



Food and Agriculture Organization  
of the United Nations

## Dacope Upazila



### Report on Climate Risk and Vulnerability Assessment and Climate Resilience Action Plan for Aquatic Ecosystem

2024

Project: Community Based Climate Resilient Fisheries  
and Aquaculture Development in Bangladesh





Report on Climate Risk and Vulnerability Assessment and Climate  
Resilience Action Plan for Aquatic Ecosystem

**Dacope Upazila**

**2024**



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# Abbreviations

AR5	IPCC Fifth Assessment Report
AT	Air Temperature
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BFRI	Bangladesh Forest Research Institute
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Meteorological Department
BMDA	Barind Multipurpose Development Authority
BOD	Bio-chemical Oxygen Demand
BPP	Biodiversity Protection Program
BWDB	Bangladesh Water Development Board
CBO	Community based Organization
CC	Climate Change
CC&DRR	Climate Change and Disaster Risk Reduction
CEGIS	Center for Environment and Geographic Information Services
CIS	Climate Information Services
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
COD	Chemical Oxygen Demand
CORDEX	Coordinated Regional Climate Downscaling Experiment
CPA	Chittagong Port Authority
CPUE	Catch Per Unit Effort
CRA	Climate Resilience Action
CRV	Climate Risk and Vulnerability
CRVA	Climate change Risk and Vulnerability Assessment
DAE	Department of Agricultural Extension
DJF	December January February
DO	Dissolved Oxygen
DoE	Department of Environmet
DoF	Department of Fisheries
DRR	Disaster Risk Reduction
DSS	Department of Social Services
DYD	Department of Youth Development
EAA	Ecosystem Approaches for Aquaculture
EAF	Ecosystem Approach to Fisheries
EbA	Ecosystem Based Adaptation
EC	Electrical conductivity
ECA	Ecologically Critical Area
ECR'97	Environment Conservation Rules 1997
ES	Ecosystem Services
ETP	Effluent Treatment Plant
EUS	Epizootic Ulcerative Syndrome
EWS	Early Warning System

F&A	Fisheries and Aquaculture
FAO	Food Agriculture Organization
FFWC	Flood Forecasting and Warning Center
FGD	Focus Group Discussion
FRSS	Fisheries Resources Survey System
FW	Fresh Water
GCM	General Circulation Model
GDP	Gross Domestic Product
GED	General Economic Division
GIS	Geographic Information System
HYV	High Yielding Variety
ICT	Information and Communication Technology
IFF	Integrated Fish Farming
IGA	Income Generating Authority
IPCC	Intergovernmental Panel on Climate Change
JJAS	June July August September
JRC	Joint River Commission
KII	Key Informant Interview
LGD	Local Government Division
LGED	Local Government Engineering Department
LGI	Local Government Institutes
MAM	March April May
MoDMR	Ministry of Disaster Management and Relief
MoEFCC	Ministry of Environment, Forest and Climate Change
MoF	Ministry of Finance
MoLJPA	Ministry of Law, Justice and Parliamentary Affairs
MoS	Ministry of Shipping
MoWCA	Ministry of Women and Children Affairs
MoWR	Ministry of Water Resources
MP	Muriate of Potash
MSL	Mean Sea Level
MT	Metric Tons
NCVA	Nationwide Climate Vulnerability Assessment
NGOs	Non-Government Organization
NRCC	National River Conservation Commission
NWRD	National Water Resources Database
ON	October November
PAs	Protected Areas
PES	Payment for Ecosystem Services
PL	Post Larvae
RAS	Recirculation Aquaculture Systems
RAWES	Rapid Assessment of Wetland Ecosystem Services
RHD	Roads and Highways Department
RSEMF	Rainfall Sensitive Environment for Migratory Fishes
RSERF	Rainfall Sensitive Environment for Resident Fishes
SGR	Specific Growth Rate

SLR	Sea Level Rise
SSP	Shared Socioeconomic Pathway
SPARRSO	Space Research and Remote Sensing Organization
SUFO	Senior Upazila Fisheries Officer
SW	South West
SWOT	Strength, Weakness, Opportunities and Threats
TDS	Total Dissolved Solids
TSE	Temperature Sensitive Environment
TSP	Triple Super Phosphate
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
UP	Upazila Parishad
WARPO	Water Resources Planning Organization
WSS	White Spot Syndrome
WT	Water Temperature



## Executive Summary

Bangladesh's economic, nutritional, and social reliance on the fisheries sector makes it extremely vulnerable to the effects of climate change on fisheries. Climate change adaptation plans are essential to reduce these vulnerabilities. At the moment, Bangladesh's early warning system (EWS) does not include particular messages on fishers' and fish farmers' readiness, thereby affecting community's capacity to respond to climate change hazards, particularly women and children. Therefore, climate-related risks and vulnerabilities affecting the fisheries and aquaculture sector, putting particular emphasis on gender, need to be identified and analyzed at the national and local levels.

The current study evaluated the climate change vulnerability of Dacope Upazila of Khulna District of the Khulna Division of Bangladesh, as it is one of the most severely affected regions by catastrophic climatic events, both historically and in recent times. The land elevation of Dacope Upazila mostly varies between 1 to 15m, and more than 50% of the area lies below 3m. These low-lying areas are subjected to floods, sea level rise, storm surges, and cyclones etc. which cause inundation, erosion of shorelines, and also contribute to coastal flooding. Almost every year, many shrimp farms in Dacope get flooded.

The region experienced numerous catastrophic severe cyclone events, especially in the last two decades, including Sidr (2007), Rashmi (2008), Aila (2009), Roanu (2016), Mora (2017), Fani (2019), Amphan (2020) and others. It has been observed that a 10 m high wave (surge plus tide) along Bangladesh coast occurs every 20 years, while a wave with a 7 m height occurs every 5 years (Rahman, 2014). Cyclone Sidr (2007), Cyclone Aila (2009) and super Cyclone Amphan (2020) were accompanied with 3m to 5.5m level of storm surge and brought the saline water into the agricultural lands and also inundated housings of many coastal communities. Besides cyclones; storm surge, tidal flooding, saline water intrusions, river bank erosion, droughts etc. have severely affected people living in the region. Specially, shrimp growers in Dacope are dealing with a number of difficulties as a result of the temperature increase, chief among them being many viral, bacterial, and fungal infections. Although lightning susceptibility of the South-West zone is comparatively less than other zones of Bangladesh, locals reported the spawning and breeding of fisheries to have been affected by this as well. Droughts associated with high temperatures and low rainfall have adverse impacts on aquaculture and inland open-water fisheries in some areas of Dacope. Ponds, rivers, canals and beels dry up or retain insufficient water during the dry/drought period, affecting fish production in aquaculture, and in open water systems in some localities of Dacope.

Future climate projections by CEGIS (2022) illustrate that, the maximum temperature will rise 2.2°C and 0.9°C during winter and summer respectively in 2050s for SSP5-8.5 when compared to 1981-2010. Likewise, the minimum temperature will rise 3.3°C and 2.2°C during winter and summer respectively in 2050s for SSP5-8.5 when compared to 1981-2010. Future rainfall projections show that rainfall will decrease during DJF, MAM and ON season by 89%, 36% and 62% respectively and increase in JJAS by 30%, while the total annual rainfall will be decreased by around 4% in 2050s when compared to the base period 1981-2010 under SSP5-8.5.

An assessment was also undertaken regarding changes in water bodies. The permanent water bodies in Dacope were found to have increased on average by 3.6% from 1990 to 2020. This may be the aftermath of gradual sea level rise and consequent increase of intertidal area, which usually create waterlogged areas in low lying regions. Sometimes the landuse was also observed to have changed in areas such as fish habitats and breeding grounds, which have negative effects on fisheries and other aquatic animals.

The water quality tests undertaken found that the dissolved oxygen values are suitable for the growth of fisheries in pond and river ecosystem but inadequate for fish gher. Temperatures recorded revealed that surface water in fish gher and pond was found slightly warm which is not favorable for aquatic ecosystem and if this condition remains for longer period, algae bloom may result due to increased nutrients and warmer temperatures. In a study by Rodgers (2008) was found out that fish mortalities occur in relation to harmful algal blooms during summer. This occurrence was also reported by communities who observed high fish mortalities during summer. Farmers also reported that, overuse of pond especially during summer, reduces water levels and changes water quality ultimately affecting fish habitat. From the vulnerability assessment it was found that Dacope, Pankhali (Chalna), Sutarkhali and Tildanga unions were

highly vulnerable to climate change induced hazards. Adaptive Capacity assessment showed Chalna, Khulna Ranga and Sutarkhali unions to have high adaptive capacity. Climate change risk on ecosystem in Dacope was calculated for both base and 2050s. From the risk analysis in both scenarios, all the unions except Chalna Paurashava are in high risk.

The study further estimated that the magnitude of temperature induced stress on river seasonal migratory fishes will increase in the 2036-2065 and 2070-2100 under SSP1-2.6 scenario by 0.41% and 0.22%, respectively with increasing 1°C mean water temperature. However, this magnitude will decrease by 0.19% with increasing 1°C mean water temperature under SSP5-8.5 scenario. It was also noted that, the magnitude of the temperature induced stress on resident fishes increased in SSP1-2.6 scenario and decreased in SSP5-8.5 scenario with increasing minimum temperature. Sensitivity of capture fisheries was assessed through indicator-based analysis where it was found that Banishanta, Dacope, Kamarkhola, Pankhali (Chalna) and Tildanga unions are highly sensitive to climate change induced hazard. Adaptive capacity assessment revealed that Bajua, Banishanta, Dacope, Kailasganj, Laudubi, Pankhali (Chalna), Sutarkhali and Tildanga unions have high adaptive capacity for capture fisheries whereas Bajua, Banishanta, Dacope, Kailasganj, Laudubi, Pankhali, Sutarkhali and Tildanga have high adaptive capacity for culture fisheries due to the presence of the indicators selected from impact chain in higher density. Vulnerability was also obtained through validated impact chain analysis and from the assessment Kamarkhola union was found to be in high vulnerability zone for culture fisheries and Banishanta, Dacope, Kamarkhola, Pankhali and Tiladanga unions are highly vulnerable for capture fisheries. Climate change induced hazard risk was obtained through impact chain analysis. For Capture fisheries, Pankhali, Chalna Pourashava, Bajua, Dacope, Kamarkhola, Sutarkhali and Banishanta unions were in high risk and Tiladanga union is in moderate risk in base period. In 2050s, Tiladanga union will also be in high risk zone along with the high-risk unions of base period. For culture fisheries, Tildanga union was found to be in high risk for both the base period and the 2050s.

Most of the women in Dacope are involved in household related activities, with only 5% women (Upazila Field Office 2022) involved in fry collection, net making, pond preparation and culture fishing. Those women involved in fish related activities were found to earn little from these compared to male counterparts. Exposure for gender-based livelihood analysis showed all the unions were highly exposed except the Chalna Paurashava and Khulna Range, whereas sensitivity analysis showed Dacope, Kailasganj, Kamarkhola, Laudubi, Pankhali (Chalna) and Tildanga unions are in highly sensitive zone for gender-based livelihood. Risk assessment shows all the unions except the Chalna Paurashava union are at high risk for gender-based livelihood for both the base period and the 2050s time slice. In 2050s the Chalna Paurashava union is found to be in a moderate risk zone while it was in the low-risk zone in the base period.

Gender inclusive climate resilience action plan for aquatic ecosystem, capture fisheries and culture fisheries livelihoods are proposed. These adaptation action plans include structural and non-structural options considering all the existing climate hazards in the study area such as cyclone, storm surge, salinity intrusion, drought, lightning, etc. For capture fisheries, adaptation actions include the development of climate-smart open water fisheries management, restoration of connectivity between the habitats, strengthening gender inclusive EWS for fisheries and aquaculture sector etc. Adaptation actions centering the culture fisheries include promotion of IoT based technology, climate resilient technology for combating climate related stresses in aquaculture, such as development of stress tolerant species of commercially important fish and species diversification.

# 1 Introduction

## 1.1 Background

Every sector, including fisheries and aquaculture (F&A), in Bangladesh is experiencing the adverse impact of climate change. Communities that depend on the F&A sector for their livelihood are already experiencing losses and damages due to climate change impacts. The uncertainty in future climate makes things worse, in addition to the inadequate capacity for impact assessment and climate-resilient planning at the governmental and community levels being a key barrier to effective adaptation strategies. Governments and local communities must therefore improve their capacity to assess, plan, implement, and track adaptation to climate change impacts on the fisheries and aquaculture sectors.

Climate change adaptation planning is complex as it requires short- and long-term planning to address short-term adaptation measures and long-term climate scenarios. Such planning can only be possible if long-term climate information for trend and impact analysis is generated and maintained in a reliable database. Consistent and proper synchronization between discrete data sets (e.g., the Bangladesh Meteorological Department's site-specific and time-series climate data, and the Department of Fisheries' (DoF) site-specific fisheries datasets) is required for assessing the impacts of climate change on the F&A.

The study is one of the first initiatives to assess climate change risk and vulnerability, particularly for the Fisheries and Aquaculture (F&A) sector. CRVA is performed for capture fisheries, culture fisheries, aquatic ecosystems, and gender engagement in the fishing sector, illustrating the variations of risk and vulnerability levels up to the union level. Further, this assessment is unique as it follows the latest IPCC AR5 approach, i.e., impact chain and indicators-based approach for CRVA, and utilizes all available latest data, including the downscaled datasets of ensembles of GCMs from CMIP6. Performing SWOT for services provided by the aquatic system is also done as a first initiative to facilitate the CRVA, identify climate-sensitive ecosystems, and develop a climate resilience action plan.

The findings from this study contributes to knowledge enhancement and awareness about the impacts of climate change at the national and local levels with a particular emphasis on gender issues. The CRVA will strengthen knowledge on climate-resilient F&A through natural resources and disaster management planning. Additionally, the study provides insights and/or recommendations as regards to mainstreaming disaster risk reduction/management in local development plans and programs for enhanced climate change resilience.

## 1.2 Study objectives

The overall goal of the study was to conduct a comprehensive Climate Change Risk and Vulnerability Assessment (CRVA) of F&A sector by highlighting the risk and vulnerability of local fishers, fish farmers from the observed and predicted effects of climate change on F&A livelihood with particular focus on women for Dacope Upazila. Specifically, the study aimed to:

- Assess detailed climate risks and vulnerabilities on F&A in the project site (Upazilas) in the integrative approach of participatory and scientific tools.
- Assess climate risks and formulate climate-resilient action plans for fishery ecosystems
- Identify and map climate change-sensitive areas for F&A in Dacope Upazila

## 1.3 Approach of the study

The study was conducted following the developed CRVA framework<sup>1</sup> for the F&A, through collecting and analyzing datasets from both scientific and participatory approaches. Three types of participatory tools

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<sup>1</sup> FAO (2022). Draft National Level Climate Risk and Vulnerability Assessment for Fisheries and Aquaculture (F&A) Sector in Bangladesh.

were used: Focused Group Discussions (FGDs), Community Survey and Key Informant Interviews (KIIs). The study conducted 3 FGDs with Community based Organizations led by Women (Net Making Group), capture fisheries group and culture fisheries group/fish farm owner. Senior Upazila Fisheries Officer (SUFO), fish trader and Gher Owner were interviewed for KIIs. Three community surveys at Sutarkhali, Pankhali and Chalna Paurashava were conducted to collect primary data of different indicators as developed under impact chains for capture fisheries, culture fisheries, aquatic ecosystem and gender-based F&A livelihoods. A catch assessment survey was conducted in nearby fish landing stations to assess the species diversity, uniformity or evenness, availability of species, and fish production. Focus Group Discussions (FGDs) were conducted in Dacope with mostly groups of people from the fishing community to collect qualitative information regarding hazards, exposure, vulnerabilities, existing coping mechanism or adaptation practices, and challenges of gender for risk reduction, livelihood mapping, ecosystem vulnerability assessment etc. The primary focus of the FGDs is to customize of the impact chain, particularly for their project site and extract weights of identified elements by them. For FGDs, about 12 people, both male and female, aged between 25-65 years were chosen.

In this study, the water temperature was calculated from the air temperature by applying the global conversion coefficient value for flowing water bodies:

$$WT_{Wet\ Season} = 1.2195 * AT - 6.0976; WT_{Dry\ Season} = 1.1842 * AT - 2.0395;$$

where, WT = Water Temperature and AT = Air Temperature

This study also calculated the instantaneous rate of natural mortality (M; 1/year), which refers to the mortality of a generation (from late juvenile to adult phases) of a population and was calculated here from Pauly's empirical equation based on the parameters of the von Bertalanffy growth function and on the mean water temperature (T) (Pauly et al., 1980).

$$M = 10^{(0.566 - 0.718 * \log(L_{inf}) + 0.02 * T)}$$

where, M = Natural Mortality, T = Mean Water Temperature and  $L_{inf}$  = the length that the fish of a population would reach if they were to grow indefinitely also known as asymptotic length

In situ water quality parameters were collected from Passur River, ponds and gher for laboratory tests to assess the habitat condition. SWOT (Strength, Weakness, Opportunities and Threats) analysis was performed for numerous ecosystem services to facilitate the development of climate resilience action plan. The process involved Focus group discussion (FGD), Community surveys, and Key Informant Interviews (KIIs), where participants were simply asked to share their perceptions about the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of the four categories of ecosystem services (i.e. provisioning, regulating, supporting and cultural). Field observation findings were also used to validate the results. Respondent's answers were ranked by selecting the three most important themes within each of the four SWOT categories analysis (i.e. scores per respondent: 1=Less/Poor condition, 2=Medium/Good condition, 3=High/Better condition. A high score for Strength/Opportunities reflects Better/High Condition, but Less/Poor condition for Weakness/Threats. Scoring of different ecosystem services has been recorded and analyzed according to the concept from RAWES method (2017) and Land-cover scores for ecosystem service assessment (A Smith, & R Dunford; 2018). The scores of SWOT for each of the major ecosystem categories were estimated using arithmetic aggregation method.

In addition to primary data of different risk and vulnerability related indicators for open water fisheries, aquaculture, gender and aquatic ecosystem, data from different secondary sources such as FRSS, BBS, NWRD and CEGIS model-based outcome were used to scrutinize and utilize datasets for relevant geo-spatial analysis of hazards, exposure, sensitivity, adaptive capacity, vulnerability and risk following the IPCC AR5 approach. Risk and vulnerability assessment were done based on blended approach of participatory appraisal techniques and scientific analysis for base and 2050s under extreme climate change scenarios. Arithmetic weighted aggregation method has been used to assess normalized score of climate risk and vulnerability for capture fisheries, culture fisheries, aquatic ecosystem and gender as per approved methodology of the CRVA framework. All relevant questionnaires and checklists for the primary surveys were developed and validated in consultation with officials of Department of Fisheries and FAO and later piloted in the Dumuria Upazila. **Figure 2.1** in **Chapter 2**, shows the survey locations for primary data collection. Photo album of surveys are illustrated in the Annex III.

## 1.4 Limitations of the study

The developed CRVA framework will be useful as a benchmark to replicate the CRVA in other locations as well. Yet, there were limitations, some of the major limitations of the study include the following:

- Limited availability of adequate data and information to desired spatial and temporal level for different indicators
- Lack of gender or sex-disaggregated datasets
- Limited resources resulted in few representative samplings. For instance, union-level primary data collection was collected in 3-4 unions only, FGDs, KIIs, water samples were limited and collected data was attributed to all other unions through appropriate correlation and expert judgment.
- For future CRVA, only future projected climate and hazard data were used without socio-economic-related data due to a lack of data and resources.



## 2 Description of Project Area

This chapter provides the general descriptions of the study area in the Dacope Upazila, highlighting the geographical setting, hydrology, climate, land cover, demography of fisheries communities etc. Further, the prevailing aquatic ecosystem and its services are outlined.

### 2.1 Geographical features

Dacope Upazila is located in the Khulna District of the Khulna Division of Bangladesh. It shares boundary with Batiaghata Upazila on the north, the Sundarbans Mangrove Forest on the south, Batiaghata and Rampal Upazilas on the east and Paikgachha Upazila on the west. The land elevation of Dacope Upazila mostly varies between 1 to 15 m where more than 50% of the land area lies below 3m. These low-lying areas are subjected to floods, sea level rise, storm surges, and cyclones etc. which cause inundation, erosion of shorelines, and also contribute to coastal flooding. The Upazila covers an area of 991 square kilometers including the Sundarbans. Apart from the mangrove forest the Rivers and Khals are observed to be the second most dominant land type among the other classes covering an area of 32497 ha or 32% of the total land cover.

### 2.2 Hydrological system

There are 8 rivers that pass through the Dacope Upazila namely Shibsra, Bhadra, Chunkuri, Pasur, Dhaki, Manga, Dhangmari and Jhopjhopia. The Shibsra River flows along the western border of the Dacope Upazila, the Bhadra River originating from India flows towards the North-West border of this Upazila, the Chunkuri River enters the Dacope Upazila from the North-East and the Pasur River flows along the Eastern border of the Upazila and towards the South. The Dhaki River enters the Upazila from the West and combines with the Chunkuri River, the Manga River flows towards the North of the Upazila, the Dhangmari River flows towards the South-East of this Upazila and the Jhapjhopia River flows towards the North. **Figure 2.1** shows the hydrologic system of Dacope Upazila.

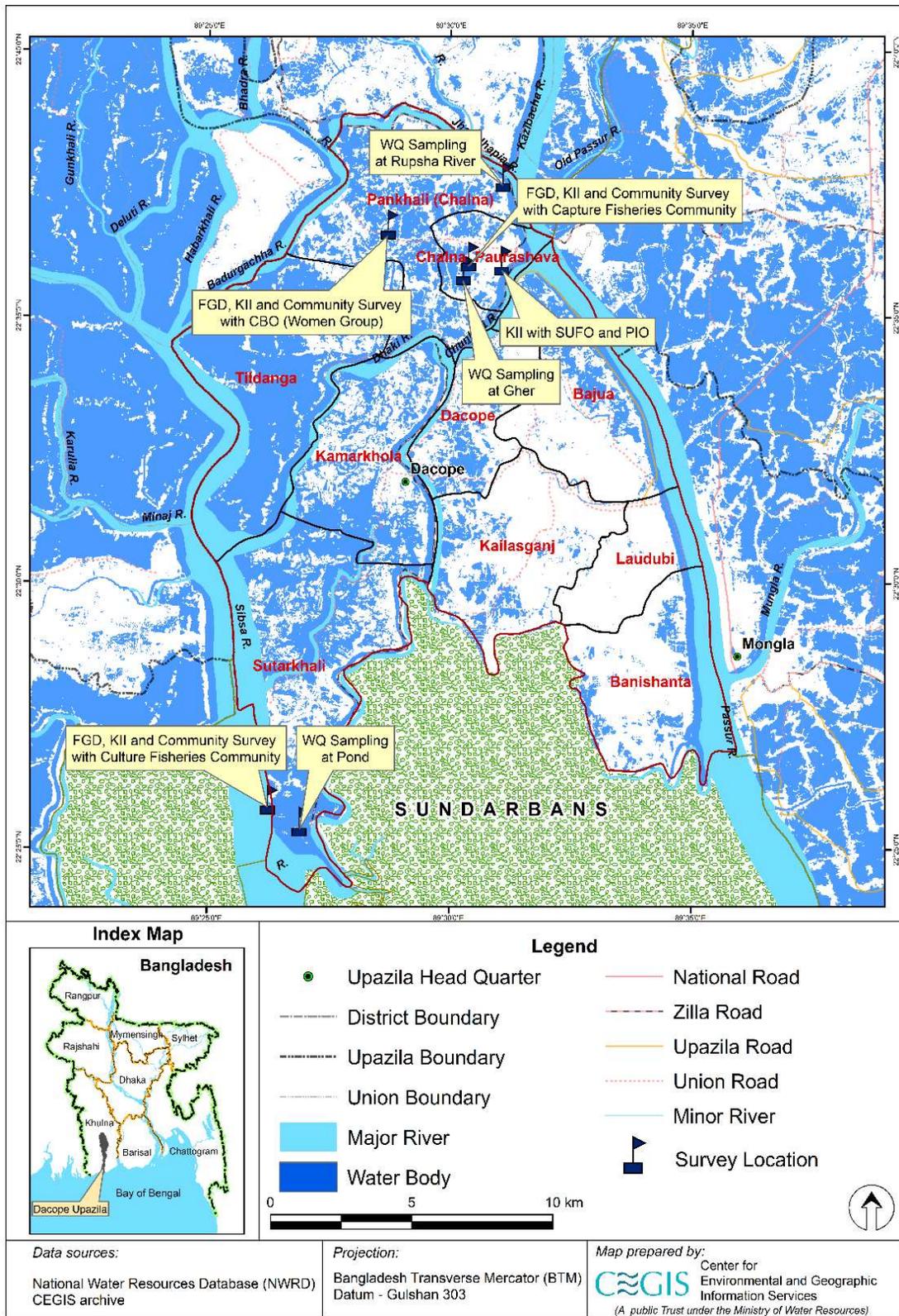


Figure 2.1: Hydrological system and locations of primary survey

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### 2.3 Aquatic ecosystem and its services

The major aquatic ecosystem within the study area consists of river and pond. Apart from major rivers namely, Shibsra, Vodra, Chunkuri, Passur, Dhaki, Manga, Dhangmari and Jhopjhopia, there are Jalmahals, ponds and ghers in Dacope Upazila. The aquatic ecosystem provides numerous services in the project area including provisioning, regulating, supporting, and cultural services. It usually provides significant amount of drinking water, fish, fuelwood, and medicinal plants as provisioning services; It regulates tidal floods, carries sediment, nutrients for aquatic plants and fauna, sequesters carbon, absorb heat, purify water naturally, transportation of freshwater, irrigation water for agriculture and flows for navigation purposes; Supports diversified flora and fauna; Additionally, it allows tourism and earning revenue from this sector. However, these services are being disrupted by different climatic and non-climatic factors.

### 2.4 Fisheries resources

Dacope Upazila is very rich in fisheries resources due to having multiple rivers and connecting Khals, influence of the Sundarbans mangrove forest, and vast aquaculture practices including shrimp farms and ponds. This Upazila has a vast water area consisting of rivers comprising an area of 4,810 ha, Khals comprising an area of 896 ha, Beels comprising an area of 580 ha, Ponds comprising an area of 526 ha, Bagda farms comprising an area of 3,980 ha, Golda farms comprising an area of 490 ha, borrow pits comprising an area of 9 ha and crab fattening farms comprising an area of 8,608 ha (at a glance, Dacope, 2020-21). These water bodies contribute about 7,735 MT of fish and fisheries products annually. This Upazila has 9,150 number of registered fishermen and 450 number of Sundarbans-going fishermen who are involved directly in fishing activities. Moreover, good numbers of post larvae (PL) collectors including male, female and children, and subsistence fishers engage in fishing activities in the nearer rivers and Khals. In addition to this, a good number of people who are involved in shrimp farms and trading related activities. Furthermore, there are several numbers of community-based fisheries associations in this Upazila, who have been supporting the fisheries sector to flourish it.

### 2.5 Demographic characteristics

Dacope Upazila has 11 unions, 25 mouzas/mahallas and 106 villages. The Upazila has a population of 1,58,309 people (Census, 2011) and approximately 50% are male and 50% are female. The total number of households is 29,600. Average literacy rate is 56%. Main occupation include agriculture, non-agricultural labor, wage laborer, forestry, fishing, commerce, service and transport. According to Dacope Fisheries office data, about 8483 people are involved in the fishing profession.

