/import/downloads/pk_sccdp_mf_final_report_mangrove_valuations.pdf.

The valuation study of mangrove plantations established under Sindh Coastal Community Development project (2013) estimated yearly benefits of PRs3.27 billion (US$32.7 million equivalent) from the mangrove planting under the project for the 3 coastal states (*talukas*).[125] The economic analysis of the study reveals a benefit cost ratio of 3.56 and an internal rate of return IRR of 25%.

The project is well aligned with the priorities of the Government of Sindh and will particularly support its objectives and targets in terms of poverty reduction, food security and addressing malnutrition and shall support a balanced regional development in the province. The component is designed to contribute to attainment of SDGs (notably SDG 1, No Poverty, SDG 2- Zero Hunger, SDG 5- Gender Equality SDG 8 – Decent Work and Economic Growth, SDG 9 – Industry, Innovation and Infrastructure and SDG 13 – Climate Action).

The Sustainable Development Goals that the Sindh Coastal Resilience Project will support are:

- Quality Education
- Gender Equality
- Industry, Innovation, and Infrastructure
- Reducing Inequality
- Climate Action
- Life Below Water
- Life On Land

Needs of the recipient

Pakistan's National Climate Change Policy (2012) and Framework for Implementation of Climate Change Policy (2013), and Nationally-Determined Contribution (NDC) to the Paris Agreement (2015) outline the country's key priorities and approaches to climate adaptation, highlighting the importance of the agriculture and water resources sectors, the risks faced by the coastal regions, and the need to make infrastructure more resilient to climatic hazards. In 2016, Pakistan adopted the Sustainable Development Goals (SDGs) as its own national development agenda. The SDGs are in harmony with the relevant UN conventions such as Convention on Biodiversity (CBD), United Nations Framework Convention Climate Change (UNFCCC), United Nations Convention on Combating Desertification (UNCCD), and The United Nations Conference on the Law of the Sea (UNCLOS). Since then, Pakistan has been working on mainstreaming the SDGs into national policies and strategies, including the 12th Five-Year Development Plan and provincial medium-term growth strategies. A major objective of the plan is '*equitable* development across Pakistan to ensure inclusive and sustainable growth', which included the Green Pakistan Program (2016-2021) to facilitate transition towards an environmentally resilient Pakistan through afforestation, biodiversity conservation, and strengthening the enabling policy environment. The recently launched 'Clean and Green Pakistan' campaign builds on the two initiatives of the country i.e. the Billion Tree Tsunami Afforestation Programme (BTTAP) and the Green Pakistan Programme (GPP).

Coastal management in Sindh falls under several federal and provincial laws, strategies, policies, and plans. This includes the Territorial Waters and Maritime Zones Act (1976), Sindh Forest Act (1994), Pakistan Environmental Protection Act (1997), Sindh Coastal Development Authority Act (1994, amended 2006), National Maritime Policy (2002). Responsibility for coastal-related issues is spread across several agencies including the Sindh Environment, Climate Change, and Coastal Development Department; Sindh Forestry and Wildlife Department; Sindh Irrigation Department; National Institute for Oceanography; Karachi Port

[125] Ibid.

Trust; Port Qasim Authority; and several others. Addressing climate-related challenges will require strengthened leadership, planning, and coordination.

The Sindh Environment Protection Act (EPA, 2014) focuses on environmental pollution "prohibits any act, deed or any activity, such as dumping of wastes or hazardous substances into coastal waters and inland water bodies that leads to pollution or impairment of or damage to biodiversity, ecosystem, aesthetics or any damage to environment and natural resources". The act also highlights assistance to the Federal Government or Federal Agency in implementation and or administration of various provision of United Nation Convention on Laws on Seas, 1980 (UNCLOS) in coastal waters of the province[126].

The population in and around the coast of Pakistan is estimated to be about 1.2 million (around 900,000 people or 140,000 households in the Indus Delta, and 300,000 people or 30,000 households in the Baluchistan Coast). A population of about 210,000 is directly dependent on coastal resources (MCC, 2018). According to Chaudry (2017), 135,000 people depend on mangroves for their livelihood in the Indus Delta.

Two villages in the creeks – Bhoori and Tippun, and one inland village Haji Musa – were surveyed in 2009 to help understand the perceptions of the community regarding the role of ecosystem services in community well-being, vulnerably to climate change, and possible institutional responses to environmental disruption. Bhoori is the largest village with 400 households. Tippun with 100 households and leveled by the 2007 cyclone. Haji Musa is a small inland village having 40 households.[127] The main observations of Keti Bunder residents were: (i) a decline in the health of mangroves, (ii) the depletion of the stocks of major fish species and hence incomes, (ii) reduced rainfall, and (iv) an increase in extreme weather events. These negative trends are the result of both exogenous physical changes (climate change and the reduced availability of fresh water) and changing patterns of resource use within the villages (overfishing and the destruction of mangroves). Fishermen were also borrowing more because of the decline in, and increasing volatility of, the income, and hence falling more into debt.

Based on another survey in 2013, 44% of households were found to depend on farming (agriculture, livestock and horticulture), 39% on fishing, 11% are daily-wage laborers (fishing and agriculture), and 6% service providers for fishing and farming (boat building, net stitching and weaving, watchmen, shop-keeping, hotel owners, technicians (Salik *et al*., 2015).

Country ownership

The National Climate Change Policy (2012), Framework for Implementation of Climate Change Policy (2013), Nationally Determined Contribution (NDC) to the Paris Agreement (2021), and Sindh Climate Change Policy (2022) identify the Indus River delta and coastal region as priority areas in need of (i) improved climate risk assessment, planning, and emergency response; (ii) enhanced water resources and coastal zone management; (iii) climate-resilient protective infrastructure; and (iv) restoration of ecosystems. The Nationally Determined Contribution estimates the cost of Pakistan's total adaptation need to be between $7 and $14 billion per year.[70]

Since 2019, ADB has engaged with the Pakistan Federal and Sindh government to develop the project, and the project has been identified as a priority investment by the Sindh Planning and Development, the Irrigation and Drainage, and the Forestry and Wildlife Departments. The project builds on and scales up existing programs these departments, who have

[126] The Sindh environmental protection act, 2014. Sindh act no. viii of 2014.
[127] The survey covered 55 individuals in Bhoori village (39 males and 16 females), 30 individuals in Tippun village (20 males and 12 females), and 40 individuals in the inland village of Haji Musa (9 males and 4 females).

collaborated with ADB to identify priority areas and prospective subprojects under the project scoping and concept design effort.

The Indus Delta was designated a Ramsar Site on 5 November 2002. From a legal and tenurial point of view the mangrove forests in Sindh are designated as protected forests and managed under the Forest Act 1927 (Hussain 2016; FAO 2016). Mangrove forests have been declared as protected forests and mangroves trees are ‘reserved’ under the Forest Act 1927, meaning that clearance, harvesting, and animal grazing in mangroves are prohibited. The forests of Sindh are managed under the Sindh Forestry Policy (2018). The policy attaches high significance to Mangrove and Coastal areas with a two-pronged approach of long-term objectives aiming at results in 2030 and short-term policy targets covering the period from 2019 to 2023[128]. The policy adopts an ecosystem-based approach aimed at “Mangrove ecosystem(s) of Sindh are continued to be conserved, restored, expanded and sustainably managed as key natural assets supporting human-wellbeing, security of the coastal communities and mitigating climate change”.

The Sindh Vision 2030 (2007) is a long-term development framework that identifies avenues for sustained sectoral growth. The vision creates synergy between the federal and provincial governments. Sindh Vision 2025 specifies a comprehensive development agenda based on a synchronized and integrated development strategy for inclusive and participatory economic growth. Sindh’s priority areas, as set out in Vision 2025 launched by the Federal Government, are energy, water management, agriculture, industrial development, education and health, urban management and infrastructure building. Climate change is recognised as the biggest threat to the physical environment and *water, energy* and *food* as three key sectors crucial for survival and pre-requisites for economic growth. The Indus Ecoregion Programme, a joint initiative of the Government of Sindh and WWF-Pakistan addresses poverty-environment linkages through sustainable natural resource management in Sindh and compliments the Sindh Vision 2030. A core objective is to exemplify the environment and poverty nexus. People in the area are dependent on the ecosystem services of the Indus Delta, recognising that the degradation of the delta has a direct impact on livelihoods and therefore poverty.

The forests of Sindh are managed under the Sindh Forestry Policy (2018). The policy attaches high significance to Mangrove and Coastal areas with a two-pronged approach of long-term objectives aiming at results in 2030 and short-term policy targets covering the period from 2019 to 2023[129]. The policy adopts an ecosystem approach aimed at “Mangrove ecosystem(s) of Sindh are continued to be conserved, restored, expanded and sustainably managed as key natural assets supporting human-wellbeing, security of the coastal communities and mitigating climate change”. Mangrove Forests have been declared as Protected Forests and mangroves trees are ‘reserved’ under the Forest Act 1927, meaning that clearance, harvesting, and animal grazing in mangroves are prohibited.

Pakistan’s National Biodiversity Strategy and Action Plan[130] addresses the coastal biodiversity management through two distinct sections; Inland and Coastal Wetlands Ecosystems and Coastal and Marine Ecosystems. It provides three strategies highlighting the mainstreaming of wetland biodiversity through mainstreaming in development policy and strategy; arresting the degradation by invasive species; and achieving the sustainable management and equitable sharing of benefits through strengthening capacity of all stakeholders. The Coastal and Marine Ecosystems emphasizes making biodiversity resilient to climate change through a system of protected areas and specific conservation measures. The sustainable use of resources through improved regulatory and institutional framework is also presented as a

[128] Sindh Forest Policy, Forest and Wildlife Department, Government of Sindh, 2018.
[129] Sind Forest Policy, Forest and Wildlife Department, Government of Sindh, 2018.
[130] Pakistan National Biodiversity Strategy and Action Plan, Ministry of Climate Change & IUCN 2015

strategy. These priorities are duly reflected in the Aichi targets corresponding to the biodiversity framework of 2010-2020.

Pakistan declared its first Marine Protected Area (MPA) at Astola Island in 2018 as a result of a resolution passed at the IUCN World Conservation Congress. IUCN has been providing the backstopping for the policy development and technical know-how for effective implementation and monitoring success indicators. The listing of Pakistan's second MPA for the Indus Delta coastal mangrove belt would solidify the project outcomes, in addition to the Forestry Department protection and Ramsar designations.

Stakeholder consultation

ADB has been engaged with the Pakistan Federal and Sindh government to develop the described project since 2019, and the project has been identified as a priority investment by the Government of Sindh. In May 2022, the key principles, risks and the implementation arrangements were discussed with civil society organizations (CSOs) and non-governmental organisations (NGOs) and feedback sought on prospective project sites and challenges. Further, detailed stakeholder consultations will be conducted during project preparation.

Efficiency and effectiveness

As this is a concept project and at pre-feasibility study stage a detailed economic appraisal has not been finalized. However, an indicative economic analysis has been undertaken and is presented in the table below. This indicates a high positive economic return can be expected on the project.

Table 6: Project Economic Benefits

Project Output	Economic benefits
Output 1: Integrated water resources, drainage and flood risk management schemes developed.	Coastal flood infrastructure has very high benefit to cost ratios (with reports of 5:1 or greater), and coastal protection is widely reported in the literature as an extremely cost-effective adaptation option.[131]
Output 2: Natural protection buffers restored.	Mangroves are reported to have high BCR for coastal resilience. [132,133] Economic benefits of mangroves are reported at US$33,000-57,000 per hectare[134] from the value of ecosystem services, including GHG mitigation and provisioning, regulating, and recreational services, both direct and indirect. Previous economic analysis of mangrove projects in the area indicates a benefit cost ratio of 4 and economic internal rate of return of 25%.
Output 3: Livelihood and economic transformation enhanced.	The component targets the poor and vulnerable households primarily focusing on youth and women. Project interventions will include asset creation, vocational/entrepreneurship training, establishing commercially viable producers' organizations and producers-public-private partnerships (4Ps) with a focus on fisheries and nature-based solution for saline agriculture. With their experience in successful delivery in neighbouring Baluchistan, IFAD have practical and educational elements with sustainability, eco-tourism and community resilience at the core.
Output 4: Strategic action planning for the coastal region strengthened.	The component will support and build capacity in key departments and stakeholders for higher-level integrated and strategic planning for the coastal region, including on climate change resilience. Developing

[131] Hinkel, J., van Vuuren, D.P., Nicholls, R.J. et al. The effects of adaptation and mitigation on coastal flood impacts during the 21st century. An application of the DIVA and IMAGE models. Climatic Change 117, 783–794 (2013). https://doi.org/10.1007/s10584-012-0564-8

[132] Climate Works Foundation (CWF) 2009: Economics of Climate Adaptation: Shaping climate resilient development: a framework for decision-making. A report of the economics of climate change adaptation working group.

