Food and Agriculture Organization of the United Nations

# Shyamnagar 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

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

**Shyamnagar Upazilla**

**2024**

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# Abbreviations

| | |
|---|---|
| AGB | Above Ground Biomass |
| 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 |
| 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 Environment |
| 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 |
| GED | General Economic Division |
| GIS | Geographic Information System |
| GoB | Government of Bangladesh |
| HSZ | High Salinity Zone |
| 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 |
| SDF | Social Development Foundation |
| 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 |
| VGD | Vulnerable Group Development |
| VGF | Vulnerable Group Feeding |
| 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 climate change vulnerability of Shyamnagar Upazila of Satkhira district of Khulna Division of Bangladesh, as it is one of the most severely affected region by recent catastrophic climatic events, both historically and in recent times. The land elevation of this upazila mostly varies between 2 to 10 m, 9.65% area is lying below Mean Sea Level (MSL) and about 70% area is lying between 0-2 m. These low-lying areas are subjected to tidal flooding, flood, sea level rise which inundate, erode shorelines, and contribute to coastal flooding.

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; coastal flooding, saline water intrusions, river bank erosion, sea level rise and drought have severely affected the people living in this region. Especially, tremendous rise in apparent temperature in the south-western region has caused fish farmers in Shyamnagar Upazila to face numerous challenges, most importantly oxygen level drop in water and various viral, bacterial and fungal diseases. 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.

Future climate projections by CEGIS (2022) show that, maximum temperature will rise by 2°C and 1°C during winter and summer respectively in 2050s for SSP5-8.5 when compared to 1981-2010. Likewise, the minimum temperature will rise by 3°C and 1.5°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 seasons by 84%, 38%, and 52% respectively and increase in JJAS by 30% while the total annual rainfall will be decreased by around 7% in the 2050s when compared to the base period 1981-2010 under SSP5-8.5.

An assessment was also undertaken regarding changes in water bodies. Both the permanent and seasonal water bodies in Shyamnagar Upazila were found to have increased from 1990 to 2020. The reason behind these changes are many, including sea level rise and consequent increase of intertidal area which create temporary waterlogged areas in low lying regions. The increasing of water body may also be due to the massive shrimp farming in the region. Salinity levels in the ponds are rising, especially during the pre-monsoon and winter seasons, which results in the disappearance of local species from the water bodies. Particularly the homeostasis of the pond environment may be negatively impacted by the coupled or combined effects of temperature and salt. This is due to the synergistic effect of both rising temperatures and an increase in salt, which further deteriorates the environment for fish species' survival.

The water quality tests undertaken found that DO (Dissolve Oxygen) values were suitable for the growth of fisheries. 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. The Vulnerability assessment found that Ramjan nagar, Kaikhali, Nurnagar, Bhurulia union were highly vulnerable to climate change induced hazards and also had low adaptive capacity. Climate change risk on ecosystem was assessed for the base period (2011) and 2050s. In this case, Kashimari, Ramjannagar, Munshiganj, and Atulia unions were found to be high risk unions for both time periods.

The study further estimated that the magnitude of temperature induced stress on river seasonal migratory fishes will be increased 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 decreased by 0.19% with an 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 both capture and culture fisheries was assessed through indictor-based analysis and Munshiganj, Gabura and Buri Goalini Unions, the unions near the Sundarbans were found to be highly sensitive to climate change induced hazard. Adaptive capacity assessment revealed that Bhurulia, Gabura, Ramjan Nagar and Shyamnagar Unions had high adaptive capacity for capture fisheries whereas Kashimari, Bhurulia, and Ishwaripur Unions had high adaptive capacity for culture fisheries. Climate change induced hazard risk for capture fisheries impact chain analysis showed Kashmiri, Atulia, Padma Pukur, Buri Goalini, Munshiganj and Gabura Unions under high risk for the base period. In 2050s, Ramjan Nagar and Kaikhali unions will be in high risk zone along with the high-risk unions of the base period. For culture fisheries, Gabura, Munshiganj and Ramjan Nagar unions are in high risk for both time periods.

Most of the women in Shyamanar are involved in household related activities with only a few of them (Upazila Field Office, 2022) involved in fry collection, net making, pond preparation and culture fishing. However, those women involved in fish related activities were found to earn little from these compared to male counterparts. Gender sensitivity analysis to climate change revealed that Munshiganj, Gabura, Buri Goalini, Nurnagar Unions were highly sensitive while the rest of the unions had low sensitivity for Gender specific fisheries livelihood. All unions of Shyamnagar Upazila had moderate adaptive capacity for gender specific fisheries livelihood except Shyamnagar Union which had low adaptive capacity.

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 uncertain future climate appears to be making things worse in addition to the inadequate capacity for 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 the F&A sector by highlighting the risk and vulnerability of local fishers, and fish farmers from the observed and predicted effects of climate change on F&A livelihood with particular focus on women for Shyamnagar 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 out climate change-sensitive areas for F&A in South Shyamnagar Upazila

## 1.3 Approach of the study

This study was conducted following the developed CRVA framework[1] for the F&A, through collecting and analyzing datasets from both scientific and participatory approaches. Three types of participatory tools

[1] 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 Surveys, and Key Informant Interviews (KIIs). The study conducted 3 FGDs with Community based Organisations 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 Gabura, Mothurapur, Kolbar 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 Shyamanagr Upazila 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 was 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).

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

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 Kholpetua River, ponds and ghers for laboratory tests to assess the habitat condition. SWOT (TDS

) 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 had 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 various secondary sources such as FRSS, BBS, NWRD and CEGIS model-based outcome have been 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. The 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 the 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 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 features of the study area in the Shyamnagar Upazila, highlighting the geographical setting, hydrology, climate, land cover, demography of fisheries communities, etc. Further, prevailing aquatic ecosystem and its services are outlined.

## 2.1 Geographical features

Shyamnagar Upazila is located in Shatkhira District of Khulna Division of Bangladesh. It shares boundary with Kaliganj (Satkhira) and Assasuni Upazilas on the North, Sundarbans and Bay of Bengal on the South, Koyra and Assasuni Upazilas on the East and West Bengal of India on the West. The land elevation of Shyamnagar Upazila mostly varies between 2 to 10 m, 10% of the area is lying below Mean Sea Level (MSL) and about 70% of the area is lying between 0-2 m. These low-lying areas are subjected to tidal flooding, flood, sea level rise which inundates, erode shorelines, and contribute to coastal flooding. The upazila covers an area of 1,968 sq. km. The Upazila is dominated mainly by Mangrove Forest, which covers almost 50% of the Upazila. Rivers and Khals are observed to be the second most dominant land type among the other classes and cover almost 30% of the total land cover. The brackish water aquaculture covers around 23119 ha area and 11.2% of total land cover. Total water body combining brackish water aquaculture, River and khals, contains about 40% (83498 ha) of the Upazila, these water bodies are source of fresh and brackish water fisheries.

## 2.2 Hydrological system

The main rivers of Shyamnagar Upazila are Raymangal, Betna, Kalindi, Kobadak, Madar, Kholpetua, Arpangachia, Malancha, Hariabhanga and Chuna. The Ichamati-Kalindi-Raymangal is the same river that is known by several names in multiple locations. It is known as the Kalindi when it flows through the Western portion of Satkhira District; further South it enters into the Sundarbans and known as the Raymangal and then falls into the Bay of Bengal. The river Betna enters the Sundarbans and changes its name to Arpangachhia as it flows through the Satkhira distrsict in the South. The river discharges into Bengal Bay as Malancha and is navigable close to its mouth. At the river's mouth, the Patri Island has emerged. The Kholpetua River is one of the largest rivers of the Ganges-Padma system. It is playing an important role in supplying fresh water from upstream area and from the local catchment. Kholpetua River is connected with Arpongachia. Arpongachia joins with Malancha River further downstream. Besides rivers, South Talpatti Island at the estuary of the Hariabhanga is notable places. **Figure 2.1** illustrates the hydrologic system of Shyamnagar.

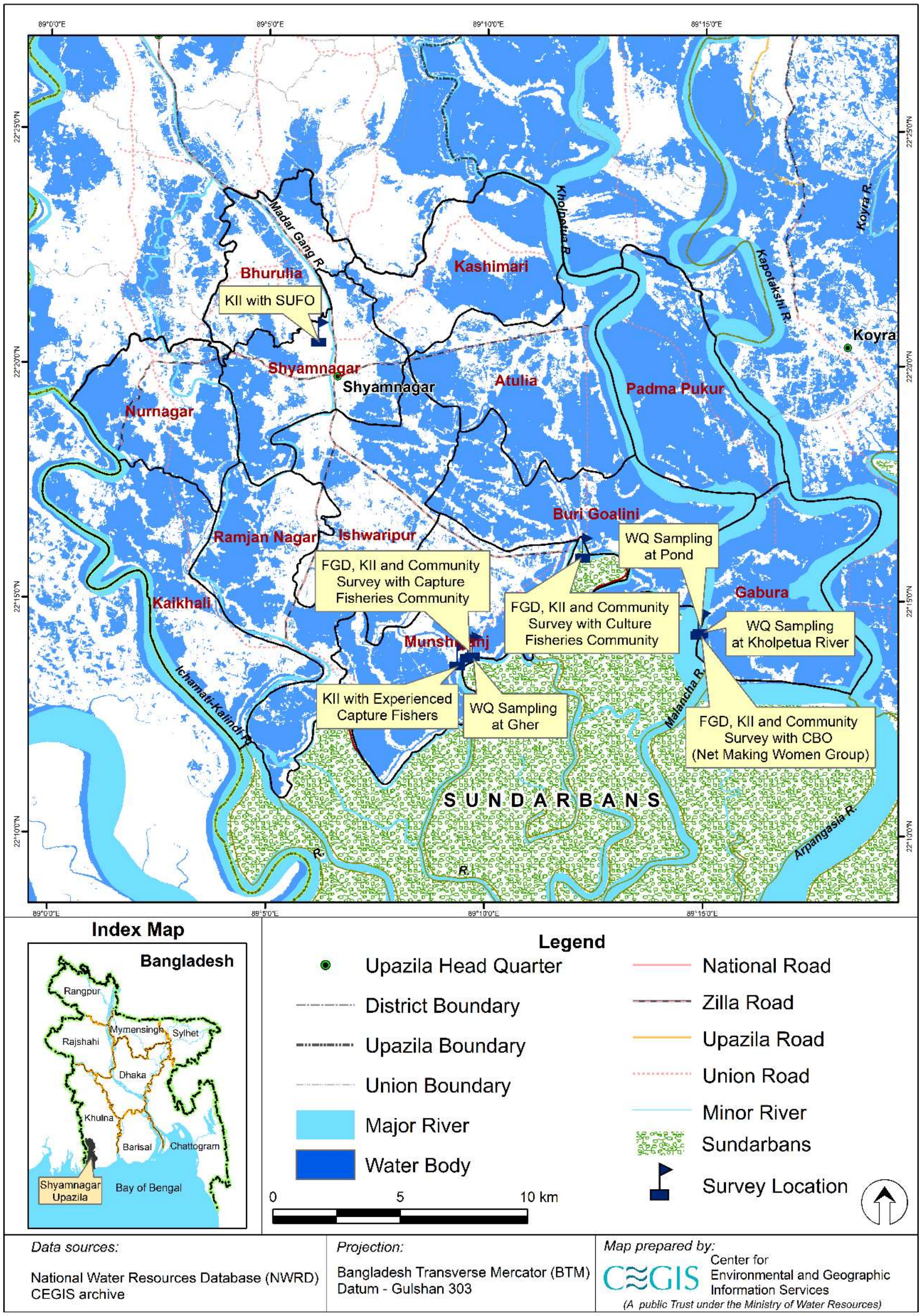



**Figure 2.1: Locations of Primary Survey**

## 2.3 Aquatic ecosystem and its services

The major aquatic ecosystem within the study area consists of rivers and ponds. In addition to the major rivers, there are 136 Jalmahals, 5,795 ponds and 15,394 ghers in Shyamnagar 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; regulates tidal floods, carries sediment, nutrients for aquatic plants and fauna, sequesters carbon, absorbs heat, purifies water naturally, transports freshwater, irrigation water for agriculture and flows for navigation purposes; supports diversified flora and fauna. Additionally, it promotes tourism.