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## 3 Climate Change Induced Hazards

Dacope Upazila faces different natural disasters and slow onset events in regular frequency and with various intensity. Many of them are driven by climate change as recognized by the community people. This chapter portrays the evidence of climate induced hazards in study area based on the community perceptions and scientific information. Both historical trends and future projections are assessed and described to pin point the potential impacts of climate change.

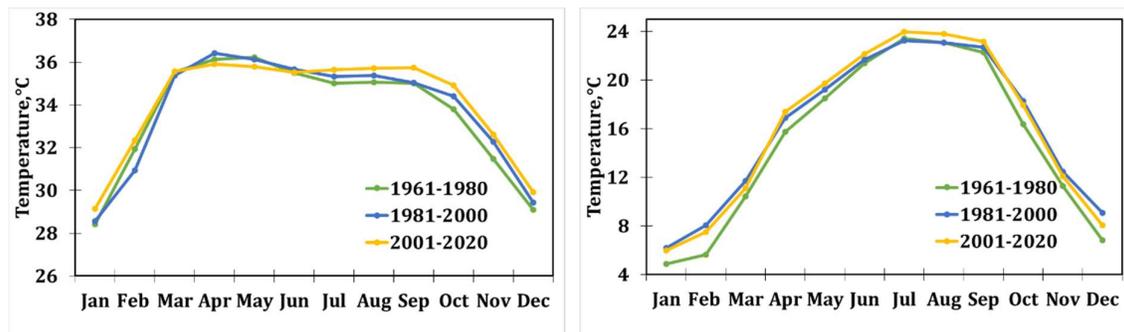
### 3.1 Climate change scenarios

#### 3.1.1 Temperature

Temperature data analysis from 1961 to 2020 for Khulna Station of Bangladesh Meteorological Department (BMD) station is presented in **Figure 3.1**. It depicts a significant increase in minimum and maximum temperature especially during August, September, and October in last two decades (20 years) than 1961-1980. During summer (March-May) average increase in maximum temperature was about 3°C and minimum temperature was 1.2°C while in winter season (December-February), minimum temperature increase was about 1°C in the last 20 years compared from 1961-1980. This variation in temperature, where both annual maximum and minimum temperature are found increasing during this last 20 years, might have substantial adverse impacts on fisheries biology and production.

Trend analysis of annual average maximum and minimum temperature reveals, the minimum temperature is increasing at a rate of (0.0181°/decade) in 1961–1980, (0.033°C/decade) in 1981–2000, and then again at (0.139°C/decade) in more recent time slices. Whereas, annual maximum temperature has a decreasing trend in 1981-2000 but in next decade it had a significant increasing trend (0.3°/decade). Both annual maximum and minimum temperature are found increasing during this last 20 years' period, historically which might affect the readiness, maturity and gonad development of fishes in breeding season.

Future climate projections by CEGIS (2022) based on 1981-2010 data illustrate that, maximum temperature will rise 2.2°C and 0.9°C during winter and summer respectively in 2050s for SSP5-8.5. Likewise, minimum temperature will rise 3.3°C and 2.2°C during winter and summer respectively in 2050s for SSP5-8.5. Mean average maximum temperature of DJF, MAM, and JJAS and ON season will be 29.1°C, 35°C, 33.8°C and 32.3°C for 2050s and mean average minimum temperature of DJF, MAM, JJAS and ON season will be 17.3°C, 25.5°C, 28.1°C and 24.4°C for 2050s under extreme climate change scenario SSP5-8.5. Higher water temperature may bring changes in physiology and sex ratios of fished species, altered timing of spawning, migrations, and/or peak abundance, changes in timing and levels of productivity across marine and freshwater systems, increased invasive species, diseases and algal blooms.



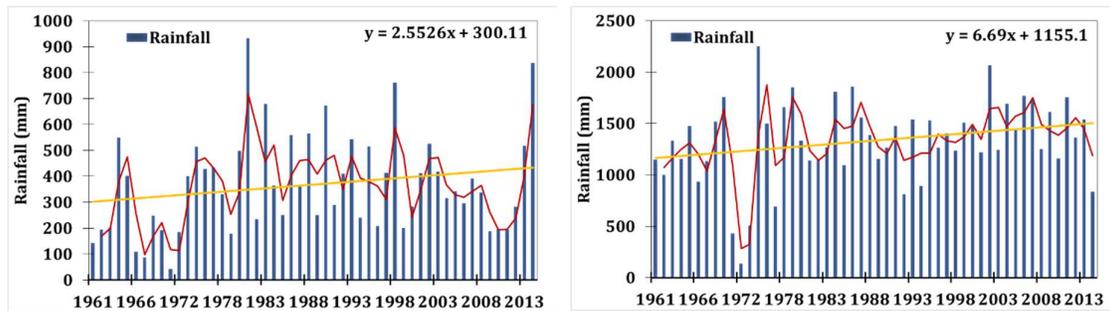
NWRD, BMD

**Figure 3.1: Average minimum (left) and average maximum (right) temperature of Khulna station**

### 3.1.2 Rainfall variability

Rainfall data analysis (1961-2020) for the dry season (October to March) and wet season (April to September) represents that the annual average dry and wet period rainfall are about 358.6 mm and 1342.1 mm respectively. Wet season rainfall is increasing with higher rate (6.69 mm/year) than that of dry season (2.55mm/year) (Figure 3.2). The area experiences distinct seasonal variations the winter season (DJF), which is generally dry and contributes only 2 percent of the total annual rainfall; the pre monsoon hot season (MAM), which perceives 17 percent of convective thunderstorms or northwester (locally known as Kalbaishakhi); and the rainy season, which receives 81 percent of the total annual rainfall. Rainfall can range from 3 mm to 846 mm during the rainy season, with June often having the highest amount of rainfall.

The future rainfall projections in 2050, compared to the base year (1981-2010), show that rainfall will decrease during DJF, MAM, and ON seasons by 84%, 38%, and 52% respectively and increase in JJAS by 30%, where the total annual rainfall will decrease by around 7% under extreme climate change scenario (SSP5-8.5).

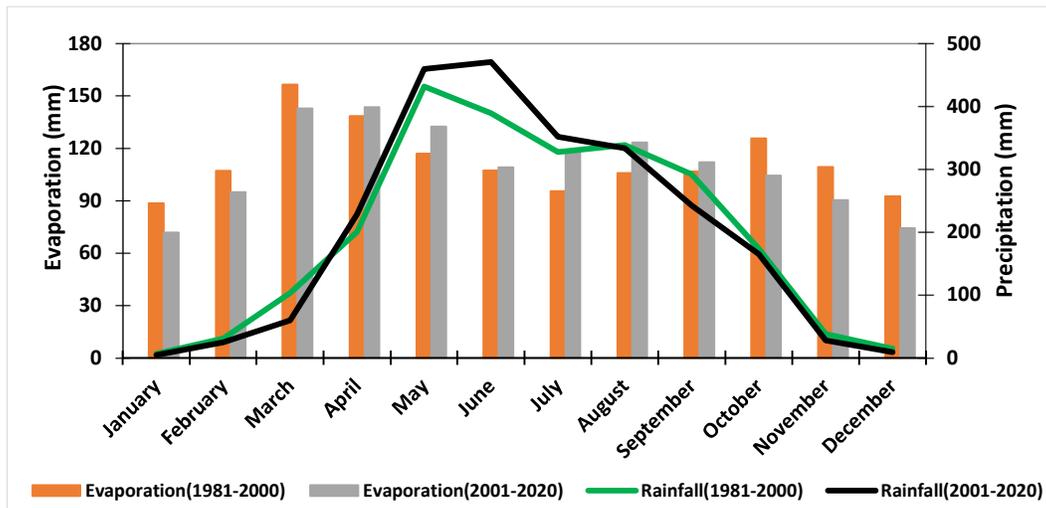


NWRD, BMD

Figure 3.2: Dry season rainfall (left) and wet season rainfall (right) temperature of Khulna station

### 3.1.3 Evaporation

Monthly variation analysis of evapotranspiration shows increasing trend during pre-monsoon and monsoon but decreasing trend during post-monsoon and dry season in 2001-2020 compared to 1981-2000 (Figure 3.3). According to a study by Wang et al (2012), reduction in evapotranspiration is generally caused by both significant decreases in wind speed and sunshine hours. Furthermore, decreasing trend in evapotranspiration signifies the water stress at the root zone as soil water content is proportional to the evapotranspiration.



NWRD, BMD

Figure 3.3: Monthly variation of rainfall and evaporation at Khulna station

### 3.2 Climate hazards and impacts

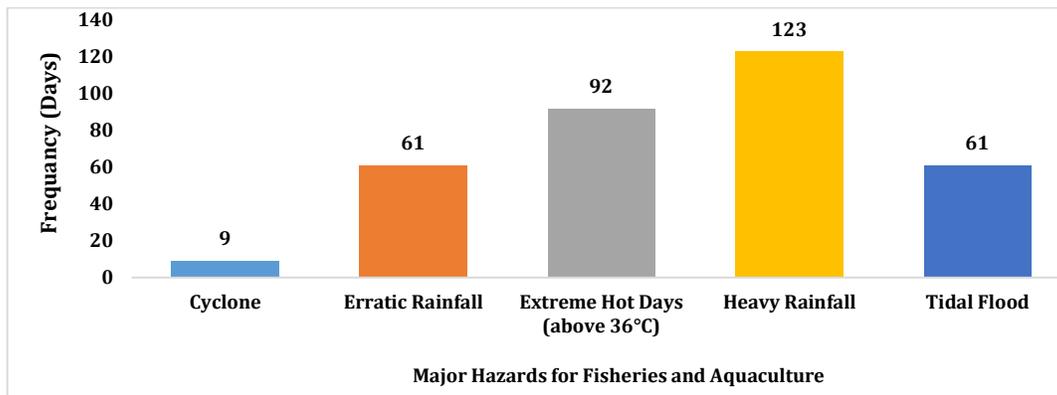
Bangladesh being a low-lying deltaic country is highly vulnerable to climate change and its induced impacts due to its geographical location and hydrological diversity. The coastal area is recurrently facing several climate hazards due to its low-lying topography and fragile ecosystem. The study region is particularly vulnerable to cyclones, storm surges, tidal floods, drought, extreme hot days, severe cold days, salinity intrusion, thunderstorms etc. Total 9 types of hazards (shown in the **Table 3.1** below) are identified by communities under this study which are reported prominent in terms of intensity and impact. According to the respondents, frequency and intensity of almost all reported hazards are increasing with high magnitude except wave action and severe cold days and wave action. In Dacope upazila cyclone was ranked on top because of its negative impact on aquaculture and fisheries-based livelihood.

**Table 3.1: Hazard ranking by local community**

Hazard	Ranking	Trends/Frequency	
		Increasing (↑)	Intensity
		Decreasing (↓)	High=3
		Static (↔)	Moderate=2
			Low=1
Flood	3	↑	3
Drought	5	↑	2
Cyclone	1	↑	3
Storm Surge	2	↑	3
Extreme Hot Days	4	↑	3
Severe Cold Days	9	↔	1
Salinity Intrusion	6	↑	2
Wave Action	7	↔	2
Thunderstorm	8	↑	2

CEGIS Field Survey, 2022

The present study identified five major climatic hazards for fisheries and aquaculture as found in Dacope Upazila (**Figure 3.4**). Among the hazards, heavy rainfall is identified as the most prominent hazard for aquaculture (especially shrimp farming). Moreover, the fishing activities are highly exposed to storm surge and cyclone. Furthermore, most of the fishers face the problem of fish handling and transportation to the existing fish landing sites and even fish markets during heavy rainfall.



**Figure 3.4: Frequency of climatic hazards on fisheries and aquaculture**

CEGIS Field Survey, 2022

According to the hazard calendar developed by the fishing community, short duration high intensity but erratic rainfall has been increasing with less rain during monsoon, salinity intrusion is more severe during dry season than before. Flood usually occurs during Chaitra to Ashin but used to occur Baishakh to Srabon in the past. However, floods often occur due to embankment failure followed by high tidal surges causing great loss to people's livelihoods. Tidal wave height has increased compared to the past due to increased sea level and extreme hot and severe cold days. Each year, during high tides one or more embankments fail causing flood and intrusion of saline water.

### Cyclone and storm surges

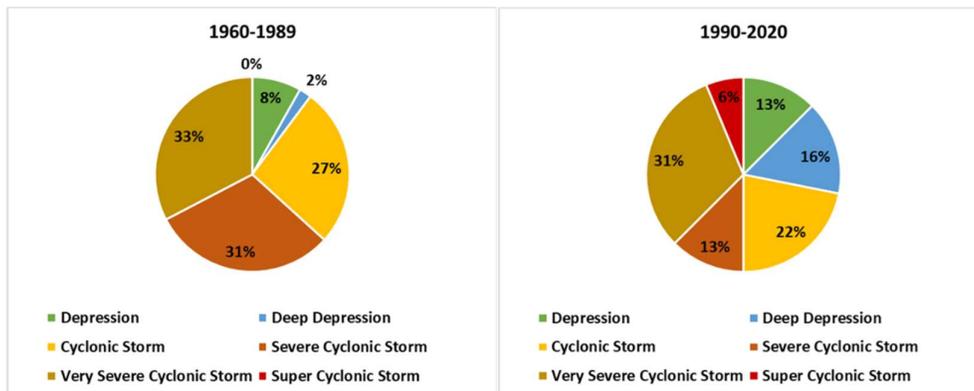
Being located in the south-western coastal region of Bangladesh, Dacope Upazila in the Khulna district has faced numerous catastrophic severe cyclone events, especially in the last two decades, including Sidr, Fani, Mora, Aila, Rashmi, Roanu, Amphan and others. It appears that 38 cyclonic events affected South-West coast between 1877 and 2010. Between 1970 and 2010, seven severe cyclones (>90 km/hours wind speed) devastated south-west coast and the local communities. In general, it has been observed that the frequency of a 10 m high wave (surge plus tide) along Bangladesh coast is about once in every 20 years, while a wave with a 7 m height occurs about once in 5 years. Cyclone Sidr (2007) and Cyclone Aila (2009) were accompanied with 3m to 5.5m level of storm surge and brought the saline water into the agricultural lands and also inundated housings of many coastal communities.

According to the local people, Dacope Upazila is highly vulnerable to cyclones and storm surges because of its geographic location on the seafront side of the district. Every year, the Sundarbans act as a biological protective shield against cyclones and storm surges. Sundarbans has been saving the coastal region repeatedly from the adverse impact of natural disasters like cyclones. However, cyclones damage river infrastructures and vegetation coverage as it uproots trees, and erode the soil, thereby damaging existing river vegetation and ecosystems which will ultimately hamper fish habitat.

Cyclone Sidr resulted in damages and losses of \$1.7 billion, or 2.6 percent of GDP in 2007. About half the losses were in the housing sector, followed by agriculture and infrastructure. Infrastructures including ponds, dighis, and gheras as well as privately owned fishing gear like boats and nets are among the damages to the fishery subsector. The cost of these damages was estimated at Tk. 463 million (\$6.7 million) for the ten most impacted areas including coastal areas of the Khulna District.

On May 25, 2009, Aila struck Bangladesh's southwest coastal regions, affecting 15 districts, 76 Upazilas, and 491 Unions. Upazila Nirbahi Office reported that around 32661.7 ha shrimp farm worth of 550 million BDT was damaged due to cyclone Aila. The super Cyclone Amphan in 2020 affected more than a million people in nine districts in Khulna and Barishal divisions of Bangladesh. Due to this cyclone, many freshwater ponds inside forests and many shrimp farms in Dacope were flooded with seawater. The frequency and impacts of such extreme events are reported to be increased under climate change scenarios.

It is observed that a severe cyclone strikes the country on average every three years. 21 tropical cyclones (wind speed >117 km/hr) and severe cyclones (wind speed between 87 to 117 km/hr) struck the Bangladesh coast between 1960 and 2010 (MoEFCC, 2018). According to CEGIS analysis (1960-2020), the number of different cyclones types hitting Bangladesh has decreased over this period – from 24 in the 1960s to 13 in 2020s. The **Figure 3.5** below highlights the changes in occurrence of cyclone between the period 1960- 1989 and 1990 - 2020. The notable changes include increase of deep depression, decrease of super cyclonic storm, occurrence of super cyclonic storm (> 222 km/hr) etc.



**Figure 3.5: Distribution of high intensity cyclone along the Bangladesh coastline**

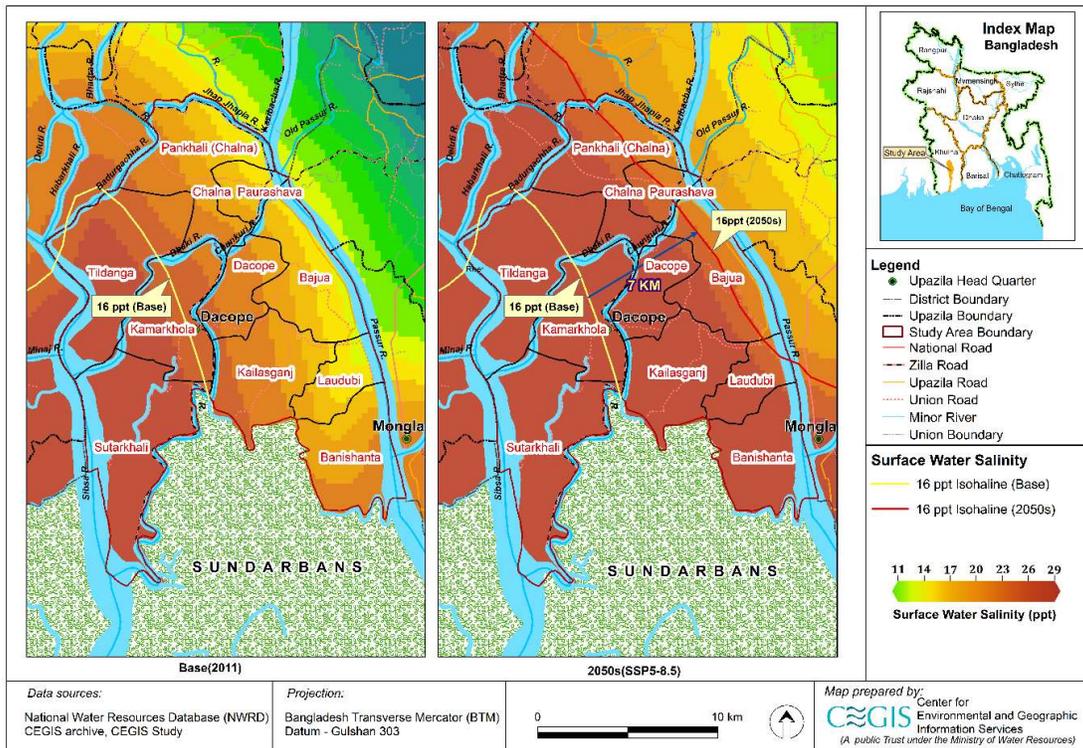
### Sea level rise and salinity

Trends analysis based on Sen's slope of 30 years BWDB, CPA and BIWTA tidal water level reveals the upward trend in the south west Ganges tidal floodplain, was 7-8 mm/year (DoE, 2016). On the other hand,

the trend was 6-10 mm/year in the Meghna Estuarine flood plain and 11-21 mm/year in the Chittagong coastal plain areas (DoE, 2016). This shows that Dacope which is situated in the south west Ganges tidal floodplain experiences higher sea level rise and salinity than the rest of the regions. Ashrafuzzaman et al. 2022 reported that a number of factors leading to sea level rise in Bangladesh, including the impact of floods, frequent and intense storms, rising water tables.

Storm surge inundation modelling for base period and 2050s indicate sea level rise will affect the unions adjacent to the rivers as such Tildanga and Sutarkhali in the west and Bajua, Laudubi and Banishanta in the east of Dacope Upazila under SIDR equivalent cyclone for both SSP1-2.6 and SSP5-8.5.

As regards salinity, Bangladesh Delta Plan 2100 (GED, 2018) highlighted that SLR is likely to cause significant changes in river salinity in the coastal zone of Bangladesh during the dry season (October to May) by 2050, which will likely to lead significant shortages of drinking water in the coastal urban areas, scarcity of water for irrigational agriculture during the dry season and significant changes in the coastal aquatic ecosystems. Simulation of the CEGIS Bay of Bengal model reveals that Dacope Upazila will be intruded by more than 16ppt surface water salinity by 2050s under extreme climate change scenario i.e. SSP5-8.5. By 2050 the 16 ppt isohaline line will shift on average 7 km inward, which will break homeostasis and lead to significant stress, slow growth, low survival rate, and thus, incur high economic loss in shrimp farming industry. **Figure 3.6** illustrates salinity intrusion in Dacope upazila for base period 2011 and future (2050) under SSP 5-8.5.



**Figure 3.6: Salinity intrusion in Dacope Upazila**

### Heat wave

Kirtman et al 2013, highlighted that the frequency and severity of heat waves in Bangladesh will increase in the future. About 39 heat waves in last 23 (1989-2011) year have been observed in Bangladesh (Hannah et al. 2017). Tremendous rise in apparent temperature in south-west zone and north-west zone has also been observed from heat index anomalies. Heat index increase governs in south-west and the increase becomes less gradually as it moves to the East (Rajib et al. 2011). With increased environmental temperature usually bacterial decomposition, pH drop, imbalance between DO and CO<sub>2</sub>, change in size and growth, high mortality, reduced digestion capacity and less food intake etc. happens in fisheries, which

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leads to production decreases and insecurities of fishermen livelihoods. Due to this temperature rise, shrimp farmers in Dacope face numerous challenges, most importantly, viral, bacterial and fungal diseases.

### *Floods*

Floods have been a severe issue in the south-western coastal districts of Bangladesh including the Dacope Upazila of the Khulna district. Both monsoon floods and tidal floods occur here. This upazila experiences floods for a variety of reasons. This is where the Polder No. 33 is located. One of the primary causes of flooding in the polder area is the rapid sedimentation of the river bed. The polder prevents the silts from reaching the floodplain area, thus they are dropping onto the riverbed instead. As a result, rivers are becoming shallower, and the quick sedimentation process has killed out numerous minor channels. The storm surge also contributes to floods in this region during cyclonic events. Other causes of flooding in this area include sea level rise, severe monsoon rain for several days, a reduction in the flow of upstream rivers, unplanned sluices, etc. The sedimentation of rivers and channels eventually degrade fish habitats, and reduce fresh water availability in winter for fish production and the conservation of biodiversity. But as floods inundate more areas in the floodplain, there may be some beneficial effects for open water fisheries/flood plain fisheries, as fish get more grazing area, nutrients, and sometimes, a longer time to grow. Due to flooding, the majority of the houses in this upazila have suffered partial damage, and many people have lost their agricultural crops. The bulk of the houses in this neighborhood were inundated with floodwater due to the tidal storm surge. More than 90% of the households in this upazila lost their financial assets, which is larger than their individual annual income levels, according to survey data. After a severe flood event in this region, most of them could not recover from their losses, which can take decades.

### *Drought*

Droughts associated with high temperature and low rainfall have adverse impacts on aquaculture and inland open water fisheries in some areas in Dacope. Ponds, rivers, canals and beels dry up or retain insufficient water during the dry/drought period, affecting fish production in aquaculture, and in open water systems in some locality of Dacope. This is now also affecting migration, breeding and growing of fish and other aquatic animals.

### *Lightning*

Lightning susceptibility map of Bangladesh based on historical human death toll due to lightning based on BMD data depicted that the lightening susceptibility of SW zone is comparatively less than another zone of Bangladesh. Reportedly, untimely lightning and thunderstorm is increasing all over countries, which are anticipated to affect the spawning and breeding of fisheries as well. Besides this, lightning damages infrastructure in fish cultivated areas and there is some evidence that fishermen and fish farm owners get injured and died due to strike of lightning while fishing in open waterbodies.

## **3.3 Hazard wise impact matrix based on community perception**

Bio physical, fisheries, ecosystem and livelihood impact of each hazard have been identified and ranked from low to high in **Table 3.2** where, red indicates high vulnerability, yellow indicates medium vulnerability and green indicates low vulnerability. During FGDs, hazards-wise effects on different aspects of the fisheries and aquaculture sector have also been identified based on the opinion of respondents. The following table shows the hazard-wise vulnerability matrix based on respondents' feedback in the FGD. The frequency and impacts of such extreme events are increased under climate change scenarios.

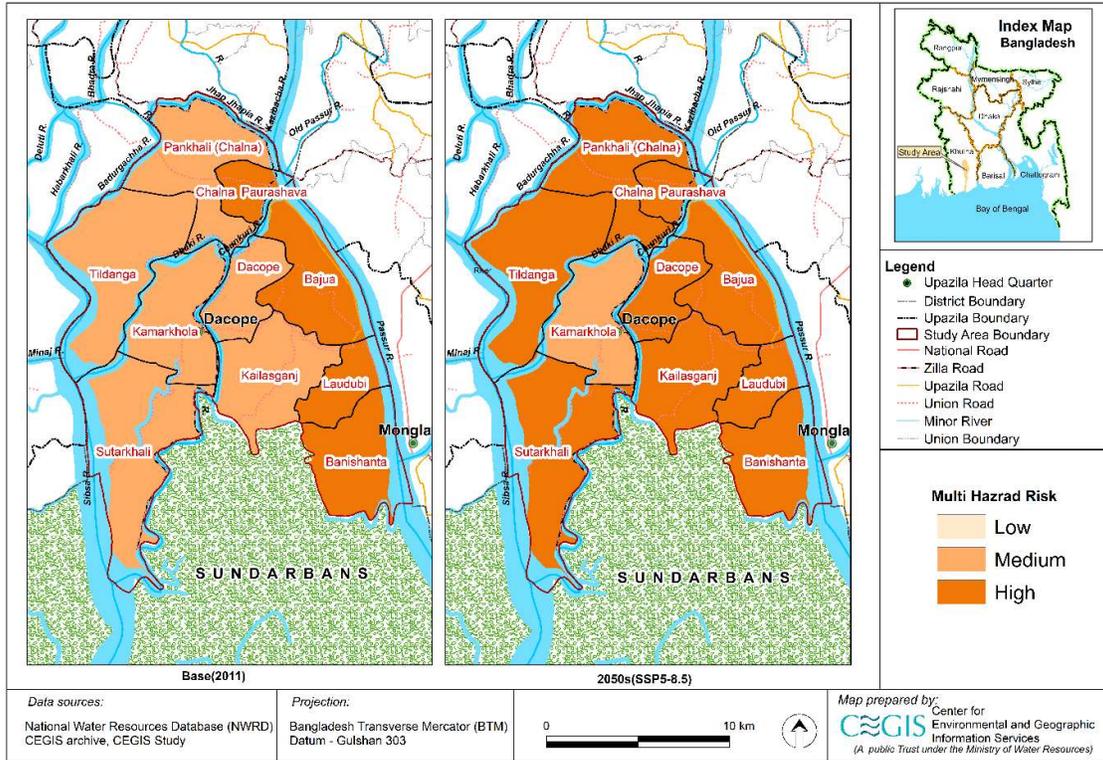
**Table 3.2: Hazard wise impact matrix based on community perception**

Sector	Impact	Flood	Drought	Cyclone	Storm Surge	Extreme hot temperature	Severe Cold Days	Salinity Intrusion	Wave Action	Lightning
Bio physical	Salinity Increase	Yellow	Red	Yellow	Red	Yellow	White	Red	Yellow	White
	Area Inundated	Green	White	Yellow	Yellow	White	White	White	White	White
	Low water availability	White	Yellow	White	Yellow	Yellow	White	White	White	White
Ecosystem	Extensive Algae Bloom (FW)	Green	White	White	Yellow	Yellow	White	White	White	White
	Decreased flora & Fauna	White	Yellow	White	Green	White	White	Yellow	White	White
	Stress on aquatic species abundance and distribution	White	Yellow	Yellow	Yellow	Green	Green	Yellow	White	White
	Infrastructure damage	Yellow	White	Red	Red	White	White	White	Red	Yellow

CEGIS Field Survey, 2022

### 3.4 Multi-hazard mapping for Dacope Upazila

A multi-hazard scenario for Dacope Upazila is also assessed utilizing field finding, community perceptions and available secondary data layer and is presented in **Figure 3.7**. Salinity intrusion, Flood, Cyclone, Storm Surge, Drought, Heat Waves, Cold Waves, Wave Action, Thunderstorm etc. were considered while assessing multi-hazard conditions. Multi-hazard conditions were assessed for two-time periods as such base period and 2050s. For future projection, due to limitation of resources only heat wave, drought, tidal flood, storm surge and cyclone are projected for 2050s and other hazards are considered constant as base period during multi-hazard mapping using geo-spatial techniques. The Chalna Paurashava, Bajua, Laudubi and Banishanta unions of Dacope Upazila are found exposed to multiple climate hazards, with highest severity in the base period. The rest of the unions are found under moderate risk for multi-hazards in the base period. For future 2050s under extreme climate change scenario, all the unions except Kamarkhola will fall under high risk of multi hazards. The Kamarkhola union is at moderate risk zone in both time slices.