[133] Baig, S., Rizvi, A., Josella, M. and Palanca-Tan, R. 2015. 'Cost and Benefits of Ecosystem Based Adaptation: The case of the Philippines'. Gland, Switzerland: IUCN, p. 32.

[134] Flint, R., D. Herr, F. Vorhies and J. R. Smith 2018. Increasing success and effectiveness of mangrove conservation investments: A guide for project developers, donors and investors. IUCN, Geneva, Switzerland, and WWF Germany, Berlin, Germany. (106) pp.

Project Output	Economic benefits
	improved planning will deliver a roadmap for adaptation to sea level, temperature and salinity changes thereby improving upon the current 'no action' trajectory.

SECTION 4: SAFEGUARDS AND OTHER REQUIREMENTS

Environment and Social Impact

The project is being developed in accordance with ADB procedures and rules, notably ADB's Safeguard Policy Statement (2009). In line with standard ADB procedures, a full environmental risk framework will be prepared, and subsequently an environmental management action plan developed. This will set out the activities to be undertaken during project implementation to ensure all environmental risk is fully managed.

Gender-sensitive development impact

The project is expected to be categorized as effective gender mainstreaming. A gender assessment and action plan will be prepared during project processing. Women in coastal areas of Sindh have one of the lowest literacy rates in Asia (ADB, 2006). The low level of education for girls starts at primary school level and increases as girls grow older (MFF, 2019). Coastal areas have a traditional hierarchical and patriarchal social systems, in which women are essentially bound to perform domestic and reproductive work, with low access to paid work. Power and control in ownership of all productive resources lie with male members of the community. MFF (2019) found that in the fishing villages surveyed, the men have complete control, as well as ownership of all fishing related equipment and make all decisions. Women have weak bargaining positions and are essentially excluded from decision making at the household and community levels (ADB, 2006, 2014; Gowdy 2011; MFF, 2019). Women cannot travel without a male member of the family, and without the permission of their father or husband. They have unequal access to education, information, health, and other social services due to patriarchal control and cultural restrictions.

C. Timor-Leste: Water Harvesting and Agriculture Value Chains Improvement Sector Project

Country: Democratic Republic of Timor-Leste
Project Location: Municipalities of Atauro, Dili (Metinaro), Atauro, Manatuto, Manufahi, and Oecusse

Summary: Project alignment with CRPP overall program design			
CRPP Outcomes	**CRPP Sub-activities**	**Contribution to CRPP Outcomes**	**Link to GCF Adaptation Result Areas**
Output 5: Climate resilient pro-poor livelihoods investments implemented.	**Activity 5.1.** Climate resilient agroecological systems.	**Outcome 3:** Food security of poor and vulnerable communities in increased.	**ARA1:** Most vulnerable people, and communities. **ARA2:** Health and well-being, and food and water security. **ARA3:** Infrastructure and built environment.
Output 6: Climate adaptation pro-poor infrastructure implemented.	**Activity 6.2.** Installation of flood and landslide protection infrastructure.	**Outcome 4:** Exposure of poor and vulnerable people to climate shocks and stresses in reduced.	

Project Summary

Timor-Leste is assessed as having high vulnerability and low readiness to climate change based on its scores on the ND-GAIN Index. The impacts of climate change will have significant implications for poverty, food security and well-being in a country where estimates suggest that 30% of the population were living on less than the internationally recognised poverty line of $1.90/day, 45% were classified as living in multi-dimensional poverty[135], and approximately 80% of the population are reliant on the agriculture sector.[136] Most agriculture is subsistence, and many rural areas suffer from food insecurity due to a combination of low productivity, high population growth and unpredictable rainfall coupled with extreme climate events[137].

Staple crops in Timor-Leste are sensitive to rising temperatures and the impacts associated with extreme rainfall, changes in the seasonality of rainfall, seawater inundation and salinization of coastal aquifers.[138] The majority of agriculture in the country is rain-fed, and as such is vulnerable to changes in the timing and amount of rainfall, and increasing variability. The supply of water (particularly water scarcity during the dry season) will likely be a significant constraint on agricultural output[139]. Agricultural systems, including livelihood conditions and food insecurity issues, will be affected both by increases in extreme events, as well as changes

[135] Human Development Index 2020: www.hdr.undp.org
[136] USAID (2017) Timor-Leste Climate Change Risk Profile. URL: https://www.climatelinks.org/resources/climate-change-risk-profile-timor-leste; ADB (2018a) Basic Statistics 2018. Available at: https://www.adb.org/publications/basic-statistics-2018 [accessed 16/11/18]
[137] Timor Leste National Communication, 2014
[138] Government of Timor Leste (2020) 2nd National Communication to the UNFCCC
[139] Scherer, N. & D. Tänzler. *The Vulnerable Twenty – From Climate Risks to Adaptation: A compendium of climate fragility risks and adaptation finance needs of the V20 countries*. Federal Foreign Office, Berlin Germany. October 1, 2018. Aldephi. 2018. URL: https://www.adelphi.de /de/system/files/mediathek/bilder/The%20Vulnerable%20Twenty%20%E2%80%93%20From%20Climate %20Risks%20to%20Adaptation%20-%20adelphi.pdf

in temperature and rainfall resulting from climate change[140]. According to climate models[141], the months of Jun-Sep, largely corresponding to the current dry season, are likely to become even drier, and there is a clear signal for increases in rainfall from February-May. There are indications that the onset of the rainy season may be delayed, with increased rainfall occurring during a shorter rainy season[142]. A significant source of agricultural losses during El Niño years is false starts to the rainy season, where the initial onset of rains is followed by an abnormal dry period before the season reliably starts. These false starts can cause crop failure as there is not enough rainfall to support crop growth following planting - farmers have reported frequent false starts during previous El Niño events, and having to plant 3-4 times due to the losses suffered. Although, changes in the ENSO cycle are still not well captured by climate models, the latest research indicates that El Niño events may become both more frequent and more severe over the course of the century[143,144]. Modelling of maize indicates reductions in yield in the range of 5-20% in the absence of adaptation, noting that much of this loss could be offset by supporting agricultural water supply through activities such as irrigation and water harvesting[145].

The Water Harvesting and Agriculture Value Chains Improvement Project (WHAIP) aims to increase the resilience of vulnerable rural communities to the negative impacts of climate change and enhance the sustainability of rural livelihoods in the Democratic Republic of Timor-Leste. Specifically, the project focuses on protecting and improving the productivity of agriculture using climate-smart approaches, including investments in water and forest management and conservation. To ensure the sustainability of project investments, the project also aims to enable smallholder producers, especially women, to expand their participation in, contribution to, and benefit from agricultural value chains. The project will support activities in the municipalities of Atauro, Dili (Metinaro), Atauro, Manatuto, Manufahi, and Oecusse which together represent the country's six agro-ecological and associated farming systems and are areas that have been identified as being at high risk from the impacts of climate change and include communities with high levels of poverty.

SECTION 1: PROJECT CONTEXT AND CLIMATE RATIONALE

Timor-Leste occupies the eastern half of the island of Timor, which it shares with the Indonesian province of East Nussa Tenggara. The country has an area of approximately 14,954km^2, which includes main land area of 13,989km^2, the Oecusse enclave of 817km^2 and two islands, Atauro island and Jaco island, respectively. The island has an extensive coastline stretching 700km, while inland the topography is mountainous, with the central mountain range above 2000m, and culminating in Folo Tatamailau, at 2963m.[146]

The population of Timor-Leste is estimated at 1,293,120 in 2019, with a median age of just 19.6, and 40% of the population under the age of 14[147] The demographic structure suggests rapid population growth over the coming decades, and is currently estimated at annual rate of

[140] United States Agency for International Development. *Climate Risk Profile: Timor-Leste*. 2017. URL: https://www.climatelinks.org/sites /default/files/asset/document/2017_Climate%20Change%20Risk%20Profile%20-%20Timor%20Leste.pdf

[141] This assessment has reviewed future climate projections based on Coupled Model Inter-comparison Project Phase 5 (CMIP5) including analysis of statistically downscaled climate projections from the U.S. National Aeronautics and Space Administration (NASA), the World Bank Climate Change Knowledge Portal (CCKP) and other sources as noted. Changes are evaluated relative to an historical baseline of 1986-2005.

[142] Government of Timor Leste (2014) Initial National Communication the UNFCCC.

[143] McPhaden, M. J., A. Santoso, and W. Cai (2019), Understanding ENSO in a changing climate, Eos, 100, https://doi.org/10.1029/2019EO124159. Published on 23 May 2019.

[144] Wang, B. et al. (2019) Historical change of El Niño properties sheds light on future changes of extreme El Niño. *Proceedings of the National Academy of Sciences* 116 (45) 22512-22517

[145] Government of Timor Leste (2014) Initial National Communication to the UNFCCC.

[146] Center for Excellence in Disaster Management and Humanitarian Assistance. *Timor-Leste Disaster Management Reference Handbook.* 2019.

[147] The Central Intelligence Agency (CIA). *CIA Factbook: Timor-Leste* (population estimate for July 2020).

2.2%. Timor-Leste ranks 141 on the Human Development Index, with a GNI per capita of $4,440 and life expectancy of 69.5 [148]

Vulnerability characteristics of the proposed intervention zone:

Timor-Leste's economy grew rapidly during 2007-2013 with average annual growth rate of 7.8% driven by high levels of public investment. However, this slowed to 1.5% during 2014-2019. While progress on some human development indicators and Sustainable Development Goals was achieved, , real gross domestic product per capita in 2020 fell to the 2013 level because of the COVID-19 outbreak, compounded by devastating floods. In 2020, the economy contracted by 8.6% compared to pre-COVID-19 forecasts of 4.9% to 5.4%.[149] The GDP rebpunded by 2.9% in 2021 and 3.2% in 2022 underlining the post-COVID-19 challenge the country faces in re-establishing growth.

Data for 2016 estimate that 30.7% of the population were living on less than the internationally recognised poverty line of $1.90/day, and 45.8% were classified as living in multi-dimensional poverty.[150] While this remains a high proportion of the population, it represents significant progress, with poverty incidence falling by almost 9 percentage points from 50.4% in 2007. There was also a significant reduction in the poverty gap index, indicating that welfare improvements were not just limited to those near the poverty line. The larger decline in the poverty gap index relative to the headcount index implies the average shortfall in consumption levels experienced by the poor in 2014 was smaller than in 2007. Poverty fell in both rural and urban areas, though the decline was larger in urban areas.[151]

Agriculture, including forestry and fisheries, provides a source of livelihoods for 80% of the population with two-thirds of all households having agricultural holdings[152]. However, the sector's contribution to non-oil GDP has steadily declined from 32% in 2006 to 17% in 2019 and annual sectoral growth has been stagnant over the past decade averaging -0.3% between 2010-2019.[153] Major crops produced include coffee, maize, rice, coconuts, dry beans, cassava, other root crops, peanuts, and vegetables. Coffee is the country's only significant agricultural export, accounting for 80-90% of non-oil exports. Almost 50 percent of the country's total cereal consumption needs are met through imports, raising concerns about securing food supplies in the event of adverse external circumstances. Livestock of many varieties (cows, horses, pigs, sheep, poultry) are widely owned but yields are low.

Women face a range of economic, social, and cultural barriers to realize their potential as smallholder farmers with decision making power and personal autonomy. Research has highlighted a significant productivity gap between women and men in agriculture. Not only are women in agriculture estimated to produce 15% less per hectare than men, they also experience unequal access to farm labor opportunities and farming tools, lower literacy, and have limited involvement in cash crop production and farmers' groups.[154]

The specific challenges confronting women in agriculture are compounded by broader social and cultural practices that marginalize women's role in community life. While there is a constitutionally mandated requirement for women to comprise at least one-third of listed

[148] UNDP http://www.hdr.undp.org/en/countries/profiles/TLS. Accessed February 2021

[149] ADB. 2019. *Asian Development Outlook 2019: Strengthening Disaster Resilience.* Manila; ADB. 2020. *Asian Development Outlook Supplement: June 2020.* Manila; World Bank. 2019. *Timor-Leste Economic Report, October 2019: Unleashing the Private Sector.* Washington, DC; and World Bank. 2020. *Timor-Leste Economic Report, April 2020: A Nation Under Pressure.* Washington, DC.