## 2.4 Fisheries resources

Shyamnagar Upazila is rich in fisheries resources due to having multiple rivers, connecting khals, influence of the Sundarbans mangrove forest and vast aquaculture farm including shrimp farm and pond. The Upazila has vast water area covering 11,292 ha of river and khal, 17,617 ha of shrimp farm including Golda and Bagda, 8 ha of borrow pit, 176 ha of crab fattening farm and 0.42 ha of Kuchia point area which contribute about 25,093 MT of fish and fisheries products annually. The Upazila has 23,044 registered fishers who are involved directly in fishing activities. Moreover, good number of people both male and female, engage in the collection of shrimp and prawn post larvae (PL) in the nearer rivers and Khals. In addition to this, a good number of people involve in shrimp processing and trading related activities.

## 2.5 Demographic characteristics

The Upazila has a population of 3,18,254; 48.2% male and 51.8% female. It has 12 unions, 127 mouzas/mahallas and 233 villages. The total number of households is 72,279 with a population density of 162 per square kilometers (Census 2011), and average household size of 4.4. Average literacy in the upazila is 64.84% (male 38% and female 26.8%). Main occupation include agriculture, agricultural labour, wage laborer, forestry, fishing, commerce, service and transport. About 6% people are associated with fish culture and capture. People in this area depend on both capture and culture fishing. According to Shyamnagar Fisheries office, about 23,044 fishers in the upazila are living based on the capture fishing and 22,528 are involved in culture fishing.

# 3 Climate Change Induced Hazards

The study area faces natural disasters and slow onset events regularly and with various intensities. 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 both community perceptions and scientific information. Both historical trends and future projections are assessed and described to highlight the potential impacts of climate change.

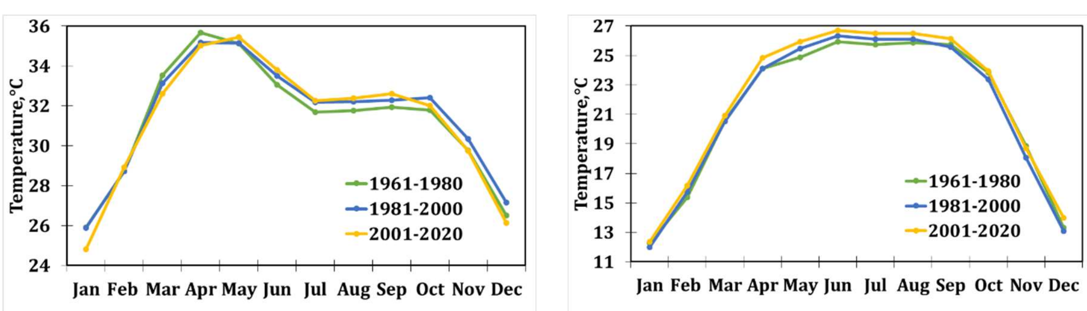
## 3.1 Climate change scenarios

### 3.1.1 Temperature

Temperature data analysis from 1961 to 2020 for Satkhira Station of Bangladesh Meteorological Department (BMD) is presented in **Figure 3.1**. It depicts a significant increase in minimum and maximum temperature especially during April to October in last two decades (20 years) than 1961-1980. During summer (March-May) average increase in maximum temperature was about 5.5°C and minimum temperature was 4°C while in winter season (December-February), minimum temperature increase was about 1.5°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, maximum temperature is increasing at higher rate of (0.3°/decade) in 1961-1980 but slowed down to (0.09°C/decade) in 1981-2000, and then again increased at (0.2°C/decade) in more recent time slices. Whereas, annual minimum 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 60 years' period, 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°C and 1.3°C during winter and summer respectively in 2050s for SSP5-8.5. Likewise, minimum temperature will rise 3°C and 1.5°C during winter and summer respectively in the 2050s for SSP5-8.5. Mean average maximum temperature of DJF, MAM, and JJAS and ON season will be 29$^0$C, 35.1$^0$C, 33.7$^0$C and 32.1$^0$C for 2050s and mean average minimum temperature of DJF, MAM, JJAS and ON seasons will be 16.8$^0$C, 25.2$^0$C, 27.5$^0$C and 23.4$^0$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.



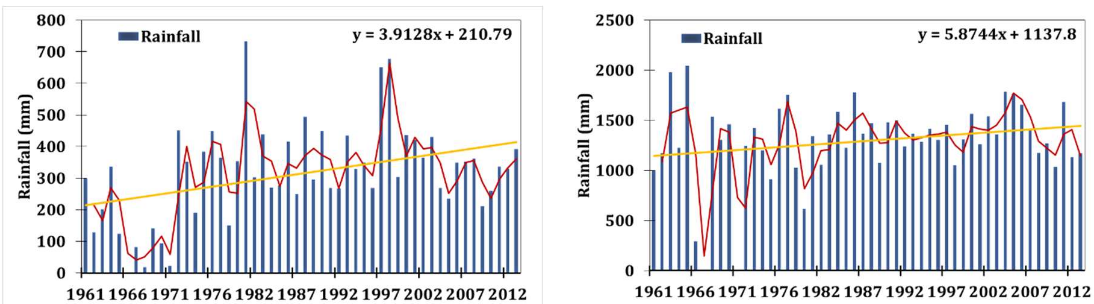

*NWRD, BMD*

**Figure 3.1: Monthly average maximum (left) and minimum (right) temperature of Satkhira station**

### 3.1.2 Rainfall variability

Rainfall data analysis (1961-2020) for the dry season (October to March) and wet season (April to September) is shown in **Figure 3.2**. that the annual average dry and wet period rainfall are about 319.58 mm and 1296.19mm respectively. Wet season rainfall is increasing with higher rate (6.69 mm/year) than that of dry season (2.5mm/year). The area experiences distinct seasonal variations; the winter season (DJF), which is generally dry and only contributes 2 percent of the total annual rainfall; and the rainy season (JJAS) receives 75 percent of the total annual rainfall. Rainfall can range from 452 mm to 1733 mm during the rainy season, with July often having the highest amount of rainfall. the pre monsoon hot season (MAM) perceives 15 percent of convective thunderstorms or northwester (locally known as Kalbaishakhi).

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.

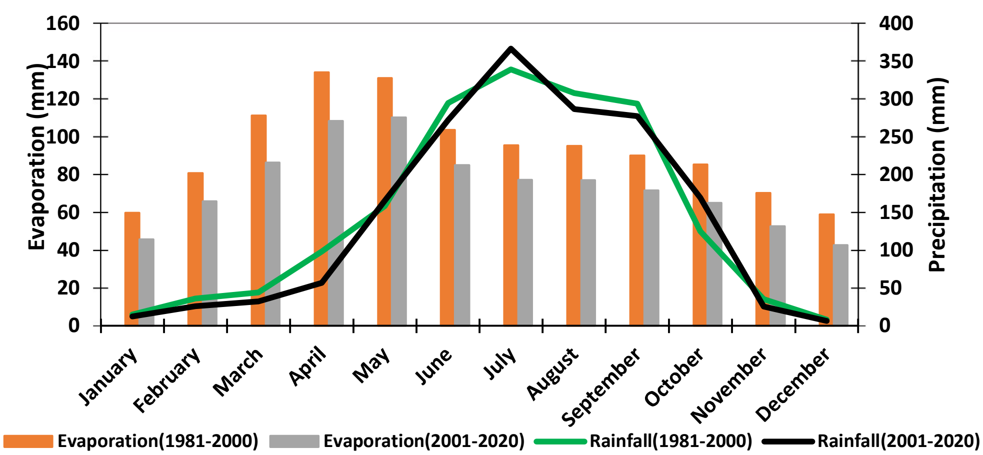



*NWRD, BMD*

**Figure 3.2:Dry season (Left) and wet season (Right) rainfall at Satkhira station**

### 3.1.3 Evaporation

Monthly variation analysis of evapotranspiration (**Figure 3.3**) shows decreasing trend during winter and pre-monsoon but increasing trend during monsoon and post-monsoon in 2001-2020 compared to 1981-2000. 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 in Satkhira station**

## 3.2 Climate hazards and its impacts

Shyamnagar Upazila is particularly vulnerable to cyclone, storm surges, salinity intrusion, riverbank erosion, sea level rise, flood, hot days, lightning, etc. Total of 10 types of hazards (shown in the **Table 3.1** below) are identified by communities under this study. According to the respondents, the frequency and intensity of almost all reported hazards are increasing with high magnitude. For instance, extreme hot days was ranked more impactful than flood, cyclone, drought, salinity intrusion, sea level rise, lightning etc.

**Table 3.1: Hazard Prioritized by local Community (2022)**

| Hazard | Ranking | Trends/Frequency<br>Increasing (↑)<br>Decreasing (↓)<br>Static (↔) | Intensity<br>High=3<br>Moderate=2<br>Low=1 |
|---|---|---|---|
| Flood/Tidal Flood | 4 | ↑ | 3 |
| Cyclone | 2 | ↑ | 3 |
| Storm Surge | 3 | ↑ | 3 |
| Drought | 5 | ↔ | 2 |
| Extreme Hot Days | 1 | ↑ | 2 |
| Salinity Intrusion | 6 | ↑ | 3 |
| Sea Level Rise | 9 | ↑ | 2 |
| Lightning | 7 | ↑ | 3 |
| Wave Action | 10 | ↑ | 3 |
| River Bank Erosion | 8 | ↑ | 3 |

*CEGIS Field Survey, 2022*

The present study identified six major climatic hazards for fisheries and aquaculture as found in Shyamnagar Upazila (**Figure 3.4**). Among the hazards, days of water unavailability or drought is identified as the most prominent hazard for capture fisheries. Moreover, fishing activities are highly exposed to heavy rainfall and extreme hot days. Furthermore, most fishermen have been facing problems in fish handling and transportation to the existing fish landing sites and even fish markets due to erratic rainfall, tidal flood and cyclones.

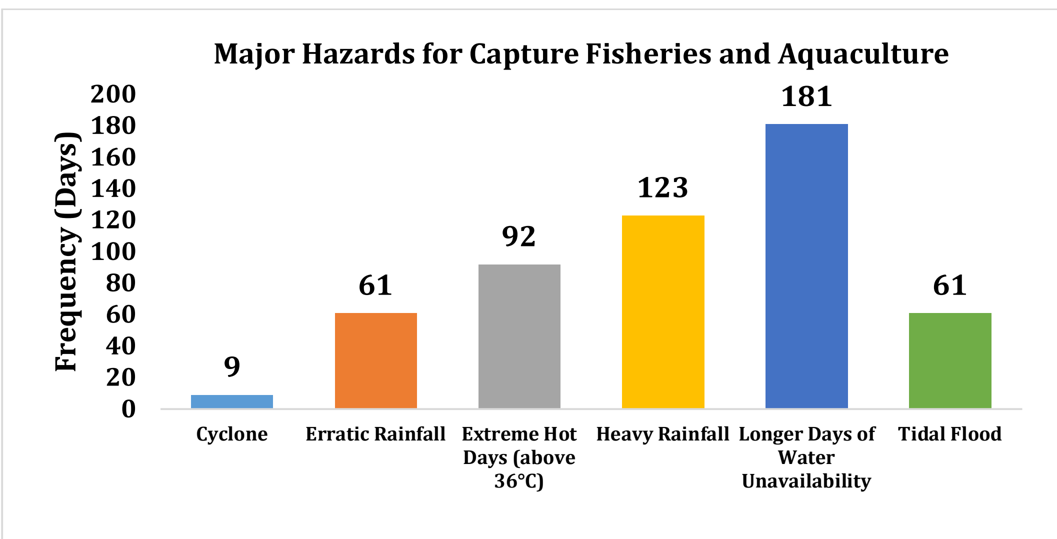



**Figure 3.4:Frequency of climatic hazards on fisheries and aquaculture**

*CEGIS Field Survey, 2022*

According to the hazard calendar developed by the fishing community, in recent years, 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. Usual time of flooding which occurs during Ashar to Ashin did not change. However, Flood often occurs due to embankment failure causing great loss to the people's livelihoods. Tidal wave height is increased compared to the past due to increased sea level and extreme hot and severe cold days.