**Figure 3.7: Multi hazard map of Dacope Upazila**

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## 4 Climate Risk and Vulnerability

This chapter presents critical outcomes of the study, which is climate risk and vulnerability for the Dacope Upazila, covering all of its unions. Risk and vulnerability have been assessed following an indicator-based approach based on the developed CRVA framework and impact chains. Separate impact chains were developed for the CRVA framework focusing on capture fisheries, culture fisheries, fisheries ecosystem, and gender-based F&A livelihoods. The following sections describe the key elements of risk and vulnerability separately for these four priority focus areas: exposure, sensitivity, adaptive capacity, vulnerability, and risk. Risk and vulnerability assessment is done based on a blended approach of participatory appraisal techniques and scientific analysis for base and 2050s under extreme climate change scenarios.

### 4.1 Aquatic ecosystem

#### 4.1.1 Exposure

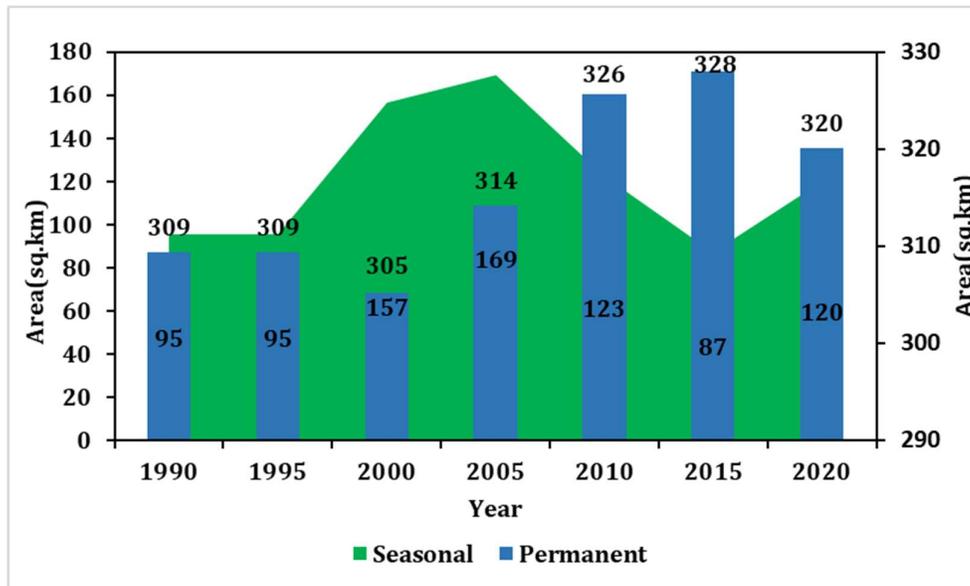
Almost every year the tropical cyclones and associated storm surges, and other climate change induced hazards cause severe devastation to the aquatic ecosystems in this region. During field visit different component of these ecosystems were observed, extent and condition also assessed accordingly. Indicator based assessment for the developed impact chains is also made to understand the ecosystem exposure to climate change induced hazards in Dacope (Annex I) and mapped after analyzed through impact chain. The exposure status of hazards to aquatic ecosystem of different unions namely Pankhali (Chalna) and Sutarkhali are identified as high (**Table 4.2**).

#### 4.1.2 Climate sensitivity of aquatic ecosystem

The rich and diversified aquatic ecosystem of the study area are found sensitive to climate change in various ways. Climate change and its extreme variability make the habitat condition unfavorable and severely disrupt the ecosystem services. The study analyzed the ecosystem climate sensitivity (change in habitat area, disruption of services and aquatic environmental conditions) of both River and Pond/gher ecosystem in terms of disruption of ecosystem services and hampered habitat condition.

##### *Change in habitat area*

The change of perennial and seasonal waterbodies assessed provides information of the intra-annual behavior of such waterbodies. **Figure 4.1** shows the change in waterbody extent from 1990-2020. The permanent water bodies in Dacope are found to be increasing from 2000 to 2015. The seasonal waterbodies increased between 1995 to 2005 and again from 2015 to 2020. Increasing trends of permanent and seasonal waterbodies found from the satellite image analysis may be the aftermath of gradual sea level rise and consequent increase of intertidal area, which usually create waterlogged areas in low lying regions. The permanent waterbodies decreased from 2015 to 2020. The seasonal waterbodies decreased between 1994 to 1995 and again from 2005 to 2015. The reason behind this may be illegal encroachments and increase in urbanization leading to rise in human settlements that eventually resulted in the filling up of the permanent waterbodies. This would have a negative impact on the fisheries sector because of the disturbance caused to the habitats and breeding grounds of fishes and other aquatic animals. Overall, this assessment revealed that increased saline or brackish water habitat and decreased freshwater habitat and, therefore, adaptation in fish farming practices need to be planned accordingly.



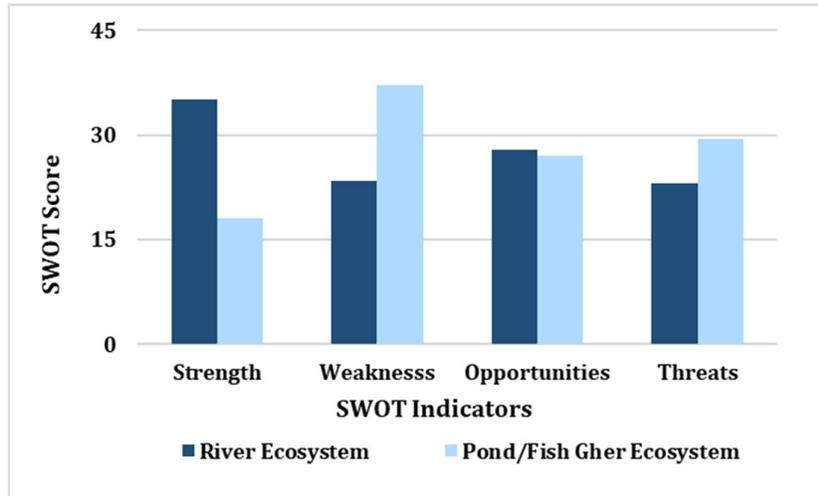
**Figure 4.1: Waterbody changes in Dacope Upazila**

*Disruptions of ecosystem services*

Aquatic ecosystem is rich with unique mangrove species and mangrove associates, salt tolerant grasses which facilitate carbon sequestration, heat absorption, nutrient cycling, sediment retention, groundwater replenishment, and most importantly act as storm surge barriers against extreme cyclone and storm surges. The study area receives an abundant amount of rainfall every year. A higher proportion of the rainfall is infiltrated as ground water infiltration, which supports flow of water in the streams, irrigation in the agricultural fields, use of water by local people, withdrawal of water for irrigation or daily use. Ponds accumulate organic matter in their sediments and therefore bury or sequester carbon. About 16.6 million Mt of carbon is buried annually in aquaculture ponds globally. The plants surrounded by rivers or ponds also support the storage of rainwater in canopy, balance the fish production and its food system through oxygen supply and fish waste uptake by algal bloom and its photosynthesis in daytime, they also provide support for other aquatic flora and fauna, food, fuel, cosmetics, folk medicine and building materials.

Apart from providing, regulating and supporting services as described above, local communities reported that aquatic ecosystem in Dacope also provides opportunities for cultural services such as revenue earning from eco-tourism. Being located at the tip of Sundarbans, this Upazila is one of the favorite locations by the tourists, who visit this place almost all year around to observe the scenic beauty, serenity, unique and diversified animals, tranquility and for their relaxation.

All four types of ecosystem services are being disrupted by climate change in combination with non-climatic factors opined by communities. A SWOT analysis (**Figure 4.2**) performed for provisioning, regulating, supporting, and cultural revealed that the river ecosystem has more strengths and opportunities than the pond ecosystem under climate change scenarios with a score of 0-15 representing low value, 16-30 representing medium value, and 31-45 representing high value. The results also show that the river ecosystem has more opportunities and strengths than the pond ecosystem, because its buffer areas are characterized by natural land-cover types and less land-use changes. The results also draw attention to the weaknesses of the pond/fish gher ecosystem, which are more threatened by urbanization and intensification of shrimp farming.



**Figure 4.2: SWOT results of aquatic ecosystem services**

To enhance the ecosystem services from both rivers and ponds/ghers ecosystem, identified weakness and threats will need to be tackled in a way that ecosystem remains conserved and services are maximized in the sustainable way. Therefore, ecosystem approaches for aquaculture (EAA) or ecosystem approach to fisheries (EAF) should be followed to manage fishery ecosystem and its climate sensitivity in a sustainable way. Integration of fishery ecosystem during structural or non-structural intervention design for adaptation and resilient building is needed to be mainstream widely to harness the desired level of the ecosystem services combating negative impacts exert by climate and non-climatic factors

The graph below (**Figure 4.3-a&b**) shows the aggregated score of the ecosystem services' strengths, weaknesses, opportunities, and threats indicators under the four categories for the river, pond, and Haor. All the indicators were ranked as per their scores obtained from field visits (i.e., scores per respondent: 1=Less/Poor condition, 2= Medium/Good condition, 3=High/Better condition). Detailed outcomes of SWOT analyses are given in Annex II.

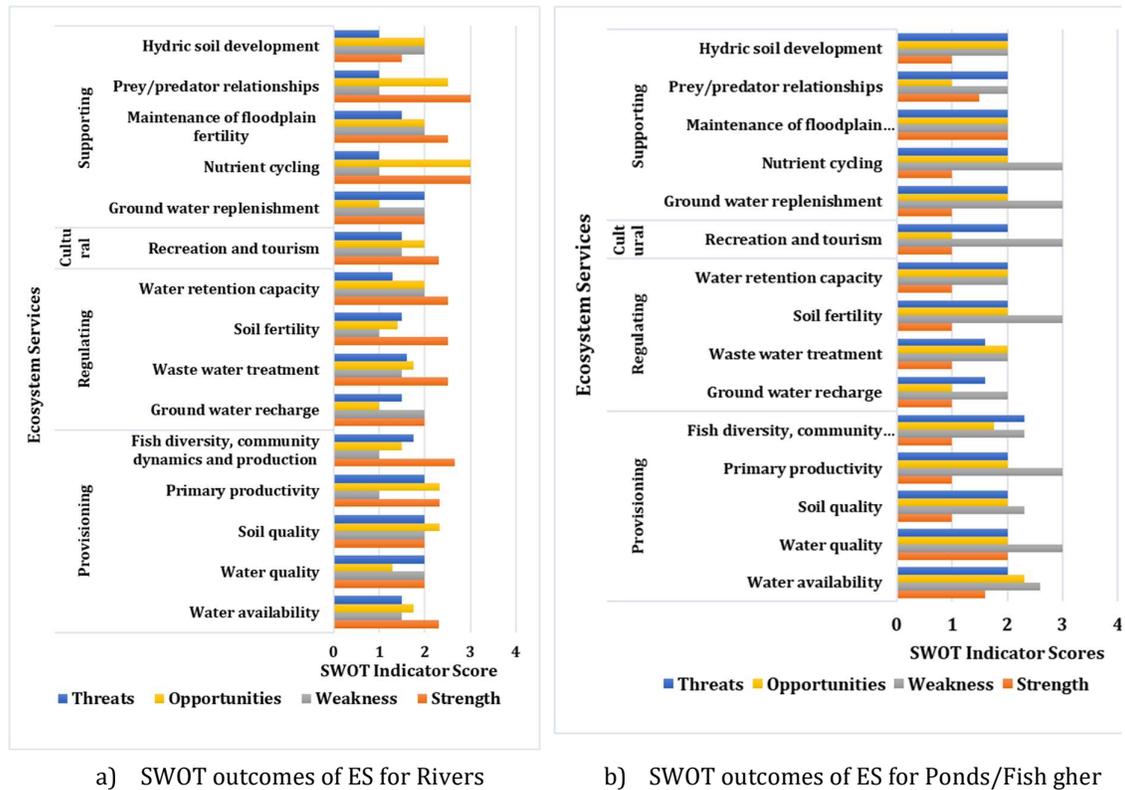


Figure 4.3: SWOT outcome for river and ponds/gher ecosystem

#### Aquatic habitat condition

Similar to ecosystem services disruption by climate change, in situ and laboratory tests of water quality also indicated ecosystem higher sensitivity deteriorating due to climate change. pH, water temperature, electrical conductivity (EC), turbidity (TDS) and BOD were found exceeding the thresholds reference value of ECR'97 and different studies for some aquatic ecosystem (marked in red color as shown in **Table 4.1**).

High water temperatures and less dissolved oxygen may result in decreased fish production (Jeppesen et al. 2010). In addition, variations in pond water temperature frequently result in stratification and decreased nutrient enrichment in surface waters and consequently changes the food web. Communities during surveys reported occurrence of frequent algal blooms due to increased water temperature and fish mortalities specialty during summer. In addition, rising trend of salinity level, especially during the pre-monsoon and winter seasons was mentioned by respondents, and usually results into disappearance of some local aquatic species. Apart from climatic factors, farmers reported water quality deterioration for overuse of pond and decreased water levels due to drought reducing habitat and production of fish. Beds of the rivers and nearby canals have been silted up that reduced water carrying capacity of rivers. Excessive sediment loads are deposited in the rivers and their tributaries that cause floods during monsoon. These water quality condition will be exacerbated under climate change condition.

Table 4.1: Surface water quality in Dacope

Sample ID & Unit	Physical and Aggregate Properties of Surface Water Resource								
	pH	Temp	DO	EC	TDS	BOD	COD	Nitrate (NO <sub>3</sub> -)	Salinity
	-	°C	mg/l	µS/cm	mg/l	mg/l	mg/l	ppm	ppt
River	8.5	30.3	5.7	12900	6450	8.88	177	7.46	11.14
Fish Gher	8.6	33.1	4.5	3390	1650	3.16	65.2	10.64	2.52
Pond	9.2	34.2	12.8	8630	4230	8.62	144.49	8.81	6.59

Sample ID & Unit	Physical and Aggregate Properties of Surface Water Resource								
	pH	Temp	DO	EC	TDS	BOD	COD	Nitrate (NO <sub>3</sub> -)	Salinity
	-	°C	mg/l	µS/cm	mg/l	mg/l	mg/l	ppm	ppt
Bangladesh standard for surface water quality (ECR'97)	6.5 – 8.5	20°C -30°C	≥5.0	1200	2100	6 or less for fisheries		10	
Study reference value	(6.5-9)	(25-32°C)	(6-7)	(30-5000 µS/cm)	(< 160-200 mg/l)	(<5 mg/l)	Study reference value	(6.5-9)	(25-32°C)

\*Green colors indicate standard reference value of water quality parameters as per ECR'97 and different study source and Red color shows the parameters which exceed the standard reference value or threshold

The combined sensitivity analysis (**Table 4.2**) using the habitat extent, condition and ecosystem services related indicators, found that Bajua, Banishanta, Dacope, Kamarkhola, Laudubi, Pankhali (Chalna), Sutarkhali and Tildanga unions were highly sensitive ecosystem whereas Kailasganj union was found to be moderately sensitive ecosystem.

#### 4.1.3 Capacity of aquatic ecosystem to adapt

Rapid restoration and regeneration of plankton and vegetation; high salt-tolerant mangrove flora and animals; ideal soil nutrients; decomposition of plant materials and, co-management of biodiversity; expanding the forest cover on newly charred land; enhancing primary productivity; a good capacity for retaining and transporting water; newly formed hydrological connection; and medium turbidity are some key inherent adaptive capacities observed during field visits. Because rivers are by nature dynamic systems continually modifying the depth, width, and sinuosity. A healthy river responds to changes in the environment and the climate regime by going through these changes. In connection with aquatic ecosystems, riparian vegetation performs a number of crucial tasks, such as evapotranspiration, and shade. As a result, it generates a buffer zone that serves as a filter for sediments and nutrients, and source of food and habitat. On the other hand, Pond ecosystems also have some inherent ability to change and cope with climate hazards. Apart from the systems inherent ability to cope with the nature, the field survey revealed that people generally use fencing and netting around ponds to prevent the escape of stocked fish as well as invasion of predator fish during floods. Local people harvest Rainwater with storage facilities for aquaculture in the dry season. Using rainwater for fish culture and pond-dike cropping increases water use efficiency. According to KIIs survey, pond-dike cropping can help to cope with increased water temperature but due to salinity, they grow less and do not survive. Plantation of suitable trees on pond-dikes can provide shade on water for fish and stabilize soil. Local people are practicing Ecosystem-based Adaptations (EbAs) in the pond ecosystem. To increase the primary productivity of the ponds local people normally use urea; triple super phosphate (TSP); murate of potash (MP); gypsum, and zinc sulphate (ZnSO<sub>4</sub>). Lime CaO, Ca(OH)<sub>2</sub> and CaCO<sub>3</sub> to improve pond biological activity, oxygen, maintain pH and remove turbidity.

Union wise adaptive capacity assessment (**Table 4.2**) based on different indicators (listed in Annex I) demonstrates the overall status of coping mechanism of the ecosystems. It is found that aquatic ecosystem in Bajua, Banishanta, Kailasganj, Kamarkhola and Laudubi have high adaptive capacity in compared to Dacope, Pankhali (Chalna) and Tildanga that have moderate adaptive capacity and the other unions have low adaptive capacity. Adaptive capacity of the ecosystem of these unions can be increased through wetland conservation, pollution control through regular monitoring and maintenance. A reserved wetland could be a sanctuary for the fauna and other aquatic habitat, it may work as a safe haven for their reproduction purpose.

#### 4.1.4 Vulnerability of aquatic ecosystem

Vulnerability of ecosystem is obtained by analyzing adaptive capacity and sensitivity of the system. The assessment (**Table 4.2**) shows that Dacope, Pankhali (Chalna), Sutarkhali and Tildanga unions are highly vulnerable to climate change-induced hazards. These unions have high sensitivity and moderate to low

adaptive capacity to cope with the hazards. On the other hand, Bajua, Banishanta, Kailasganj, Kamarkhola and Laudubi unions are found moderately vulnerable and ecosystems of the other unions are found low vulnerable to climate change induced hazards.

**Table 4.2: Summary of climate vulnerability assessment for aquatic ecosystem in Dacope upazila**

Union	CRVA Elements			
	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Bajua	Low	High	High	Medium
Banishanta	Medium	High	High	Medium
Chalna	Low	Low	Low	Low
Dacope	Medium	High	Medium	High
Kailasganj	Medium	Medium	High	Medium
Kamarkhola	Medium	High	High	Medium
Khulna Range	Low	Low	Low	Low
Laudubi	Medium	High	High	Medium
Pankhali (Chalna)	High	High	Medium	High
Sutarkhali	High	High	Low	High
Tildanga	Low	High	Medium	High

#### 4.1.5 Risk of aquatic ecosystem

Climate change risk (**Figure 4.4**) on ecosystem in Dacope has been calculated for both base period and 2050s following the CRVA framework (attached in Annex I). The unions Laudubi, Banishanta, Bajua and Chalna Pourashava are highly exposed to multi-hazard risk in both present and future time periods. Dacope, Kailasganj, Pankhali, Tiladanga and Sutarkhali unions which are under moderate multi hazard risk at present are projected to fall under high multi hazard risk in the future. These various hazards affect the aquatic ecosystem negatively throughout the year in these unions. Both the permanent and seasonal waterbody in Dacope have been reported to increase in recent years which may be due to the increasing shrimp farming or SLR. These waterbodies are abundant with saline water which can be a threat to the fresh water aquatic ecosystem at the same time these waterbodies can potentially improve the brackish water ecosystem. Apart from the saline water each year tropical cyclones destroy or heavily damage the ecosystem nearby the Sundarbans area. The inland waterbodies i.e ponds, gheras are affected by extreme heat and drought, due to extreme heat natural habitat condition is degrading though DO depletion, water temperature increase, extensive algae bloom.

From the risk analysis of aquatic ecosystem considering extreme climate change scenarios, all the unions except Chalna Paurashava are found under high risk in both time slices. Chalna Paurashava is found under low-risk zone in both the time slices.

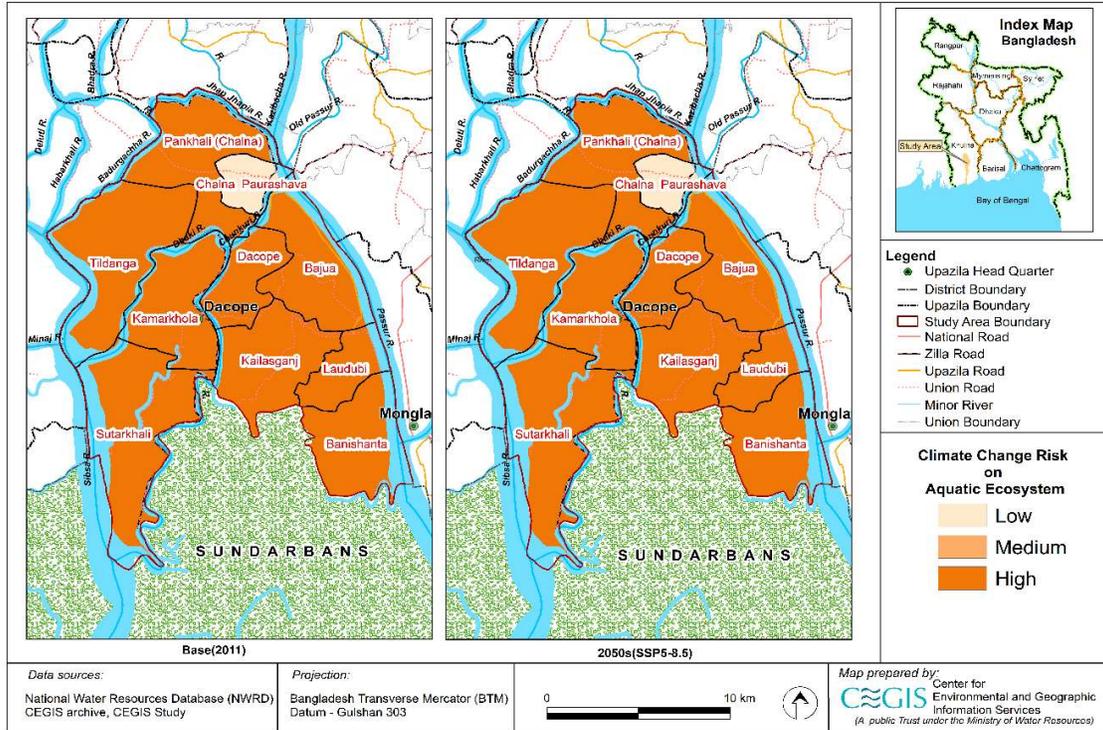


Figure 4.4: Climate risk on aquatic ecosystem in Dacope Upazila

## 4.2 Capture fisheries

### 4.2.1 Exposure

The open water fisheries resources are dominated by the riverine ecosystem. This section focuses on the spatial distribution of the available ecosystem (a detailed description is given in the ecosystem section) and fish diversity in respect to the exposure indicators of this ecosystem.

#### *Fish habitat area*

The Upazila possesses a riverine habitat of about 4,592 ha, union-wise distribution of riverine habitat is given in the **Table 4.3** below.

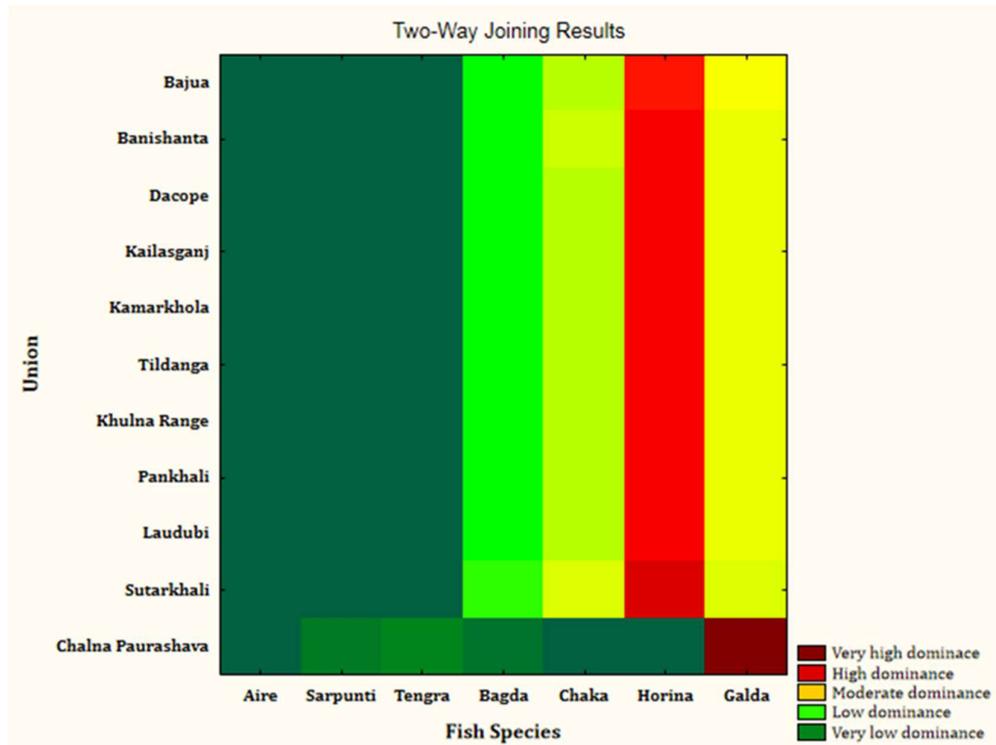
Table 4.3: Area of riverine habitat in different unions of Dacope Upazila

Unions	Riverine Habitat area (ha)
Bajua	72
Banishanta	74
Chalna Paurashava	108
Dacope	18
Kailasganj	59
Kamarkhola	188
Khulna Range	3960
Laudubi	14
Pankhali (Chalna)	16
Sutarkhali	26
Tildanga	57
<b>Total</b>	<b>4073</b>

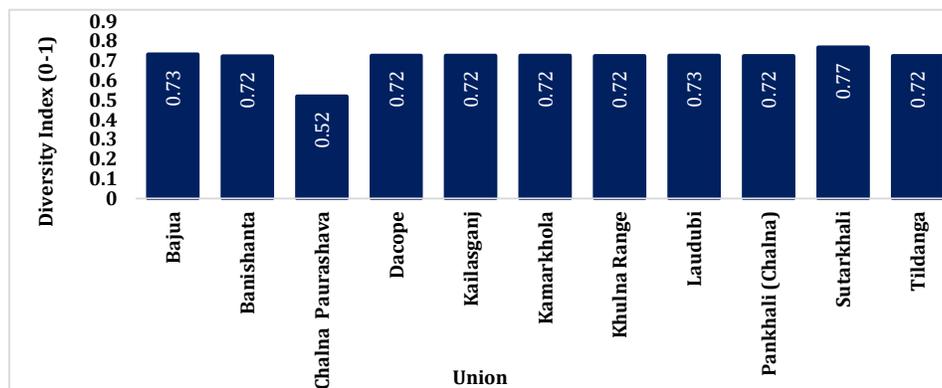
CEGIS estimation based on LandSat8 image, 2019

### Fish diversity

The riverine ecosystem is characterized by mesohaline, which can support euryhaline and some salt tolerant fish species. The Two-way Cluster Analysis was applied in this study to present the distribution pattern of available fish species found in the instantaneous catch among the unions in Dacope Upazila. The present study found that the instantaneous catch is highly dominated by Galda (**Figure 4.5-A**). The colors in the following figure denote the composition of fish species. Very high dominance indicates composition of 80%-100%, high dominance indicates the composition of 60%-79%, moderate dominance indicates the composition of 40%-59%, low dominance indicates 30%-39% and very low dominance indicate less than 30% of species in the composition.