[150] United Nations Development Program (UNDP). Development Index 2020. 2020. URL: www.hdr.undp.org

[151] Government of Timor-Leste. 2016. *Poverty in Timor-Leste 2014.* Dili.

[152] Defined as an economic unit under single management with one of the following: a minimum of 200 m^2 (0.02 ha) of land used for agricultural production; a minimum of two large livestock; a minimum of three small livestock; or a minimum of 10 poultry (see Government of Timor-Leste. 2020. *Timor-Leste 1st Agricultural Census Highlights.* Dili).

[153] Government of Timor-Leste. 2020. *National Accounts 2000-2019.* Dili.

[154] World Bank. 2018. *Women Farmers in Timor-Leste: Bridging the Productivity Gap.* Washington, DC.

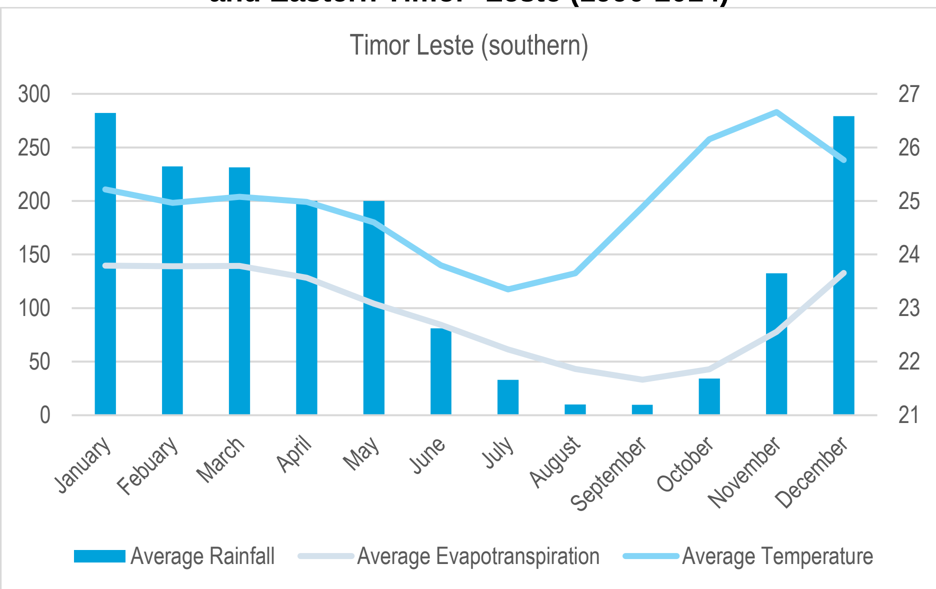
candidates for election at a national level, nearly all village chiefs continue to be men. Gender-based violence remains widespread and is one of highest in the world with 59% of ever-partnered women aged 15-49 years experiencing violence at least once in their lifetime.[155] Younger women are particularly at risk of sexual violence and early marriage. Recent surveys have also highlighted risks women face as a result of the COVID-19 pandemic in terms of increased gender-based violence and unpaid care work within families.

Climate baseline and justification for adaptation intervention.

Timor-Leste has a hot and humid tropical climate influenced by the Western Pacific monsoon and the mountainous relief of the island. Average annual temperatures vary little throughout the year, but altitude exerts a strong influence, with average annual temperatures ranging from 27°C on the coast, to 15°C in the central mountainous areas.[156,157]

There is significant inter-annual variability in rainfall, with the El Niño Southern Oscillation (ENSO) exerting a strong influence over rainfall variability. El Niño conditions bring drier conditions and shorter, delayed wet seasons, often causing droughts, whilst La Niña conditions cause higher rainfall even in the dry season and are linked to higher tropical cyclone activity. For the period 1950-1999 Dili recorded its two record low rainfall totals during the El Niño events of 1982-83 and 1997-98, and provinces such as Ainaro can see rainfall totals reduce by up to 50% of the annual average.[158] Rainfall also varies significantly from north to south, with parts of the north of the island receiving as little as 500mm/year, whereas the western mountainous areas can receive up to 2800mm/year[159]. The wet season lasts from Dec-March in the north of the island, with a prolonged 8-month dry season, but extends from November to June or July in the south of the island, as shown in **Figures 11 and 12**.

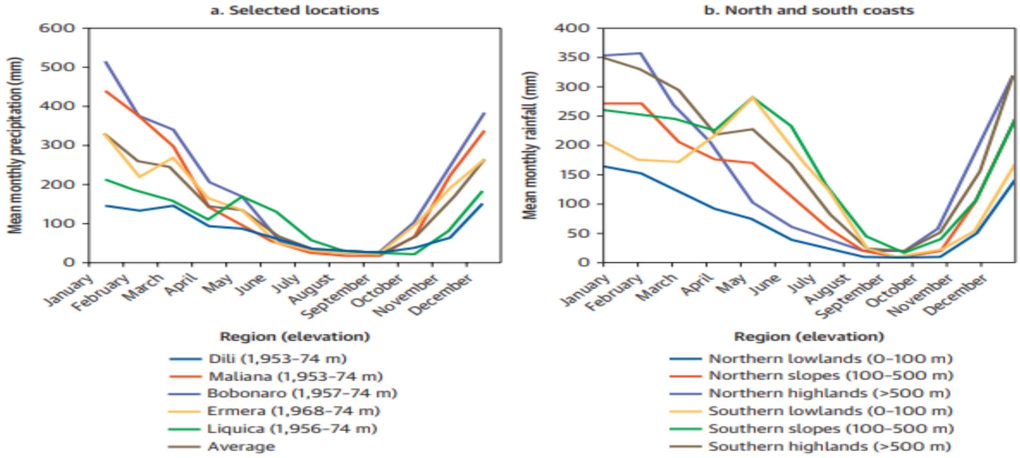
Figure 11: Mean monthly rainfall, temperature and evapo-transpiration for Southern and Eastern Timor- Leste (1990-2014)



Source: https://ewgis.org/catchx-global/. Data provided through Catch-X is as follows: Precipitation data is from the global MSWEP dataset, modelled runoff, temperature and evapo-transpiration from the EU-funded eartH2observe dataset.

[155] The Asia Foundation. 2015. *Intimate Partner Violence Against Women in Timor-Leste: Understanding the differences between the Nabilan Baseline Study and the Demographic and Health Survey.* Dili.
[156] United States Agency for International Development. *Timor-Leste Climate Risk Profile*. 2017.
[157] Government of Timor-Leste. *Timor-Leste Disaster Management Reference Handbook*. 2019
[158] Government of Timor-Leste. *National Adaptation Programme of Action.* 2010.
[159] Government of Timor-Leste. *Timor-Leste Disaster Management Reference Handbook*. 2019

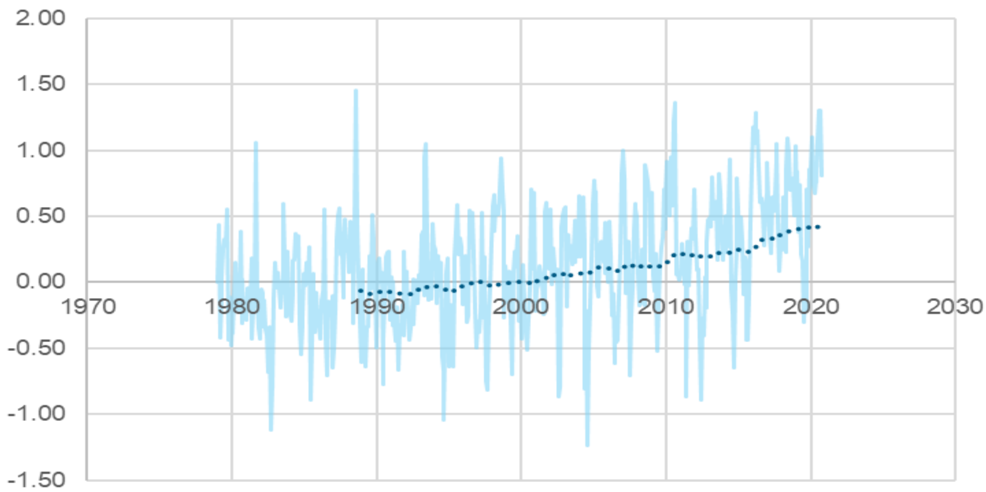
Figure 12: Distribution of annual precipitation for locations across Timor-Leste



Source: The World Bank. Timor-Leste Water Sector Assessment and Roadmap. 2018.

Temperature changes: Estimates of the rate of temperature change vary from 0.16C/decade since 1950[160] to a more modest 0.11C/decade from 1979-2005[161]. **Figure 13** displays the trend in temperature since 1980 around Dili, in the North, based on reanalysis data to provide continuity. The increase since around 2000, in particular, has been pronounced. Minimum, Maximum and Average temperatures will all increase under all scenarios. As shown in **Table 7** For RCP4.5 average annual temperatures are likely to increase around 1°C for the 2036-2065 period, and 1.1-1.6°C for the 2066-2095 period, while for RCP8.5 increases are larger, with 1.2C-1.6°C expected for 2036-2065, and 2.2-3.0°C for 2066-2095, all relative to 1986-2005.

Figure 13: Monthly anomalies with respect to long term average temperature based on ERA5 reanalysis data (decadal moving average trend)



Source: KNMI Data Explorer.

[160] USAID (2017) Timor Leste Climate Risk Profile
[161] Timor Leste National Adaptation Programme of Action (NAPA)

Table 7: An overview of temperature change (ºC) projected Timor-Leste over different time horizons, emissions pathways, and measures of temperature, showing the median estimates of the full CCKP model ensemble and the 25th, 50th and 75th percentiles.

Scenario		Annual average of monthly maximum		Annual average		Annual average of monthly minimum	
		2036-2065	2066-2095	2036-2065	2066-2095	2036-2065	2066-2095
RCP4.5	25th	0.86	1.18	0.79	1.09	0.72	1.00
	50th	0.95	1.29	0.92	1.26	0.96	1.23
	75th	1.14	1.58	1.19	1.58	1.10	1.54
RCP8.5	25th	1.19	2.26	1.24	2.25	1.23	2.24
	50th	1.33	2.60	1.30	2.47	1.33	2.46
	75th	1.59	3.00	1.56	2.93	1.55	2.94

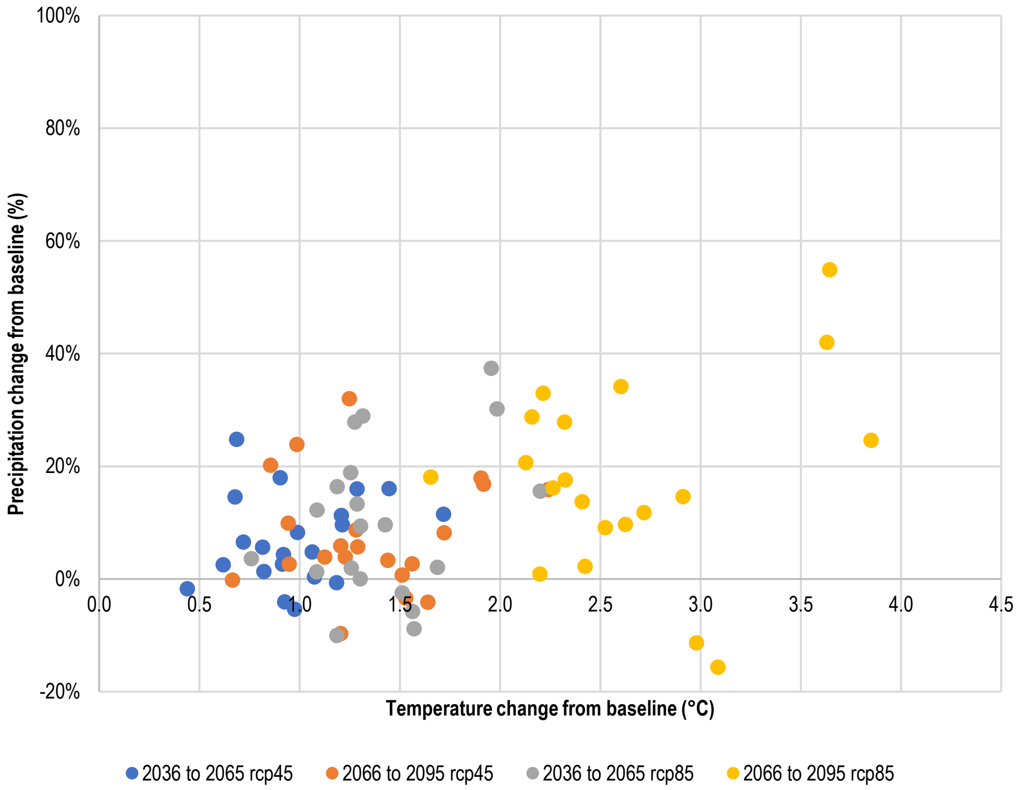
Source: The World Bank Group Climate Change Knowledge Portal (CCKP). Climate Data: Projections. 2019. URL: https://climateknowledgeportal. Worldbank .org /country/timor-leste/climate-data-projections.