***Cyclone and storm surges***

Being located in the south-western coastal region of Bangladesh, Shyamnagar Upazila in Khulna districts 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. Storm surge inundation modelling for base period and 2050s considering sea level rise illustrates unions adjacent to the rivers as such Gabura, Buri Goalini, Padma pukur, Kashimari, and Atulia in the East and Numanagar and Kaikhali in the West of Shayamnagar Upazila are mostly affected by SIDR equivalent cyclone under both SSP1-2.6 and SSP5-8.5 scenarios. In 2050s for SSP5-8.5 scenario, inundation extent and impact will be higher in Gabura, Atulia, Padma Pukur and Kashimari Union.

Every year, The Sundarbans act as a biological protective shield against cyclones and typhoons. However, cyclone damages river infrastructure and vegetation coverage as it uproots trees, and erodes the soil, thereby damaging existing river vegetation and ecosystems which will ultimately hamper fish habitat.

On May 25, 2009, Aila struck Bangladesh's southwest coastal regions, affecting 15 districts, 76 Upazilas, and 491 Unions. At least 30 kilometres of embankment have been partially damaged in Dacope, Botiaghata, Paikgasa, and Dumuria upazilas due to Aila. Fish farms of 1,545 hectares of land in 24 unions of coastal Koyra, Dacope, Paikgachha, Batiaghata and Dumuria upazilas of Khulna have been damaged by the tidal surge caused by cyclone Yaas in 2021. The super Cyclone Amphan in 2020 affected more than a million people in nine districts in Khulna and Barishal divisions of Bangladesh. Many freshwater ponds inside forests and shrimp farms in Dumuria were flooded with seawater due to this cyclone. 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 in 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.

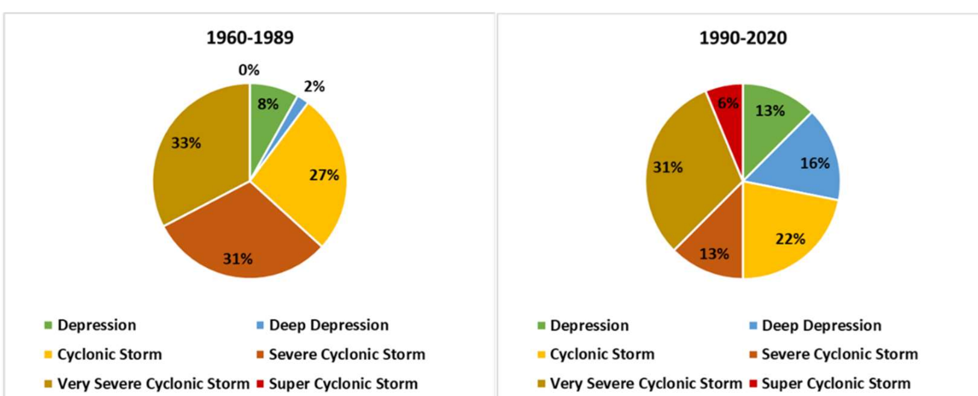



**Figure 3.5: Distribution of high intensity cyclone along the Bangladesh coastline**

*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, which 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 Shyamnagar, which is situated in the south west Ganges tidal floodplain experiences higher sea level rise and salinity than the rest of the regions.

Bangladesh Delta Plan 2100 (GED, 2018) indicates 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 lead significant shortages of drinking water in the coastal urban area, scarcity of water for irrigational agriculture during dry season and significant changes in the coastal aquatic ecosystems. Simulation by CEGIS Bay of Bengal model (2020) reveals that Shyamnagar Upazila will be intruded by more than 25ppt surface water salinity by 2050s under extreme climate change scenario i.e. SSP5-8.5. As presented in the **figure 3.6** below, 7 out of 12 unions of Shyamnagar Upazila are experiencing surface water salinity near 30ppt and rest of the union are above 25ppt. By 2050 in all the union of Shyamnagar Upazila will be experiencing salinity over 25ppt and 25ppt isohaline line will shift on average 10 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.

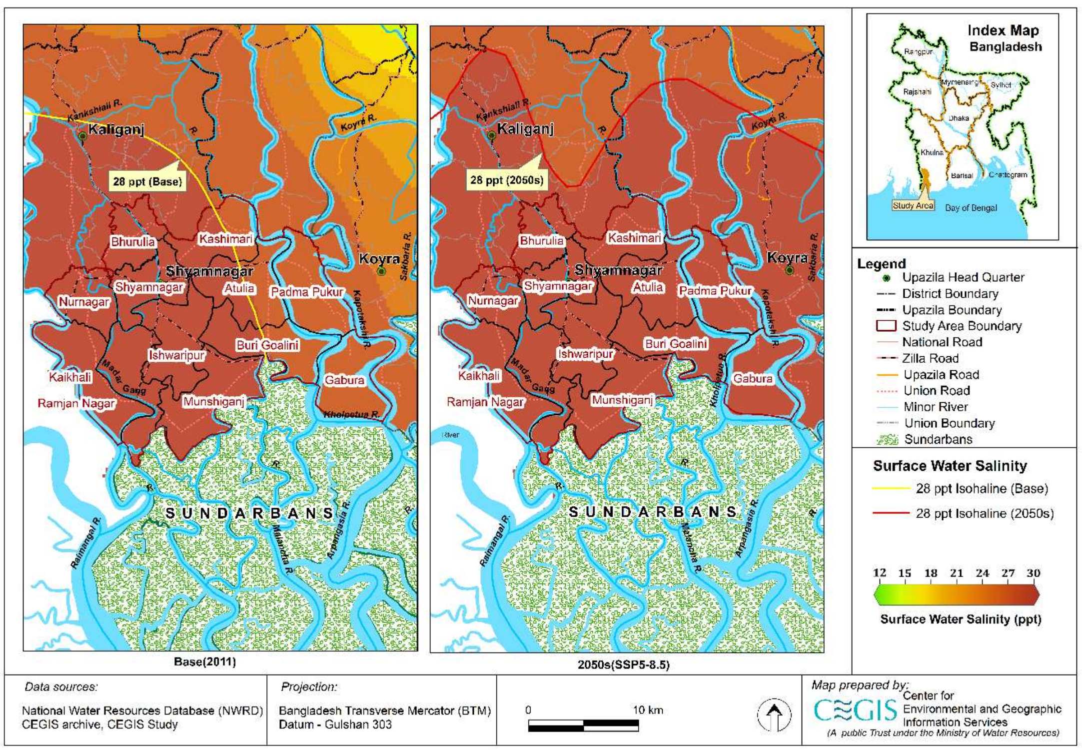



**Figure 3.6: Salinity intrusion in Shyamnagar Upazila**

*Heat wave*

Heat wave frequency and severity are expected to increase in the future (Kirtman et al. 2013). About 39 heat waves in the last 23 years (1989-2011) have been observed in Bangladesh (Hannah et al. 2017). With increased environmental temperature, increase in bacterial decomposition, pH drops, imbalance between DO and $CO_2$, change in size and growth, high mortality, reduced digestion capacity and less food intake happen in fisheries, which decreases fisheries production and affects fishers' livelihoods. Due to this temperature rise, shrimp farmers in Shyamnagar are facing numerous challenges, most importantly various viral, bacterial and fungal diseases (Islam et al. 2018).

### *Floods*

Almost every year, many shrimp farms in Shyamnagar get flooded. River bank erosion, mainly due to floods, is causing river siltation in Kholpetua, Malancha and Chuna Rivers in Shyamnagar Upazila. This reduced the water holding capacity of rivers, degrades fish habitats, and reduces 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 and fishers who used to go fishing around the Sundarbans by boat, capture fishes in floodplains during the floods.

### *Drought*

Droughts associated with high temperature and low rainfall have adverse impacts on aquaculture and inland open water fisheries in some areas in Shyamnagar Upazila. 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 Shyamnagar. This is now also affecting affects migration, breeding and growing of fish and other aquatic animals.

### *Lightning*

CEGIS (2022) analysed lightning susceptibility of Bangladesh based on historical human death toll due to lightning based on BMD data. It 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 the country, which are anticipated to affect the spawning and breeding of fisheries. Besides this, lighting damages infrastructure in fish-cultivated areas. There is some evidence that fishermen and fish farm owners get injured and die due to lightning strikes 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 them 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: Impact of hazard based on community perception**

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

*CEGIS Field Survey, 2022*

## 3.4 Multi-hazard mapping for Shyamnagar upazila

A multi-hazard scenario for Shyamnagar Upazila was assessed using field finding, community perceptions and available secondary data layer and is presented in **Figure 3.7**. Salinity intrusion, flood, cyclone, storm surge, drought, extremely hot days, sea level rise, lightning, 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 salinity intrusion, storm surge, sea level rise and temperature data are projected for 2050s and other hazards are considered constant as base period during multi-hazard mapping using geo-spatial techniques. Almost all the unions of Shyamnagar Upazila are found exposed to multiple climate hazards. All the unions except Burulia, Shyamnagar, and

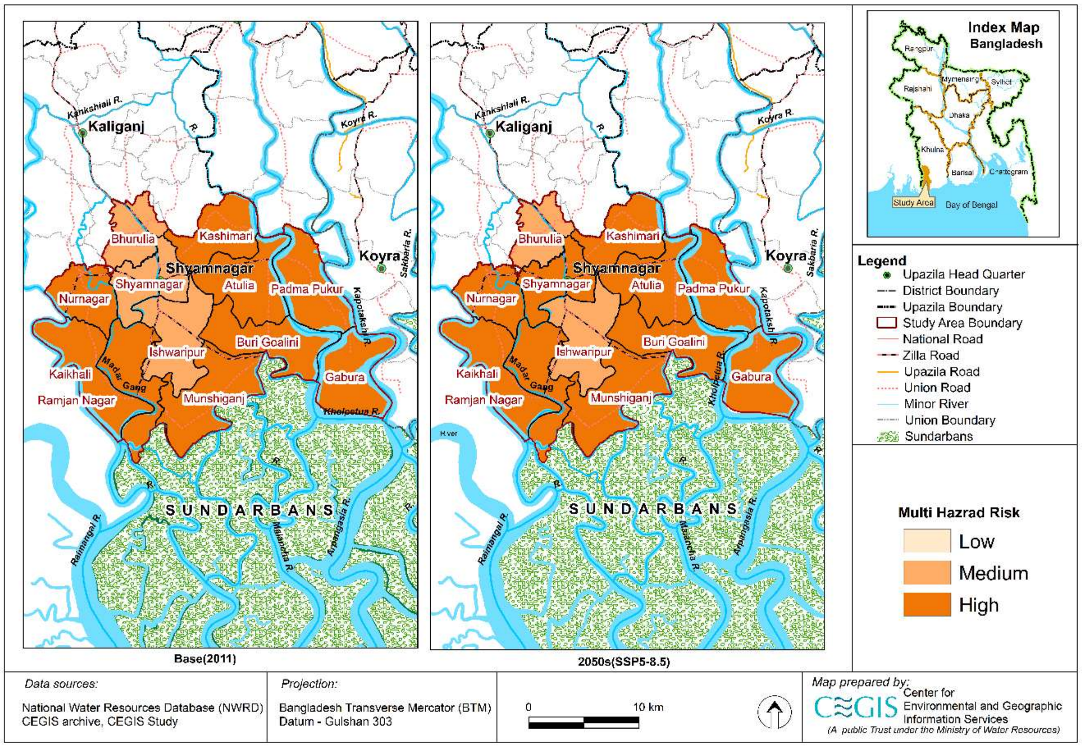



**Figure 3.7: Multi-hazard maps in Shyamanagar Upazila**

Ishawripur were found under high-risk for multi-hazards in the base period. For future 2050s under extreme climate change scenario, Shyamnagar union will also fall under high-risk zone for multi hazards along with the high risk unions of the base period. **Figure 3.7** below highlight the multihazards outlook for 2050 based on 2011.