(A)



(B)

**Figure 4.5: Species composition (A) and Biodiversity index (B) of the instantaneous catch in different unions of Dacope Upazila**

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This study also analyzed the Shannon-Weiner Index (Bio-diversity Index) in order to assess the species evenness in the riverine ecosystem (**Figure 4.5-B**). The values of this index range from 0 to 1. The fractal intervals of the index values can be used to characterize the various magnitude of evenness in distribution, i.e., the value of 0.41-0.6 indicates moderate evenness (a number of species are in similar composition), 0.61-0.8 indicates high evenness (maximum number of species are in similar composition), and above 0.8 indicates very high evenness. The analysis by this study show that the fish species in all unions, except Chalna Paurashava are evenly distributed within the riverine ecosystem of Dacope Upazila.

### **Livelihoods**

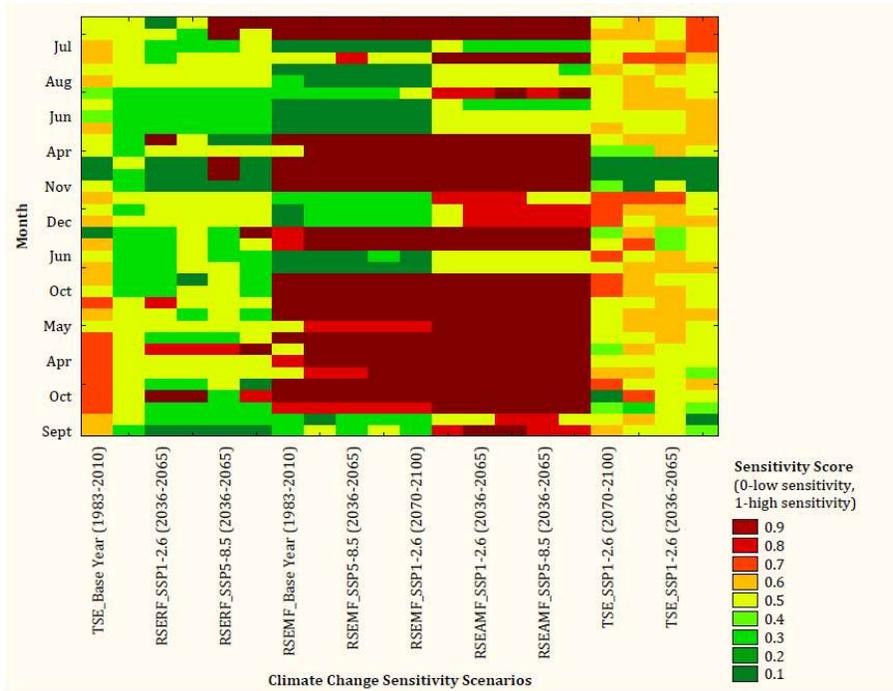
According to Dacope Fisheries office data (2022), about 8,483 people are involved in capture fishing where 8,059 are male and 424 are female. The field finding shows that the highest number of 222 of women involved in capture were from Sutarkhali Union whereas the lowest number of 7 women were from Dacope Union. The study also found that the average monthly income for male capture fishers was BDT. 15,000-20,000. But most women utilise the catch mostly for family consumption, and usually sell only after surplus.

Dacope Upazila union wise exposure for capture fisheries was also assessed. In this regard indicators formulated from impact chains were identified. These impact chains and indicators were validated by DoF officials. Indicators like abundance of species in open waterbodies, migratory route, and number of endangered species etc. were considered for exposure assessment. A complete list of indicators for exposure assessment is attached in the (Annex I). From the exposure assessment (**Table 4.7**) it was found that Kamarkhola and Sutarkhali are highly exposed to climate change induced hazards, may be due to high presence of river ecosystem within these Upazilas. Chalna Paurashava has moderate exposure and the rest of the unions have comparatively lower exposure for capture.

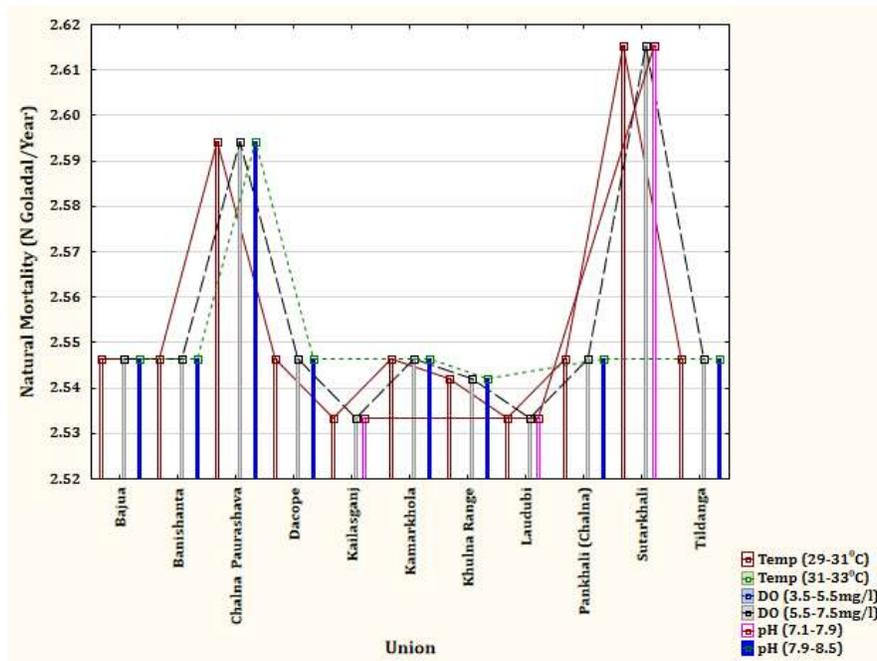
#### **4.2.2 Sensitivity**

##### **Habitat under threshold**

The present study calculated the sensitivity scores ranging from 0 (low sensitive-deep green in **Figure 4.6-a**) to 1 (very high sensitive-deep red)) for habitat condition to support biological activities of different fish species (particularly resident fishes) in respect of temperature variability (TSE: Temperature Sensitive Environment), and to influence spawning, growth, maturation and even migration pattern and extent of river/beel resident, seasonal migrant and adventitious visitor fishes sensitive to rainfall variability under different scenarios (Base scenario (1983-2010), SSP5-8.5 (2050), SSP5-8.5 (2100), SSP1-2.6 (2050) and SSP1-2.6 (2100))(Figure 4.6 (a)). The study predicted that the magnitude of temperature induced stress environment for the river's seasonal migratory fishes will be increased in the 2036-2065 and 2070-2100 average years under SSP1-2.6 scenario by about 0.41% and 0.22% with increasing 1°C mean water temperature (**Figure 4.6 (b)**).



(a)



(b)

**Figure 4.6: (a) Climate change sensitivity scenarios (b) Habitat sensitivity to natural mortality in the SSP1-2.6 and SSP5-8.5 scenarios**

Sensitivity analysis, CEGIS (2022). TSE: Temperature Sensitive Environment; RSERF: Rainfall Sensitive Environment for Resident Fishes; RSEMF: Rainfall Sensitive Environment for Migratory Fishes; 1-12: Months per Year

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### *Fish breeding/spawning*

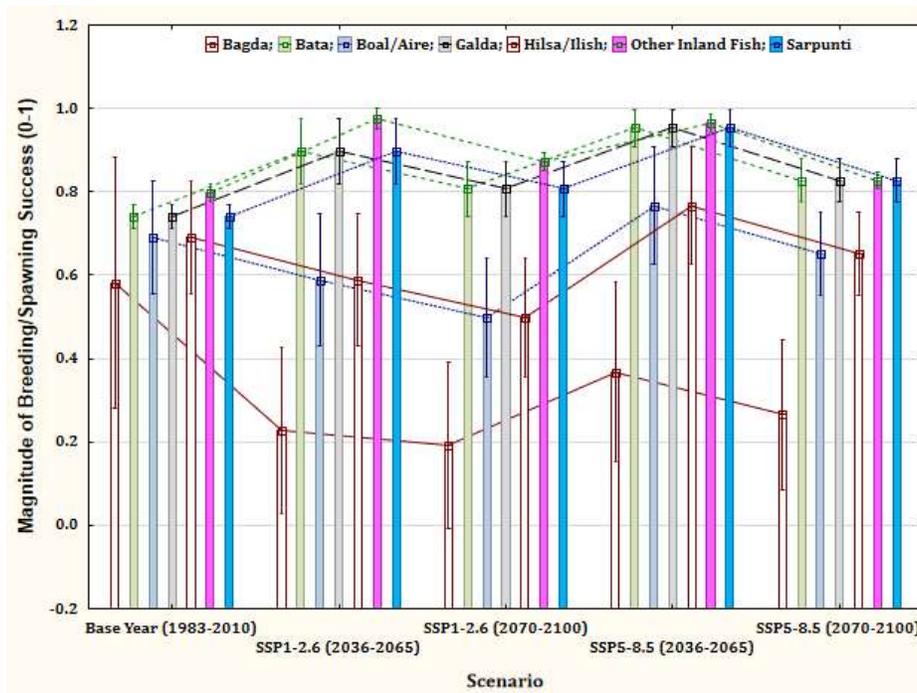
Maximum species use river as breeding and spawning ground. On the other hand, the breeding and spawning ground of Bagda and Galda is estuary. Breeding season of Chela is from late June to early September and spawning season is from July to August. Breeding and spawning season of both Galda and Bagda is in the month of January and, another during February-April. Aire start breeding in the month of June and continue up to September and, spawns in from July to August. Bele has two breeding and spawning seasons (**Table 4.4**). During the rainy season, fish migrates from one place to another for spawning and breeding purposes. Timing of rainfall is a crucial factor for gonadal development which may triggered the freshwater species for successful spawning and breeding. Climate change may alter the timing of rainfall, so fish spawning time may also shift which may result in decrease fertilization rate.

**Table 4.4: Breeding and spawning season of the available fish species in the instantaneous catch**

Species	Locality	Breeding season	Spawning Season
Chela	River	June-September	August
Baim	River	March-June	July - September
Bele	River	• March-April September- October	• May-June October- November
Tengra	Pond	• June-September	• July and August
Bagda	Estuary (Sundarbans)	January	February- April
Galda	Estuary (Sundarbans)	January	February- April
Aire	River	June-September	July and August
Datina	River	December-April	Jan-March

*Literature review and CEGIS Field Survey, 2022*

It is indicated from various studies that maximum fluctuations of aquatic ecosystem from the optimum ranges might result in lowering chances for fertilization success, and thus reducing breeding and spawning success. The present study predicted that the changing scenario of water temperature and rainfall pattern play an important role in changing the phenological events of different fish groups, including fishes of euphotic, desphotic, and aphotic zones, river residents, and also migratory fish groups. It has been found that the magnitude of breeding/spawning success might be significantly decreased in the case of Bagda, Boal/Aire, Galda and Hilsa in the SSP1-2.6 scenario (**Figure 4.7**).



**Figure 4.7: Magnitude of breeding/spawning success of the available fish species**

CEGIS Field Survey, 2022

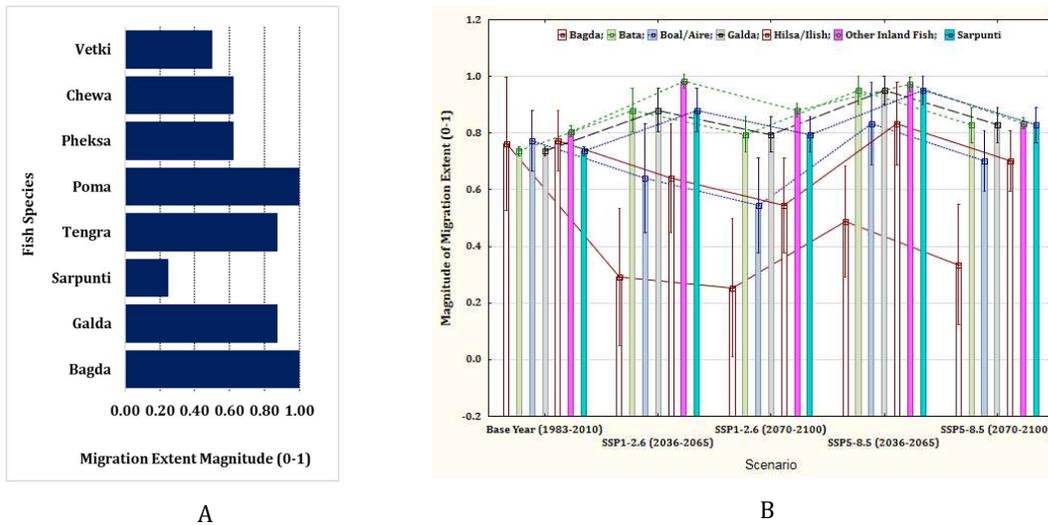
### Fish migration

The rivers in the Upazila provide necessary ecological demand for feeding, breeding/spawning and nursing of fries and juvenile fishes of different migratory fish species. According to the local fishers and Upazila Fisheries Officials, major longitudinal migratory fishes are Pangas (*Pangasius pangasius*), Koral (*Lates calcarifer*), Ramchos (*Polynemous paradiseus*), and Poma (*Otolithoides pama*). The lateral migration occurs mostly for small fishes like Tengra (*Mystus bleekeri*), Guli (*Mystus gulio*), Paissa (*Liza Persia*), and small shrimp/prawn are mostly limited between river and Khal.

This study analyzed the magnitude of the migration extent for available fishes from the instantaneous catch among the unions of the upazila (**Figure 4.8-A**). The values ranging from 0 to 1 are divided into five (05) fractile intervals. A value of less than or equal to 0.2 indicates very strict migration (available in only one particular habitat condition), 0.21- 0.4 indicates strict migration (favor to migrate to one particular habitat condition, but migrate adventitiously to other habitat condition), 0.41-0.6 indicates moderate migration extent (frequently migrate to different habitat conditions but in limited unions), 0.61-0.8 indicates wide migration extent (frequently migrate to different habitat conditions among the unions), and above 0.8 indicates very wide migration extent (very frequently migrate to different habitat conditions among the unions). Moreover, the catch assessment survey found that Poma and Bagda have a very high migration extent, distributing all the rivers of all the unions (**Figure 4.8-A**). According to the SSP5-8.5 (2036-2065) scenario, the migration rate for Hilsa, Aire, Bata, Sarpunti, and Galda will expand. The future scenarios, however, would decline the migratory rates of Bagda (**Figure 4.8-B**).

Fish migration may be affected by various climatic factors such as, salinity ingression, erratic rainfall, changes of flooding seasonality, temperature fluctuation, etc. Salinity ingression may pose threats to freshwater fish assemblages and their habitats. The migration length may be decreased in the riverine ecosystem due to salinity ingression because of sea level rise. During the rainy season, fish migrates from one place to another for spawning and breeding purposes. The timing of rainfall is a crucial factor for gonadal development-as it triggers successful spawning and breeding among freshwater species. Climate change may have altered the timing of rainfall, impacting fish spawning time that may result into decreased fertilization rate. Fish migration occurs for quality habitat and available food. Food availability i.e.,

phytoplankton, zooplankton, benthos-particle is one of the major determiners for fish migration which mainly depends on temperature. The primary productivity decreased following temperature fluctuations which hampers fish migration rate in the riverine ecosystem. On the other hand, excess rainfall causes floods, leading into responsible for water turbidity and siltation, which may block the migration route.

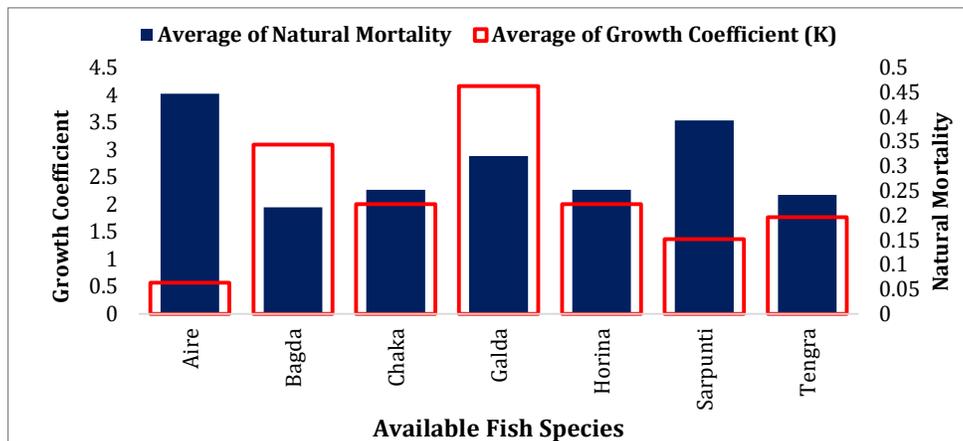


**Figure 4.8: Migration extent of different migratory fish species**

CEGIS Field Survey, 2022

**Growth coefficient and natural mortality**

Chingri has a higher growth coefficient (about 0.5), whereas the majority of fish species have a lower growth coefficient (0.3) (Figure 4.9). This suggests that given the quality and health of the current environment, some fish species may develop more slowly. In the examined riverine system, the current study also discovered that Aire and Sarpunti have the highest mortality rates, losing more than three generation cohorts per year, while other fish species were reported to lose two generation cohorts annually (Figure 4.9).



**Figure 4.9: Growth coefficient and natural mortality of the available fish species in the instantaneous catch**

CEGIS Catch Assessment Survey, 2022; Fish Base Life-History Data

The study found that under the SSP1-2.6 scenario, the growth performance magnitude may significantly decrease for Galda, Bagda, Sarpunti, Bata, and other readily accessible inland fishes (Figure 4.10). Future possibilities for Aire would not result in any noticeable changes from the base year. And this magnitude

would be greatly impacted by an increase in mean temperature of roughly 10% for Sarpunti, Galda, and other inland fishes in the SSP1-2.6 scenario, but amplified in the SSP5-8.5 scenario (Figure 4.10). It suggests that the growth rate of these fish may be slower under the SSP1-2.6 future scenario but faster in the SSP5-8.5 future scenario.

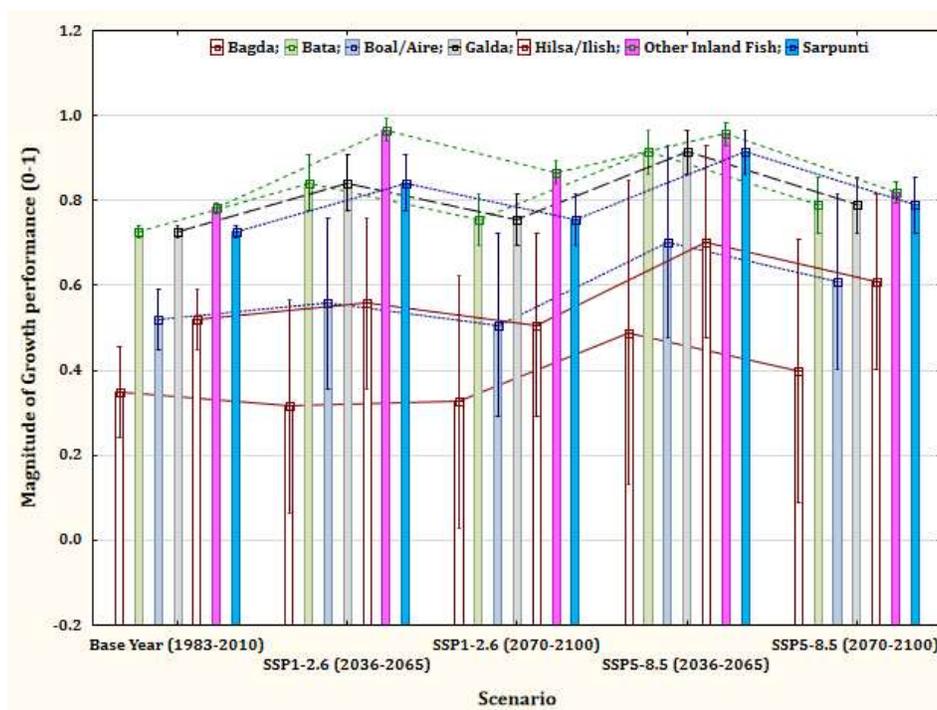


Figure 4.10: Magnitude of growth performance of the available fish species

Impact Chain Analysis, CEGIS (2022)

### Fish production

With the changes mentioned above in habitat condition, fish diversity, fish migration, and fish biology in respect of different climate change scenarios, total fish production in different unions of Dacope Upazila would be about 1,415 MT, 1,440MT, 1,485 MT, and 1,482 MT in SSP1-2.6 (2050), SSP1-2.6 (2100), SSP5-8.5 (2050) and SSP5-8.5 (2100) scenarios respectively as shown in Table 4.5.

Table 4.5: Capture fish production under different climate change scenario

Union	Fish Production (MT)				
	Base Year	SSP1-2.6 (2050)	SSP1-2.6 (2100)	SSP5-8.5 (2050)	SSP5-8.5 (2100)
Bajua	22	22	23	23	23
Banishanta	23	23	23	24	24
Chalna Paurashava	4	4	4	5	5
Dacope	5	5	5	5	5
Kailasganj	6	6	6	6	6
Kamarkhola	18	18	18	19	19
Khulna Range	1,217	1,220	1,242	1,280	1,278
Laudubi	8	8	8	8	8
Pankhali (Chalna)	17	17	18	18	18
Sutarkhali	58	58	59	61	61
Tildanga	33	33	34	35	35

Union	Fish Production (MT)				
	Base Year	SSP1-2.6 (2050)	SSP1-2.6 (2100)	SSP5-8.5 (2050)	SSP5-8.5 (2100)
<b>Total =</b>	<b>1,411</b>	<b>1,415</b>	<b>1,440</b>	<b>1,485</b>	<b>1,482</b>

Impact Chain Analysis, CEGIS (2022)

### Livelihoods

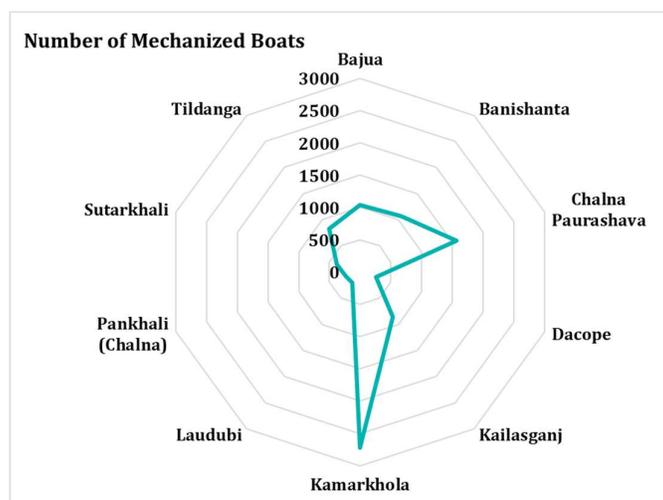
Sensitivity of fishing base livelihoods due to climate change is determined by their dependency on fishing resources in terms of unavailability of alternative livelihoods, lack of financial capital, lack of institutional support for the diversification of income sources, and a lack of human capital to engage in AIGAs. Due to seasonal variability, post harvesting loss, low income of fishermen made them highly sensitive by the climatic shocks.

As a part of the risk assessment, sensitivity of fisheries sector in Dacope upazila was also assessed. According to the assessment (**Table 4.7**), Banishanta, Dacope, Kamarkhola, Pankhali (Chalna) and Tildanga unions were highly sensitive to climate change induced hazard. Bajua and Sutarkhali unions were found to have a moderate sensitivity and rest of the unions were found to have low sensitivity zone for capture fisheries. Generally, cyclone intensity increases from April to May and September to November. Because of these extreme climatic events, fishing season reduces which has considerable impacts on the fishermen's income by reducing fishing days. Dependency on the fishing makes the livelihoods of fishermen highly sensitive to climate change as fishing and fish processing have a high exposure to cyclones and flooding. This climate sensitivity poses serious impacts particularly on low-income fishermen.

### 4.2.3 Adaptive capacity

#### Mechanized boats

The fishers face increased frequency of climate induced hazardous events like cyclone, storm surge, etc. in carrying out fishing activities. In this context, they have been limited capacity to adapt with the mentioned climatic events as most of the fishers are poor and having narrow scope of coping with the hazardous situation. However, fishers usually undertake various initiatives to cope with such environmental stress for reducing health and economic risk. Among the initiatives, they profoundly use the mechanized boat for operating the fishing gears. Along with other multiple benefits, they can return to safe place from fishing within the shortest possible time being noticed/informed about any hazardous event. According to the local people, a good number of fishers possesses mechanized boat in this Upazila for catching fish. Availability of fishing boats by unions in Dacope Upazila is shown in **Figure 4.11**.



**Figure 4.11: Availability of mechanized boats**

CEGIS Field Survey, 2022

## Fishing gear

In the Upazila, various types of fishing gear are used to catch maximum fish within the shortest period of time for strengthening the economic capability and reduce socio-economic vulnerability. In this study, different types of fishing gears and catch have been observed during the field investigations. The gear specific detail information of catch and catch per unit effort (CPUE) are shown in **Table 4.6**.

**Table 4.6: CPUE of mostly available fishing gears during the study period**

Gear Name	Within 10 Years				Before 10 Years			
	Haul Number	Haul Duration (Hr.)	Catch (kg)	CPUE (Kg/hr.)	Haul Number	Haul Duration (Hr.)	Catch (kg)	CPUE (Kg)
Behundi Jal	6	12	3.2	0.27	6	12	5	0.42
Vesal Jal	35	15	5.85	0.39	35	15	8	0.53

CEGIS Field Survey, 2022

Similar to exposure and sensitivity assessment, adaptive capacity was assessed for Dacope Upazila through indicator-based impact chain analysis. This assessment (**Table 4.7**) reveals that Bajua, Banishanta, Dacope, Kailasganj, Laudubi, Pankhali (Chalna), Sutarkhali and Tildanga unions have high adaptive capacity for capture fisheries. Rest of the unions are in low adaptive capacity zone for capture fisheries in this region.