Precipitation: There is broad agreement among the models for an increase in annual precipitation, with larger increases expected in the higher emissions scenario RCP8.5, and higher increases towards the end of the century. It is important to note, however, that there are several models which suggest decreases in annual precipitation, as illustrated in **Figure 14**. **Figure 14** depicts the variation in GCM outputs with respect to projected changes in temperature (ºC) on the horizontal axis and changes in precipitation (% relative to baseline) on the vertical axis, for both RCP4.5 and RCP8.5, and for projection periods 2036-2065 and 2066-2095, respectively. **Figure 15** shows the distribution of monthly rainfall changes throughout the year corresponding to RCP4.5 for 2036-2065. The months of Jun-Sep, largely corresponding to the current dry season, are likely to become even drier, and there is a clear signal for increases in rainfall from February-May.

Importantly, while overall annual precipitation may increase, there are indications that the onset of the rainy season may be delayed, with increased rainfall occurring during a shorter rainy season[162]. For example, analysis in the 2nd National Communication notes a likely delay to the onset of the rainy season[163]. Rainfall variability in Timor Leste is driven by the ENSO cycle, and the evolution of ENSO under climate change will play an important role in determining drought and inter-annual variability in rainfall in the country. Changes in the ENSO cycle are still not well captured by climate models, however, the latest research indicates that El Niño events may become both more frequent and more severe over the course of the century[164].

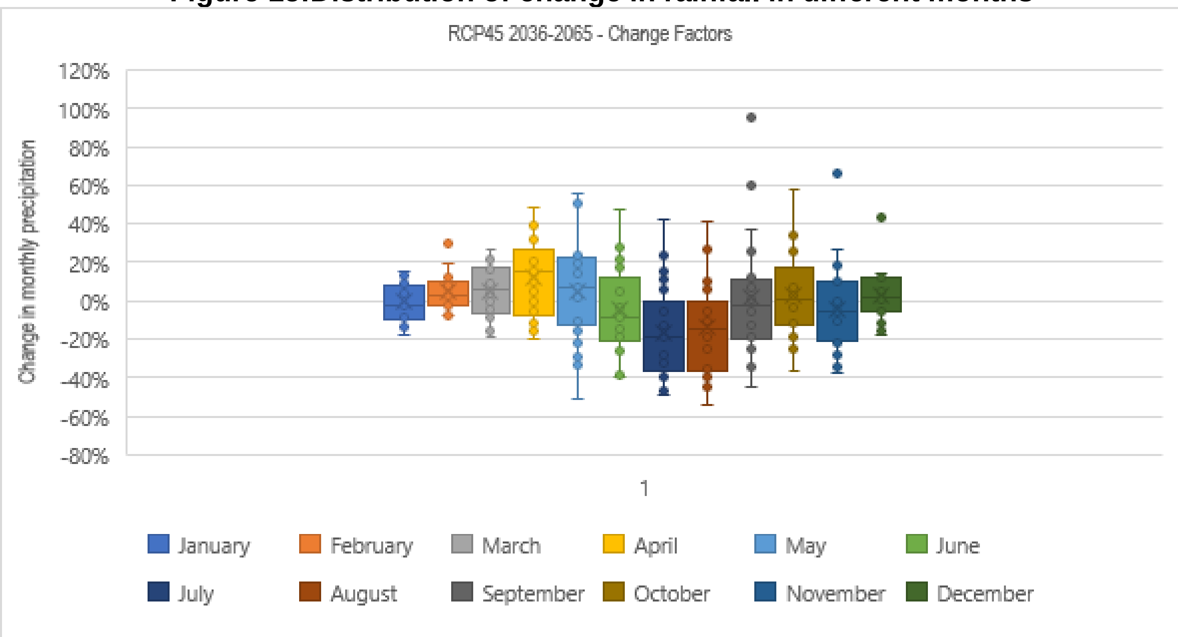
[162] Government of Timor Leste (2014) Initial National Communication the UNFCCC.
[163] Government of Timor Leste (2020) 2nd National Communication the UNFCCC.
[164] McPhaden, M. J., A. Santoso, and W. Cai (2019), Understanding ENSO in a changing climate, Eos, 100, https://doi.org/10.1029/2019EO124159. Published on 23 May 2019.

Figure 14: ‘Projected average temperature anomaly’ and ‘projected annual rainfall anomaly’ in Timor-Leste. Outputs of 16 models within the ensemble simulating RCP 4.5 and RCP8.5 over the period 2036-2065 and 2066-2095



Source: The World Bank Group Climate Change Knowledge Portal (CCKP). *Climate Data: Projections.* 2019. URL: https://climateknowledgeportal. Worldbank .org /country/timor-leste/climate-data-projections.

Figure 15:Distribution of change in rainfall in different months



The intensity of rainfall is also expected to increase in Timor Leste, with larger increases in extreme rainfall towards the end of the century. Analysis of changes in the proportion of days exceeding the historical 95th and 99th percentile values, is summarised in **Table 8**. Under RCP4.5 there is a clear signal of increased heavy rainfall, with an average +14.5% increase in the number of days exceeding the 99th percentile by mid-century, and a 38.6% increase in days for the 2066-2095 period.Analysis of changes in the proportion of days exceeding the historical 95th and 99th percentile values, is summarized in **Table 8**. Under RCP 4.5 there is a clear signal of increased heavy rainfall, with an average +14.5% increase in the number of days exceeding the 99th percentile by mid-century, and a 38.6% increase in days for the 2066-2095 period.

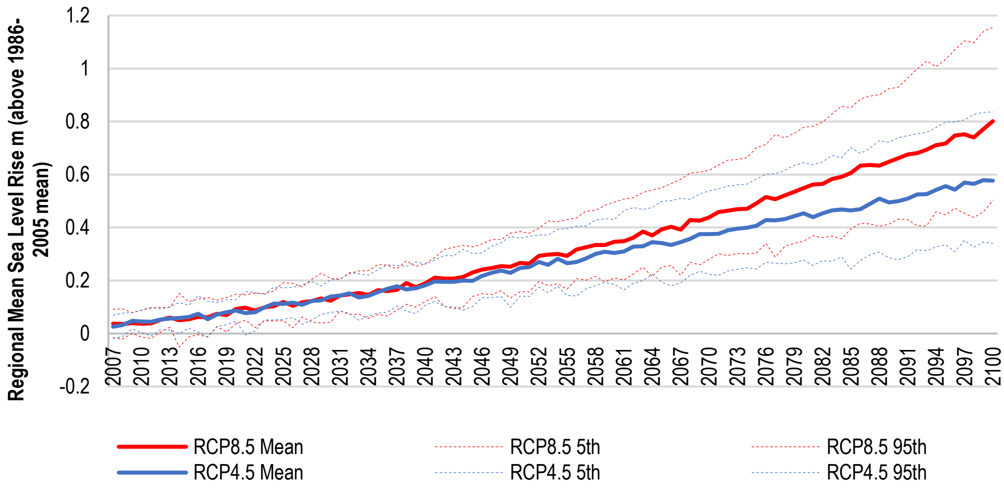
Table 8: Changes in number of days exceeding 95th and 99th percentile for RCP 4.5. 25th, 50th and 75th percentiles of the ensemble of climate models

Scenario	2036-2065		2066-2095	
	95th	99th	95th	99th
25th	-4.38	-2.73	18.25	19.55
50th	2.01	14.55	27.37	38.64
75th	17.15	25.45	32.76	72.50

The 2nd National Communication also presents analysis of changes in a variety of indicators of extreme rainfall. There is a clear increase in the intensity and frequency of heavy rainfall events, including both annual maximum 5-day precipitation, and annual maximum daily precipitation. This is evident across all of the selected municipalities, with changes likely to be most pronounced in Manatuto and Manufahi, and increases lower for Dili and Atauro[165].

Sea-level rise: To mid-century, mean sea level rise follows a similar trajectory regardless of whether RCP4.5 or RCP8.5 is used, with a mean increase of 25cm, and increases of 37cm at the top of the range of projections. Beyond that there is significant divergence; the mean value for the higher emissions RCP8.5 shows an increase of 80cm by 2100, while the mean value for RCP4.5 is 58cm. Even under the lower emissions scenario, increases of just over 80cm are possible, while in the high emissions scenario sea level rise could exceed 1m. Recent research and modelling of sea level rise has tended to increase the amount of sea level rise expected, as a result of improved understanding of ice sheet dynamics[166], so from a risk assessment perspective, it may be prudent to assume higher values.

Figure 16: Mean Sea Level Rise to 2100 for Timor-Leste



Natural hazards. According to the World Risk Report, which generates rankings based on exposure and vulnerability to Natural Hazards, Timor-Leste ranks 20th globally (24th in

165 Government of Timor Leste (2020) 2nd National Communication the UNFCCC.
166 See IPCC. 2019. Special Report on the Ocean and Cryosphere in a Changing Climate; Garner *et al. 2018. Evolution of 21st Century Sea Level Rise projections. Earth's Future* 6(11): 1603-1615.

exposure, 51st in vulnerability (of which 43rd, 42nd and 82nd in susceptibility, lack adaptive capacity and lack coping capacity)[167]. Floods, droughts, landslides and cyclones are the major natural hazards. Flooding is the most frequent disaster, with riverine and flash flooding occurring during periods of extreme rainfall; significant flood events were recorded in 2001, 2003, 2006, 2013, 2019 and 2020[168]. Analysis of disaster losses from 1992-2013 shows that Dili, Manufahi and Manatuto provinces suffered the 2nd, 3rd, and 4th highest losses from flooding, respectively, while Oecusse was affected but to a lesser degree[169]. La Niña events are frequently associated with heavy rainfall and increased flooding. In addition to the direct impact of flooding, for example on crops and infrastructure, there are frequently secondary effects such as increases in water-borne and vector-borne diseases[170]. Floods in 2013 displaced around 20,000 people and led to school closures and the contamination of drinking water supply. Flood risk is expected to increase in the future as extreme rainfall events become more common, and the increasing population means that more people live in flood-prone areas. Cyclones also lead to flooding; however, these are more common in the east of the island.

Landslides are a major hazard triggered either by heavy rainfall, or seismic activity, and all five target municipalities have recorded losses due to landslides. Deforestation and unsustainable land practices have destabilised many slopes, and increased soil erosion, thus increasing landslide risk.

Landslide risk will increase in the future in the target municipalities as the intensity of rainfall increases. The World Bank carried out a detailed mapping of natural hazards as part of the *Building Climate and Disaster Resilience in Communities along Dili-Ainaro and Linked Road Corridor* Project[171]. This assessment evaluated natural hazards and risks across 49 *sucos* along the proposed route of the road, with a focus on floods, landslides, and high winds. Although focussed on Ainaro and Aileu, the assessment also highlighted high risk of landslides in the NW of Manufahi province with landslides a major risk to road infrastructure and residential buildings.