# 4 Climate Risk and Vulnerability

This chapter presents the key outcomes of the study, which is climate risk and vulnerability for the Shyamnagar Upazila covering all of its unions. Risk and vulnerability were assessed following an indicator-based approach and 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. Following sections describe the key elements of risk and vulnerability separately for these four priority focus areas, which are, exposure, sensitivity, adaptive capacity, vulnerability and risk. Risk and vulnerability assessment is done based on 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 ecosystem in this region. Indicator-based assessment for the developed impact chains was also used to access the ecosystem exposure to climate-change induced hazards in Shyamnagar (Annex I). The exposure status of hazard to the aquatic ecosystem of different unions namely Atulia, Kashimari, Bhurulia, Nurnagar, Kaikhali, Munshiganj and Gabura 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 unfavourable and severely disrupt the ecosystem services. The study analysed the ecosystem climate sensitivity (change in habitat area, disruption of ecosystem services and aquatic habitat condition) of both River and Pond/gher ecosystem.

*Change in habitat area*

The change of perennial and seasonal waterbodies assessed provides information on the intra-annual behavior of such waterbodies. **Figure 4.1** shows the change in waterbody extent from 1990-2020. Both the permanent and seasonal water body in Shyamnagar increased from 1990 to 2020. A total 22% area of permanent waterbody extent increased in Shyamnagar from 1990 to 2020. Increasing trends of the permanent and the seasonal waterbodies found from the satellite images analysis may be the aftermath of gradual sea level rise and consequent increase of intertidal area, which usually create temporary waterlogged areas in low lying regions. The increasing of water body may also be due to the massive shrimp farming in the region. In the coastal areas climate and water related disasters such as floods, cyclone, storm surges and tsunamis may cause inundation which leads to increase in waterbodies. Overall, this assessment revealed that increased saline or brackish water habitat and overall increase in waterbody and, therefore, adaptation in fish farming practices need to be planned accordingly.

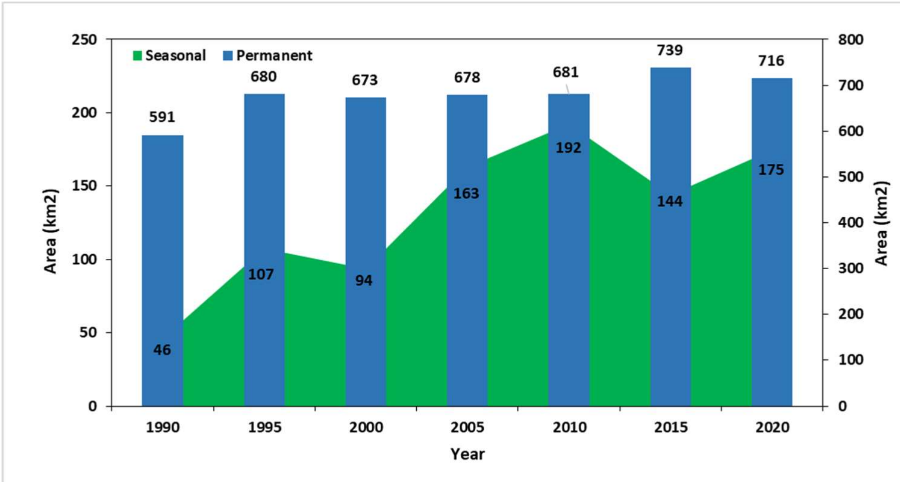



**Figure 4.1:Waterbody changes in Shyamnagar Upazila**

***Disruptions of ecosystem services***

The aquatic ecosystem of the study area provides numerous ecosystem services as reported by the communities during FGDs and community surveys. Potential ecosystem services found are food, fuel, timber, medicines, ornamental resources, and clay soil. Local people extract a significant amount of fish, fuelwood, and medicinal plants and plant parts, and grass from the river, and pond ecosystems. Harvested rainwater in the pond after purification and boiling is generally used as drinking water source for 80% consumers, due to high salinity and iron contents in the river water. Pond water is also used for domestic and household purposes. The river water is mainly used for saline water fish farming, navigation, communication, and waterway trades.

Aquatic ecosystem is rich with unique mangrove species and mangrove associates, 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, which supports flow of water in the streams, irrigation in the agricultural fields, use of water by local people, withdrawal of water for daily use. For instances, pond water level becomes too low during dry season due to increased drought and higher water consumption by communities which cause drinking water crisis. Salinity in river water becomes more unfavorable for brackish water fishes due to increased salinity concentration which hamper fish migration and production, create imbalance of dissolve oxygen hence disrupts fish production due to increased water temperature and salinity, frequent erratic behavior of weather even in pre-monsoon and winter. 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 rainwater storage in the canopy, balances the fish production and its food system through oxygen supply and fish waste uptake by algal bloom and its photosynthesis in the daytime, 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 Shyamnagar also provides opportunities for cultural services such as revenue earning from eco-tourism. Being surrounded by different rivers, many tourist's attraction places are developed beside the river in this Upazila which attract tourists all year round to observe the scenic beauty, serenity, unique and diversified animals, tranquility and for their relaxation. As reported in the FGDs and KIIs, higher tourists usually visit during winter with an average 400 people per day followed by pre-monsoon with 150 people per day. Monsoon season is less attractive to tourists due to unfavourable weather condition.

All these four categories 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 has more weaknesses and threats with a score of 0-15 representing low value, 16-30 representing medium value, and 31-45 representing high value. The results show that both the river and pond ecosystem are in moderate conditions but the pond ecosystem has higher strengths-opportunities and lower weakness- threats because of their natural land-cover types and ideal water quality. The results also showed that the river has more weakness and threats and low strengths-opportunities due to rapid urbanization and environmental pollution and encroachment.

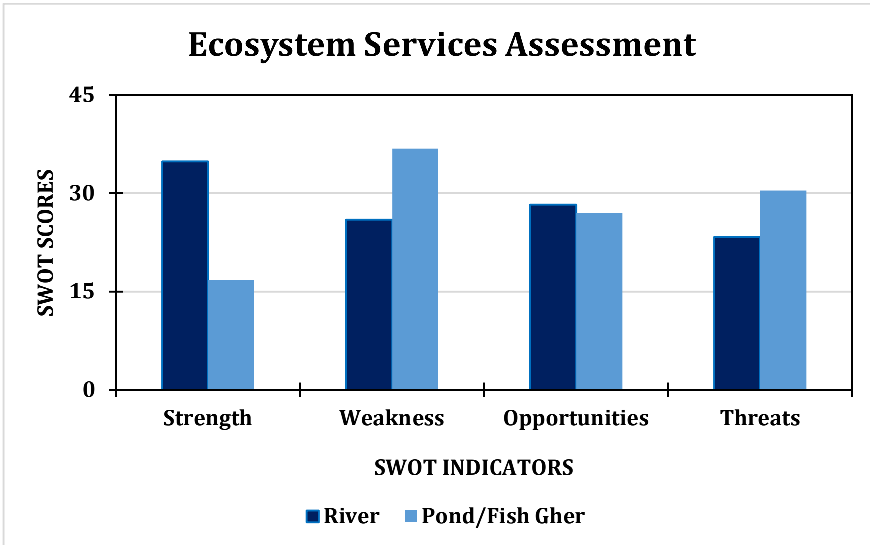
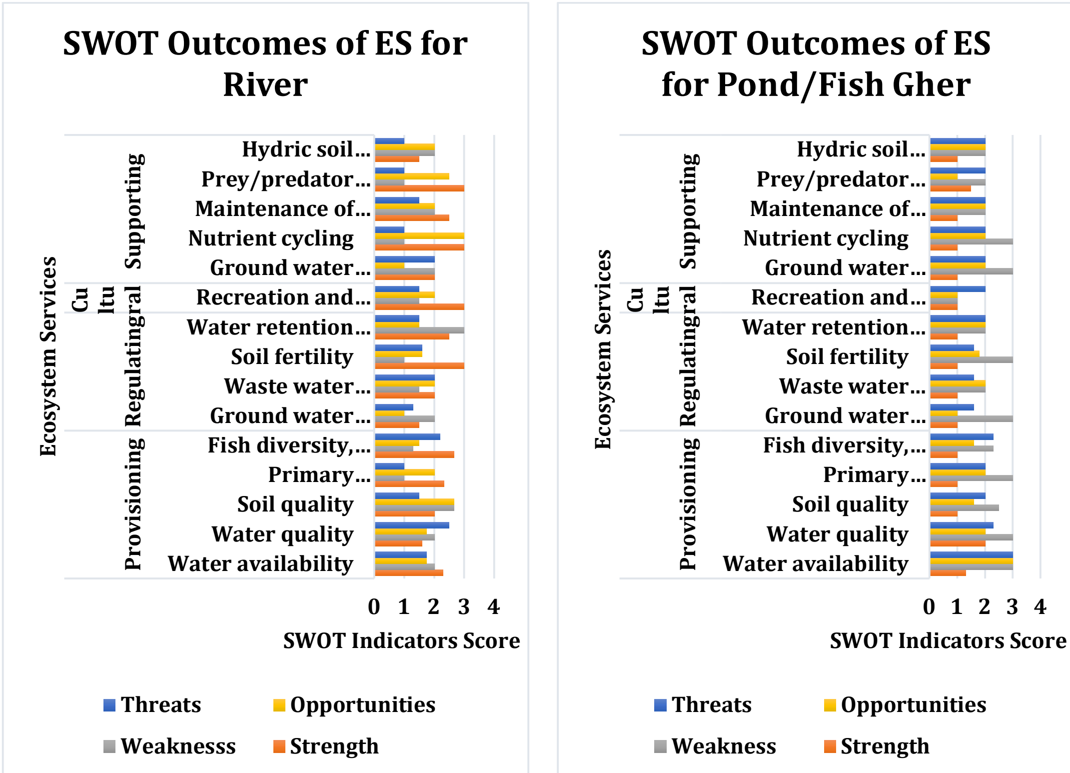



Figure 4.2: SWOT results of aquatic ecosystem services

To enhance the ecosystem services from both rivers and fish pond ecosystem, identified weakness and threats will need to be addressed to increase the related benefits sustainably. 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 mainstreamed widely to harness the desired level of the ecosystem services combating negative impacts exerted 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 and pond. 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.




a) SWOT outcomes of ES for Rivers    b) SWOT outcomes of ES for Ponds/Fish gher

**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 sensitivity to be deteriorating due to climate change. DO, Temperature, pH, BOD, COD and Nitrate were found suitable and within the thresholds reference value for rivers and fish pond but EC and TDS were found to exceed the thresholds reference value of ECR'97 and different studies (marked in red as shown in **Table 4.1**).