### 4.2.4 Vulnerability

The study assessed vulnerability of capture fisheries of Dacope Upazila through validated impact chain analysis. Generally high vulnerability occurs when for particular union sensitivity is high but adaptive capacity is low. From the assessment (**Table 4.7**), Kamarkhola union was found to be in high vulnerability. This union had high sensitivity and low adaptive capacity. Bajua, Banishanta, Dacope, Pankhali (Chalna), Sutarkhali and Tildanga unions were in moderate vulnerability zone while rest of the unions were in low vulnerable zone. The capture fisheries-based livelihoods specially in Kamarkhola union will be highly vulnerable to climate change.

**Table 4.7: Summary of climate vulnerability assessment for capture fisheries in Dacope Upazila**

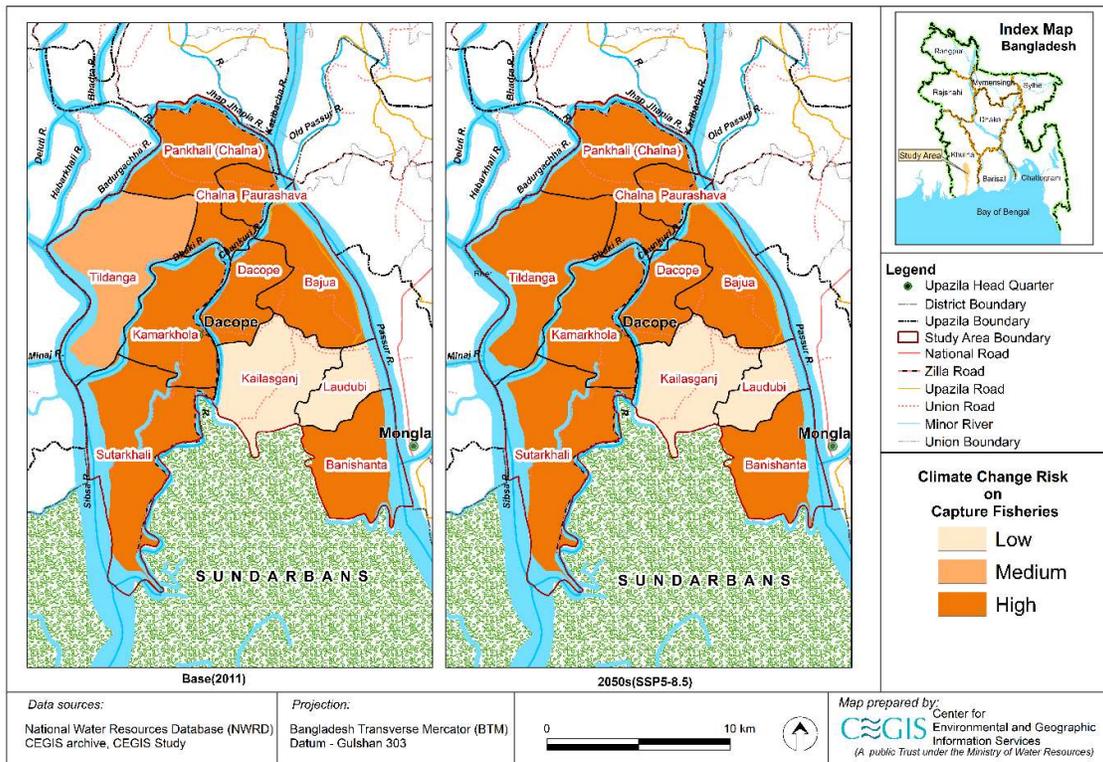
Union	CRVA Elements			
	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Bajua	Low	Medium	High	Medium
Banishanta	Low	High	High	Medium
Chalna Paurashava	Medium	Low	Low	Low
Dacope	Low	High	High	Medium
Kailasganj	Low	Low	High	Low
Kamarkhola	High	High	Low	High
Khulna Range	Low	Low	Low	Low
Laudubi	Low	Low	High	Low
Pankhali (Chalna)	Low	High	High	Medium
Sutarkhali	High	Medium	High	Medium
Tildanga	Low	High	High	Medium

### 4.2.5 Risk

The study also assessed the risk associated to capture fisheries for base and 2050s time period. The unions Laudubi, Banishanta, Bajua and Chalna Pourashava are highly exposed to multi-hazard risk in both present and future time periods. Dacope, Kailasganj, Pankhali, Tildanga and Sutarkhali unions which are under moderate multi hazard risk at present are projected to fall under high multi hazard risk in the future. This affects capture fisheries activities negatively throughout the year in these unions. Passur, Sibsa, Badurgacha, Chunkuri, Dhaki, Jhopjhopia run through the unions of Dacope which create capture fisheries opportunity in these unions but also leave them exposed to flood, erosion, sea level rise etc. Due to lack of proper early warning system, fishermen often get caught up in heavy rainfall and storm while fishing in

these rivers and lose their boats, nets, fishing gear, catch and even their lives. Their conventional fishing boats and other equipment are not adequate to cope with the changing climatic threats. Additionally, the unions adjacent to the rivers and the Sundarbans face salinity ingress which hampers the freshwater fisheries activities in Sutarkhali, Kamarkhola and Tildanga unions at present and will continue to affect more unions when salinity intrudes further inwards. Due to increasing temperature, the water temperature is also rising, affecting the water quality adversely. Lack of oxygen in the water lead to hampered growth rate and increased mortality of fish. Moreover, the fishermen in the region lack for appropriate freezing, storage and transportation facility hence often loose a considerable amount of their catch.

From the risk analysis of capture fisheries, all the unions except Kailasganj and Laudubi were found to be in high-risk zone in the 2050s time slice. Kailasganj and Laudubi unions are in the low-risk zone in both time slices. The Tildanga union was in the moderate risk zone in the base period but it was found in the high-risk zone in the 2050s time slice. The income and livelihoods of high-risk unions will face more losses and damages due to recurrent climatic extreme event. **Figure 4.12** below shows the risk of capture fisheries in Dacope.



**Figure 4.12: Climate risk on capture fisheries in Dacope Upazila**

## 4.3 Culture Fisheries

### 4.3.1 Exposure

The aquaculture in the study area include Pond, Bagda Gher, Golda Gher, Borrow pit and Crab Fattening Farm. The habitat assessment of these aquaculture habitats and cultured fish species are briefly described in respect of the exposure indicators in the following sections.

#### Habitat

There were about 4,996 ha of aquaculture farm including shrimp/prawn/fish farm in Dacope Upazila. Among the Shrimp/Prawn/Fish farm, some are the Bagda Gher where Bagda (*Peneus monodon*) along with other shrimp and fish are cultured all the year-round, and the Golda Gher where rice and white fish (major carp, tilapia, etc.) are cultured in mix way in the wet season. Major carp, exotic carp and other fast-growing fish species are cultured in the ponds following poly-culture technology. The small sizes ponds hold water mostly for 36-40 weeks in a year and are used for aquaculture following extensive culture method. **Table 4.8** presents union wise fish habitat under Dacope Upazila.

**Table 4.8: Area of shrimp/prawn/fish farm in different unions of Dacope Upazila**

Unions	Water area (ha)
Bajua	240
Banishanta	174
Chalna Paurashava	24
Dacope	29
Kailasganj	151
Kamarkhola	367
Khulna Range	114
Laudubi	43
Pankhali (Chalna)	37
Sutarkhali	387
Tildanga	3,430
<b>Total</b>	<b>4,996</b>

CEGIS estimation based on LandSat8 image 2019

#### Cultured fish species

Tilapia, Perse and Bagda were found to be highly cultivable fish species in Dacope Upazila (**Table 4.9**). The farm owners mainly cultivated finfishes in order to cope with the production loss from Bagda because of its high mortality rate due to temperature-driven viral infection.

**Table 4.9: Composition of cultured fish species in shrimp/prawn/fish farms**

Species name	Species composition (%)
Bagda	10.08
Catla	2.61
Chitol	0.30
Grass carp	0.04
Mirror carp	0.60
Mrigal	2.38
Pangas	0.84
Perse	26.78
Rui	5.99
Sarpunti	2.39
Tilapia	44.85
Vetki	3.14
<b>Total</b>	<b>100</b>

CEGIS Field Survey, 2022

## Livelihoods

Recently, increasing salinity is disrupting agricultural production, which has led to an increase in shrimp farming in the region. Most of the people in this region who are involved in agriculture are mostly involved in shrimp farming or fish culture. On the other hand, all women are mainly involved in household work. It is found that most of the women who are involved in household work help the male in fish farming. However, exclusively the number of women involved in fish farming is very negligible.

The agricultural lands surrounding this river catchment are being turned into shrimp farms, but the high saline water is also a challenge for farmers and attracts shrimp business people. The average monthly income of males from farming is BDT. 15,000-18,000. The earning of the women is very narrow compared to the men. Women have different kinds of social barriers which leads them to earn less compared to their counterpart. Their average monthly income lies between BDT. 6500-10000.

The study further made an assessment to understand the culture fisheries exposure to climate induced hazards in Dacope Upazila and eleven exposure indicators were selected (Annex I) and mapped following the impact chain analysis. **Table 4.15** below shows the exposure status of Dacope Upazila and from the assessment, it revealed that Tildanga union are in a highly exposed zone and the rest of the unions were exposed at a low rate for culture fisheries.

### 4.3.2 Sensitivity

The aquaculture production becomes vulnerable when different sensitivity and adaptive capacity indicators are seen. The condition of other sensitivity and adaptive capacity indicators are briefly described in the following sections.

#### Habitat condition

Pond water quality starts to degrade when temperature reaches to higher than 33 °C and results in slow growth and reduce fish feeding efficiency (A. Adey et. Al., 2015, M. Shahjahan, 2021). Temperature higher than 36°C is lethal for most fish species. Temperature less than 22 °C can also cause less feed intake and less body weight (Singh, 2019). Moreover, pH ranges from 6.8 to 8.5 is the optimum preferable for most fish species and 3.8 is the lethal limit to which most fishes cannot survive within 12 hours (G. L. Allan and G. B. Maguire, 1992). This study found out that shrimp/prawn/fish farms are facing significant stress environment with respect to TDS in most of the unions, whereas in terms of pH, temperature and DO, it is very slightly beyond optimal range for 1 union (**Table 4.10**). It has also been predicted that extreme temperatures coupled with erratic rainfall patterns have direct impacts on fish physiology, growth, feeding behavior and mortality in aquaculture habitat. Moreover, excessive rainfall will breach the dyke of fish pond or shrimp farm and increase the natural mortality due to the reduction of pH.

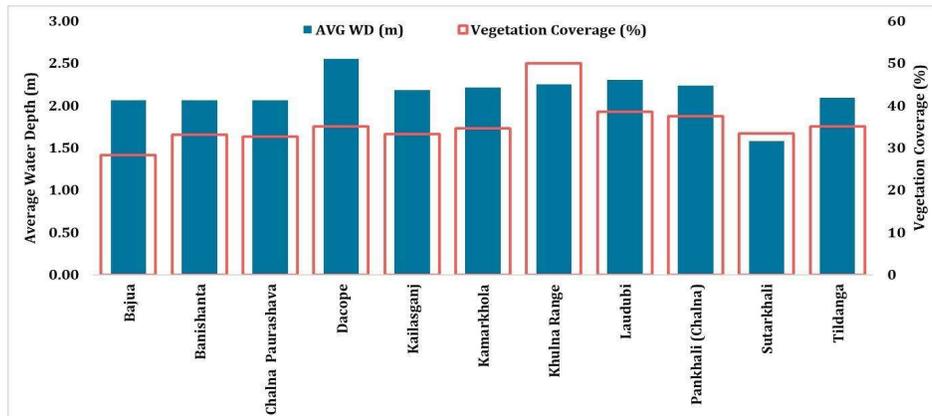
**Table 4.10: Stress magnitude of shrimp/prawn/fish farm ecosystem in Dacope Upazila**

Unions	pH	TDS (gm/l)	Water Temperature (°C)	DO (mg/l)	BOD (mg/l)
Bajua	8.20	692	30	5.40	3.04
Banishanta	8.25	1233	30	7.20	1.00
Chalna Paurashava	8.07	1174	30.9	6.53	0.05
Dacope	8.53	384	30	5.74	1.00
Kailasganj	8.18	1243	30.9	6.58	3.14
Kamarkhola	8.19	1270	30.9	6.47	3.52
Khulna Range	8.18	621	30.9	8.11	2.71
Laudubi	7.47	704	30	7.18	1.20
Pankhali (Chalna)	7.42	288	30	5.18	7.60
Sutarkhali	7.79	1368	30	4.95	0.81
Tildanga	8.16	0.08	30	6.59	3.09
Acceptable Range of Fish Community including Crustaceans	Growth Limit: 6.8-8.5 Lethal Limit: 3.8	0.3-120	Lethal Limit: 36 °C Optimum Range: 25-30°C Significantly Lower Growth Rate	>5	<50

Unions	pH	TDS (gm/l)	Water Temperature (°C) (<1%/day SGR*): <15°C and > 33°C	DO (mg/l)	BOD (mg/l)

Literature review and CEGIS Field Survey, 2022

The present study found that the average water depth of the fish pond and shrimp/prawn farm is above the minimum required water depth (1m) in all the unions of Dacope Upazila (**Figure 4.13**). Furthermore, more than 50% vegetation coverage (considering both the floating and sub-merged vegetation) was found in the aquaculture farms in Khulna Range. The farms having higher coverage of submerged vegetation (>50%), are expected to produce high abundance of methanotrophs, which can act as a biological sink for the greenhouse gas methane. Based on methodology by Fan et al. (2019), the present study found that the submerged vegetation may potentially influence methanotrophs in two ways: by increasing the alpha diversity of the methanotrophic community or by increasing methanotrophic abundance through inducing anaerobic root zone conditions, thereby increasing methane oxidation potential.



**Figure 4.13: Average water depth and vegetation coverage in the fish ponds and shrimp/prawn/fish farms in different unions of the Dacope Upazila**

CEGIS Field Survey, 2022

#### Growth coefficient and natural mortality

The growth coefficient and natural mortality of fishes, which have been exposed to the climate change events, were selected as the major sensitivity factor for aquaculture production. It has been found out that the highest growth in aquaculture is among the Bagda (about 0.25cm per day). However, the highest mortality has also been found in case of Bagda (**Figure 4.14**). From this survey, this mortality is mainly as a result of viral infection accelerated by increasing temperatures.



**Figure 4.14: Exposure of shrimp and fin fishes to major climate induced hazards**

### Production loss due to climate-induced disease

The farms in different unions of Dacope Upazila were estimated to lose about 563 MT of fish production in total due to climate-induced disease and different extreme events as shown in **Table 4.11**. During field survey, three climate induced diseases have been identified, among them antenna cut and White Spot Syndrome (WSS) are caused by extreme high temperature and, Epizootic Ulcerative Syndrome (EUS) as a result of extended days of severe cold temperature.

**Table 4.11: Status of fish production loss due to climate induced disease**

Unions	Fish production loss (MT)
Bajua	27
Banishanta	20
Dacope	3
Kailasganj	17
Kamarkhola	41
Khulna Range	13
Pankhali (Chalna)	1
Sutarkhali	44
Tildanga	397
<b>Total</b>	<b>563</b>

CEGIS Field Survey, 2022

### Fish production

The changes mentioned above in habitat condition and fish biology with growth coefficient and natural mortality in respect to different climate change scenarios, total fish production in different unions of the Dacope Upazila would be about 6,340 MT, 6,455 MT, 6,655 MT and 6,644 MT in SSP1-2.6 (2050), SSP1-2.6 (2100), SSP5-8.5 (2050) and SSP5-8.5 (2100) scenarios respectively as shown in **Table 4.12**.

**Table 4.12: Aquaculture fish production under different climate change scenario**

Union	Fish Production (MT)				
	Base Year	SSP1-2.6 (2050)	SSP1-2.6 (2100)	SSP5-8.5 (2050)	SSP5-8.5 (2100)
Bajua	304	305	311	320	320
Banishanta	220	220	224	231	231
Chalna Paurashava	-	-	-	-	-
Dacope	36	36	37	38	38
Kailasganj	191	192	195	201	201
Kamarkhola	464	465	474	488	488
Khulna Range	144	144	147	151	151
Laudubi	2	2	2	2	2
Pankhali (Chalna)	6	6	6	6	6
Sutarkhali	490	492	501	516	515
Tildanga	4,466	4,478	4,559	4,700	4,692
<b>Total =</b>	<b>6,324</b>	<b>6,340</b>	<b>6,455</b>	<b>6,655</b>	<b>6,644</b>

Impact Chain Analysis, CEGIS (2022)

### Livelihoods

In Dacope Upazila, fish gher owners are facing losses due to the climate induced shocks. With the loss of income, they cannot go beyond the vicious cycle of poverty. Extreme poverty line is the minimum income to support basic foods and the moderate poverty line is the income to support basic food and non-food expenses. Small farmers who are dependent on the aquaculture production face problems in selling

because of regularly occurred disasters. Sometimes, their production loss and washing out of ponds force them to take loan from NGOs and local lenders. Apart from that disrupted communication make some problems in selling, even getting proper price from the market. In this way, regular disaster and communication problem could not support them to get out of the poverty cycle. In this aspect, choosing resilience and AIGs are becoming challenging for them to cope with the changing condition.

An indicator-based sensitivity analysis (**Table 4.15**) was also made to identify sensitive unions of Dacope Upazila. Total thirteen indicators (Annex 1) were used to represent the sensitivity of ecosystem in Dacope.. According to the sensitivity analysis Bajua, Banishanta, Kamarkhola, Pankhali (Chalna) and Tildanga unions are found to be highly sensitive while Chalna Paurashava, Dacope and Khulna Range unions are moderately sensitive and the rest of the unions are low in terms of sensitivity for culture fisheries.

### 4.3.3 Adaptive capacity

There are two types of adaptive measures found to be adopted by the farm owner in order to adapt with the climatic extreme events in the unions of Dacope Upazila. One includes aquaculture production system and another is the disease control as discussed below.

#### *Aquaculture production system*

The study found that the farm owners in all unions take about 61 days (from November to December) to prepare the land for aquaculture. They use about 251kg of fertilizer and 129kg of lime per hectare for their farm management (**Table 4.13**). Stocking rate of these farms mainly depends on the farm area and water depth. Vegetation coverage also have an influence on the farm management. Union wise fertilizer and lime use in the Upazlia is given in the **Table 4.13**.

**Table 4.13: Aquaculture production system in different unions of Dacope Upazila**

Union	Land Preparation (Days)	Fertilization (kg/ha)	Lime (kg/ha)
Bajua	61	245	115
Banishanta		250	135
Chalna Paurashava		255	120
Dacope		240	115
Kailasganj		245	125
Kamarkhola		255	130
Khulna Range		240	135
Laudubi		265	125
Pankhali (Chalna)		270	145
Sutarkhali		255	135
Tildanga		245	135

*CEGIS Field Survey, 2022*

#### *Climate-induced disease control measures*

The aquaculture farm owners frequently use aqua-medicine and liming for antenna cut and White Spot Syndrome and aqua-medicine, liming and salt for controlling WSS and EUS (**Table 4.14**).

Three climate induced diseases were identified during the field survey, among them antenna cut and White Spot Syndrome (WSS) are caused due to extended days of extreme high temperature and, Epizootic Ulcerative Syndrome (EUS) happens because of extended days of severe cold temperature. The local aquaculture farm owners frequently use aqua medicine and liming for antenna cut and White Spot Syndrome and aqua-medicine, liming and salt for controlling WSS and EUS (**Table 4.14**).

**Table 4.14: Adaptive measures for disease control**

Climatic Cause	Disease	Disease Control Measures	Response (%)
Extended days of extreme high temperature	Antenna Cut	Using Aqua-medicine and Liming	18
	WSS		42

Climatic Cause	Disease	Disease Control Measures	Response (%)
Extended days of severe cold temperature	EUS	Using Aqua-medicine, Liming and Salt	11
		No measures	29

CEGIS Field Survey, 2022

Union-wise adaptive capacity was also assessed (**Table 4.15**) through different indicator-based impact Chains. These indicators mainly demonstrate the coping mechanism of the culture fisheries in hostile condition induced by climate change. However, the culture fisheries scenario assessment in this study followed total 17 adaptive capacity indicator. Although due to study limitation, the study team could cover only three unions during field visit. The study team assessed union-wise conditions by consulting SUFOs, key informants, secondary data sources and expert judgment. A set of indicator lists are attached (Annex I). From the adaptive capacity assessment of the culture fisheries in Dacope Upazila it was found that Bajua, Banishanta, Dacope, Kailasganj, Laudubi, Pankhali (Chalna), Sutarkhali and Tildanga unions are highly adaptive for culture fisheries whereas Chalna Paurashava, Kamarkhola and Khulna Range unions are low in terms of adaptive capacity for culture fisheries.

#### 4.3.4 Vulnerability

The vulnerability of culture fisheries (**Table 4.15**) of Dacope Upazila was also assessed through validated impact chain analysis. Generally high vulnerability occurs when for particular union sensitivity is high but adaptive capacity is low. From the assessment Kamarkhola union was found to be in high vulnerability. This union had high sensitivity and low adaptive capacity. Bajua, Banishanta, Chalna Paurashava, Dacope, Khulna Range, Pankhali (Chalna) and Tildanga unions are found to be in moderate vulnerability while rest of the unions were found to be in low vulnerable zone.

**Table 4.15: Summary of climate vulnerability assessment for culture fisheries in Dacope Upazila**

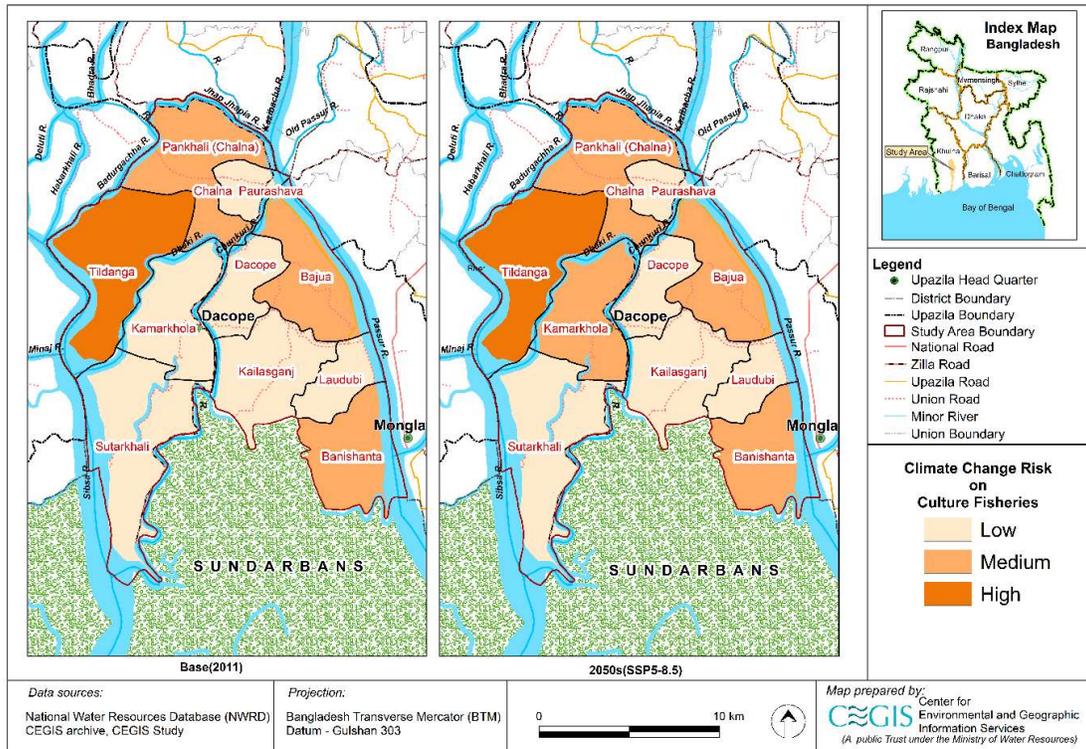
Union	CRVA Elements			
	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Bajua	Low	High	High	Medium
Banishanta	Low	High	High	Medium
Chalna Paurashava	Low	Medium	Low	Medium
Dacope	Low	Medium	High	Medium
Kailasganj	Low	Low	High	Low
Kamarkhola	Low	High	Low	High
Khulna Range	Low	Medium	Low	Medium
Laudubi	Low	Low	High	Low
Pankhali (Chalna)	Low	High	High	Medium
Sutarkhali	Low	Low	High	Low
Tildanga	High	High	High	Medium

#### 4.3.5 Risk

Climate change induced hazard/risk for culture fisheries was assessed through impact chain analysis for base and 2050s time period. Tiladanga, Sutarkhali, Kamarkhola and Bajua unions contain the highest number of aquaculture farms in Dacope. However, these unions have also faced high amount of production loss. As these unions are adjacent to the Shibsa and Passur rivers, they face inundation and salinity intrusion which affects freshwater aquaculture negatively. During cyclone and flood events major portion of Dacope gets inundated due to its low-lying topography and lack of proper cyclone and flood protection infrastructure. Fish farmers often elevate the banks of their ponds to prevent saline water intrusion during flood. Lack of proper storage and transportation facility result in considerable production loss. The rising temperature also increase the oxygen demand of water in the fish farms and lead to reduced fish growth rate and death of fish fry and juvenile fish. The farmers often use banana leaf, coconut leaf, palm leaf and bamboo baskets to maintain optimum water temperature and quality of water as adaptive techniques during summer.

The culture fisheries risk assessment fund Tildanga union to be in high risk for both the base period and the 2050s time slice. Pankhali (Chalna), Bajua and Banishanta unions are in moderate risk at both the base

period and the 2050s time slice. The Kamarkhola union was in the low-risk zone in the base period but it has been found to be in the moderate risk zone in the 2050s time slice. Chalna Paurashava, Sutarkhali, Dacope, Kailasganj and Laudubi are in the low-risk zone in both time slices. **Figure 4.15** shows the risk of culture fisheries in Dacope.



**Figure 4.15: Climate change risk on culture fisheries in Dacope Upazila**

#### 4.4 Gender

The Gender equality and women’s empowerment agenda for the 8FYP is based on pursuing strategies and actions, not only enhance women’s capabilities, and access to resources, and opportunities, but also address the barriers in structures and institutions. This section assesses the gender base vulnerability keeping the attention on women, children, aged and disabled people in terms of exposure, sensitivity and adaptive capacity. In doing this, both quantitative and qualitative data were collected from the field and analyzed to identify the risks, risks mitigation action and future adaptation measures for developing a gender-responsive future plan on fish capture and aquaculture related activities.

Just like many other coastal areas of Bangladesh, Dacope Upazila has marginalized people dependent on threatened natural resources, especially women. As already stated, women are also involved in these activities such as fry collection, net making, pond preparation etc. however in the broader sense, women do not contribute much to decision-making, though they are involved much in the production processes.

Under this section, findings from the gender-based vulnerability are presented, considering the impacts of climate change on women, children, aged and disable people in terms of the exposure, sensitivity and adaptive capacity. During the assessment, both quantitative and qualitative data was collected from the field and analyzed to identify the risks, mitigation action and future adaptation measures for developing a gender-responsive future plan on fisheries and aquaculture.

##### 4.4.1 Exposure

The impact of climate change has increased the number of various hazards that adversely affect fisheries and aquaculture. In fisheries and aquaculture sector, exposure determines the risks to be exposed of

fisheries resources (i.e. ponds, Gher, Fishing Gear, boats) and vulnerable communities who are affected due to the climate change.

Apart from fish culture and capture activities, women are also involved in agricultural activities which are also exposed to climate change impacts. Women are mainly involved in household work but women assist men in activities related to fish farming such as pond preparation, feeding, harvesting, fertilizer application, taking care of the pond etc. Women who are involved in such activities spend about 3/5 hours daily for these activities. Due to the disasters, reduced working hour and decreased fish production in the fish farms impact to the household income which is higher for female owning or leasing out ponds.