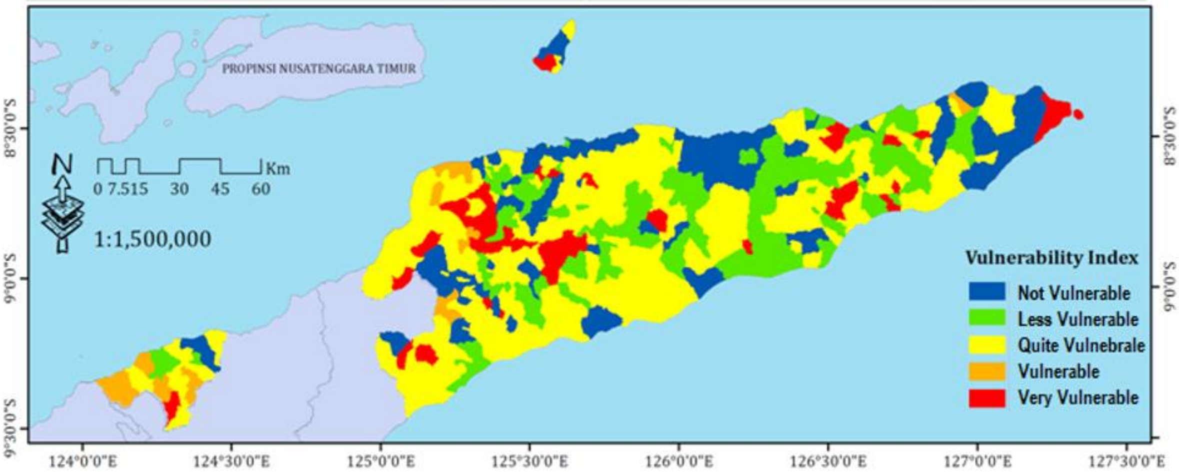
Droughts occur regularly, and drought conditions can be made more extreme or extended under El Niño conditions, with major decreases in the yield of major agricultural crops. The country experienced a major drought from 2015-2017. It is estimated that the 2015/16 El Nino drought impacted approximately half the area of Maize of Rice planted in the country, with 50% of households reporting loss of livestock, and 50% suffering from food insecurity as a result of the drought[172]. Drought poses a major risk across all of the target areas for the project and is a major threat to agricultural production in Oecusse, and Dili and Atauro in particular. Although there remains uncertainty over how the ENSO cycle will change under climate change, current understanding suggests that severe El Niño events will become more common over the course of the century[173], and there may also be an increase in the frequency of El Niño events[174], with the result that the likelihood of severe drought in the country will increase.

[167] https://weltrisikobericht.de/english/
[168] Timor-Leste Disaster Risk Management Handbook. 2019.
[169] ADPC. 2013. A country situation report on disaster risk assessment related activities.
[170] *ibid*
[171] World Bank (2015) *Natural Hazard Synthesis Report*. Building Climate and Disaster Resilience in Communities along Dili-Ainaro and Linked Road Corridor Project. https://www.gfdrr.org/sites/default/files/publication/Final%20Hazard%20Risk%20Assessment%20Synthesis%20Report_%20Timor%20Leste.pdf
[172] Government of Timor Leste (2020) 2nd National Communication to the UNFCCC
[173] McPhaden, M. J., A. Santoso, and W. Cai 2019. Understanding ENSO in a changing climate, Eos, 100, https://doi.org/10.1029/2019EO124159. Published on 23 May 2019.
[174] Wang, B. et al. 2019. Historical change of El Niño properties sheds light on future changes of extreme El Niño. *Proceedings of the National Academy of Sciences* 116 (45) 22512-22517

Climate change impacts

The Initial Nationally Determined Contribution (INDC) carried out a *suco*-level vulnerability assessment, which concluded that 59% of the country's *sucos* were at least "quite vulnerable" on a 5-point scale, based on current exposure, sensitivity and adaptive capacity[175]. A number of *sucos* in the target municipalities are categorized as at least 'quite vulnerable', with several assessed as 'very vulnerable' – including in Oecusse, Atauro, and Manufahi.

Figure 17: Spatial Distribution of Sucos (village) in Timor-Leste and their consequent Vulnerabilities



Source: Government of Timor-Leste (2014) *Timor-Leste Initial National Communication to the UNFCCC.*

Climate change is a stress multiplier—its effects will be most pronounced among groups that are already poor and marginalized. Rural communities that are relatively isolated and reliant on rainfed, subsistence agriculture have limited access to resources and limited capacity to cope with and recover from climate-related hazards. In the absence of adaptation, the increased variability in rainfall, and increases in extreme events, such as flooding and landslides, will pose a significant challenge to poverty-reduction efforts. Climate change poses a major threat to efforts to improve the food security situation in the country, with poor, rural populations relying on subsistence agriculture particularly at risk.

Climate change poses severe risks to agricultural production and productivity with the effects likely to fall most heavily on the livelihoods of smallholder farmers least able to cope. Changes in the level, distribution, and availability of rainfall under both medium-to-low and high emissions scenarios indicate that the seasonality of rainfall will become less predictable, with shorter more intense rainy seasons, more prolonged dry seasons, and more frequent El Niño events. These changes are in turn likely to lead to a range of negative impacts on agriculture with increased flooding, soil erosion, and/or drought, disrupted planting seasons, and increased biological and ecological stress that undermines productive potential.

Agricultural systems will be affected both by increases in extreme events, as well as changes in temperature and rainfall. The majority of agriculture in the country is rainfed and vulnerable to changes in the timing and amount of rainfall and increasing variability. Available water resources are likely to come under increased stress as a result of changes in rainfall patterns and temperatures,[176] as well as rapid population growth and an associated increase in demand. Although overall rainfall may increase, the likely increases in the dry season will increase water stress in many areas, while the combination of higher temperatures (and higher rates of evapo-transpiration) and longer dry seasons will increase soil moisture deficits.

[175] Government of Timor-Leste (2014) Timor-Leste Initial National Communication to the UNFCCC.
[176] Government of Timor-Leste. 2014. Initial National Communication to the UNFCCC.

Changes in climate combined with large-scale deforestation contributing to loss and drying up of water sources.[177]

A significant source of losses during El Niño years is false starts to the rainy season, where the initial onset of rains is followed by an abnormal dry period before the season reliably starts. These false starts can cause crop failure as there is not enough rainfall to support crop growth following planting, for example in Manatuto, farmers reported frequent false starts during previous El Niño events, and having to plant 3-4 times due to the losses suffered. The 2016-17 El Niño event caused sharp reductions in agricultural yields, with a decrease of 40% in Maize production, and 57% in Rice production[178], and subsequently increased food insecurity. Oecusse and Dili are both important rice-producing areas and there is clear need to address these losses; for example, if water storage is developed through the application of water harvesting technology, it might be possible to reduce the impacts of these false starts on crop development.

Modelling for maize shows reductions in yield in the range of 5-20% in the absence of adaptation but notes that much of this loss could be offset by supporting agricultural water supply through activities such as irrigation and water harvesting[179]. These losses may be conservative, as they do not attempt to capture any increase in losses from extreme events. Coffee, which is produced in some parts of Manatuto, faces challenges from rising temperatures and increasing extreme rainfall events, which can damage crops during growth periods, and affect overall yield and quality of the crop[180].

Many rural communities are highly reliant on groundwater resources, which can be highly seasonal, and in some cases run dry during the dry season. At present, there is limited understanding of sustainable groundwater yield, and how this will change under different climate scenarios, however, it is important to note that the aquifers underlying Oecusse, and large parts of Manatuto and Manufahi are low yielding, and as such there is limited potential for the development of groundwater resources in these areas[181]. Increased seasonality in rainfall, coupled with higher temperatures may negatively affect the quality and quantity of groundwater resources, and in coastal areas sea-level rise will lead to increased saline intrusion into coastal aquifers. Meanwhile, increases in extreme rainfall, and associated flooding and landslides, has the potential to damage water infrastructure if this is not appropriately designed to ensure it is resilient to these risks.

Sea-level rise will exacerbate problems with coastal erosion, and saline intrusion in coastal aquifers. Given the importance of the coastal lowlands for production of both Rice and Maize, these impacts could negatively affect production of staple crops. Climate change poses a major threat to efforts to improve the food security situation in the country, with poor, rural populations relying on subsistence agriculture particularly at risk.

Table 9 summarizes the risks to water sources from the impacts of climate change.

Table 9: Climate sensitivity of water sources

Drought	Heavy Rainfall; flooding	Extreme heat	Cyclones, storms	Landslides
● Seasonality impacts the water sources. Rivers can have dry/low flows during	● Increased rainfall intensity causes increased rates	● Timor-Leste rivers are short, fast-flowing and	● Com bined sewer storm water over-flows	● Contami nation of water sources e.g.

[177] Oxfam (2012). Weathering Change in Timor-Leste: Participatory Action Research in Timor-Leste identifying climate change and associated impacts experienced at the community level
[178] *Ibid.*
[179] Government of Timor Leste. 2014. Initial National Communication to the UNFCCC.
[180] USAID. 2017. Timor-Leste Climate Risk Profile.
[181] ADPC (2013) A country situation report on disaster risk assessment related activities.

Drought	Heavy Rainfall; flooding	Extreme heat	Cyclones, storms	Landslides
dry season and flash flooding and high river flows in the wet season • Depletion of groundwater aquifers due to reduce groundwater recharge from intermittent/reduced rainfall • Shallow well systems run dry • Changes in rainfall patterns undermine the viability of critical water supply infrastructure in communities • Localised aquifers located in mountain areas have low potential yields and limited opportunities for development. • Aquifers susceptible to rainfall changes, responding rapidly (seasonally).	of runoff leading to reduced groundwater recharge. • Contamination of water sources from floodwater and animal faeces • Borehole pumping control and treatment installation failure within flooded area.	intermittent so are very sensitive to increased temperatures and evaporation. • Lower DO and reduced water quality from upstream STW effluent.	contaminate local surface waters.	increased turbidity. • High sediment loads combined with water pollution can make water unfit for consumption and can lead to regular urban water shortages in some areas.

Source: ADB; Atkins Consulting, Climate Risk and Vulnerability Assessment for Timor Leste Water Supply and Sanitation Investment Project. ADB TA9414, September 2020.

As mentioned above, agricultural systems in Timor-Leste, including the livelihood conditions and food insecurity issues, will be affected both by increases in extreme events, as well as changes in temperature and rainfall[182]. The majority of agriculture in the country is rain-fed, and as such is vulnerable to changes in the timing and amount of rainfall, and increasing variability. Production of maize and rice as the country's main staple crops, for example, is already insufficient to meet current domestic demand, forcing the government to rely on imports. These staple crops, in addition to peanuts, are sensitive to rising temperatures and the impacts associated with extreme rainfall, seawater inundation and salinization of coastal aquifers.[183] Further, amplification effects on existing environmental degradation, loss of agricultural land and reductions in soil fertility especially the supply of water (particularly water scarcity during the dry season) will likely compound to create constraints on agricultural output[184]. **Table 10** provides an overview of the potential impacts of climate change on crop-based agriculture.