EC values of river and fish pond water samples were 5960µS/cm and 73200µS/cm respectively (**Table 4.1**). The desirable range of EC is 100 to 2,000 µS $cm^{-1}$ and acceptable range is 30-5,000 µS $cm^{-1}$ for fish culture (Stone and Thomforde 2004). Therefore, the present values of EC for river and fish pond are not suitable for fish culture. TDS of water mainly indicates the presence of various minerals and the standard level of TDS for fisheries is about 165 mg $L^{-1}$ and suitable range is 160 to 200 mg $L^{-1}$ for growth and production (Huq and Alam, 2005; Rahman et al., 2015). So, from the study it has been seen that TDS values of the present study are not suitable for aquaculture either.

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 is mentioned by respondents, which usually results in the disappearance of local species from the water bodies. Acidic waters reduce the appetite and retard growth. Apart from climatic factors, farmers reported water quality is deteriorating for overuse of pond and decreasing water levels due to drought which results in degradation of habitat and reduced production of fish. According to key informants, drought increased the concentration of waste metabolites (ammonia, carbon dioxide and nitrites) that can alter the ecosystem of ponds, and thus affect growth and production of fish. The water quality conditions will exacerbate under climate change conditions.

**Table 4.1: Surface water quality in Shayamnagar Upazila**

| Sample ID | Physical and Aggregate Properties of Surface Water Resource | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH | Temp | DO | EC | TDS | BOD | COD | Nitrate ($NO_3$-) | Salinity |
| | - | $^0$C | mg/l | µS/cm | mg/l | ppm | ppm | ppm | ppt |
| **River** | 8.4 | 30.9 | 6.3 | 33000 | 16400 | 5 | 240 | 8.4 | 30.3 |
| **Fish Gher** | 8.2 | 33 | 6.9 | 36600 | 18100 | 8.96 | 230 | 5.1 | 32.6 |
| **Pond** | 9.3 | 35.6 | 13.4 | 8140 | 4100 | 10.64 | 180 | 9 | 5.7 |
| **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 | 25 | 10 | |
| **Reference value** | (6.5-9) | (25-32°C) | (6-7) | (30-5000 µs/cm) | (< 160-200 mg/l | (<5 mg/l) | (<200 mg/l) | | |

*Green colors indicate standard reference value of water quality parameters as per ECR'97 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, it has been found that Ramjan nagar, Shyamnagar, Atulia and Padma pukur unions were highly sensitive ecosytems, whereas Kaikhali, Nurnagar, Bhurulia and Kashimari unions were found as moderately sensitive ecosystem.

### 4.1.3 Capacity of aquatic ecosystem to adapt

Rapid restoration and regeneration of plankton and vegetation; abundance of flora and animals; soil health; decomposition of leafs and plant parts and co-management of biodiversity; expanding the forest cover on newly char land; enhancing primary productivity; a good capacity for retaining and transporting water; and medium turbidity are some key inherent adaptive capacity of river and pond 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, like cope with climate hazards. Apart from the system's inherent ability to cope with the nature, 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. 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); muriate of potash (MP); gypsum, and zinc sulphate ($ZnSO4$). Lime CaO, $Ca(OH)2$ and $CaCO3$ are being used to improve biological activity, oxygen, decomposition, maintain pH of pond water and remove turbidity.

Union-wise adaptive capacity assessment (**Table 4.2**) based on different indicators (listed in Annex I) demonstrates the overall status of the coping mechanism of the ecosystems. It is found that the aquatic ecosystem in Gabura and Padmapukur had high adaptive capacity compared to Ramjan Nagar, Kaikhali, Nurnagar and Bhurulia which had 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 ecosystem. From the assessment (**Table 4.2**), it is found that Ramjan Nagar, Kaikhali, Nurnagar, Bhurulia unions are highly vulnerable to climate change induced hazards. These union have high sensitivity and low adaptive capacity to cope with the hazards. Shyamnagar, Atulia, Munshiganj, Buri Goalini and Padma pukur unions are found moderately vulnerable and other unions ecosystem are found low vulnerable to climate-change induced hazards.

**Table 4.2: Summary of climate vulnerability assessment for aquatic ecosystem in Shymnagar Upazila**

| Union | CRVA Elements | | | |
|---|---|---|---|---|
| | Exposure | Sensitivity | Adaptive Capacity | Vulnerability |
| **Atulia** | High | High | Medium | Medium |
| **Bhurulia** | High | Medium | Low | High |
| **Buri Goalini** | Medium | Low | Medium | Medium |
| **Gabura** | High | Low | High | Low |
| **Ishwaripur** | Low | Low | Medium | Low |
| **Kaikhali** | High | Medium | Low | High |
| **Kashimari** | High | Medium | Medium | Low |
| **Munshiganj** | High | Low | Medium | Medium |
| **Nurnagar** | High | Medium | Low | High |
| **Padma Pukur** | Medium | High | High | Medium |
| **Ramjan Nagar** | Low | High | Low | High |
| **Shyamnagar** | Low | High | Medium | Medium |

### 4.1.5 Risk of aquatic ecosystem

Climate change risk (**Figure 4.4**) on ecosystem in Shyamnagar has been calculated for both base period and 2050s following the CRVA framework (attached in Annex I). The unions Kashmiri, Atulia, Padma Pukur, Buri Goalini, Gabura, Munshiganj, Kaikhali and Ramjan Nagar are highly exposed to multi-hazard risk in both present and future time periods which affects aquatic ecosystem negatively throughout the year in these unions. Both the permanent and seasonal waterbody in Shyamnagar 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, ghers 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, Kashimari, Ramjannagar, Munshiganj, and Atulia unions are at high risk in both time slices. Gabura union is under moderate risk in base period but in 2050s will be under high risk zone. Nurnagar, Buri goalini, Padmapukur union are in medium risk and Shyamnagar, and Ishwaripur are found under low risk in both time slices.

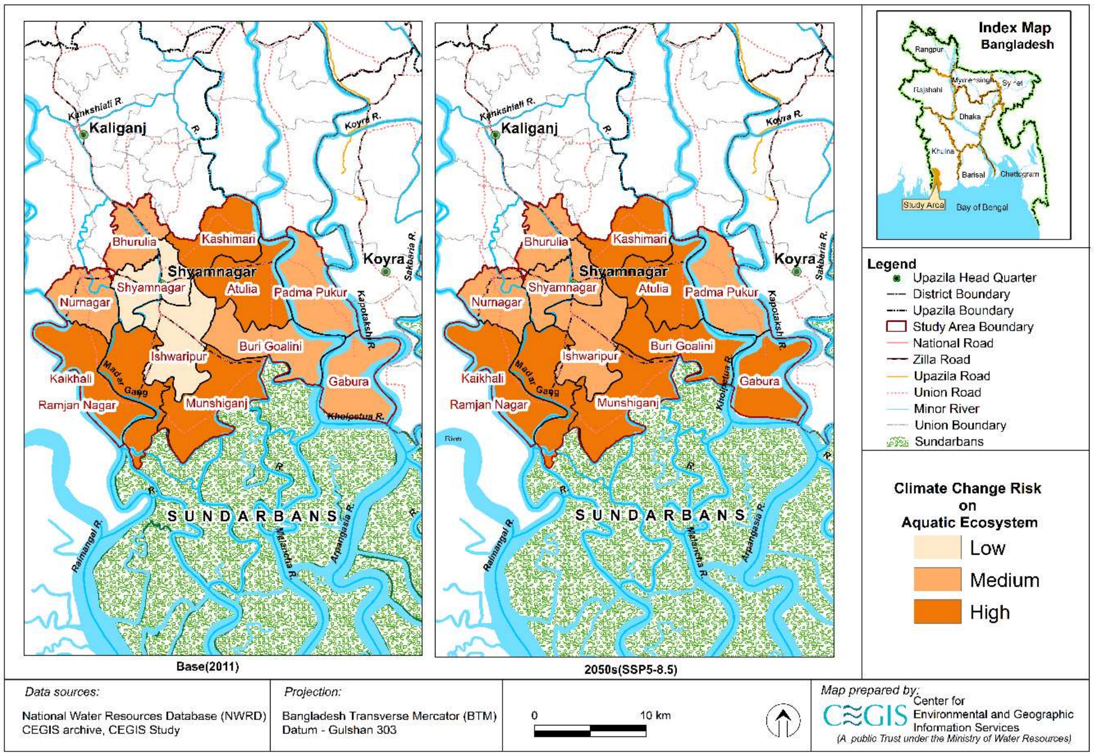



**Figure 4.4: Climate risk of aquatic ecosystem in Shyamnagar Upazila**

## 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 (detailed description is given in the ecosystem section) and fish diversity in respect of the exposure indicators of this ecosystem.

***Fish habitat area***

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

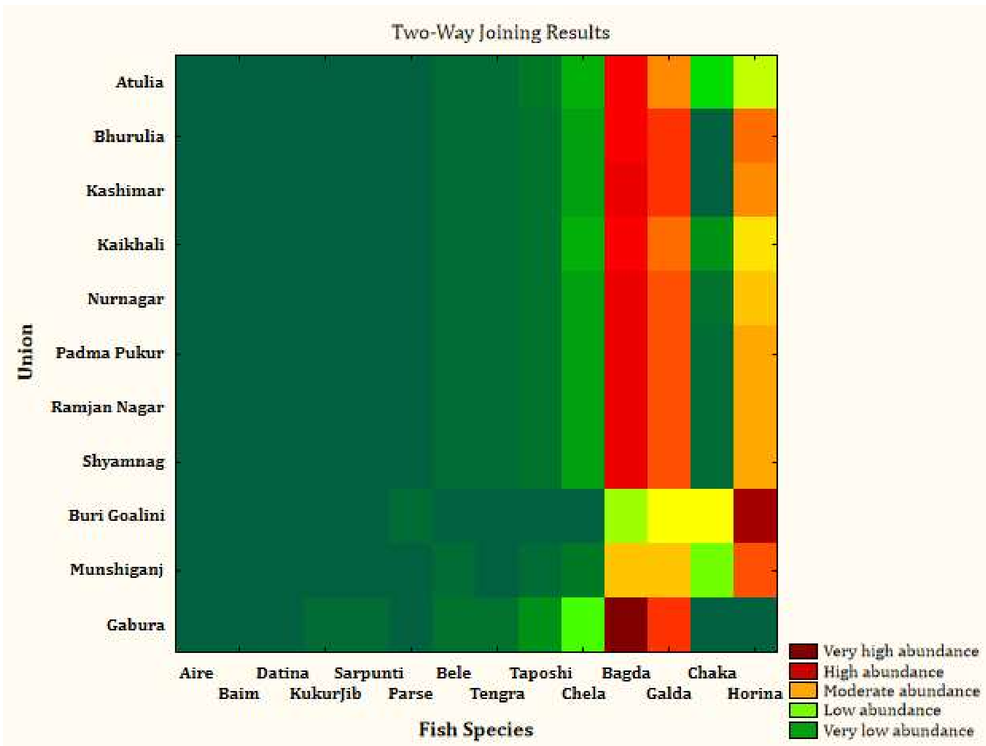
**Table 4.3: Status of riverine habitat in different unions of Shyamnagar Upazila**

| Unions | Water area (ha) |
|---|---|
| Atulia | 367 |
| Bhurulia | 184 |
| Buri Goalini | 551 |
| Gabura | 780 |
| Kaikhali | 597 |
| Kashimari | 138 |
| Munshiganj | 643 |
| Nurnagar | 230 |
| Padma Pukur | 551 |
| Ramjan Nagar | 321 |
| Shyamnagar | 230 |
| **Total** | **4,592** |