According to Upazila Fisheries Officer, the total number of fishermen in the region is 8483. Considering the data of Upazila field office, the number of females related to fisheries is 5% which is approximately 424.

The **table 4.16** shows the distribution of fish capture and fish culture dependent people whose income and livelihood are under the threat of climate change impact. Dependency rate of those household area is also depicted in the table.

**Table 4.16: Distribution of engagement in fish related activities with family members dependency**

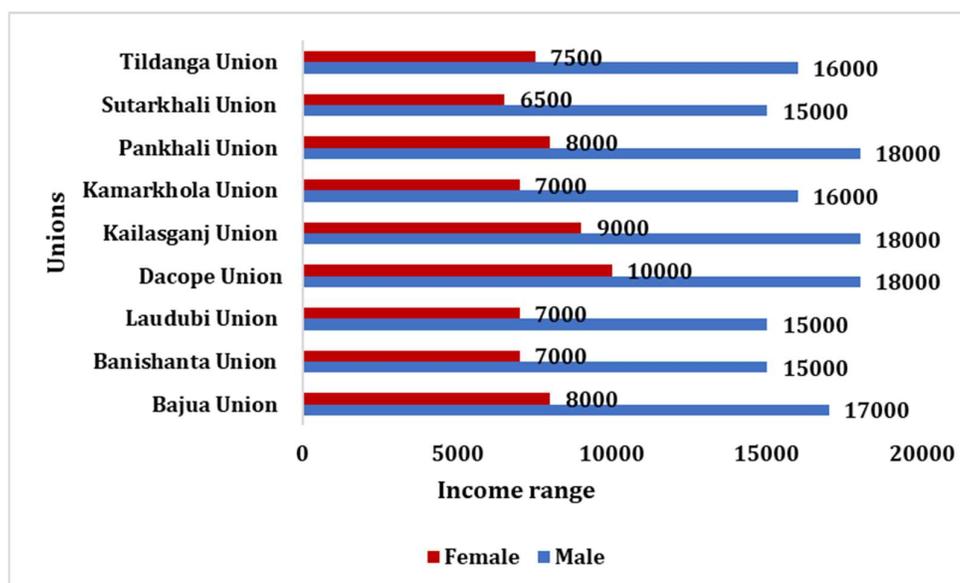
Name of the Unions	Male (% of fish related occupants)	Female (% of fish related occupants)	Dependent members (%)
Bajua	95	5	34.1
Banishanta	95	5	37.5
Laudubi	95	5	38.5
Dacope	95	5	36.4
Kailasganj	95	5	34.8
Kamarkhola	95	5	36.9
Pankhali	95	5	37.8
Sutarkhali	95	5	39.1
Tildanga	95	5	40.0

*CEGIS Field Survey, 2022 and BBS, 2022*

#### 4.4.2 Sensitivity

Poverty conditions, mobility, gender-based risks, health and physical condition are the most sensitive receptors for the regular occurrence of flood, erosion, cyclone, extreme heat, drought, siltation and wave action where women, children, aged and disable people are highly exposed to these disasters. All these hazards are not equally affecting the exposed communities; it depends on the resistance capacity of the community. Women has little access and control over land, labor and development resources including credit, technology, training and information. In this perspective, they have more sensitivity than a male member. Thus poverty, dependence on male members, socially determined skewed power relations, lack of access to productive resources make women more sensitive to hazardous situations particularly in changing climate situations.

**Figure 4.16** shows the monthly income level of the fish farmers who owned the fish ponds/Gher in Dacope Upazila. Due to social challenges, women who own fish farms on an average earn BDT. 7777.00 monthly. Average income from the fish sector for a male member is BDT. 16444. Respondents from the different unions in Dacope Upazila stated that their average income is not sufficient to maintain their daily life. In some crisis moments, they hand over money to the male members, creating constraints on self-reliance. There are social and religious norms by which female members face restrictions to work outside. They don't have the opportunity to be involved in alternative income-generating activities. As a result, poor conditions and fewer income opportunities continue to make them more sensitive to the changing climatic conditions.



Literature review and CEGIS Field Survey, 2022

**Figure 4.16: Monthly average income of women fish farmers by union**

There are very few work opportunities for women in the region and even in emergency situations there is no work opportunity at all. Additionally, women labor wages are much lower than for men. Whereas a male laborer is paid Tk 400 to Tk 450 for a working day, women are on average paid between Tk 250 to maximum Tk 300. Less income makes them more sensitive to the changing climatic condition. In some areas of Dacope upazila which are adjacent to the Sundarbans, the people especially women and aged people suffer a lot due to lack of sufficient health facility. Moreover, fragile infrastructures made the situation more sensitive. The sensitivity indicators mentioned in the study are: domestic violence, involvement in decision making, accessibility to employment, violence in post disaster period, working hour and income loss. Based on the analysis of those indicators, gender sensitivity in this study area is depicted in **table 4.17**.

**Table 4.17: Impacts of climate change/hazards on Gender**

Indicators	Impacts
<b>Loss of income, savings and employment</b>	Different hazards in this area affects the income people associated with fisheries sector. Employment and income generation were disrupted due to natural calamity. During disaster period, the female fishers cannot go for fishing in the river. Women are involved in different fisheries related activities as net making, pond preparing, feeding the fishes etc. During the flood, saline water enters the pond and make the water inhabitable for fish. It does a great loss for the women fish farmers. They cannot sell their products properly due to the disasters which make them vulnerable. It lowers their income. As a result, women who are involved in fish culture cannot earn more from culture fish farming. The net loss in income leads to a loss of savings, thus making it even harder for households to cope with disasters. The lack of savings and income loss made them more vulnerable in which decision making at households, pond management, and market level disrupted.
<b>Limited access to market</b>	Road communication systems in the unions of southern Dacope have collapsed after the cyclone Sidr and Aila. Market access became limited due to damaged road and transport system to buy or sell their goods. Women are forced to trade within the village or accept lower prices offered by male buyers from other areas. Moreover, disabled and aged people have to be confined in their households because of the fragile infrastructures.
<b>Sickness and Disease</b>	The frequency of sickness has increased. Men and women who are involved in fish fry collection have to stay in saline water for a long time which affects their health. However, mostly women are faced by various diseases due to staying in salt water for a long time and even less medical facilities as the area is located in remote coastal region. Women and adolescent girls are usually responsible to fetch drinking water from distant sources, even

Indicators	Impacts
	5-6 kilometers each day in some areas. Even during their pregnancy women are forced to fetch water irrespective of the distance between the source and their dwellings. During the menstruation period, fish fry collectors faced severe gynecologic diseases. It is found from the field survey that most of cases, women need to go to cities for treatment, which is a financial burden for them. Flood related deaths are often caused by drowning and snake bites, which tend to occur in increasing numbers for children, followed by adult women.
<b>Property</b>	It is generally found that the absence of ownership on prime resources such as land and lack of access either to common properties or to governance processes increase the vulnerability of these disadvantaged groups in any given hydro-geophysical context. The changed hydro geophysical contexts under climate change will push the women in distress by further alienating them from governance processes and/or resource endowment. Disaster destroys houses and homesteads are now unusable for vegetable production because of salinity ingression.
<b>Social Security</b>	Women's involvement in household activities is not counted as economic activity in the study area. They do not get social dignity. Employed women sometimes face social problems. There is no separate facility for working women in the market and cyclone shelters which also makes them vulnerable.

According to the **Table 4.19** the unions named Dacope, Kailasganj, Kamarkhola, Laudubi, Pankhali (Chalna) and Tildanga are highly sensitive due to the moderate condition of domestic violence, moderate accessibility to income opportunities, post harvesting loss and working hour. Thus, Dacope, Kailasganj, Kamarkhola, Laudubi, Pankhali (Chalna) and Tildanga unions are found as highly sensitive in comparison with other unions of the Dacope Upazila according to the results on sensitivity indicators on gender.

#### 4.4.3 Adaptive capacity

Women experience particular constraints in their capacity to adapt to existing and predicted impacts of climate change. It is necessary to enhance women's access, control and ownership of resources and their access to the development of resources such as information and credit.

Field finding shows that, 83% of women respondents know about climate change. The percentage having knowledge of fisheries techniques and the percentage having knowledge about pests and diseases is 67% and 83% accordingly but none of them have knowledge in reducing the salinity of the drinking water. About 42% of the respondents have received training on alternative livelihoods. The adaptive capacity scorecard shows that they are getting the facilities to be adaptive and fight against the challenge of climate change-induced problems. But they feel that there are insufficient training facilities on alternative livelihoods, climate change adaptation, climate resilient housing, pond management and infrastructures. Therefore, it is required to take more initiative to build more adaptive capacity to fight against the reality provided by the increased climatic events.

**Table 4.18: Status of adaptive capacity of women involved in fishing and fish farming**

Adaptive capacity indicators	Status (%)
Understanding on Climate Change Impact	83
Knowledge of Fisheries Techniques	67
Knowledge of Pest and Diseases in Fish	83
Receive Early Warning Message Regularly	67
Watching Television or Social Media	58
Having Cell Phone	58
Having Smart Phone but no Internet	33
Having Smart Phone with Internet	17
Watching Television Once in a Week	33
Accessibility to Shelter during Cyclone/Floods	67

Adaptive capacity indicators	Status (%)
Knowledge on Hygiene during menstrual and pregnancy period	67
Knowledge on Drinking Water Boiling or Chlorination	75
Training Received on Climate Change	33
Training on Alternative Livelihood	42
Training on Climate Change Impact and Adaptation	33
Knowledge on Reducing the salinity from drinking water	0
Training on Climate Resilient Housing, Pond management and Infrastructures	58

Adaptive capacity assessment (**Table 4.19**) showed Chalna Paurashava, Dacope, Kamarkhola and Khulna Range has low adaptive capacity for gender specific fisheries livelihood.

#### 4.4.4 Vulnerability

Vulnerability for gender specific livelihood was also assessed for Dacope Upazila using impact chains developed for Southwest region (**Table 4.19**). Vulnerability assessment showed Dacope and Kamarkhola unions were highly vulnerable. While Bajua, Banishanta, Kailasganj, Laudubi, Pankhali (Chalna) and Tildanga unions were in moderately vulnerable zone. Unions with high vulnerability have low adaptive capacity and high sensitivity level. Rest of the unions were found to be in low vulnerability level.

**Table 4.19: Summary of climate vulnerability assessment for gender (women) engaged in F&A-specific livelihood in Dacope Upazila**

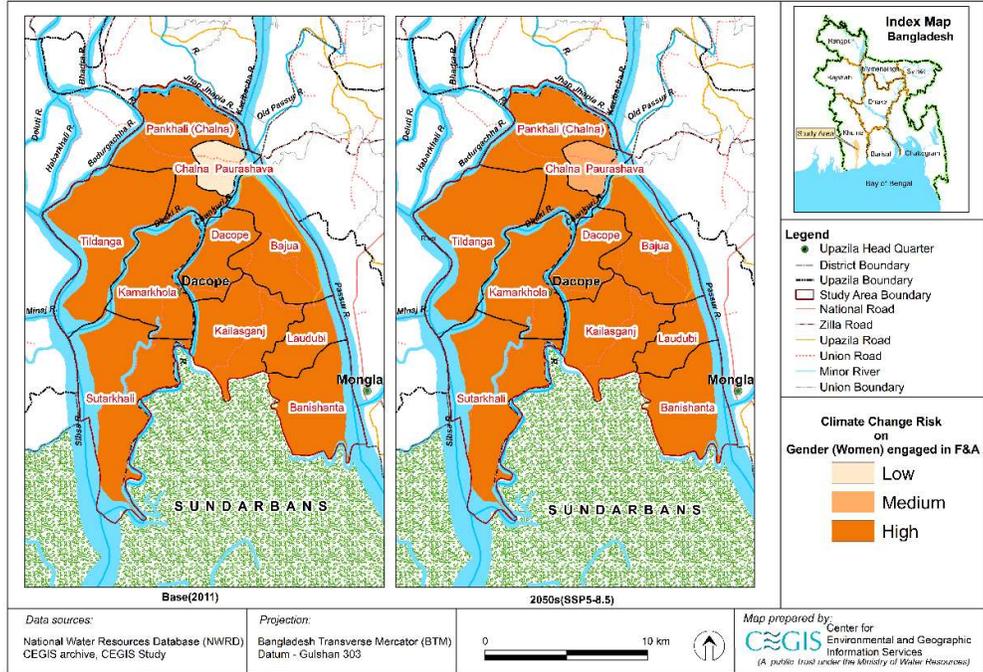
Union	CRVA Elements			
	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Bajua	High	Medium	High	Medium
Banishanta	High	Medium	High	Medium
Chalna Paurashava	Low	Low	Low	Low
Dacope	High	High	Low	High
Kailasganj	High	High	High	Medium
Kamarkhola	High	High	Low	High
Khulna Range	Low	Low	Low	Low
Laudubi	High	High	High	Medium
Pankhali (Chalna)	High	High	Medium	Medium
Sutarkhali	High	Low	High	Low
Tildanga	High	High	Medium	Medium

#### 4.4.5 Risk

The study assessed union-wise risk on gender-based livelihood due to climate change induced hazard for two-time period. In Dacope, the women have low involvement in fisheries related activities along with a little to no ownership of fish farms and decision-making powers which makes them exposed to hazards and climate change. Even for women involved in fishing and aquaculture, the wage rate is significantly lower. Specially in Sutarkhali, Kamarkhola, Laudubi and Banishanta unions, the wage rate of women is shockingly low than men. Salinity intrusion in the unions near the Sundarbans is affecting their health adversely. Lack of proper hygiene knowledge and WASH facility further aggravate their health issues.

Risk assessment shows all the unions except the Chalna Paurashava union are at high risk for gender-based livelihood for both base period and the 2050s time slice. In 2050s the Chalna Paurashava union is found to be in moderate risk zone while it was in the low-risk zone in the base period.

**Figure 4.17** shows the risk on gender (women) engaged on F&A based livelihood in Dacope Upazila.



**Figure 4.17: Climate risk on gender (women) engaged in F&A in Dacope Upazila**



## 5 Climate Resilience Action Plan

Climate risk reduction and resilience development among society, institutions, and ecosystem is key to adapting against adversities of climate change. This chapter focuses on developing a climate resilience action plan for reducing assessed risk and vulnerabilities for the F&A sector in Dacope Upazila. A resilient framework can apply to improve F&A-based livelihoods focusing on gender and boosting aquatic ecosystem health. Livelihoods diversification; human skills and institutional capacity development; sustainable development of human and ecosystem well-being through Ecosystem Approaches to Fisheries (EAF) or Ecosystem Approaches to Aquaculture (EAA); gender-responsive local led actions, etc., are among outlined priorities towards development of the resilience action plan.

This section elaborates on the implementation strategies of the developed climate-resilient adaptation plan for Dacope Upazila. The approach undertaken was to group related hazards which may have similar adaptations or risk reduction options. Following tables present adaptation options for hazards prominent in Dacope Upazila and identified their risk.

### Open water fisheries

The **Table 5.1** below outlines the risks related to cyclones, storm surges, salinity intrusion, flood, and tidal flood on capture fisheries and gives potential adaptations and risk reduction options that should be undertaken or promoted by different stakeholders under capture fisheries.

**Table 5.1: Risk of cyclone, storm surges, salinity intrusion, flood, tidal flood and wave action on capture fisheries with adaptation options**

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder(s)	When to Implement
1	Fisher's life may be at risk during fishing in the sea/river or large open waterbodies due to cyclone, storm surge, floods, tidal floods and wave action	<ul style="list-style-type: none"> <li>Develop and strengthen EWS and its dissemination for F&amp;A</li> </ul>	<ul style="list-style-type: none"> <li>Protect fishers' life, livelihoods and ensure social security through pre-informed early warning messages</li> </ul>	DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, NGOs, Electronic, web and print media	Within 3 years
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for the fishing communities</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of family to recover sudden loss of family member</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies	Within 3 years
		<ul style="list-style-type: none"> <li>Training for emergency disaster response and risk management</li> </ul>	<ul style="list-style-type: none"> <li>Increase adaptive capacity and know how to respond on disaster</li> </ul>	DoF, BFRI, MoDMR, LGD, DSS, MOWCA, Training and Knowledge Institutes	Within 3 years
		<ul style="list-style-type: none"> <li>Awareness raising program and behavioral change</li> </ul>	<ul style="list-style-type: none"> <li>Protect fishers' life, livelihoods and ensure social security</li> </ul>	DoF, BFRI, MoDMR, DSS, MoWCA, LGD, NGOs, Training and Knowledge Institutes	Within 3 years
2	Fishing boats and gear may be lost or damaged due to extreme waves or current	<ul style="list-style-type: none"> <li>Develop and strengthen EWS and its dissemination for F&amp;A to facilitate emergency safeguard of boats or fishing gears</li> </ul>	<ul style="list-style-type: none"> <li>Safeguard the fishing gears and boats against hazards</li> <li>Reduce economic loss of the fishermen</li> </ul>	DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, Electronic, web and print media	Within 3 years
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishers community</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishermen to recover any losses incurred from damages</li> <li>Ensure sustainability of income and livelihoods</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Provide climate resilience funds for repair or purchase of boats of gears</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishermen to recover any</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs, NGOs	Within 3 years

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder(s)	When to Implement
			losses incurred from damages		
		<ul style="list-style-type: none"> <li>Repair fishing and gears before every monsoon</li> </ul>	<ul style="list-style-type: none"> <li>Protection of boats or gears and economic loss through proactive adaptation</li> </ul>	Fishing communities	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Construction of storage areas for fishing tools</li> </ul>	<ul style="list-style-type: none"> <li>Ensure support to prevent fishing gear and safety equipment damages during disasters</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs, NGOs	Within 3 years
		<ul style="list-style-type: none"> <li>Awareness raising program and behavioral change</li> </ul>	<ul style="list-style-type: none"> <li>Enhance adaptive capacity and resilience</li> </ul>	DoF, BFRI, MoDMR, DSS, MoWCA, LGD, Training and Knowledge Institutes	Within 3 years and continue
3	Reduced river and beel habitats due to siltation and habitat condition degradation after floods/tidal floods	<ul style="list-style-type: none"> <li>Regular dredging of all large, medium and small rivers, beels</li> </ul>	<ul style="list-style-type: none"> <li>Revitalization of rivers, beels and restoration of fisheries habitat</li> <li>Reduce aquatic ecosystem vulnerability</li> </ul>	BWDB, MoS, DoE, NRCC, DoF, WARPO	Annual and periodic
		<ul style="list-style-type: none"> <li>Maintaining connectivity of khals, beel and rivers</li> </ul>	<ul style="list-style-type: none"> <li>Revitalization of rivers, beels and restoration of fisheries habitat</li> <li>Reduce aquatic ecosystem vulnerability</li> </ul>	BWDB, MoS, DoE, NRCC, DoF, WARPO	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Restoration of fish habitats and breeding grounds</li> </ul>	<ul style="list-style-type: none"> <li>Increase productivity of fisheries</li> </ul>	DoF, BFRI, DoE, MoS, NRCC, WARPO	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Delay fishing activities until river/beel water become clean</li> </ul>	<ul style="list-style-type: none"> <li>Reduce production losses</li> </ul>	DoF, BFRI, MoLJPA, LGIs	Within 3 years and continue
4	Overall fishing activities may be hampered due to extreme	<ul style="list-style-type: none"> <li>Awareness raising and capacity building for enhancing coping mechanism</li> </ul>	<ul style="list-style-type: none"> <li>Increase adaptive capacity and resilience, income generation activities and improve living standard</li> </ul>	DoF, BFRI, MoDMR, DSS, MoWCA, LGD, Training and Knowledge Institutes	Within 3 years and continue

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder(s)	When to Implement
	weather, cyclone/floods or wave actions	<ul style="list-style-type: none"> <li>Arrangement of opportunities and skill development for alternative livelihoods generation</li> </ul>	<ul style="list-style-type: none"> <li>Increase adaptive capacity and resilience, income generation activities and improve living standard</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, MoDMR, MoEFCC, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishermen community</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Strengthen flood management measures</li> </ul>	<ul style="list-style-type: none"> <li>Reduce disruptions in fishing activities and economic losses</li> </ul>	BWDB, LGED, DoF, WARPO	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Climate sensitive zoning, plan and regulate fishing activities accordingly</li> </ul>	<ul style="list-style-type: none"> <li>Reduce disruptions in fishing activities and economic losses</li> </ul>	DoF, BFRI, MoLJPA, LGIs	Within 3 years and continue
5	Migration disruptions, diseases outbreak, hampered and decreased mortality of fish leading to production loss due to floods, sea level rise and salinity	<ul style="list-style-type: none"> <li>Integrated coastal zone and mangrove management</li> </ul>	<ul style="list-style-type: none"> <li>Protection of fish biodiversity and increase fish production combating impacts of climate change</li> </ul>	DoF, BFRI, BFD, WARPO, BWDB, LGED, LGIs, MoDMR, MoEFCC, DSS, DYD	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Stock enhancement of threatened fish species</li> </ul>	<ul style="list-style-type: none"> <li>Enhance resilience of fish species, increase adaptive capacity of fisheries ecosystem and reduce production losses</li> </ul>	DoF, BFRI, LGD, Knowledge Institutes, Academia	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Research and monitoring of movement of salinity front, migration extent and diseases of major fish species</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, Knowledge Institutes, Academia, DoE	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Increase freshwater flow from upstream of coastal rivers</li> </ul>	<ul style="list-style-type: none"> <li>Reduce salinity and disruptions in migrations</li> </ul>	MoWR, NRCC, LGED, MoS, WARPO, JRC	Within 3 to 5 years

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder(s)	When to Implement
		<ul style="list-style-type: none"> <li>Innovate and release stress tolerant fish species</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Conservation of freshwater sanctuaries, beel nursery and breeding ground</li> </ul>	<ul style="list-style-type: none"> <li>Spawning and breeding of healthy fisheries and enhance fisheries production, boost income</li> </ul>	DoF, BFRI, NRCC, WARPO, LGIs, DoE, MoLJPA	Within 3 years and continue
6	Loss of livelihoods, shifting occupation and increased poverty with disproportionate impact on women	<ul style="list-style-type: none"> <li>Provide subsidies and skill development for alternative livelihoods ensuring women's participation</li> </ul>	<ul style="list-style-type: none"> <li>Reduce gender vulnerability, income loss and living standard</li> <li>Enhance adaptive capacity and resilience to combat disproportionate impacts on gender</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Training on gender and youth inclusive C&amp;DRR and EWS for fish farmers</li> </ul>	<ul style="list-style-type: none"> <li>Enhance adaptive capacity and resilience to combat climate disasters</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduction of zero interest or low interest-based credit facilities to recover disaster risk</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies, Bangladesh Banks and Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> <li>Reduce gender indiscrimination and inequality</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies	Within 3 to 5 years

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder(s)	When to Implement
		<ul style="list-style-type: none"> <li>Provide climate resilience funds specially focusing on marginal women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs	Within 3 years and continue
7	Aquatic habitat degradation and decreased water quality due to flood and salinity	<ul style="list-style-type: none"> <li>Monitoring of water quality after the disaster and refrain from fishing activities</li> </ul>	<ul style="list-style-type: none"> <li>Information about the habitat condition and plan fishing activities accordingly</li> </ul>	DoF, BFRI, Knowledge Institutes, Academia, DoE, LGIs, MoLJPA	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Regular dredging of rivers and beels</li> </ul>	<ul style="list-style-type: none"> <li>Allow natural cleansing of water and improve water quality</li> </ul>	BWDB, MoS, DoE, NRCC, DoF, WARPO	Annually
		<ul style="list-style-type: none"> <li>Conservation and expansion of coverage of different indigenous aquatic plants</li> </ul>	<ul style="list-style-type: none"> <li>Allow natural cleansing of water and improve overall habitat condition</li> </ul>	DoF, BFRI, DoE, BFD, LGIs, LGD	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Conservation of freshwater sanctuaries, beel nursery and breeding ground</li> </ul>	<ul style="list-style-type: none"> <li>Spawning and breeding of healthy fisheries and enhance fisheries production, boost income</li> </ul>	DoF, BFRI, NRCC, WARPO, LGIs, DoE, MoLJPA	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Ensure proper and smooth drainage of water after the floods through effective and integrated water management and operational infrastructures with fish pass</li> </ul>	<ul style="list-style-type: none"> <li>Reduce chances of water quality degradation after floods</li> </ul>	BWDB, LGED, RHED, MoS, WARPO, DoF, BFRI	Within 3 to 5 years
8	Disruption in post-harvest storage management, damage of infrastructures and communication facilities due to floods/cyclone or storm surge	<ul style="list-style-type: none"> <li>Development of climate proofed post-harvest storage management, communication infrastructures and marketing facilities in gender inclusive way</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Rehabilitation of post-harvest storage management, communication infrastructures and marketing facilities in climate resilient way</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder(s)	When to Implement
		<ul style="list-style-type: none"> <li>Climate sensitive planning and extend F&amp;A post-harvest storage facilities and relevant infrastructures</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years

The **Table 5.2** below outlines the risks related to Drought, lightning, and Heat stress on capture fisheries and gives potential adaptations and risk reduction options that should be undertaken or promoted by different stakeholders under capture fisheries.

**Table 5.2: Risk of drought, lightning, and heat stress on capture fisheries with adaptation options**

Drought, Lightning, Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
1	Low water availability and drying up of aquatic habitat during drought	<ul style="list-style-type: none"> <li>Regular dredging of all large, medium and small rivers, beels</li> </ul>	<ul style="list-style-type: none"> <li>Revitalization of rivers, beels and restoration of fisheries habitat</li> <li>Reduce aquatic ecosystem vulnerability</li> </ul>	BWDB, MoS, DoE, NRCC, DoF, WARPO	Annual and periodic
		<ul style="list-style-type: none"> <li>Maintaining connectivity of khals, beel and rivers</li> </ul>	<ul style="list-style-type: none"> <li>Revitalization of rivers, beels and restoration of fisheries habitat</li> <li>Reduce aquatic ecosystem vulnerability</li> </ul>	BWDB, MoS, DoE, NRCC, DoF, WARPO	Within 3 to 5 years
2	Rise of water temperature, algae bloom and reduction in dissolved oxygen due to heat stress	<ul style="list-style-type: none"> <li>Coverage of selective aquatic vegetation in the water body e.g. water hyacinth to improve habitat suitability and biochemical treatment of water</li> </ul>	<ul style="list-style-type: none"> <li>Establishment of selective fish sanctuaries with brush shelters.</li> </ul>	DoF, BFRI and other professional academic institute	Within 3 years and continue
3	Post-harvest storage management may get disrupted due to extreme heat and crisis of ice/cold storage facilities	<ul style="list-style-type: none"> <li>Development and rehabilitation of climate proofed post-harvest storage management, communication infrastructures and marketing facilities in gender inclusive way</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years

Drought, Lightning, Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
		<ul style="list-style-type: none"> <li>Climate sensitive planning and extend F&amp;A post-harvest storage facilities and relevant infrastructures</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years
4	Food intake behavior change, disruptions in growth & migration and increased mortality due to cold wave and excess rain	<ul style="list-style-type: none"> <li>Development of stress tolerant species, improve habitat suitability and enhance aquatic biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
5	Loss of fishermen lives due to lightning	<ul style="list-style-type: none"> <li>Strengthening Gender inclusive ICT based EWS for the Fisheries and aquaculture sector</li> </ul>	<ul style="list-style-type: none"> <li>Protect fishers' life, livelihoods and ensure social security through pre-informed early warning messages</li> </ul>	DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, Electronic, web and print media	Within 3 years
		<ul style="list-style-type: none"> <li>Installation of lightning arresters or resting sheds nearby to large open waterbodies</li> </ul>	<ul style="list-style-type: none"> <li>Protect fishers' life, livelihoods and ensure social security</li> </ul>	DoF, BFRI, LGED, LGD, MoDMR	Within 3 years
		<ul style="list-style-type: none"> <li>Awareness raising and capacity building for enhancing coping mechanism</li> </ul>	<ul style="list-style-type: none"> <li>Increase adaptive capacity and resilience, income generation activities and improve living standard</li> </ul>	DoF, BFRI, MoDMR, DSS, MoWCA, LGD, Training and Knowledge Institutes	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishermen community</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies	Within 3 to 5 years

Drought, Lightning, Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
6	Loss of livelihoods, shifting occupation and increased poverty with disproportionate impact on women	<ul style="list-style-type: none"> <li>Provide subsidies and skill development for alternative livelihoods ensuring women's participation</li> </ul>	<ul style="list-style-type: none"> <li>Reduce gender vulnerability, income loss and living standard</li> <li>Enhance adaptive capacity and resilience to combat disproportionate impacts on gender</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Training on gender and youth inclusive C&amp;DRR and EWS for fish farmers</li> </ul>	<ul style="list-style-type: none"> <li>Enhance adaptive capacity and resilience to combat climate disasters</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduction of zero interest or low interest-based credit facilities to recover disaster risk</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies, Bangladesh Banks and Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> <li>Reduce gender indiscrimination and inequality</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Provide climate resilience funds specially focusing on marginal women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs	Within 3 years and continue

### Culture Fisheries

The **Table 5.3** below outlines the risks related to cyclones, storm surges, salinity intrusion, flood, tidal flood and wave action on culture fisheries and gives potential adaptations and risk reduction options that should be undertaken or promoted by different stakeholders under culture fisheries.