Table 10: Potential impacts of climate change on crop-based agriculture

Climatic Variables Subject to Change	Potential Impacts on Crop-based Agriculture
Increases in mean growing season temperatures	• Reduced yield • Reduced time to maturity

[182] United States Agency for International Development. *Climate Risk Profile: Timor-Leste*. 2017. URL: https://www.climatelinks.org/sites /default/files/asset/document/2017_Climate%20Change%20Risk%20Profile%20-%20Timor%20Leste.pdf
[183] Government of Timor Leste (2020) 2nd National Communication to the UNFCCC
[184] Scherer, N. & D. Tänzler. *The Vulnerable Twenty – From Climate Risks to Adaptation: A compendium of climate fragility risks and adaptation finance needs of the V20 countries*. Federal Foreign Office, Berlin Germany. October 1, 2018. Aldephi. 2018. URL: https://www.adelphi.de /de/system/files/mediathek/bilder/The%20Vulnerable%20Twenty%20%E2%80%93%20From%20Climate %20Risks%20to%20Adaptation%20-%20adelphi.pdf

Climatic Variables Subject to Change	Potential Impacts on Crop-based Agriculture
	• Increase in seasonal water demand[a] • Reduced exposure to climatic hazards (flood, windstorm, hail, etc.) • Increased or altered risks from pests, diseases[b] • Potential changes in competition with weeds[b] • Increased risk from wildfire
Increases in temperature, frequency of very hot days	• Increased heat stress • Increased water demand • If during critical stages (flowering, pollination, fruiting, grain filling) yield reduction or loss
Increases in minimum temperatures; decreased frequency of cold days and nights	• Extended growing season in cold environments • Increased yield in cold environments • Reduced risk of frost damage in cold environments • Potential changes in competition with weeds
Increases in intense precipitation events	• Direct damage to crops (particularly if hail) • Increased waterlogging, constraints to timely cultivation • Damage to drainage systems • Increased extent and intensity of erosion and waterlogging • Increased pest incidence
Increase in drought conditions	• Lower yields from crop damage, stress, and/or failure • Loss of arable land as a result of land degradation and wind erosion • Increased risk of wildfires
Increase in flood conditions	• Direct damage to; loss of standing crops • Loss of soil through erosion • Waterlogging of soil, delay in planting
Changes in seasonal precipitation accumulation	• Dependent on direction of change – potentially favorable if precipitation increases in historically water-constrained region • Potential changes in competition with weeds, pests[b]
Increase in frequency, severity of tropical storms	• Direct damage to crops from high wind speeds; intense precipitation
Increase in atmospheric concentration of CO_2	• Increased biomass production and increased physiological efficiency of water use in both crops and weeds • Increased efficiency of water use by crops • Potential for increased weed competition with crops[b] • Photosynthesis, growth, and yield of C_3 plants (e.g., wheat and rice) likely to increase[c] • Impact on C_4 plants (e.g., maize, sugarcane) less significant • Possible re-partitioning of biomass away from grain to leaves, stem and roots • Possible changes in assimilation of nitrogen fertilizer • Possible changes in nutrient content
Increase in atmospheric concentration of ozone	• Suppression of yield for many major crops

Notes:

a. may be off-set by shorter growing period.
b. poorly understood at present.
c. observed responses in free atmosphere CO_2 exchange (FACE) experiments are often significantly less than predicted by theory or model simulation.

Source: Various sources, by authors.

Major crops produced in Timor-Leste include coffee, maize, rice, coconuts, dry beans, cassava, other root crops, peanuts, and vegetables. Maize and rice, the two staple grain crops, are both sensitive to the projected impacts of climate change. **Table 11** summarizes several of the physiological impacts of temperature increase on wheat and rice.

Table 11: Climate change risk factors for maize and rice

Crop	Crop-specific Climate Risks and Benefits
Maize	● each degree day spent above 30°C reduces yield by 1% under optimal rainfed conditions, and by 1.7% under drought conditions ● Possible gains in yield with warming at relatively cool sites. ● Significant yield losses at sites where temperatures commonly exceed 30°C (corresponding to areas where the growing season average temperatures = 23°C or maximum temperatures = 28°C). ● Daytime warming is more harmful to yield than night-time warming. ● Drought increases yield susceptibility to warming even at cooler sites
Rice (paddy)	Heat stress at key developmental stages can result in: ● reduced duration of crop growth, ● increased spikelet sterility, ● reduced duration of grain-filling, ● increased respiratory losses leading to lower yields and lower grain quality ● elevated night temperatures have larger impact on yield than day-time highs ● 1°C increase in temperature above critical threshold (>24°C) can result in a 10% reduction in grain yield

Source: Thornton P, Cramer L (editors), 2012. Impacts of climate change on the agricultural and aquatic systems and natural resources within the CGIAR's mandate. CCAFS Working Paper 23. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

Description of adaptation needs

Undernutrition is a significant issue facing the country, and the likely adverse effects on agricultural production, as well as the expected lower nutritional value of food grown under elevated levels of CO_2 will pose a challenge to efforts to ensure that the population is food secure.[185] When the negative climate change impacts are added to the pre-existing low level of productivity and returns to agriculture, which already pose substantial threats to food security and agricultural sustainability, there is a risk that Timor-Leste will experience a significant crisis in terms of decreased agricultural production and food security, increased poverty and dependency, and widespread environmental degradation. Strategies that promote and support transformational adaptation are needed to counter this risk and instead put the country's agricultural systems on a pathway to environmental regeneration, sustainability, and greater profitability, especially for smallholder farmers.

Adapting to the predicted impacts of climate change will require the adoption of a wide range of climate-smart agricultural (CSA) practices[186] as well as changes in knowledge, attitudes, and practices of participants in agricultural markets. Different agroecological zones will experience different impacts due to climate change. With a relatively high population density, the dry rainfed areas near the capital face a particular challenge from the effects of increased demand for land accompanied by hotter temperatures with less predictable rainfall. The five target municipalities that will be covered by the project—Atauro, Dili (Metinaro), Atauro, Manatuto, Manufahi, and Oecusse—comprise a wide variety of the farming systems and standards of living. The upland areas of Manatuto and Manufahi include some of the poorest areas of the country and face multiple challenges of rugged terrain, a limited range of agricultural outputs, and distance from markets. Lowlandareas in Manatuto, Manufahi, and Oecusse will need to enhance measures to protect agricultural land and infrastructure from flooding. Rainfed rice producing areas and other low diversity farming systems (e.g., Atauro

[185] Thornton P, Cramer L (editors), 2012. Impacts of climate change on the agricultural and aquatic systems and natural resources within the CGIAR's mandate. CCAFS Working Paper 23. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

[186] CSA aims to simultaneously achieve three interlinked outcomes of increased productivity, enhanced resilience, and reduced emissions. A wide range of strategies fall within the definition of CSA with interventions being determined on the basis of specific local circumstances (see FAO.2017. Climate Smart Agriculture Sourcebook, 2nd edition. Rome. (Accessible at http://www.fao.org/climate-smart-agriculture-sourcebook/en/).

and Metinaro) will need to expand their range of crop choice and explore options for integrating agroforestry to improve vegetative cover and soil fertility.

Given the predicted climate change impacts, a mix of adaptation and mitigation strategies is needed to minimize water loss, maximize the use of available water, and reduce overall water demand. Prolonging water discharge in upland areas can contribute to the retention of productive topsoil, reduce erosion and landslides, and help avoid losses downstream from damage caused to agricultural and other infra and coastal fisheries from flooding and siltation. Priority interventions include investing in smallscale infrastructure to harvest, store, and release water when it is needed most within a local catchment. Modification of farming practices can also reduce the overall demand for water by substituting existing crops with drought-resistant varieties and/or less water-dependent crops.

For the benefits from investments in water harvesting and storage to be secured and leveraged, complementary interventions will be needed to promote farming systems that are both more diversified and more adaptable to climate change, especially in forest landscapes. Diversification of existing farming systems can improve the management and conservation of water and forest resources and at the same time contribute to increased agricultural productivity. Strategies include the integration of additional crops (e.g., drought-resistant varieties in drier areas, and/or land stabilizing trees and grasses in sloping areas); use of improved planting material, seeds; and the application of affordable agricultural technologies. Agroforestry-based interventions using native species serve not only to regenerate deforested areas and stabilize landslide-prone areas but can also help diversity the range of agricultural outputs produced within a given farming system and contribute to improved livelihood opportunities for farmers and better risk management. Site-specific interventions aimed at encouraging diversification will need to be designed and tested to confirm their suitability to local farming conditions and ensure increased returns for farmers.

For smallholders to obtain the full economic benefits from different climate-smart investments, improved market performance will be necessary across all elements of agricultural value chains including inputs (seeds, assets, technologies); information (price, weather); market intermediation and consolidation; access to finance; access to markets; and marketing and distribution. The private sector, in partnership with the public sector and non-profit organizations, plays a critical role in providing market-related services. While there are emerging positive examples of private sector engagement in agriculture[187], many gaps remain. Different forms of private sector organization that build on local farmer groups, blended with local and international finance and market operators will be needed to accelerate the process of agricultural transformation in the context of on-going climate change.

The deep and pervasive constraints that women face both in agriculture and broader society seriously undermine the social and economic contribution women can make to the process of transformational adaptation in agriculture. Increased access to economic and productive assets with gender-responsive information and education coupled with dramatically expanded opportunities for participation in local decision making and leadership will be needed to release the potential of women to contribute to and benefit from a more sustainable, prosperous and better adapted agricultural production system.

Proposed solution

The WHAIP will directly address the problems stated above by (i) improving vegetative cover, especially in upland and forested areas; (ii) increasing investment in agricultural diversification based on assessments of local farming systems; (iii) strengthening the functioning of

[187] For example, the USAID-supported Developing Agricultural Communities Project (2010-2015) and Avansa Agrikultura Project (2015-2020).

agricultural market systems; and (iv) increasing the harvesting and storage of rainfall for agricultural and other uses.

Many forms of climate smart agriculture that focus on improving land and water management using ecosystem-based approaches such as conservation agriculture and agroforestry can deliver the triple win of increased production, increased resilience, and reduced GHG emissions, while also increasing diversity and establishing new products[188,189,190]. For example, there is increasing evidence and agreement on the feasibility of agroforestry practices that enhance productivity, livelihoods and carbon storage. The integration of trees and shrubs into crop and livestock systems, when properly managed, can potentially restrict soil erosion, facilitate water infiltration, improve soil physical properties and buffer against extreme events[191,192,193,194].

Improved irrigation and water storage techniques have been identified as promising options to manage changes in rainfall variability and improve the reliability of supply of water for production. Community level water storage and irrigation systems that make use of local surface run-off can reduce financial costs as well as avoid the costs to ecosystem integrity and human well-being that can be associated with intensive irrigation[195]. Rainwater harvesting techniques (RWHTs) present a low-cost approach for mediating dry spell impacts in rainfed agriculture. Such measures can provide an additional source of water for crop production at the most critical stages of the growing season, reducing the impact of extended periods of dry-spells and drought and changes in precipitation patterns, thereby increasing yields, nutrition and food security[196,197].

SECTION 2: PROJECT DESCRIPTION

Project outcomes. The project outcome is livelihood and resilience of selected rural communities improved.

Project outputs. The project will have three outputs:

- Output 1: Climate-resilient farming systems and market linkages developed.

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191 Sida, T.S., F. Baudron, H. Kim, and K.E. Giller, 2018: Climate-smart agroforestry: Faidherbia albida trees buffer wheat against climatic extremes in the Central Rift Valley of Ethiopia. Agricultural and Forest Meteorology, 248, 339–347, doi:10.1016/j.agrformet.2017.10.013.

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194 Coulibaly, J.Y., B. Chiputwa, T. Nakelse, and G. Kundhlande, 2017: Adoption of agroforestry and the impact on household food security among farmers in Malawi. Agricultural Systems, 155, 52–69, doi:10.1016/j.agsy.2017.03.017.

195 Schipper, E.L.F., A. Revi, B.L. Preston, E.R. Carr, S.H. Eriksen, L.R. Fernandez-Carril, B. Glavovic, N.J.M. Hilmi, D. Ley, R. Mukerji, M.S. Muylaert de Araujo, R. Perez, S.K. Rose, and P.K. Singh, 2022: Climate Resilient Development Pathways. In:Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

196 Abdullah, Hasan M. & Rahman, Md. *Initiating rain water harvest technology for climate change induced drought resilient agriculture: Scopes and challenges in Bangladesh.* Journal of Agriculture and Environment for International Development - JAEID. 109. 189-208. 2015

197 Rockström, Johan. "*for food and nature in drought-prone tropics: vapour shift in rain-fed agriculture.* Philosophical transactions of the Royal Society of London. Series B, Biological sciences vol. 358,1440. 1997-2009. 2003. DOI:10.1098/rstb.2003.1400

- Output 2: Community-based water harvesting and flood protection infrastructure constructed.
- Output 3: Institutional and organizational capacity of farmer groups, communities and government strengthened.

Project activities (investment project by ADB)

Output 1 will (i) increase vegetative cover in agricultural systems, (ii) promote and support the diversification of farming systems, including the integration of crops, crop varieties, and agricultural practices better adapted to predicted future rainfall patterns,[198] and (iii) enhance the performance of value chains for agricultural products that have the potential to improve livelihoods for smallholder farmers.[199]

Output 2 will design and construct (i) structures to improve the supply of year-round water for agriculture and other uses (rainwater harvesting and storage), and (ii) physical flood barriers to protect people, infrastructure, property, and livelihoods.