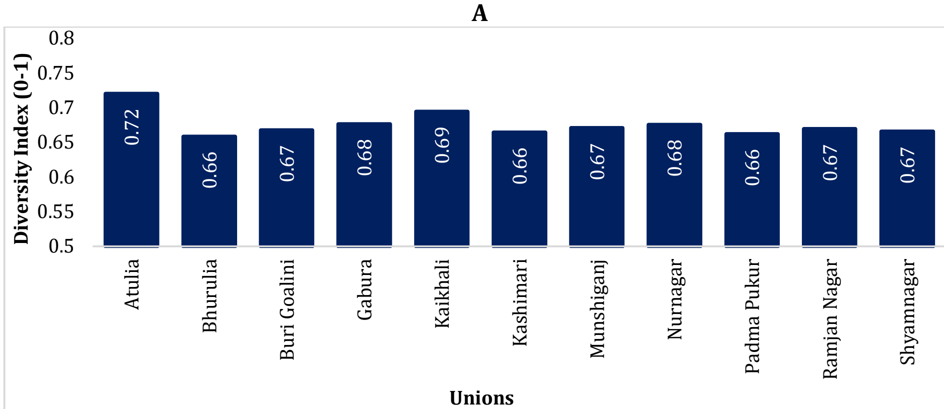
*Satellite image LandSat8, 2019*

*Fish diversity*

The riverine ecosystem is characterized by the High Salinity Zone (HSZ), having more than 10ppt mean salinity, which can support high saline 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 Shyamnagar Upazila. The present study found that the instantaneous catch is highly dominated by Bagda, Harina and Galda. Some euryhaline fish species, like Datina, was found in some extent in Munshiganj, Nurnagar, Buri Goalini, Gabura and Kaikhali unions of the Shyamnagar Upazila (**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 Shyamnagar Upazila**

***Livelihoods***

Fishing is a very risky activity for the people who are involved in capture fishing in Shyamnagar Upazila due to disasters which occur frequently in this area. In the last few decades, it was exclusively hampering the livelihood of fishermen. Every year fishermen lose their lives and fishing gears because of the climatic shocks. This study shows that about 1920 registered fishers go to Sundarbans and deep sea for fishing. Besides, a number of fishers also catch fishes from nearby rivers and canals.

Additionally, on average 10 to 12 fishermen work in a single fishing trawler where few part time fishers are involved in other jobs. The poor fishers are mainly exposed due to not being able to cope with the disasters. Sometimes, they have to take loans with high interest from local money lenders to mitigate losses incurred from fishing.

Indicators for abundance of species in open waterbodies, migratory route, and number of endangered species etc. were considered for exposure assessment. Exposure assessment results **(Table 4.7)** found that Buri goalini, Padma Pukur, and Ramjan nagar are highly exposed to climate change-induced hazards which may be due to the high presence of river ecosystem within. Gabura, Munshiganj, Atulia,and Kashimari unions are moderately exposed. Rest of the unions have comparatively lower exposure for capture.

### 4.2.2 Sensitivity

***Habitat under threshold***

According to the SWOT analysis on the provisioning services of the riverine ecosystem, a strong water availability condition was observed in the study area because of ensuring availability of optimum water in dry season and water retention time by the surrounding hydrological system and low sandy bed materials. It was observed that days of high temperature, high evaporation rate and no rainfall create a stress environment because of oxygen depletion, lowering water depth of connecting khals due to increased water loss and siltation. The present study calculated the sensitivity scores ranging from 0 (low sensitive-deep green in **Figure 4.6**) 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). 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.

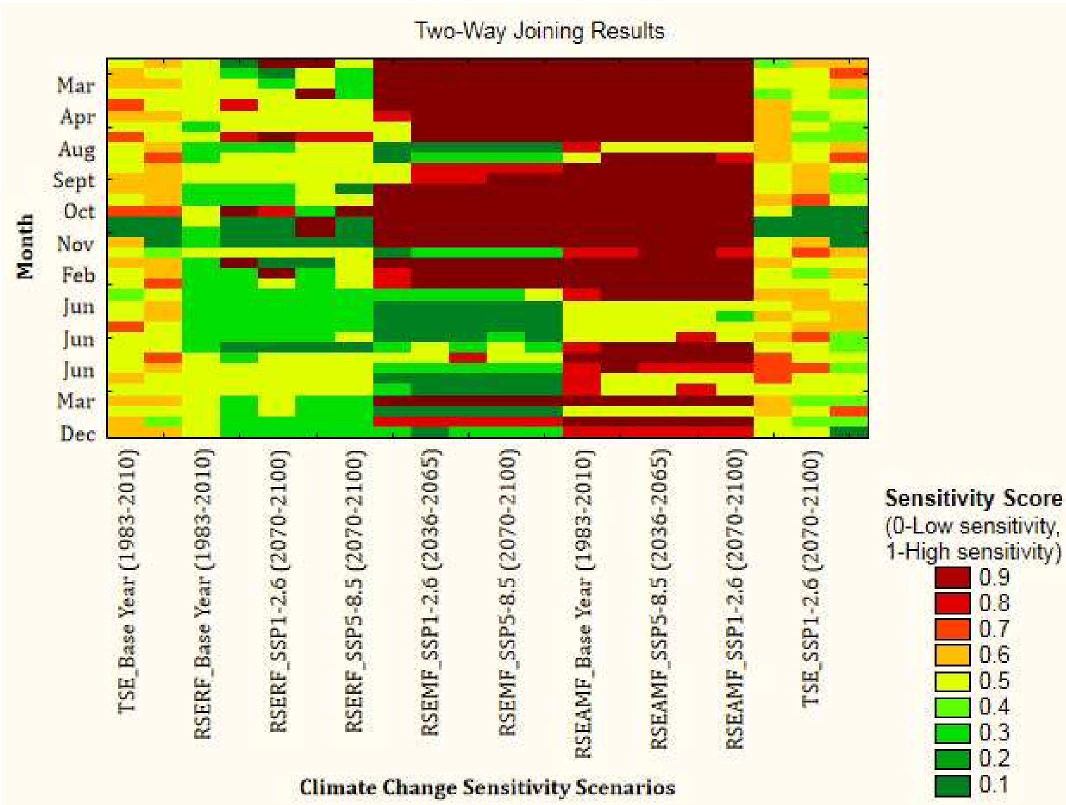



**Figure 4.6: Habitat sensitivity to natural mortality in the SSP1-2.6 and SSP5-8.5 scenarios**

*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*

### *Fish Breeding/Spawning*

Most species use rivers as breeding and spawning grounds. On the other hand, the breeding and spawning ground of Bagda and Galda is estuary. Breeding season of Chela and Sarpunti 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 starts breeding in June and continue up to September and, spawns in 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 trigger the freshwater species for successful spawning and breeding. Climate change may alter timing of rainfall, so fish spawning time may also shift which may result in decreased fertilization rate.

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

| Species | Locality | Breeding season | Spawning Season |
|---|---|---|---|
| Sarputi | River | Late June to early September | July and August |
| Chela | River | June-September | August |
| Baim | RIver | March-June | July - September |
| Bele | River | • March-April<br>• September- October | • May-June<br>• 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 found from various studies that maximum fluctuations from the optimum ranges might result in lowering chances for fertilization success, and thus in 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 resident, and also migratory fish groups. It has been found that the magnitude of breeding/spawning success might be significantly decreased in case of Galda, Bagda, Sarpunti, Bata and other available inland fishes in the SSP1-2.6 scenario (**Figure 4.7**). And this magnitude would be highly decreased in case of Bata by about 0.4% with increasing mean temperature and by about 0.1% with increasing mean rainfall. It indicates that Bata might not migrate in the river system for spawning in the future SSP1-2.6 scenario.

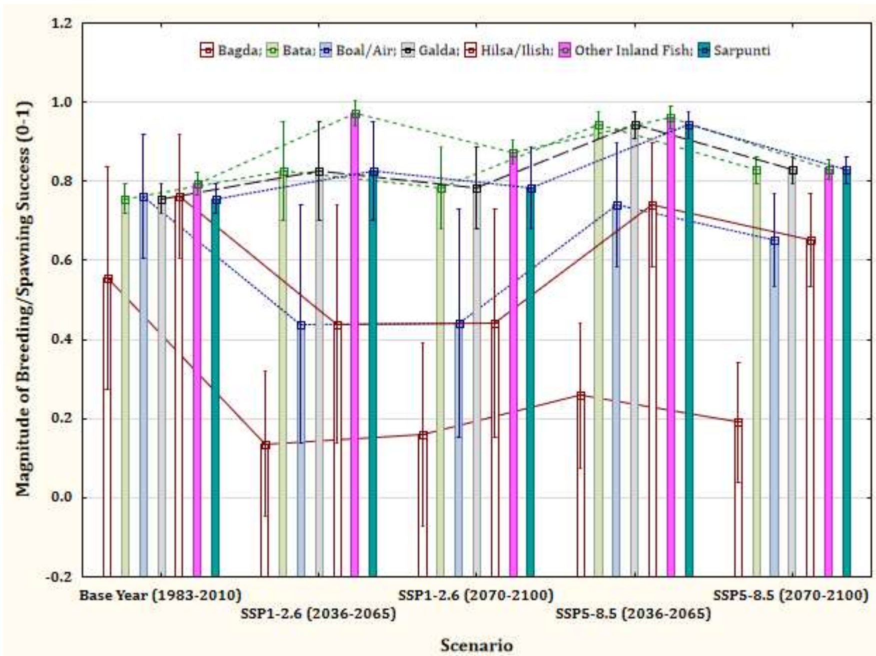
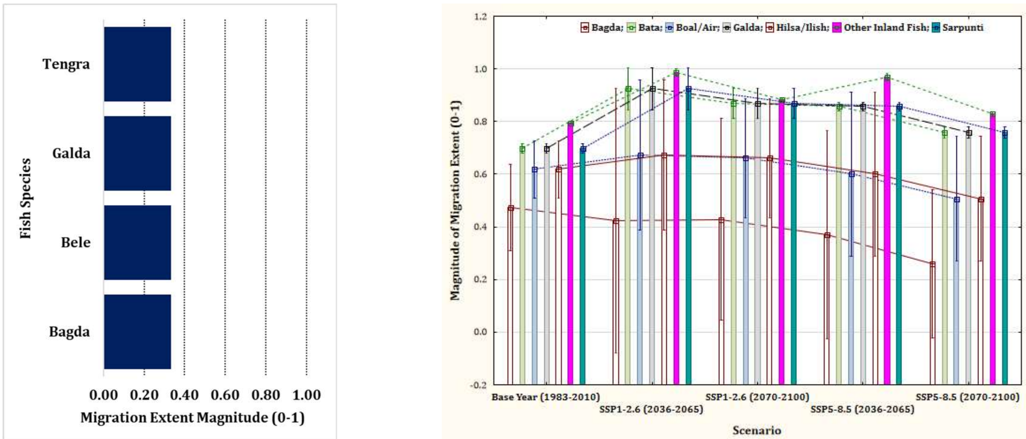



**Figure 4.7: Magnitude of Breeding/Spawning success of the available fish species**

*CEGIS Field Survey, 2022*

***Fish migration***

The rivers of the Shyamnagar 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 in the rivers are Pangas (*Pangasius pangasius*), Koral (*Lates calcarifer*), Ramchos (*Polynemous paradiseus*), Poma (*Otolithoides pama*), Dandi (*Sillaginopsis panijus*) and Tirel (*Eleutheronema tetradactylum*). The lateral migration occurs mostly for small fishes like Tengra (*Mystus bleekeri*), Guli (*Mystus gulio*), Failsha (*Liza Persia*), and small shrimp/prawns are mostly limited between the rivers and khal. Moreover, the catch assessment survey found that Bagda, Galda, Bele, Tengra and Taposhi have the very high migration extent (0.8-1), distributing all the rivers of all the unions (**Figure 4.8**). Parse and Datina have high (0.6-0.8), Sarpunti moderate (0.4), Baim low (0.2-0.4) and Aire (<0.2) very low migration extent. It has been predicted that the migration rate for Hilsha, Aire, Bata, Sarpunti and Galda would increase in SSP5-8.5 (2036-2065) scenario. On the other hand, migration rate of Bagda and other inland fishes would not be changed with the future climate change scenarios.