**Table 5.3: Risk of cyclone, storm surges, salinity intrusion, flood, tidal flood and wave action on culture fisheries with adaptation options**

Cyclone, Storm Surge, Sea Level Rise, Salinity Intrusion, Flood, Tidal Floods & Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
1	Pond and gher dykes may get damaged and overflowing of fishes due to storm surge, floods or tidal floods or wave action	<ul style="list-style-type: none"> <li>Construction of climate proofed dykes or wave control structures or use of nets</li> </ul>	<ul style="list-style-type: none"> <li>Reduce production losses and income losses</li> </ul>	DoF, BFRI, LGED, LGIs, BWDB	Within next 3 years
		<ul style="list-style-type: none"> <li>Plantation of native species, fruit trees or vegetable farming and mangroves as natural barrier over the pond dykes</li> </ul>	<ul style="list-style-type: none"> <li>Reduce production losses and income losses</li> <li>Boost vegetable and fruit production and income</li> </ul>	DoF, BFRI, LGED, LGIs, BFD, DAE	Within next 3 years
		<ul style="list-style-type: none"> <li>Strengthening Gender inclusive ICT based EWS for the Fisheries and aquaculture sector</li> </ul>	<ul style="list-style-type: none"> <li>Protect fisheries related infrastructures and assets through pre-informed early warning messages</li> </ul>	DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, Electronic, web and print media	Within 3 years
2	Fish and fishing assets (boats, nets and gear) may get damaged due to storm surge, floods or flash floods	<ul style="list-style-type: none"> <li>Strengthening Gender inclusive ICT based EWS for the Fisheries and aquaculture sector</li> </ul>	<ul style="list-style-type: none"> <li>Protect fisheries related infrastructures and assets through pre-informed early warning messages</li> </ul>	DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, Electronic, web and print media	Within 3 years
		<ul style="list-style-type: none"> <li>Construction of storage areas for fishing tools</li> </ul>	<ul style="list-style-type: none"> <li>Protect fisheries related infrastructures and assets</li> <li>Reduce economic losses and income</li> </ul>	DoF, BFRI, LGED, LGIs, RHD, Private Sectors	Within 3 years
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies	Within 3 to 5 years

Cyclone, Storm Surge, Sea Level Rise, Salinity Intrusion, Flood, Tidal Floods & Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
			<ul style="list-style-type: none"> <li>Reduce gender discrimination and inequality</li> </ul>		
		<ul style="list-style-type: none"> <li>Provide climate resilience funds specially focusing on marginal women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs	Within 3 years and continue
3	Habitat degradation, disease outbreak, disruptions in growth, due to sea level rise, tidal floods and salinity	<ul style="list-style-type: none"> <li>Development of stress tolerant species, improve habitat suitability and enhance aquatic biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Deepening of the ponds/shrimp farms to retain water &gt;1.0 meter</li> </ul>	<ul style="list-style-type: none"> <li>Improvement of habitat condition</li> <li>Control of disease outbreak</li> <li>Increase in fish production</li> <li>Increase of income</li> </ul>	DoF, BFRI, LGIs, Academic Institutes, private sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Application of aerator for oxygenation, aqua-medicine use in the aquaculture farms</li> </ul>	<ul style="list-style-type: none"> <li>Reduce/neutralize environmental effects</li> <li>Reduce disease outbreak</li> <li>Increase fish production</li> </ul>	DoF, BFRI, LGIs, Academic Institutes	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Identify and select simultaneous cultures of fish or shellfish along with other culture systems in light of integrated fish farming (IFF)</li> </ul>	<ul style="list-style-type: none"> <li>Fish production increase</li> <li>Income increase</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia, private sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Facilitate in development and extension of stress-tolerant functional aqua-feed</li> </ul>	<ul style="list-style-type: none"> <li>Improve habitat condition</li> <li>Facilitate boosting fisheries nutrients</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Heighten dikes of freshwater retention ponds to halt salinity ingress</li> </ul>	<ul style="list-style-type: none"> <li>Safeguard fish species and production</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue

Cyclone, Storm Surge, Sea Level Rise, Salinity Intrusion, Flood, Tidal Floods & Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
		<ul style="list-style-type: none"> <li>Introduce IoT based water quality monitoring such as salinity/pH/DO/water temperature in the aquaculture farms</li> </ul>	<ul style="list-style-type: none"> <li>Secure income</li> <li>Risk informed decision making by fishermen themselves</li> <li>Reduce habitat and production loss</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia, Fishing Communities	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Pond rehabilitation to improve water quality with Urea, TSP, lime etc</li> </ul>	<ul style="list-style-type: none"> <li>Improve habitat condition</li> <li>Facilitate boosting fisheries nutrients</li> </ul>	DoF, BFRI, LGIs, , Knowledge Institutes, Academia	Within 3 years and continue
4	Mortality of fry/Juvenile of fish due to floods/flash floods or storm surge	<ul style="list-style-type: none"> <li>Extension of resilient climate technology for combating climate-related stresses in Aquaculture</li> <li>Development of stress tolerant species of commercially important fish and species diversification</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
5	Pond habitats degradation due to siltation after floods or storm surge	<ul style="list-style-type: none"> <li>Excavation or re-excavation of dighi, pond, reservoir or construction-relevant infrastructure for freshwater harvesting</li> </ul>	<ul style="list-style-type: none"> <li>Good quality, healthy and improved pond ecosystems to increase productivity and profit.</li> <li>Protect ecosystem to increase production and reduce vulnerability of the local community.</li> </ul>	DoF, BFRI, BFD, WARPO, BWDB, MoS, DoE	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Restoration of fish habitats and breeding grounds</li> </ul>	<ul style="list-style-type: none"> <li>Improve the fish habitat condition</li> </ul>	DoF, BFRI, BFD, WARPO, BWDB, MoS, DoE	Within 3 to 5 years
6	Loss of livelihoods, shifting occupation and increased poverty & internal displacement with disproportionate impact on women	<ul style="list-style-type: none"> <li>Provide subsidies and skill development for alternative livelihoods ensuring women's participation</li> </ul>	<ul style="list-style-type: none"> <li>Reduce gender vulnerability, income loss and living standard</li> <li>Enhance adaptive capacity and resilience to combat disproportionate impacts on gender</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue

Cyclone, Storm Surge, Sea Level Rise, Salinity Intrusion, Flood, Tidal Floods & Wave action					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
		<ul style="list-style-type: none"> <li>• Training on gender and youth inclusive C&amp;DRR and EWS for fish farmers</li> </ul>	<ul style="list-style-type: none"> <li>• Enhance adaptive capacity and resilience to combat climate disasters</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>• Introduction of zero interest or low interest-based credit facilities to recover disaster risk</li> </ul>	<ul style="list-style-type: none"> <li>• Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies, Bangladesh Banks and Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>• Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women</li> </ul>	<ul style="list-style-type: none"> <li>• Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> <li>• Reduce gender discrimination and inequality</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>• Provide climate resilience funds specially focusing on marginal women</li> </ul>	<ul style="list-style-type: none"> <li>• Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs	Within 3 years and continue

The **Table 5.4** below outlines the risks related to Drought, Lightning, and Heat stress on culture fisheries and gives potential adaptations and risk reduction options that should be undertaken or promoted by different stakeholders under culture fisheries.

**Table 5.4: Risk of drought, lightning, and heat stress on culture fisheries with adaptation options**

Drought, Lightning, and Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
1	Low water availability and drying up of ponds/ ghers, overall culture habitat reduction due to drought	<ul style="list-style-type: none"> <li>Regular dredging of all connected river reaches with fish farms or ponds</li> </ul>	<ul style="list-style-type: none"> <li>Revitalization of rivers, beels and restoration of fisheries habitat</li> <li>Reduce aquatic ecosystem vulnerability</li> </ul>	BWDB, MoS, DoE, NRCC, DoF, WARPO	Annual and periodic
		<ul style="list-style-type: none"> <li>Digging or excavation of ponds/dighi or reservoirs to store more water</li> </ul>	<ul style="list-style-type: none"> <li>Reduce salinity and disruptions in migrations</li> </ul>	MoWR, NRCC, LGED, MoS, WARPO, JRC	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Identification of vulnerable fish farms in respect of water availability and arrange for irrigation measures</li> </ul>	<ul style="list-style-type: none"> <li>Reduce climate risks due to drought</li> </ul>	DoF, BFRI, LGIs, MoWR, BMDA, DAE	Within 3 years and continue
2	Rise of water temperature, algae bloom, reduction in dissolved oxygen and reduced fish production due to heat wave	<ul style="list-style-type: none"> <li>Development of stress tolerant species</li> <li>Improve habitat suitability and enhance aquatic biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
3	Occurrence of death for fry/Juvenile of fish due to extreme heat or cold	<ul style="list-style-type: none"> <li>Extension of resilient climate technology for combating climate-related stresses in Aquaculture</li> <li>Development of stress tolerant species of commercially important fish and species diversification</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue
4	Food intake behavior change, disruptions in growth & migration and increased mortality due to cold wave and excess rain	<ul style="list-style-type: none"> <li>Development of stress tolerant species, improve habitat suitability and enhance aquatic biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction</li> </ul>	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue

Drought, Lightning, and Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
5	Post-harvest storage management during extreme heat	<ul style="list-style-type: none"> <li>Development and rehabilitation of climate proofed post-harvest storage management, communication infrastructures and marketing facilities in gender inclusive way</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Climate sensitive planning and extend F&amp;A post-harvest storage facilities and relevant infrastructures</li> </ul>	<ul style="list-style-type: none"> <li>Reduce post-harvest losses and economic losses</li> <li>Reduce recurrent cost of government for O&amp;M</li> </ul>	LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD	Within 3 to 5 years
		<ul style="list-style-type: none"> <li>Construction of sheds over the ponds or ghers</li> </ul>	<ul style="list-style-type: none"> <li>Protection of fisheries and reduce production losses</li> </ul>	DoF, BFRI, LGD, LGED, LGIs, Private Sectors	
6	Loss of livelihoods, shifting occupation and increased poverty & internal displacement with disproportionate impact on women	<ul style="list-style-type: none"> <li>Provide subsidies and skill development for alternative livelihoods ensuring women's participation</li> </ul>	<ul style="list-style-type: none"> <li>Reduce gender vulnerability, income loss and living standard</li> <li>Enhance adaptive capacity and resilience to combat disproportionate impacts on gender</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Training on gender and youth inclusive C&amp;DRR and EWS for fish farmers</li> </ul>	<ul style="list-style-type: none"> <li>Enhance adaptive capacity and resilience to combat climate disasters</li> </ul>	DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduction of zero interest or low interest-based credit schemes to recover from disaster risks</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of fishers to recover from any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, NGOs, Insurance companies, Bangladesh Banks and Private Sectors	Within 3 years and continue
		<ul style="list-style-type: none"> <li>Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies	Within 3 to 5 years

Drought, Lightning, and Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
			<ul style="list-style-type: none"> <li>Reduce gender discrimination and inequality</li> </ul>		
		<ul style="list-style-type: none"> <li>Provide climate resilience funds specially focusing on marginal women</li> </ul>	<ul style="list-style-type: none"> <li>Improve financial stability of women to recover any losses incurred from damages due to climate hazards</li> </ul>	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs	Within 3 years and continue

### Gender

The **Table 5.5** below outlines the risks related to drought, lightning and heat stress on culture fisheries and gives potential adaptations and risk reduction options that should be undertaken or promoted by different stakeholders under culture fisheries.

**Table 5.5: Risk on women with adaptation options**

ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
1	Lack of awareness, empowerment and capacity building	<ul style="list-style-type: none"> <li>Arrangement for awareness building on Climate change and its impacts</li> <li>Training on optimum usage of resources for homestead and livelihoods development</li> </ul>	<ul style="list-style-type: none"> <li>Improving Capacity on CCA</li> <li>Improving knowledge on CCA</li> <li>Ensure empowerment and access to resources</li> <li>Improving knowledge on CCA</li> <li>Resilient Livelihoods and Infrastructures</li> <li>Improving Capacity on CCA</li> </ul>	DoF, MoWCA, NILG, MoLGRDC and MoSW with relevant organizations/institutes, CBO, NGOs, CSOs	Before and After Disaster

ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
		<ul style="list-style-type: none"> <li>• Training on safety and security management of livelihood and homestead for pre, during and after disasters</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure empowerment and access to resources</li> </ul>		
		<ul style="list-style-type: none"> <li>• Training on handling the necessary tech-based devices for ensuring early warning</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure empowerment and access to resources</li> </ul>		
2	Lack of infrastructure dedicated for women	<ul style="list-style-type: none"> <li>• Training on Understanding the necessity of using civic facilities during disaster</li> </ul>	<ul style="list-style-type: none"> <li>• Understanding the necessity of using civic facilities during disaster</li> </ul>	DoF, MoWCA, MoLGRDC, MoSW, NILG with relevant organizations/institutes, CBO, NGOs, CSOs	Before and After Disaster
		<ul style="list-style-type: none"> <li>• Training on management of civic facilities in emergencies during disaster</li> </ul>	<ul style="list-style-type: none"> <li>• Capacity building on the management of these civic facilities in emergencies during disaster</li> </ul>		
		<ul style="list-style-type: none"> <li>• Building cyclone shelter with separate accommodation, hygiene and WASH facilities for women</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure mobility and accessibility to the cyclone and flood centre</li> <li>• Reducing gender base violence during and post disaster period</li> </ul>		
		<ul style="list-style-type: none"> <li>• Construction of separate market shed for women</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure accessibility to the market and Growth Centre</li> <li>• Ensuring safety - security during and post disasters</li> </ul>		
3	Disasters hampering income generating activities	<ul style="list-style-type: none"> <li>• Creation of alternative IGAs and training on IGAs for livelihood management due to impact of disaster</li> </ul>	<ul style="list-style-type: none"> <li>• Ensuring support in livelihood during disasters</li> <li>• Ensuring sustainability of income and livelihood</li> </ul>	MoWCA, DoF, DDM, MoSW, DYD, NILG, CreLIC, CBOs, NGOs and CSOs.	During and after Disaster
		<ul style="list-style-type: none"> <li>• Training on IGAs with diseases management of livestock and poultry products</li> </ul>	<ul style="list-style-type: none"> <li>• Ensuring support in livelihood during disasters</li> <li>• Ensuring sustainability of income and livelihood</li> </ul>		
		<ul style="list-style-type: none"> <li>• Training on cow fattening and multi farming approach</li> </ul>	<ul style="list-style-type: none"> <li>• Ensuring support in livelihood during disasters</li> </ul>		

ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
			<ul style="list-style-type: none"> <li>Ensuring sustainability of income and livelihood</li> </ul>		
4	Violence and accidental occurrences towards women	<ul style="list-style-type: none"> <li>Required training for emergency response team from Community, NGOs and GOs Level</li> <li>Training on handling the gender sensitive issues during disaster and post disaster</li> </ul>	<ul style="list-style-type: none"> <li>Stopping violence and accidental occurrence during and after disaster period</li> </ul>	MoWCA, DoF, DDM, MoSW, DYD, NILG, CreLIC, CBOs, NGOs and CSOs.	During and after Disaster
5	Inadequate lead time in early warning	<ul style="list-style-type: none"> <li>Instant and direct dissemination of early warning to women staying at home</li> <li>Transmitting early warning through digital medium i.e mobile SMS, megaphone announcement etc.</li> </ul>	<ul style="list-style-type: none"> <li>Safe evacuation before disaster</li> <li>Protection of livestock and property</li> <li>Safe evacuation before disaster</li> <li>Protection of livestock and property</li> </ul>	DoF, BMD, FFWC, DDM	Before and during Disaster

## 6 Conclusions and Recommendations

This study assessed the key risks and vulnerabilities of the F&A sector, specifically the fishers' livelihoods, with a special focus on gender and aquatic ecosystem in the project area of Dacope Upazila through a comprehensive assessment. Blended participatory appraisal techniques such as FGDs, KIIs, and representative community surveys; scientific analysis based on the latest available data and information are utilized for the assessment. The assessed risk and vulnerabilities are mapped through geospatial analysis following the indicator-based approach of the approved CRVA framework for the F&A sector in Bangladesh. Impact chains analyses for capture fisheries, culture fisheries, aquatic ecosystems, and gender-based F&A livelihoods were used to prioritize indicators, collect data through a participatory and scientific approach, and then did a weighted aggregation of multiple indicators using geospatial tools. The risk and vulnerability maps were prepared following risk severity or vulnerabilities for each of the unions of the Dacope Upazila. In situ and laboratory tests of rivers and ponds/ghers were performed, followed by the SWOT analysis of ecosystem services to analyze the climate sensitivity of aquatic ecosystems.

Cyclone, coastal flooding, saline water intrusions, river bank erosion, sea level rise and drought were found to have severely affected the people lives in this region. The region experiences cyclone accompanied with high storm surge almost every year which inundates ponds and fish farms. Fish farmers in Dacope Upazila are faced with a number of difficulties as a result of the dramatic increase in perceived temperature in the south-western region, most notably significant decrease in water oxygen as well as various viral, bacterial, and fungal infections. Additionally, the natural mortality rate has been increasing with increasing hot days and other climatic hazards. Climate change sets to increase the frequency of lightning strikes which affects the spawning and breeding of fisheries as well. During the dry/drought period, ponds, rivers, canals, and beels dry up or retain insufficient water, affecting fishing production in open water systems in some localities of Dacope Upazila. Fish and/or other aquatic species migration, reproduction, and growth are also being impacted by the drought conditions usually experience in the area.

From risk assessment, all unions except Tiladanga, Laudubi and Kailashganj unions were in high risk zone in the base period and will likely continue to remain the same in 2050s along with Tiladanga union for capture fisheries. For Culture Fisheries, Tiladanga union was in high risk for both base period and 2050s. The SWOT analysis shows that the river ecosystem has more opportunities and strengths than the pond ecosystem, because its buffer areas are characterized by natural land-cover types and less land-use changes. The results also draw attention to the weaknesses of the pond/fish gher ecosystem, which are more threatened by urbanization and intensification of shrimp farming.

A climate resilience action plan has been prepared following the principles of the climate resilience framework; ecosystem approaches to fisheries and aquaculture. Community preferences of actions for climate risk reduction are considered for the resilience action plan. Key stakeholders were mapped to implement the action plan. Necessary capacity development initiatives and institutional management measures are suggested to boost the motivation of stakeholders to implement locally-led resilience action plan of the Dacope Upazila smoothly. Different ecosystem-based adaptation options, technical/financial incentives, and alternative livelihood generation for fishermen required policy reforms or nonstructural solutions like human skill development and capacity building of institutions are considered under this plan. Particular emphasis is given to creating an enabling environment for women's participation in the climate adaptation process for the F&A, raising women's voices from the micro level to the macro level, creating gender-specific disaster risk reduction policies, and promoting women's empowerment through capacity building to combat pre, during and post-disaster period. Implementing the locally-led climate resilience action plan would significantly reduce the risk and vulnerabilities of climate change and build resilience for F&A-based livelihood, women fishers, and climate-sensitive aquatic ecosystems. The fisheries and aquaculture production would be revamped in the region, and sustainable economic development will be achieved.

Collection of union-wise data and information for different indicators of risk, vulnerabilities, and adaptive capacities, and particularly, sex, age, and disability-specific F&A data for each of the unions within the given limited resources were major challenges and limitations of the study. Although the study consulted with multiple respondents from the fisheries and fisheries-related communities residing in 2-3 vulnerable unions and organizations in the Dacope Upazila, consultations and validation in each of the unions would improve the study outcome. Further, a comprehensive assessment of such information may improve the study outcome, making it more specific and locally evidence-based, which may be undertaken in the future considering the fundamental and unique framework developed in this study.

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## Glossary

Adaptation strategy	An adaptation strategy is a program, project or approach that has been developed to respond to anticipated climate change impacts in a specific area of potential concern.
Adaptive capacity	The general ability of institutions, systems, and individuals to adjust to potential damage, to take advantage of opportunities, or to cope with the consequences.
Aquaculture	Aquaculture is the farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants. Aquaculture occurs in both inland (freshwater) and coastal (brackish water, seawater) areas.
Aquatic ecosystem	A water-based environment, wherein, living organisms interact with both physical and chemical features of the environment.
Biodiversity	Biological diversity means the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (UN, 1992)
Biomass	The total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass. The quantity of biomass is expressed as a dry weight or as the energy, carbon or nitrogen content.
BOD	Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed (i.e., demanded) by aerobic biological organisms to break down organic material present in a given water sample at a certain temperature over a specific period.
Capture fisheries	Capture fishery refers to harvesting naturally occurring living resources in both marine and freshwater environments.
Climate change	Climate change refers to any change over time, whether due to natural variability or due to human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods.
Climate Change Adaptation	Climate change adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.
Climate change impacts	The effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health status, ecosystems, economic, social and cultural assets, services (including environmental) and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific period and the vulnerability of an exposed society or system.
Climate change risk	The potential for climate change impacts where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as the probability of occurrence of hazardous climate events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability and hazard.

Climate sensitivity	Climate sensitivity refers to the change in the annual global mean surface temperature in response to a change in the atmospheric CO <sub>2</sub> concentration or other radiative forcing.
Climate vulnerability	The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and the variation to which a system is exposed, its sensitivity and its adaptive capacity.
COD	Chemical oxygen demand (COD) is the amount of oxygen needed to oxidize the organic matter present in water.
Community based Organization	Community-based organization means a public or private nonprofit organization of demonstrated effectiveness that— is representative of a community or significant segments of a community; and provides educational or related services to individuals in the community.
Culture fisheries	Culture fisheries is the cultivation of selected fishes in confined areas with utmost care to get maximum yield.
Disaster	Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.
Disaster risk reduction (DRR)	Disaster risk reduction is aimed at preventing new and reducing existing disaster risks and managing residual risks, all of which contributes to strengthening resilience and therefore to the achievement of sustainable development.
Early warning systems (EWS)	The set of technical, financial and institutional capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss. Dependent upon context, EWS may draw upon scientific and/or Indigenous knowledge. EWS are also considered for ecological applications e.g., conservation, where the organization itself is not threatened by hazard but the ecosystem under conservation is (an example is coral bleaching alerts), in agriculture (for example, warnings of ground frost, hailstorms) and in fisheries (storm and tsunami warnings). [UNISDR (2009)]
Ecologically Critical Area	Areas or ecosystems affected adversely or endangered to reach a critical condition by the changes brought through various human activities.
Ecosystem services	Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food or fiber, (3) regulating services such as climate regulation or carbon sequestration, and (4) cultural services such as tourism or spiritual and aesthetic appreciation.
Epizootic Ulcerative Syndrome	Epizootic ulcerative syndrome (EUS) is considered to be an infection with the oomycete known as <i>Aphanomyces</i> invades.
Equity	A principle that ascribes equal worth to all human beings, including equal opportunities, rights, and obligations, irrespective of origins.
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected. See also Hazard, Risk and Vulnerability.
Gender	Gender refers to the characteristics of women, men, girls and boys that are socially constructed. This includes norms, behaviors and roles associated with being a woman, man, girl or boy, as well as relationships with each other.

Global Circulation Model	Global Circulation Model (GCM) is a model that simulates general circulation of planetary atmosphere or oceans. The term general circulation is used to indicate large-scale atmospheric or oceanic motions with its persistent as well as transient features on various scales.
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.
Land use	Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation and city dwelling). In national greenhouse gas inventories, land use is classified according to the IPCC land use categories of forest land, cropland, grassland, wetland, settlements, other.
Livelihood	The resources used and the activities undertaken in order to live. Livelihoods are usually determined by the entitlements and assets to which people have access. Such assets can be categorized as human, social, natural, physical or financial.
Mean Sea Level	Mean Sea Level (MSL) is the datum for measurement of elevation and altitude. Mean Sea Level is the equipotential surface of the Earth as described by the World Geodetic System.
Muriate of Potash	Potassium Chloride (KCl) used chiefly of fertilizer grades.
Resilience	The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation.
Risk assessment	The qualitative and/or quantitative scientific estimation of risks.
Sensitivity	The degree to which climate variability or change affects a system or species adversely or beneficially. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).
Total Dissolved Solids	Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form.