Output 3 will support the expansion of participatory land use planning approaches and develop and adopt village natural resource management regulations and community-based climate adaptation plans, informed by village-level climate change vulnerability assessments. It will enhance of village leaders capacity, at least 30% women, for adaptive management of farm land and natural resources and enhance local stakeholders' capacity for sustainable climate resilient farm and landscape management

Project location. The target areas of the project will be the municipalities of Atauro, Dili (Metinaro), Atauro, Manufahi, Manatuto and Oecusse.

Use of GCF funds

GCF grant resources will support and leverage ADB's investments in physical infrastructure and other inputs planned under the WHAIP. Specifically, GCF grants will be used to maximize the adaptation benefits from investments in water and forest management and conservation, and the diversification of farming systems, coupled with incentives to encourage the move towards more sustainable, climate-sensitive, and gender-responsive agricultural practices.

Agricultural value chains do not currently provide the necessary signals to incentivize smallholders to adopt more sustainable agricultural practices. Farmers generally lack access to knowledge and know-how needed to make the transition; proposed science-based solutions do not always consider the full range of social, economic, and cultural factors that drive farmer decision making. The GCF grant will therefore be used to deepen understanding of existing farming systems in the target municipalities. In consultation with smallholders a range of climate-smart options will be identified to enhance adaptation and incentives provided to support smallholders in their efforts to implement more sustainable practices and accelerate the process of transforming agriculture.

As market systems do not fully value the benefits of improved water and forest management practices, the GCF grant will be used to provide incentives to smallholders for their investments of time, effort, and foregone income in adopting climate-smart agricultural practices, for example through temporary cash-for-work schemes. The GCF grant will also be used to analyze, identify, and engage a range of service providers that can support efforts to embed more sustainable practices in agricultural value chains. These practices will draw on

[198] Solutions will include integrated crop-livestock-forestry systems, rehabilitation of degraded lands, agroforestry systems, sustainable forestry, and bioengineering.
[199] Based on products identified, activities may include inputs (seeds, technologies/assets); information (price, weather, extension services); market intermediation and consolidation; access to finance; access to markets; and marketing.

market-driven innovations elsewhere in the region that are demonstrating success in supporting transformational adaptation, while ensuring they are appropriate for specific local contexts in Timor-Leste. Success in implementing the project in the target municipalities would provide a positive basis for replication to other areas.

Increased productivity and resilience, coupled with investments in higher soil fertility and crop diversification from the application of climate-smart and water-saving agricultural practices, will help generate the necessary market signals to incentivize more sustainable farming systems that will ultimately lead to increased incomes for poor rural households. Demonstration plots, field schools, and farmer-to-farmer extension processes will allow farmers and farmer groups to experiment and learn new farming methods that increase resilience and productive potential. Harvest and post-harvest technologies that enable improved handling and processing of crops and reduce post-harvest losses will add additional value to agricultural output, and the provision of small-scale innovative technologies and equipment (e.g., solar irrigation pumps, solar driers, greenhouses, digital soil and water metering) will further strengthen farmers capability to produce higher value agricultural products.

Increasing the number, range, and activity of participants within agricultural value chains will be essential to improve market functionality. Different types of private sector operators linked to different functions within agricultural value chains, including several NGOs that are already active, will be encouraged to increase sustainable income-earning opportunities for smallholder farmers by improving incentives for the products generated through the adoption of climate-smart agricultural practices supported by the project.

Climate smart investments in water management will play a critical role in both adapting to and mitigating the challenges presented by future climate change predictions. Planned investments in water harvesting infrastructure can contribute to adaptation by making better use of scarce water resources across time and space, as well as mitigation by reducing the downstream impacts of flooding due to changes in rainfall patterns and also poorly adapted agricultural practices. There are already some examples of innovative water harvesting designs that have been implemented in Timor-Leste;[200] however, their application at scale across multiple locations has not yet been tested. The GCF grant would therefore be used to lay the groundwork for scaling up water harvesting infrastructure with ADB financing by reviewing existing regional and global experience with community water harvesting interventions, including active stakeholder participation and testing design options prior to scaling up.

Given the critical role that women play in agricultural production systems as well as within households, the GCF grant will integrate a strong gender perspective in the two project outputs. For livelihoods, the grant will support efforts to develop women's capacity and agency to participate in project activities, e.g., through women farmers' groups. For infrastructure related to accessing and using water resources, the grant will ensure gender-responsive perspectives are integrated into the design and implementation arrangements for water harvesting investments.

The exact activities will be identified based on detailed climate risk assessments to be undertaken during project preparation.

Implementation arrangements

[200] See for example the jointly funded EU-FAO rainwater harvesting project (http://www.fao.org/timor-leste/news/detail-events/en/c/1259217/) and also the EU-supported Raumoco watershed project implemented by Hivos.

The executing agency for the project will be the Ministry of Agriculture and Fisheries (MAF). Implementing agencies will be the Directorate of Directorate of Agroforestry and Industrial Crops under MAF and the MAF offices in the municipalities that will be covered under the project. The State Secretariat for Environment will provide complementary information and education on climate change-related issues to stakeholders.

SECTION 3: IMPACT POTENTIAL

Paradigm Shift

Scaling up and replication. The project seeks to improve agricultural productivity and address the underlying barriers to the adoption of more climate-resilient agricultural practices. It will achieve this objective by providing a combination of technical information, financial incentives, and gender-responsive engagement opportunities. Climate-smart agroforestry and forestry activities that engage women and men in their design will be applied to restore ecological function by reducing unsustainable and environmentally harmful agricultural practices that have significantly degraded land in many areas. Expanded participation of the private sector in linking producers to markets and providing critical support services to small farmers will help to create market-based incentives to enable farmers to make the transition from previously unsustainable to climate-resilient agricultural practices. Given the high-level of poverty among small farmers, the behavioral change needed to move from unsustainable to sustainable agricultural practices is unlikely to happen unless farmers are provided with the right financial incentives to reduce the perceived risk of adopting different farming practices. As Timor-Leste is a relatively small country, albeit with some significant local variations, there would be substantial opportunity to replicate the knowledge and experience gained through project operations of WHAIP to other areas of the country.

Innovative solutions and approaches: Building on the knowledge and experience gained through the development of a community-based natural resource management manual,[201] the project will support early testing and scaling up of processes and investments that support transformational adaptation of agriculture in targeted municipalities. Project activities will focus on climate resilient farming systems that provide and empower farmers and communities with appropriate knowledge on farming techniques, equipment, finance, and information to adapt to extreme weather events, such as floods and drought. In close cooperation with MAF, the grant will test appropriate designs for water harvesting infrastructure together with other community-managed assets that promote increased climate resilience and productivity in agriculture based on locally identified needs.

Creation of enabling environment (and sustainability of outcomes). Given the continued reliance of much of the country's population on agriculture as a source of livelihood, the project will play a key role in responding to the continuing high levels of rural poverty in the five target municipalities. The project will support the government's commitment to respond to the challenges of climate change in agriculture, consistent with stated policy objectives in INDC and Ag Strategy plan. In so doing it will also aim to contribute to specific objectives related to increased production and overall returns to agriculture.

The sustainability of project outcomes will be assured after completion through different pathways: (i) improved skills and knowledge through capacity development activities, trainings and skill development on climate-smart agricultural practices, crop diversification and improved market systems to ensure a widespread adoption and application of acquired skills by key stakeholders; (ii) increased financial returns for farmers and other market participants

[201] JICA. 2015. *Community-baesd natural resource management – Operations Manual.* (Accessible at https://www.jica.go.jp/project/english/easttimor/008/materials/c8h0vm0000drxpsn-att/materials11_en.pdf).

in agricultural value chains to ensure the continued development of climate resilient production systems; and (iii) allocated funding by government agencies sufficient to cover O&M costs.

Sharing of knowledge and learning. Information, education, and communication will be an important function integrated into project activities. Learning materials will be produced in a way that is accessible to both women and men rural farmers. Practical field-level demonstrations will be delivered providing an opportunity for mutual learning and knowledge exchange. Technical material for MAF staff and other stakeholders will be produced to guide operations in the field.

Sustainable development potential.

Through investments in community level adaptation, the project directly targets the pillars of sustainable development - environment, social and economic.

a. **Environment:** A core objective of the project is to support the transition from unsustainable, environmentally damaging agricultural practices. While rational from a short-term, revenue maximizing perspective, these practices are leading to rapid degradation of landscapes, deforestation, and declining productivity—processes that are likely to accelerate rapidly as the predicted impacts of climate change put further pressure on available resources. Project outputs are therefore designed to transform adaptation by reversing the current damaging practices through environmentally sensitive practices, investing in climate-resilient infrastructure, and adopting institutional arrangements that will ensure long-term sustainability.
b. **Social:** The project will aim to build solidarity at a community level by engaging the full range of stakeholders involved in agricultural production systems and value chains. Recognizing their important, though often unrecognized, contribution to agriculture coupled with the additional burden of unpaid household labor, efforts will focus particularly on strengthening the participation of women in project activities. In particular the project will focus on closing the productivity gap between men and women by enhance women's access to the finance and assets necessary to improve livelihood outcomes.
c. **Economic:** The project aims to increase the participation of the private sector—both for-profit and non-profit organizations—in agricultural value chains as a means to increase income-earning opportunities for rural farmers. Strengthened links between producers and consumers are intended to improve incentives for farmers to produce for the market leading to increased returns. The project will also seek to improve access to finance by linking to established microfinance providers. By focusing project activities at the community level, it is expected that project benefits will primarily flow to local women and men farmers.

The project also supports the following SDG targets:

1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision- making in political, economic and public life.

13.1 Strengthen resilience and adaptive capacity to climate- related hazards and natural disasters in all countries.
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation- neutral world.

Needs of the recipient

Data for 2016 estimate that 30.7% of the population were living on less than the internationally recognized poverty line of $1.90/day, and 45.8% were classified as living in multi-dimensional poverty. Such conditions make the population more vulnerable to shocks and stresses. Agriculture accounts for 9% of GDP, and 41% of employment, however, excluding oil revenue plays a much more significant role in the economy. Most agriculture is subsistence farming, with coffee the only major crop grown for export. Rural areas suffer from food insecurity, due to a combination of low productivity, high population growth and unpredictable rainfall coupled with extreme climate events. Gender analysis shows that for women, these circumstances are felt even more acutely. Most farming households have minimal engagement with agricultural markets and can be characterized as low-input, low-output producers. Although the Timor-Leste people have some capacity to adapt to these complex changes, such coping strategies are still reliant on climate-sensitive natural resources, aggravated by their limited access to alternative livelihoods. Traditional gender roles exacerbate the risks for women in a changing climate, while minimal access to weather and climate forecasting hinders adaptive actions. With agricultural systems, including the livelihood conditions and food insecurity issues, expected to be severally affected by both by increases in extreme events, as well as changes in temperature and rainfall, solutions in adaptation are urgently needed. As an LDC, Timor-Leste lacks the financial resources to address climate threats, especially for the most vulnerable, and the constraints on the public budget mean Government cannot fill the adaptation funding gap. The COVID-19 crisis is expected to worsen the economic situation and result in large scale livelihood losses and increased food insecurity.

Country ownership

The project will support the government's efforts "to increase productivity and production of the agricultural sector that could have congruent positive impacts on food and nutrition security and poverty alleviation and sustainable growth in the context of climate change".[202] Project outputs will also contribute to the country's commitment in its Initial Nationally Determined Contribution to mainstream climate change adaptation in the action plans of all sectors[203] and support the implementation of adaptation measures and project profiles outlined in the National Adaptation Programme of Action to Climate Change.[204]

The project also aligns well with Timor-Leste's GCF country programme which includes the following main priorities for adaptation:

(i) Build climate proof and environmentally sustainable infrastructure to protect water resources, including enhancing water harvesting, distribution and management systems

[202] Government of Timor-Leste. 2017. *Agriculture Policy and Strategic Framework - Towards Nutrition-Sensitive, Climate Smart Agriculture and Food Systems.* Dili.
[203] Government of Timor-Leste. 2016. *Intended Nationally Determined Contribution.* Dili.
[204] Government Timor-Leste. 2010. *National Adaptation Programme of Action to Climate Change.* Dili.