A B

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

***Growth coefficient and natural mortality***

The present study calculated the Growth Coefficient (K) of each available fish species found in the instantaneous catch during the study period. The Growth Coefficient is a parameter of the von Bertalanffy growth function, expressing the rate (1/year) at which the asymptotic length is approached. This value was calculated through using the maximum length of the studied fish species according to the formula of Pauly et al. (1998). Higher growth coefficient (>0.5) was found in case of Bele and Baim, whereas some fish species have lower growth coefficient (<0.3) (**Figure 4.9**). This indicate that the fish species, even the small-sized fishes (like Chela), may have lower growth under the present habitat condition and quality. It has been found that Aire, Baim, Bele, Datina, Kukurjib and Parse have higher mortality rate, losing more than three generation cohorts per year while other fishes were found to loss two generation cohorts annually (**Figure 4.9**).

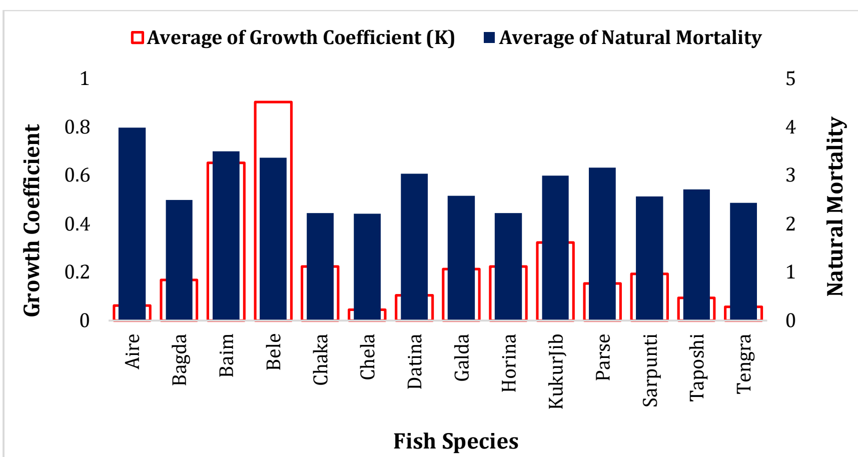



**Figure 4.9: Growth coefficient and natural mortality of the available fish species in the instantaneous catch**

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

The study found that under the SSP1-2.6 scenario, the magnitude of growth performance may also be increased for Galda, Sarpunti, Bata, and other readily accessible inland fishes (**Figure 4.10**). Future possibilities for Bagda and 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. 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.

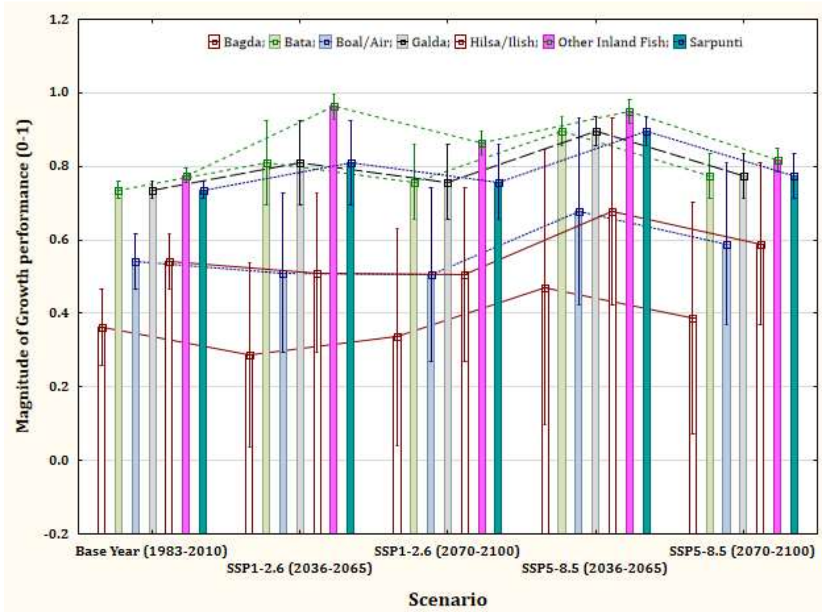



**Figure 4.10: Magnitude of growth performance of the available fish species**

*Impact Chain Analysis, CEGIS (2022)*

***Fish production***

The above-mentioned changes in habitat condition, fish diversity, fish migration and fish biology in respect of different climate change scenarios, total fish production in other unions of the Shyamnagar Upazila would be about 1,120 MT 1,169MT, 1,155 MT and 1,199 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) |
| Buri Goalini | 142 | 146 | 153 | 151 | 157 |
| Gabura | 374 | 385 | 402 | 397 | 412 |
| Munshiganj | 196 | 201 | 210 | 208 | 216 |
| Atulia | 21 | 21 | 22 | 22 | 23 |
| Bhurulia | 20 | 20 | 21 | 21 | 22 |
| Ishwaripur | 157 | 162 | 169 | 167 | 173 |
| Kaikhali | 21 | 21 | 22 | 22 | 23 |
| Kashimari | 15 | 16 | 16 | 16 | 17 |
| Nurnagar | 122 | 126 | 131 | 130 | 135 |
| Ramjan Nagar | 5 | 5 | 5 | 5 | 6 |
| Shyamnagar | 15 | 16 | 16 | 16 | 17 |
| Total = | **1,088** | **1,120** | **1,169** | **1,155** | **1,199** |

*Impact Chain Analysis, CEGIS (2022)*

***Livelihoods***

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

Fishers who are involved in the capture fishing have to face 3 months' ban period that negatively affect their livelihoods. Although during those ban days, Govt has taken initiatives to provide food assistance, field findings depicted that is not adequate in comparison with the number of fishers. On the other hand, with the restriction of entrance in the Sundarbans area, lack of credit to go to sea, and local issues, fishers contribute to earn as fish laborer. Most of the time they have to work on other boats because of lack of engine base fishing trawler. Moreover, fishers from this area also go to the Dublar char as fish laborer. Even after that, their received earning is not enough for supporting their livelihoods. The poverty condition of fish laborer, small and marginal fishers exist in this area. Furthermore, fishers take loans from the local lenders with high interest that also contribute to their poverty condition and sometimes they are not able to repay the interest thus become more vulnerable.

However, considering the enormous potentials of the inland capture fisheries, GoB has taken up programs to supplement fish stock in natural water bodies by release of fish fingerlings of various indigenous species and selected exotic species. GoB has also taken up programmes to enhance natural stock by establishing beel nurseries, maintaining sanctuaries, habitat restoration by re-excavation of canals, constructing fish passes reopening the important migratory routes. Maintaining sanctuaries combining banned seasons, gear restrictions and protected areas is hindered by the inability of the government to provide alternative livelihood support to fishers particularly during ban seasons. During the last decades, visible positive impacts due to Social Safety Net programme is evident in hilsa fishery management. So, enhancing Social Safety Net support to vulnerable fisher-folk will be helpful for sustaining capture fisheries.

With the increase of number of capture fishers, Department of Fisheries has taken initiatives to create alternative livelihood options for them. In this regard, a project titled: Sustainable Coastal and Marine Fisheries Project (SCMFP) is under implementation stage. The DoF and Social Development Foundation (SDF) provide different training program on generating alternative livelihoods for the fishers. In this regard, fishers started to be engaged in livestock farming, homestead agriculture, even aquaculture after receiving the training. This program has an opportunity for capture fishers to alleviate poverty and provide new window of earning opportunity.

As a part of the risk assessment, sensitivity of fisheries sector in Shyamnagar Upazila was also assessed (**Table: 4.7**). Unions near the Sundarbans were found highly sensitive for capture fisheries. Munshiganj, Gabura and Buri Goalini unions were found highly sensitive to climate change induced hazard. Only Padmapukur union was found to be in moderately sensitive zone and rest of the unions were in low sensitive zone for capture fisheries. Generally, cyclone intensity increases from April to May and September to November. Because of these extreme climatic events, fishing seasons reduce 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 Fishers adaptive capacity

***Mechanized boat***

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 limited capacity to adapt with the mentioned climatic events as most of the fishers are poor and have narrow scope of coping the hazardous situation. However, fishers usually undertake various initiatives to cope with such environment 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 Shyamnagar Upazila is shown in **Figure 4.11**.

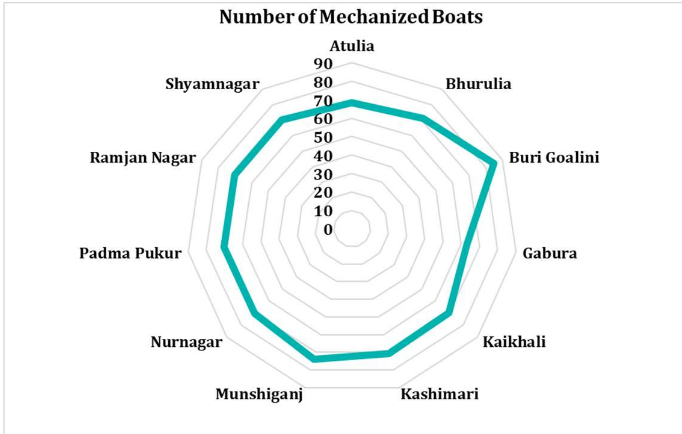



**Figure 4.11: Availability of mechanized boats**

*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 investigation. 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/hr.) |
| Behundi Jal | 4 | 3.5 | 1.43 | 0.41 | 4 | 3.5 | 1.43 | 0.41 |
| Vesal Jal | 15 | 5 | 2.4 | 0.48 | 15 | 5 | 2.4 | 0.48 |

*CEGIS Field Survey, 2022*

Similar to exposure and sensitivity assessment, adaptive capacity was assessed for Shyamnagar Upazila through indicator-based impact chain analysis. This assessment (**Table 4.7**) reveals that Kashimari, Atulia, and Ishwaripur unions have high adaptive capacity for capture fisheries. Ramjan Nagar, Buri Goalini, Gabura, Padma Pukur, and Bhurulia unions have moderate adaptive capacity for capture fisheries in this region. Rest of the unions are in low adaptive capacity zone.

### 4.2.4 Vulnerability

The study assessed vulnerability of capture fisheries of Shyamnagar 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**), Munshiganj, Buri Goalini, and Gabura unions were found to be highly vulnerable. These unions had high sensitivity and low to moderate adaptive capacity. Shyamnagar union was found to be in moderate vulnerability while rest of the unions were found to be in low vulnerable zone. The capture fisheries based livelihoods especially in Munshiganj, Buri Goalini, and Gabura will be highly vulnerable to climate change.