## Annex I: CRVA framework and selected indicators

### CRVA Framework

Steps	Activities	Agenda	National Level	Local Level
1	Preparing the CRVA	<ul style="list-style-type: none"> <li>Understand context of CRVA, define objectives and possible outcome</li> <li>Define scope (sector, topic), extent (geographic level or vertical level) and timeframe (current and future)</li> <li>Assess resources and stakeholders' involvement requirement</li> <li>Stock take available information</li> <li>Prepare implementation plan</li> </ul>	<ul style="list-style-type: none"> <li>Capture and Culture Fisheries</li> <li>CRVA on Fisheries Livelihood and Ecosystem</li> <li>Base (2000s) and Future (2050s and 2085s)</li> <li>Climate Change Scenarios (SSP1-2.6 and SSP5-8.5)</li> <li>Up to district level</li> <li>Separate assessment for selected 6 regions</li> <li>National level stakeholders</li> <li>Review and stock take</li> </ul>	<ul style="list-style-type: none"> <li>Capture and Culture Fisheries</li> <li>CRVA on Fisheries Livelihood and Fish Ecosystem</li> <li>Base (2000) and Future (2050s and 2085s)</li> <li>Climate Change Scenarios (SSP1-2.6 and SSP5-8.5)</li> <li>Up to union level</li> <li>Separate assessment for each project site or Upazila</li> <li>Local level stakeholders, community and gender</li> <li>Review and stock take</li> </ul>
2	Developing Impact Chains	<ul style="list-style-type: none"> <li>Identify climate impacts and risks affecting the system</li> <li>Determine hazards (climate signal and direct impacts) and intermediate impacts</li> <li>Determine vulnerability (i.e. sensitivity and lack of adaptive capacity which are contributing to risk)</li> <li>Determine exposures or elements at risk</li> <li>Brainstorm adaptation measures to reduce the risk</li> </ul>	<ul style="list-style-type: none"> <li>Brainstorming among study team experts based on draft NCVA impact chain</li> <li>Develop initially conceptualized impact chain for selected 6 regions and as per defined scope for F&amp;A</li> <li>Identify recommended adaptation measures including Ecosystem based Adaptation (EbA) considering gender inclusion and sustainable livelihoods</li> <li>Share with relevant stakeholders and client</li> <li>Get feedback and assign weights of identified CRVA elements through Budget Allocation Approach</li> <li>Finalise the impact chain for next step</li> </ul>	<ul style="list-style-type: none"> <li>Bring the national level impact chain for the respective region under which project site located</li> <li>Conduct FGDs, KIIs and Community Survey</li> <li>Update or modify the impact chain including the weight through Budget Allocation Approach</li> <li>Identify recommended adaptation measures including EbA considering gender inclusion and sustainable livelihoods</li> <li>Compile Field based Outcome</li> <li>Brainstorming among study team experts</li> <li>Finalise the impact chain for each project site</li> </ul>

Steps	Activities	Agenda	National Level	Local Level
3	<b>Identifying and Selecting Indicators</b>	<ul style="list-style-type: none"> <li>• Select indicators for hazards</li> <li>• Select indicators for vulnerability and exposure based on functional relationship with risk</li> <li>• Identify proxy indicators, if any</li> <li>• List all indicators and discard redundant or repeated indicators for same CRVA components</li> </ul>	<ul style="list-style-type: none"> <li>• Compiling data and information availability</li> <li>• Selecting indicators of CRVA components based on data and information availability at desired level from secondary sources</li> <li>• Identify proxy indicators</li> <li>• Deduct redundant data</li> </ul>	<ul style="list-style-type: none"> <li>• Compiling data and information availability from FGDs, KIIs and Community Survey, Water Quality test</li> <li>• Selecting indicators of CRVA components based on data and information availability at desired level from both secondary and primary sources</li> <li>• Identify proxy indicators</li> <li>• Deduct redundant data</li> <li>•</li> </ul>
4	<b>Data Acquisition and Management</b>	<ul style="list-style-type: none"> <li>• Data collection, database construction and linking relevant data to chosen indicators</li> </ul>	<ul style="list-style-type: none"> <li>• Data collection and processing</li> <li>• Gender disaggregation which are possible</li> <li>• Threshold or intensity identification from trend, frequency and indices analysis</li> <li>• Climate data downscaling for each region for future projections from CORDEX CMIP5 datasets for South Asia along with national level projections from recent CMIP6 dataset.</li> <li>• Land cover or water bodies change assessment</li> <li>• Inventory preparation with unit for each indicator</li> </ul>	<ul style="list-style-type: none"> <li>• Data collection and processing</li> <li>• Gender disaggregation which are possible</li> <li>• Threshold or intensity identification from trend, frequency and indices analysis through both secondary sources and using feedback from local stakeholders and community</li> <li>• Climate data downscaling for each region for future projections from CORDEX CMIP5 datasets for South Asia along with national level projections from recent CMIP6 dataset.</li> <li>• Land cover or water bodies change assessment</li> <li>• Inventory preparation with unit for each indicator</li> </ul>
5	<b>Normalisation of Indicator Data</b>	<ul style="list-style-type: none"> <li>• Transfer different data sets into unit-less values on a common scale (i.e., 0 to 1) based on functional relationship and standard normalisation formula</li> </ul>	<ul style="list-style-type: none"> <li>• Normalisation of indicator data based on functional relationship</li> </ul>	<ul style="list-style-type: none"> <li>• Normalisation of indicator data based on functional relationship</li> </ul>
6	<b>Weighting and Aggregating of Indicators to CRVA Components</b>	<ul style="list-style-type: none"> <li>• Assign weights to the various indicators</li> <li>• Arithmetic aggregation indicators to CRVA components</li> </ul>	<ul style="list-style-type: none"> <li>• Assign weights derived from Impact Chain Finalisation workshop</li> <li>• Geo-spatial weighted arithmetic aggregation using GIS</li> </ul>	<ul style="list-style-type: none"> <li>• Assign weights derived from FGDs, KIIs and based on National level impact chain of that region</li> <li>• Geo-spatial weighted arithmetic aggregation using GIS</li> </ul>

Steps	Activities	Agenda	National Level	Local Level
			<ul style="list-style-type: none"> <li>Estimate total score of each CRVA components i.e. for hazard, exposure and vulnerability</li> </ul>	<ul style="list-style-type: none"> <li>Estimate total score of each CRVA components i.e. for hazard, exposure and vulnerability</li> </ul>
7	<b>Aggregating of CRVA Components</b>	<ul style="list-style-type: none"> <li>Assign weight and arithmetic aggregation of vulnerability components (i.e., adaptive capacity and sensitivity)</li> <li>Assign weight and arithmetic aggregation of CRVA components i.e., among hazards, exposure and vulnerability</li> <li>Estimate the total CRVA score and normalise the score again to single value (0 to 1)</li> </ul>	<ul style="list-style-type: none"> <li>Assign weight among CRVA components derived from impact chain finalisation workshop</li> <li>Geo-spatial weighted arithmetic aggregation using GIS</li> <li>Estimate total score and normalise the CRVA score</li> </ul>	<ul style="list-style-type: none"> <li>Assign weights derived from FGDs, KIIs and based on National level impact chain of that region</li> <li>Geo-spatial weighted arithmetic aggregation using GIS</li> <li>Estimate total score and normalise the CRVA score</li> </ul>
8	<b>Presenting the Outcomes of CRVA</b>	<ul style="list-style-type: none"> <li>Summarise and present the findings of CRVA in maps using GIS and graphs (spider, pie or bar chart)</li> <li>List down possible adaptation measures to reduce climate risk and vulnerability</li> </ul>	<ul style="list-style-type: none"> <li>CRA maps for current and future for each selected region showing spatial variation up to District Level</li> <li>Separate maps for Capture and Culture Fisheries highlighting gender perspectives</li> <li>CRV map for fishery ecosystem</li> <li>List of potential recommendations for adaptation measures</li> <li>Validating the outcome of CRVA with stakeholders</li> <li>Update (if necessary) and publish the finalised CRV maps</li> </ul>	<ul style="list-style-type: none"> <li>CRV maps for current and future for each project site or Upazila showing spatial variation up to Union level</li> <li>Separate maps for Capture and Culture Fisheries highlighting gender perspectives</li> <li>CRV map for fishery ecosystem</li> <li>List of potential recommendations for adaptation measures</li> <li>Validating the outcome of CRVA with stakeholders</li> <li>Update (if necessary) and publish the finalised CRV maps</li> </ul>

*Selected indicators of impact chain*

Hazard indicators used for Project Level Climate Change Risk and Vulnerability Assessment at Dacope Upazila

	Factor	Indicator
<b>Hazard</b>	Salinity intrusion	Salinity Concentration
	Heat wave	Extreme temperature days( >36°C)
	Drought/ Less availability of Water	Successive non rainy days
	Flood/Tidal Flood	Inundation Depth and Tide Ingress
	Siltation	Channel Connectivity
	Storm Surge	Inundation Depth
	Thunderstorm	Frequency /Intensity/Injuries
	Flash Flood	Timing of Flash Flood
	Wave action	Wave Action/Wind Direction
	Fog	Number of Foggy Days
	Low Temperature	Number of Cold Days (<10°C)

Exposure indicators used for Project Level Climate Change Risk and Vulnerability Assessment at Dacope Upazila

Indicators excluded in CRVA

	Factor	Indicator	
<b>Culture Fisheries</b>	Culture Type	Fishing Culture Pattern and Abundance or Production per Species	
	Shrimp/ Prawn Culture	Production	
	Fishermen	Number/Percentage of Fishermen (between aged 14-60 years)	
	Marginal Fishermen	Number/Percentage of Poor Fishermen	
	Women	Percentage of Women involved in fishing	
	Hatchery	Presence (Density/Location/Number) of hatchery	
	Fish Farm		Presence (Density/Location/Number) of fish pond
			Presence (Density/Location/Number) of fish farm
	Post-harvest Infrastructure (transport, market etc.)	Presence (Density/Location/Number) of post-harvest infrastructure	
<b>Capture Fisheries</b>	Number and composition of fish species (Hilsa, Brackish water species)	Number/abundance of species	
	Endangered and Threaten species	Number/abundance of endangered/threatened species	
	Fish migratory route	Change in migratory route	
	Regional fish species	No of Species	

	Factor	Indicator
	No. of Fishers	Number/Percentage of Fishermen (between aged 14-60 years)
	Number of marginal Fishers	Number/Percentage of Poor Fishermen
	Women Participation	Percentage of Women involved in fishing
	Post-harvest infrastructure (transport, market etc.)	Presence of post-harvest infrastructure
Ecosystem	Flora	Number/abundance/composition of species
	Fauna	Number/abundance of endangered/threatened species
	Habitat	Density of aquatic habitat area
	ECAs	Presence/Density of ECAs
	PAs	Presence/Density of PAs

Sensitivity indicators used for Project Level Climate Change Risk and Vulnerability Assessment at Dacope Upazila

Indicators excluded in CRVA

	Factor	Indicator	
Culture Fisheries	Unfavorable soil condition	Soil Nutrient Content	
	Unfavorable aquatic condition	Water quality (pH, TDS, DO, BOD, COD, N2O, Temperature)	
	Fish Disease	Type of disease occurring	
	Fish Growth		Fish Growth Rate
			Fish Size
	Mortality Rate	Mortality Rate	
	Low resistance to Salinity	Fish Growth/Avoidance rate in higher salinity concentration	
Low resistance to Temperature	Fish Growth/Avoidance rate in higher temperature		
Capture Fisheries	Unfavorable soil condition	Soil Nutrient Content	
	Unfavorable aquatic condition	Water quality (pH, TDS, DO, BOD, COD, N2O, Temperature, Depth, Flow, Velocity etc.)	
	Fish Disease	Type of disease occurring	
	Fish Growth		Fish Growth Rate
			Fish Size
	Mortality Rate	Mortality Rate	
	Low resistance to Salinity	Fish Growth/Avoidance rate in higher salinity concentration	
Low resistance to Temperature	Fish Growth/Avoidance rate in higher temperature		
Ecosystem	Habitat Condition	Soil condition (Soil Nutrient Content)	
		Water Quality ((pH, TDS, DO, BOD, COD, N2O, Temperature, Depth, Flow, Velocity etc.)	

	Factor	Indicator
	Community Composition	No of Species/Abundance of species
	Reproductively	Reproduction rate
	Ecosystem Services	Ecosystem Services Harnessed/Disrupted
	Water resources conservation	Presence/Number of functional water resources management structures (regulator, sluices, culverts etc.)
	Water infrastructure management	Presence of WMG in community
	Monitoring and evaluation	Number of monitoring program

Adaptive Capacity indicators used for Project Level Climate Change Risk and Vulnerability Assessment at Dacope Upazila

Indicators excluded in CRVA

	Factor	Indicator
Culture Fisheries	Awareness Raising Program on CC	Number of Awareness Program on CC/literacy rate
	Training/Education on CC Impact and Adaptation	Number of Training/Education Received on Climate Change
	Advanced fishing gear/material use	Number/Density of Mechanized boats /Nets
	Use of RAS and Bio floc	Practice/Coverage of RAS and Bio floc
	Functional ETP	Number of Functional ETP Plants
	Quality fish Stocking	Number/Density of HYV Breeding Farm/Hatchery
	Proper leasing framework	Presence of lease framework
	Number of markets	Number of Fish Market
	Storage Facilities	Number/Density of Storage Facilities/Cold Storage
	Opportunities for Dry Fish Processing	Dry Fish Production
	Fish Feed Production	Production per capita Fishermen/Farm
	Road Connectivity to Markets/Landing sites	Density of Road
	Availability of freezer van	No of Van Available/transport index
	Climate Information Services (EWS)	Coverage of CIS/EWS
	E-Commerce	Involvement in E-Commerce by Fishermen
	Water Resources Management	Presence/Number of functional water resources management structures (regulator, sluices, culverts etc.)
Availability of fish pass/fish friendly structure/fish pass	Number/Density of Fish Pass	
Capture Fisheries	Awareness Raising Program on CC	Number of Awareness Program on CC
	Training/Education on CC Impact and Adaptation	Number of Training/Education Received on Climate Change
	Advanced fishing gear/material use	Number/Density of Mechanized boats /Nets
	Functional ETP	Number of Functional ETP Plants
	Proper leasing framework	Presence of lease framework

	Factor	Indicator
	Fishing Ban season	Number of adequate ban days
	Subsidies for fishermen	Availability of subsidies (PES/BPP) program
	Number of markets	Number of Fish Market
	Storage Facilities	Number/Density of Storage Facilities/Cold Storage
	Opportunities for Dry Fish Processing	Dry Fish Production
	Road Connectivity to Markets/Landing sites	Density of Road
	Availability of freezer van	No of Van Available
	Climate Information Services /(EWS)	Coverage of CIS/EWS
	E-Commerce	Involvement in E-Commerce by Fishermen
	Water Resources Management	Presence/Number of functional water resources management structures (regulator, sluices, culverts etc.)
	Availability of fish pass/fish friendly structure/fish pass	Number/Density of Fish Pass
Ecosystem	Low species richness	Abundance of Species
	Loss of ecosystem	Ecosystem Services Harnessed/Disrupted
	Resistance to Salinity	Aquatic species growth/avoidance rate in higher salinity concentration
	Resistance to Temperature	Aquatic species growth/avoidance rate in higher temperature
	Provisions for Nature Conservation	Number/Area of reserved wetland/sanctuary/ECAs
	Monitoring and Enforcement	Number of monitoring/patrolling/enforcement program
	Water Resources Management	Presence/Number of functional water resources management structures (regulator, sluices, culverts etc.)
	Availability of fish pass/fish friendly structure/fish pass	Number/Density of Fish Pass
	Weak ecosystem management practices	Number of Awareness Program on CC



## Annex II: SWOT analysis of aquatic ecosystem

### SWOT scoring and outcomes for River ecosystem

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Provisioning	Water availability	2.3	1.5	1.75	1.5	The strength of water availability received high score due to better condition of availability of optimum water in the dry season good water retention time and diversified water use when water stays sweet for six months after monsoons. Weakness scores medium condition because of good surrounding hydrological system and low sandy bed materials but the main delicacy is channel connectivity is lost due to siltation. There are good opportunities to increase water availability through dredging or re-excavation practices and community-based management. Moderate levels of encroachment and plan of upstream development are the main threats that score medium but the overuse or extraction of water is low due to salinity.
	Water quality	2	2	1.3	2	Water quality received a medium score for strength as the Optimum Physio-Chemical Parameters (Temperature, DO, TDS, pH) from the field test are good for water quality but due to salinity water cannot be used for multipurpose for 6 months when the water salt concentration changes to high levels so, for salinity increases, weakness of water quality is scored medium. However, EbA interventions for dust management and the presence of law enforcement and co-management are good opportunities for water quality improvement but the presence of functional ETP is absent there so, the opportunities received medium scores. Extreme heat and drought due to climate change are the main threats to water quality. Moreover, chemicals and pesticides used in surrounding crop field and fish gher causes the water quality more vulnerable so threats scored medium here

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Soil quality	2	2	2.33	2	The strength of soil quality is scored medium as the optimum soil nutrients is in good condition due to the mangrove forest. The weakness of the soil quality scored medium due to presence of ordinary peat soil which is a very soft soil with low shear strength and high compressibility exists in an unconsolidated state. Soil is also polluted by anthropogenic activities. Opportunities for soil quality improve assigned high scores because of increasing forest and vegetation coverage. There are medium threats to soil quality as chemicals and pesticides used in surrounding crop field and fish gher and waste dumping by local peoples.
	Primary productivity	2.33	1	2.33	2	Availability of high plankton because of Sundarbans, good sediment retention, export and floodplain fertility provide high strength scores for primary productivity. Weakness for primary productivity scores low as less time is needed to restore plankton and aquatic vegetation after disasters because of ecosystems inherent capacities such as availability of seedlings and gene flow. Opportunities for primary productivity get high scores because of increasing forest, vegetation coverage and EbA interventions. However, Threats scored medium due to unsustainable harvest of the ecosystem resources.
	Fish diversity, community dynamics and production	2.66	1	1.5	1.75	This indicator received highest scored for strengths as water for integrated use for fishery and nature is sufficient and water quality is suitable for soil and saline water fisheries. Moreover, primary productivity is high. Weakness is scored low due to good water retention capacity and less time needed to regenerate primary productivity. Presence of green coverage is good, fishing ban period is applied, community-based activities is active which are good opportunities and received medium score. Frequent climate extreme event are the main threats to fish diversity, community dynamics and production. However, Limited access to climate and hydrology information also a big threat and received moderate score

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
<b>Regulating</b>	Ground recharge water	2	2	1	1.5	The strength for ground water recharge is moderate because of low sandy soil type and high vegetation coverage. Clay soil type is the main weakness and scored medium here due to low water holding capacity. As this is a natural ecosystem so there are few opportunities for ground water recharge. Main threats are unsustainable use of forest and poor management of domestic waste which is scored moderate.
	Waste treatment water	2.5	1.5	1.75	1.6	The strength of waste water treatment received highest score due suitable condition of aquatic vegetation and presence of molluscs. Weakness scores medium condition because of average dense turbidity. Presence of co-management, awareness of the role of ecosystem for climate resilience and law enforcement are good opportunities for this indicator and received medium scores. Poor management of domestic waste and increased dependence on forests are the main threats that scored medium.
	Soil fertility	2.5	1	1.4	1.5	Strength for soil fertility scored highest as existing biodiversity makes the soil fertile by decomposing organic materials which provide suitable habitat. So, the weakness gets poor score. Opportunities for soil quality improve assigned good scores because of increasing forest and vegetation coverage and sustainable management. Presence of embankment and agro-chemicals use in the surrounding gher are the main threats to soil fertility which scored medium.
	Water retention capacity	2.5	2	2	1.3	Water retention and conveyance capacity is good and strength for this indicators scored high though siltation is the greatest weakness and received moderate score. There are average opportunities for dredging and new hydrological connection so it scored medium. Presence of embankment and poor deforestation slightly disrupt water retention so the threats scored lowest.
<b>Cultural</b>	Recreation and tourism	2.3	1.5	2	1.5	High resource availability, scenic beauty and sustainable management provide satisfying score for cultural services but the main weakness is ecotourism is not so planned and lack sustainable management which received moderate score. Opportunities received good score for community based livelihood. The main threats are environmental pollution by the tourist and overexploitation of resources which received an average score.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Supporting	Ground water replenishment	2	2	1	2	The strength for ground water replenishment is moderate because of low sandy soil type and good vegetation coverage. Clay soil type is the main weakness and scored medium here due to low water holding capacity. As this is a natural ecosystem so there are few opportunities for groundwater recharge which received less score. Main threats are management of domestic waste and unplanned urbanization which is scored moderate.
	Nutrient cycling	3	1	3	1	Nutrient cycling gets highest score due to existing biodiversity which makes the soil fertile by decomposing organic materials and enrich nutrients to the soil. So, the weakness gets poor score. Opportunities for nutrient cycling received highest score because of increasing forest and vegetation coverage and sustainable management. Disasters and encroachments are the main threats for nutrients cycling which received poor scores.
	Maintenance of floodplain fertility	2.5	2	2	1.5	The strength of this indicator received maximum score because floodplains are highly fertile as sediment is rich in organic matter and nutrients. Floodplains are home to some of the most biologically rich habitats on Earth. They provide opportunities of spawning grounds for fish and critical areas of rest and foraging for migrating waterfowl and birds. So, opportunities received a good score. Weakness and Threats received average score as stream bank erosion, which can undermine the stability of nearby infrastructure or disperse or degrade quality soils necessary for nutrient cycling and vegetative viability
	Prey/predator relationships	3	1	2.5	1	Strength and opportunities for this indicator are high for multitrophic interaction and high species & genetic diversity as Sundarbans mangrove forest is supporting the ecosystem. So, weakness for this indicator received negligible score. Frequent climate extreme events are the main threats for Prey/predator relationships which received a poor score

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Hydric soil development	1.5	2	2	1	The strength of this indicator is moderate because of good vegetation coverage. Clay soil type is the main weakness and scored medium here due to low water holding capacity. Opportunities received good score due to the natural ecosystem support. Presence of embankment and infrastructure are the main threats to hydric soil development which gets poor scores.
<b>Total</b>	Total Service=15	35.09	23.5	27.86	23.15	

#### SWOT scoring and outcomes for Pond/Fish farm ecosystem

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
<b>Provisioning</b>	Water availability	1.6	2.6	2.3	2	The strength of water availability received medium score due to vulgar condition of availability of optimum water in the dry season and low water retention time but water use is significant. Weakness scored high because of lack of surrounding hydrological system, low sandy bed materials and ground water table depletion. There are good opportunities to increase water availability by rainwater harvesting, re-excavation practices and community-based management. Overuse of ponds and increase plan of upstream development are the main threats that received moderate scores.
	Water quality	2	3	2	2	The strength for water quality received medium scored as the Optimum Physio-Chemical Parameters (Temperature, DO, TDS, pH) from the field test is below average for water quality but water is used for multipurpose. Weakness for water quality is scored very high due to high salinity intrusion during flood and occurrence of algal bloom due to climate change. However, EbA interventions and community-based management are good opportunities for water quality improvement so the opportunities received medium scores. Extreme heat and drought due to climate change are the main threats to water quality deterioration. Moreover, chemicals and pesticides used in surrounding crop field and fish gher causes the water quality more vulnerable so threats received moderate score.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Soil quality	1	2.3	2	2	The strength of soil quality is scored poor as the optimum soil nutrients are not in good condition due to lack of vegetation. The weakness of the soil quality scored high due to the presence of ordinary peat soil which is a very soft soil with low shear strength and high compressibility exists in an unconsolidated state. Soil is also polluted by anthropogenic activities. Opportunities for soil quality improve assigned medium score due to increasing suitable crops and vegetation coverage. There are medium threats on soil quality as chemicals and pesticides used in surrounding crop field and fish gher and household discharge to the ponds
	Primary productivity	1	3	2	2	Presence of low aquatic vegetation provides low strength scores for primary productivity. Weakness for primary productivity scores high as comparatively more time needed to restore plankton and aquatic vegetation after disasters because of salinity stress. Opportunities for primary productivity set medium score for increasing awareness to plant suitable tree, vegetation coverage and EbA interventions. However, moderate threats on productivity due to unsustainable harvest of the ecosystem resources received medium score.
	Fish diversity, community dynamics and production	1	2.3	1.75	2.3	This indicator scored lowest for strengths as water for integrated use for fishery and nature is not sufficient and water quality is not very suitable for soil and fisheries. Moreover, primary productivity is low. Weakness is scored high due to low water retention capacity, rapid deteriorating water quality and more time needed to regenerate primary productivity. Presence of green coverage is not sufficient but community-based activities is active and awareness on the role of ecosystem for climate resilience increase which are the good opportunities and received medium score. Frequent climate extreme event is the main threats Fish diversity, community dynamics and production. However, Limited access to climate and hydrology information also a big threat which scored maximum here.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Regulating	Ground recharge water	1	2	1	1.6	The strength for ground water recharge is low because of low sandy soil type and poor vegetation coverage. Clay soil type is the main weakness and scored medium here due to low water holding capacity. Moreover, vegetation growth limits due to salinity is another great weakness. There are few opportunities for ground water recharge by altering soil condition and planting suitable crops. Main threats are high dependence on vegetation, unsustainable use of water, and unplanned urbanization which is scored moderate.
	Waste treatment water	1	2	2	1.6	The strength of waste water treatment received poor score due to vulgar condition of aquatic vegetation. Weakness scores medium condition because of low aquatic vegetation and average dense turbidity. EbA interventions, community-based management and awareness raising are good opportunities for this indicator and received good scores. High dependence of vegetation, management of domestic waste and unplanned urbanization are the main threats which scored medium for this indicator.
	Soil fertility	1	3	2	2	Strength for soil fertility score lowest due to lack of flora and fauna. So, the weakness gets highest score for low abundance of flora and fauna. Opportunities for soil quality improve assigned good score by increasing suitable tree and vegetation coverage, sustainable management and increase awareness on the role of ecosystem for climate resilience. Re-excavation and agro-chemicals use are the main threats for soil fertility which scored medium.
	Water retention capacity	1	2	2	2	Water retention and conveyance capacity are very poor due to climate change and strength for this indicator scored low. Siltation due to flood is the greatest weakness and received average score. There are good opportunities for re-excavation and connecting with new hydrological system so it scored medium. Presence of poor embankment and low vegetation disrupt water retention so the threats scored average.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
<b>Cultural</b>	Recreation and tourism	1	3	1	2	Poor biodiversity, scenic beauty and unsustainable management provides low satisfying score for cultural services and the main weakness is the ecosystem is not so planned and scored high. Opportunities received low score for poor community-based livelihood. The main threats are environmental pollution and over exploitation of resources and received moderate score for threats.
<b>Supporting</b>	Ground water replenishment	1	3	2	2	The strength for ground water replenishment is poor because of low sandy soil type and vegetation coverage. Dominant clay soil type is the main weakness and scored highest here due to low water holding capacity. There are few opportunities for ground water recharge by increasing vegetation and modifying soil texture which received medium score. Main threats are management of domestic waste and unplanned urbanization which scored moderate.
	Nutrient cycling	1	3	2	2	Nutrients cycling gets lowest score due to lack of biodiversity which makes the soil infertile by low decomposing organic materials. So, the weakness gets highest score due to lack of nutrients cycling. Opportunities for nutrient cycling received moderate score because of increasing suitable tree and vegetation coverage and sustainable management. Frequent climate extreme event are the main threats for nutrients cycling which scored medium.
	Maintenance of floodplain fertility	2	2	2	2	The strength for this indicator received low score because floodplains are sometimes highly fertile as sediment is rich in organic matter and nutrients but contains excessive amount of salts. Floodplains are home to some of the most biologically rich habitats on Earth. They provide opportunities of spawning grounds for fish and critical areas of rest and foraging for migrating waterfowl and birds. So, opportunities received good score. Weakness and Threats received average score as stream bank erosion, which can undermine the stability of nearby pond infrastructure or disperse or degrade quality soils necessary for nutrient cycling and vegetative viability

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Prey/predator relationships	1.5	2	1	2	Strength and opportunities for this indicator are low for low multitrophic interaction, species and genetic diversity. So, weakness for this indicator received medium score. Frequent climate extreme event are the main threats for Prey/predator relationships which received average score.
	Hydric soil development	1	2	2	2	The strength of this indicator is low because of inferior vegetation coverage. Clay soil type is the main weakness and scored medium here due to low water holding capacity. Opportunities received good score due to community-based management and EbA interventions. Presence of unsustainable embankment is the main threat for hydric soil development which scored medium.
Total	Total Service=15	18.1	37.2	27.05	29.5	

# Annex III: Photo Album of FGDs, KIIs, community survey and in-situ test

## Focus Group Discussion at Dacope



FGD with CBO at Pankhali



FGD with CBO at Pankhali-2



FGD with CBO at Pankhali-3



FGD with CBO at Pankhali-4



FGD with Capture Fisheries Group at Borokhalisha



FGD with Capture Fisheries Group at Borokhalisha-2

**KIIs, Community survey, case assessment and water quality sample collection**



KII with Upazila Chairman at UP



KII with local Knowledgeable person at Kalabogi



KII with Culture fisherman at Kalabogi



KII with Sufo at UP



Water Sample Collection at Rupsha River



Community survey with Capture Fisheries Group