(ii) Implement integrated sustainable land management which promote fixed/permanent agriculture, reduce crop burning, reduce erosion, and increase soil fertility.
(iii) (a) Reforest degraded lands and provide a sustainable fuel wood source to areas with high vulnerability, and (b) develop integrated agroforestry and watershed management
(iv) Improve physical infrastructure and natural vegetation methods to prevent landslides in hill sites, roads and riverbanks that are made vulnerable by climate change.
(v) Enhance government and community strategies to respond to drought exacerbated by climate change

Efficiency and effectiveness

As this is a concept project and at pre-feasibility study stage a detailed economic appraisal is not yet possible. However, an indicative economic analysis has been undertaken and is presented in the table below. This indicates a high positive economic return can be expected on the project.

Table 12: Project Economic Benefits

Project Output	Economic benefits
Output 1: Climate-resilient farming systems and market linkages developed	Climate smart agriculture has been found to have high benefit to cost ratios.[205] Economic review of IFAD's Adaptation for Smallholder Agriculture Programme reported positive benefit cost ratios across 32 country-level projects, up to 6:1 (and EIRRs of between 15% and 35%).[206] Flood and drought tolerant crops are an effective and efficient strategy with positive BCRs are positive.[207]
Output 2: Physical flood barriers / rainwater harvesting and storage	Flood infrastructure typically found to have high benefit to cost ratios (averaging 5:1). [208,209] Economic benefits from avoided losses, but additional benefits associated with green infrastructure from avoided GHG emissions and wider socio-economic benefits. Economic studies report rainwater harvesting has high benefit to cost ratios.[210, 211]

SECTION 4: SAFEGUARDS AND OTHER REQUIREMENTS

Stakeholder consultation

The project is at an early stage of development. Given travel limitations imposed by COVID-19, stakeholder consultation to date has focused on engagement with MAF. The Ministry has indicated its support for the project and provided valuable guidance on the most appropriate location for projects activities. Future consultations will involve engaging with other government ministries, communities in the five target municipalities, private sector operators, development partners and other stakeholders.

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[205] International Fund for Agricultural Development (IFAD). *The Economic Advantage Assessing the value of climate-change actions in agriculture.* 2016. https://cgspace.cgiar.org/bitstream/handle/10568/77628/Economic_Advantage.pdf?sequence=1
[206] Ferrarese C., E. Mazzoli, & R. Rinaldi. *Review of economic and livelihood benefits for ASAP-supported investments*. IFAD Publications, Rome, Italy. 2017.
[207] Prasad, YG., Maheswari, M., Dixit, S., Srinivasarao, Ch., Sikka, AK., Venkateswarlu, B., Sudhakar, N., Prabhu Kumar, S., Singh, AK., Gogoi, AK., Singh, AK., Singh, YVand Mishra, A. (2014), "Smart Practices and Technologies for Climate Resilient Agriculture". Central Research Institute for Dryland Agriculture (ICAR), Hyderabad. 76 p.
[208] Mechler, R. Nat Hazards (2016) 81: 2121. https://doi.org/10.1007/s11069-016-2170-y.
[209] ECONADAPT. Assessing the economic case for adaptation to extreme events at different scales. Deliverable 5.1 https://econadapt.eu/sites/default/files/docs/Deliverable%205-1%20approved%20for%20publishing_1.pdf.
[210] Hutton, G., Haller, L. Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level.. Water, Sanitation and Health Protection of the Human Environment. World Health Organization. Geneva 2004.
[211] Dallman, S., Chaudhry, A.M., Muleta, M.K. et al. The Value of Rain: Benefit-Cost Analysis of Rainwater Harvesting Systems. Water Resour Manage 30, 4415–4428 (2016). https://doi.org/10.1007/s11269-016-1429-0.

Environment and Social Impact

The project will adopt a community-driven development approach to the implementation with support for infrastructure limited to smallscale, community-managed investments. The project aims to improve the resilience of vulnerable communities and their physical assets to combat the impacts of climate change. It will develop the capacity of the mandated government agencies and finance investment in small-scale rural infrastructure in five priority municipalities, especially for water harvesting, community flood protection, irrigation schemes, and catchment management activities such as reforestation and agroforestry.

ADB will implement its standard approach to environmental and social safeguards which will be undertaking during the detailed project design phase. The initial environmental and social risks are both assessed as moderate as the impacts are generally localized, community-based, limited in scale, and readily manageable through the application of standard mitigation measures.

The project's environmental and social impacts would come mainly from the construction/rehabilitation and catchment management activities, including possible disturbance/loss of vegetation at worksites, erosion and sedimentation, contamination of water during construction, generation of noise, worker and public safety risks, clearing of native vegetation for agroforestry, impacts to cultural heritage/sacred sites, conflict associated with land tenure, and possible benefit exclusion of, or adverse impacts to women, indigenous people and other vulnerable groups. Any subprojects financed by the project will undergo the environmental licensing process required under Timor-Leste's Environmental Licensing Law, which includes obligatory screening, commensurate impact assessment, and government review.

Gender-sensitive development impact

To release the potential of women to contribute to and benefit from a more sustainable, prosperous, and better adapted agricultural production systems, the project will include specific activities designed to increase access to economic and productive assets for women with gender-responsive information and education coupled with dramatically expanded opportunities for participation in local decision making and leadership.

Strategies to achieve gender-responsive development impact will include expanding access to finance to enable women to secure the necessary assets to increase productivity, together with time-saving investments, especially related to accessing water. With the exception of coffee as the leading cash crop, the financial returns to labor in most of agriculture are low. In addition, there is risk aversion in the face of uncertainty on the part of many farmers and relatively slow expansion of microfinance operations that limits access to finance. Given these limitations, initial investments to improve productivity will need to be in the form of small grants to targeted poor households, with a focus on women farmers. Guidelines will be developed to provide details on criteria for allocating the small grants to both maximize their impact on increasing adaptation-driven agricultural productivity and women's economic empowerment while avoiding creating dependency. Linking access to microfinance can provide a pathway to longer-term sustainable finance.

Increasing women's meaningful participation in household and community-level decision making processes will be essential to realize the potential benefits from increased investment opportunities. The project will support the formation and/or further development of women-led farmers groups that will provide a two-way platform of engagement to increase voice and provide information and education on climate change and gender-related issues, while also engaging women farmers on their own experience and aspirations for improving agricultural performance.

4. LIST OF POTENTIAL EXECUTING AND IMPLEMENTING AGENCIES

Below provides a list of indicative or potential executing and implementing agencies per country, including subnational implementing agencies, for projects that will be supported under CRPP IF.

ADB defines "executing agency", as identified in a financing agreement, is responsible for the carrying out of a loan, grant or a TA grant-funded project. The term EA may be extended to include an implementing agency (IA) that the EA designates to implement the project and recruit consultants. [212]

CRPP IF Outputs	Indicative executive and implementing agencies
Output 4: Information and systems for delivering applied climate-risk informed investments at-scale improved Activity areas: • Climate information services for key sectors to meet local adaptation needs • Climate risk informed social protection systems • Climate risk information systems for decentralization policies	**Cambodia** • *Executing agencies/entities:* Ministry of Water Resources and Meteorology; Ministry of Social Affairs, Veterans and Youth, National Committee for Sub-national Democratic Development • *Implementing agencies:* Provincial Department of Ministry of Water Resources and Meteorology; provincial government **Indonesia,** • *Executing agency/entity:* Meteorological, Climatogical and Geophysical Agency Ministry of Social Affairs, Ministry of Village, Development of Disadvantaged Regions and Transmigration. • *Implementing agency:* Provincial department **Lao PDR** • *Executing agencies/entities:* Ministry of Natural Resources and Environment, Ministry of Labour and Social Welfare, • *Implementing agencies:* Provincial and/or municipal office of Natural Resources and Environment, Social Affairs, etc. **Papua New Guinea** • *Executing agency/entity:* PNG Weather Service • Implementing agencies: PNG Weather Service **Pakistan** • *Executing agency/entity:* Planning and Development Board, Government of Sindh (GoS) • *Implementing agencies:* Irrigation Department, GoS, Forestry and Wildlife Department, Agriculture Department, Livestock and Fisheries Department, and Technical Education & Vocational Training Authority, GoS; Sindh Coastal Development Authority, GoS; National Institute for Oceanography, Ministry of Science and Technology **Timor-Leste** • *Executing agency/entity:* National Directorate of Meteorology and Geophysics, Ministry of Social Solidarity and Inclusion

[212] Project Administration Instructions (PAI) No. 2.01: Definitions, Principles and Responsibilities (adb.org)

<table>
<tr><th>CRPP IF Outputs</th><th>Indicative executive and implementing agencies</th></tr>
<tr><td></td><td>Implementing agencies: National Directorate of Meteorology and Geophysics, Ministry of Social Solidarity and Inclusion
Vanuatu
Executing agency/entity: Ministry of Climate Change Adaptation, Meteorology and Geohazards, Energy, Environment and National Disaster Management
Implementing agencies: Ministry of Climate Change Adaptation, Meteorology and Geohazards, Energy, Environment and National Disaster Management</td></tr>
<tr><td>Output 5: Pro-poor livelihood adaptation investments implemented

Activity areas:
Climate resilient agroecological systems
Information technology and risk management services for climate resilient livelihoods.
Climate resilient agriculture supply chains</td><td>Cambodia
Executing agency/entity: Ministry of Agriculture, Forestry and Fisheries; Ministry of Water Resources and Meteorology; Ministry of Environment
Implementing agencies: Provincial and/or municipal level offices (e.g., Provincial Department of Water Resources and Meteorology; Provincial Department of Agriculture)
Indonesia
Executing agency/entity: Ministry of Agriculture,
Implementing agencies: Provincial Department of Agriculture
Lao PDR
Executing agency/entity: Ministry of Agriculture and Forestry
Central level implementing agency: Department of Irrigation; Department of Technical Extension and Agricultural Processing; Department of Agriculture; Department of Agricultural Land Management, Department of Rural Development and Cooperatives; provincial and/or municipal office of Natural Resources and Environment, Agriculture and Forestry, etc.
Papua New Guinea
Executing agency/entity: Department of Forestry, Department of Agriculture and Livestock
Implementing agency: Province-level office
Timor-Leste
Executing agency/entity: Ministry of Agriculture and Fisheries (MAF)
Implementing agencies: Department of Higher Education, Science, Research and Technology; Directorate of Agroforestry and Industrial Crops and municipal-level MAF offices
Vanuatu
Executing agency/entity: Ministry of Agriculture, Livestock, Fisheries, Forestry and Biosecurity
Implementing agencies: Ministry of Agriculture, Livestock, Fisheries, Forestry and Biosecurity</td></tr>
</table>

CRPP IF Outputs	Indicative executive and implementing agencies
Output 6: Pro-poor climate adaptive-infrastructure investments implemented Activity areas: • Ecosystem-based infrastructure • Flood and landslide protection infrastructure • Multipurpose emergency shelters	**Cambodia** • *Executing agency/entity:* Ministry of Agriculture, Forestry and Fisheries, Ministry of Environment • *Implementing agencies*: Provincial and/or municipal level offices (e.g., Provincial Department of Water Resources and Meteorology) **Indonesia** • *Executing agency/entity:* Ministry of Public Works and Housing • *Implementing agencies:* Directorate General of Human Settlements; Directorate General of Housing Provision, Directorate General of Regional Development in Ministry of Home Affairs; Local and provincial governments **Lao PDR** • *Executing agency/entity:* Ministry of Agriculture and Forestry; Ministry of Natural Resources and Environment • *Implementing agency:* Department of Agriculture; Department of Agricultural Land Management, Department of Rural Development and Cooperatives; Provincial and/or municipal office of Natural Resources and Environment, Agriculture and Forestry, etc. **Pakistan** • *Executing agency/entity:* Planning and Development Board, Government of Sindh (GoS) • *Implementing agency:* Irrigation Department, GoS, Forestry and Wildlife Department, Agriculture Department, Livestock and Fisheries Department, and Technical Education & Vocational Training Authority, GoS; Sindh Coastal Development Authority, GoS; National Institute for Oceanography, Ministry of Science and Technology **Papua New Guinea** • *Executing agency/entity:* Department of Works • Implementing agencies: Department of Works **Timor-Leste** • *Executing agency/entity:* Ministry of Agriculture and Fisheries (MAF) • *Implementing agencies:* Directorate of Agroforestry and Industrial Crops; Provincial and/or municipal-level MAF offices **Vanuatu** • *Executing agency/entity:* Ministry of Internal Affairs; Port Vila Municipal Council • *Implementing agencies:* Ministry of Internal Affairs; Port Vila Municipal Council