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

| Union | CRVA Elements | | | |
|---|---|---|---|---|
| | Exposure | Sensitivity | Adaptive | Vulnerability |
| **Atulia** | Medium | Low | Medium | Low |
| **Bhurulia** | Low | Low | High | Low |
| **Buri Goalini** | High | High | Medium | High |
| **Gabura** | Medium | High | High | High |

| Union | CRVA Elements | | | |
|---|---|---|---|---|
| | Exposure | Sensitivity | Adaptive | Vulnerability |
| **Ishwaripur** | Low | Low | Medium | Low |
| **Kaikhali** | Low | Low | Medium | Low |
| **Kashimari** | Medium | Low | Low | Low |
| **Munshiganj** | Medium | High | Low | High |
| **Nurnagar** | Low | Low | Medium | Low |
| **Padma Pukur** | High | Medium | Low | Low |
| **Ramjan Nagar** | High | Low | High | Low |
| **Shyamnagar** | Low | Low | Low | Medium |

### 4.2.5 Risk

The study also assessed the risk associated to capture fisheries for the base and 2050s time period. The unions Kashmiri, Atulia, Padma Pukur, Buri Goalini, Gabura, Munshiganj, Kaikhali and Ramjan Nagar are highly exposed to multi-hazard risk in both present and future time periods which affects capture fisheries activities negatively throughout the year in these unions. Rivers Kapotaksh and Kholpetua run through unions Kashmiri, Atulia, Padma Pukur, Buri Goalini and Gabura which create capture fisheries opportunity in these unions but also leave them exposed to flood, erosion, sea level rise etc. Similarly, tributaries from Raimangal River runs through Kaikhali, Ramjan Nagar, Nurnagar and Bhurulia unions and expose them to such hazards. 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 Sundarbans face salinity ingression which hampers the freshwater fisheries activities in Kaikhali, Ramjan Nagar, Buri Goalini, Gabura, Munshiganj, Ishwaripur, Nurnagar and Shyamnagar unions. 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 risk analysis for capture fisheries, most of the unions in the east of Shyamnagar Upazila namely Kashimari, Atulia, Munshiganj, Buri Goalini, Padma Pukur and Gabura were found to be in high risk in the base period. In 2050s, Ramjannagar union will be in high-risk zone along with the high-risk unions at the base period. Initially Bhurulia union was in low-risk zone in the base period but due to increased impact of climate change it will be in moderate risk zone in 2050s. The income and livelihoods of high-risk unions will face more losses and damages due to recurrent climatic extreme event. Following **Figure 4.12** shows the risk of capture fisheries in Shyamnagar.

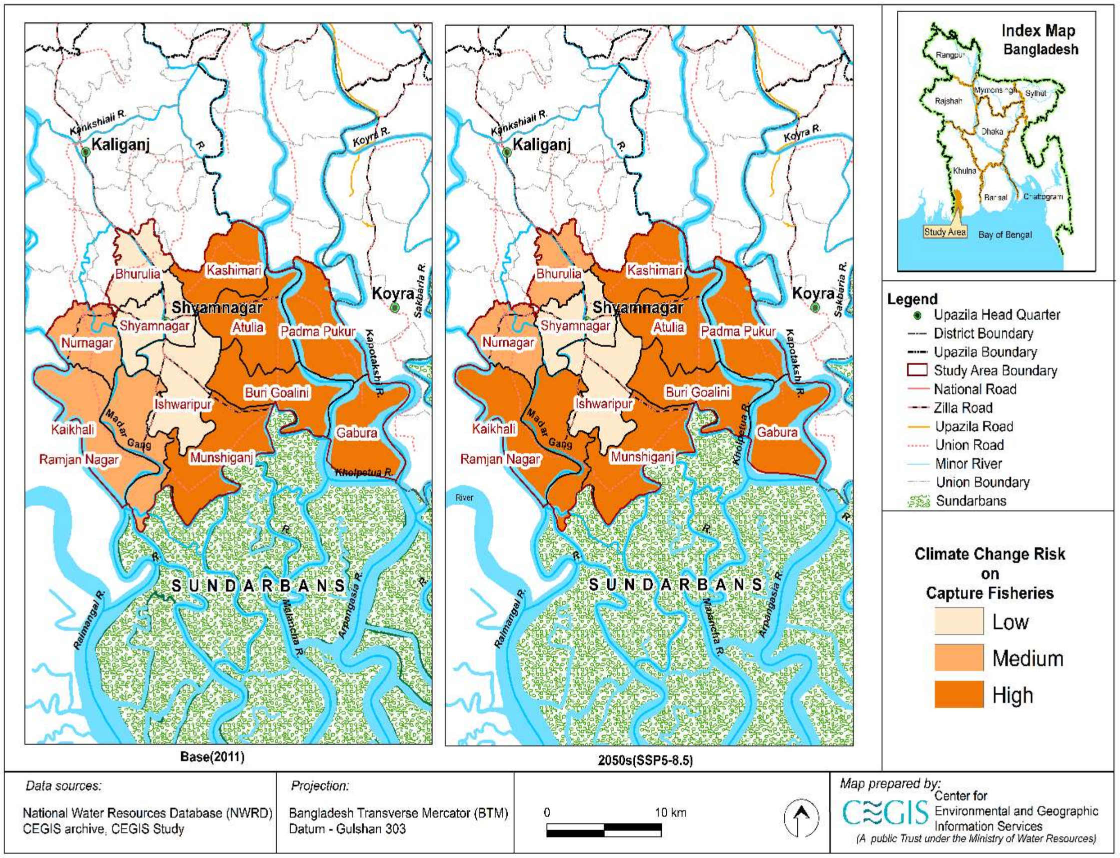



**Figure 4.12: Climate risk of capture fisheries in Shyamnagar Upazila**

## 4.3 Culture fisheries

### 4.3.1 Exposure

About 25,119ha area is under the aquaculture in the Shyamnagar Upazila. The aquaculture habitat includes shrimp/prawn/fish farm and fish pond. The habitat assessment of these aquaculture habitat and cultivable fish species are briefly described in respect of the exposure indicators in the following sections.

***Habitat***

In total 17,600 ha area of shrimp/prawn/fish farm are exist in Shyamnagar Upazila. Among the Shrimp/Prawn/Fish farm, some are Bagda Gher where Bagda (*Peneus monodon*) along with other shrimp and fish are cultured all the year-round, and some are Golda Gher where Golda (*Macrobrachium rosenbergii*) and white fish (major carp, tilapia, etc.) are cultured in mix way in the wet season. The aquaculture status of different unions in Shyamnagar Upazila is shown in **Table 4.8**.

**Table 4.8: Spatial distribution of shrimp/prawn/fish farm in different unions of Shyamnagar Upazila**

| Unions | Water area (ha) |
|---|---|
| Atulia | 689 |
| Bhurulia | 689 |
| Buri Goalini | 3,026 |
| Gabura | 2,258 |
| Ishwardipur | 715 |
| Kaikhali | 873 |

| | |
|---|---|
| Kashimari | 542 |
| Munshiganj | 2,769 |
| Nurnagar | 674 |
| Padma Pukur | 3,409 |
| Ramjan Nagar | 1,003 |
| Shyamnagar | 953 |
| **Total** | **17,600** |

*Satellite image LandSat8, 2019*

***Cultured fish species***

Sarpunti, Silver Carp and Tilapia were found to be highly cultivable fish species in Shyamnagar Upazila (**Figure 4.9**). The farm owners mainly cultivate fin fish 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 the cultured fish species in the shrimp/prawn/fish farms and Bio-folio in the unions**

| Species name | Species composition (%) |
|---|---|
| Bagda | 0.51 |
| Catla | 2.13 |
| Harina | 0.02 |
| Mrigal | 8.06 |
| Paira | 0.05 |
| Parse | 0.09 |
| Rui | 2.58 |
| Sarpunti | 20.73 |
| Silver Carp | 51.82 |
| Tilapia | 13.99 |
| Vangon | 0.01 |
| Vetki | 0.01 |
| **Total** | **100** |

*CEGIS Field Survey, 2022*

***Livelihoods***

It is observed that about 55 % people in this Upazila are dependent on fishing and aquaculture as the main occupation. Besides, they involve in agriculture (25 %), and private businesses (12%) remained involve in other sources of income. In terms of exposure on livelihoods, gher and pond owner who are dependent on this aquaculture sector are in risks to be exposed due to climatic events. Though with the increase of multiple business opportunity considering the shrimp, road communication is requird to be developed. But it is observed that with occurrence of cyclone and strom surge, roads and growth centers are also affected which potentially causes problems in getting market accessibility. In this aspect, gher livelihoods are being exposed with the changing climatic shocks and events.

Pond fish farmer were faced with various types of economical, technical, social and environmental problems during culture period. Majority of farmers (26%) regarded seasonal flood, cyclone and storm surge as the most vital disasters that make more vulnerable. Lack of money for pond management, insufficient water in dry season, non-availability of fish fry, and fish disease also adds to their vulnerability.

The study further made an assessment to understand the culture fisheries exposure to climate induced hazards in Shyamnagar Upazila and eleven exposure indicators were selected (Annex I) and mapped following the impact chain analysis. **Table 4.16** below shows the exposure status of Shyamnagar Upazila. From the assessment, Ramjan Nagar, Ishwaripur, Munshiganj, Buri Goalini unions were found to be in high exposure and Kashimari, Gabura and Atulia were moderately exposed 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 indicators and adaptive capacity are briefly described in the following sections.

***Habitat condition***

Pond water quality starts to degrade when the temperature reaches higher than 33 °C and results in slow growth and reduced fish feeding efficiency (A. Adey et al., 2015, M. Shahjahan, 2021). Temperature higher than 36°C is the lethal limit 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 pH, water temperature and DO are in optimum range but TDS exceed in all unions of the Upazila (**Table 4.10**). It has been predicted that extreme temperatures coupled with erratic rainfall patterns directly impact on fish physiology, growth, feeding behavior and mortality in the aquaculture habitat. Moreover, excessive rainfall will breach the dyke of the fish pond and increase natural mortality due to depletion of pH.

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

| Unions | PH | TDS (gm/l) | Water Temperature (°C) | DO (mg/l) | BOD (mg/l) |
|---|---|---|---|---|---|
| Atulia | 7.47 | 244 | 30 | 7.18 | 1.20 |
| Bhurulia | 7.42 | 704 | 30 | 5.18 | 4.60 |
| Burigoalini | 8.18 | 1243 | 30.9 | 6.58 | 3.14 |
| Gabura | 8.19 | 1270 | 30.9 | 6.47 | 3.52 |
| Ishwaripur | 7.79 | 288 | 30 | 4.95 | 0.81 |
| Koikhali | 8.18 | 1368 | 30 | 6.59 | 3.09 |
| Kashimari | 8.20 | 692 | 30 | 5.40 | 3.04 |
| Munshiganj | 8.18 | 621 | 30.9 | 8.11 | 2.71 |
| Nurnagar | 8.25 | 1233 | 30 | 7.2 | 1.00 |
| Padmapukur | 8.07 | 1174 | 30.9 | 6.53 | 3.30 |
| Ramjannagar | 8.53 | 384 | 30 | 5.74 | 1.00 |
| Shyamnagar | 8.18 | 1243 | 30.9 | 6.58 | 3.14 |
| Acceptable Range of Fish Community including Crustaceans | Growth Limit: 6.8-8.5 Lethal Limit: 3.8 | 0.3-120 | Lethal Limit: 36 °C<br>Optimum Range: 25-30°C<br>Significantly Lower Growth Rate (<1%/day SGR*): <15°C and > 33°C | >5 | <5 |

*SGR: Specific Growth Rate*

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 the Shyamnagar Upazila (**Figure 4.13**). Moreover, in case of Bhurulia, Kashimari, Nurnagar, Padmapukur, Ramjannagar and Shyamnagar unions, water depth was found to be optimum level for aquaculture production. Furthermore, more than 50% vegetation coverage (considering both the floating and sub-merged vegetation) was found in the aquaculture farms in Bhurulia and Nurnagar unions (**Figure 4.13**). The farms having higher coverage of submerged vegetation (>50%), only found in Bhurulia and Nurnagar unions, are expected to produce high abundance of methanotrophs, which can act as a biological sink for the greenhouse gas methane. According to L. Fan et al. (2019), the present study predicted that the submerged vegetation might influence methanotrophs in two ways: increasing the alpha diversity of the methanotrophic community or methanotrophic abundance through inducing anaerobic root zone conditions, facilitating increasing methane oxidation potential.

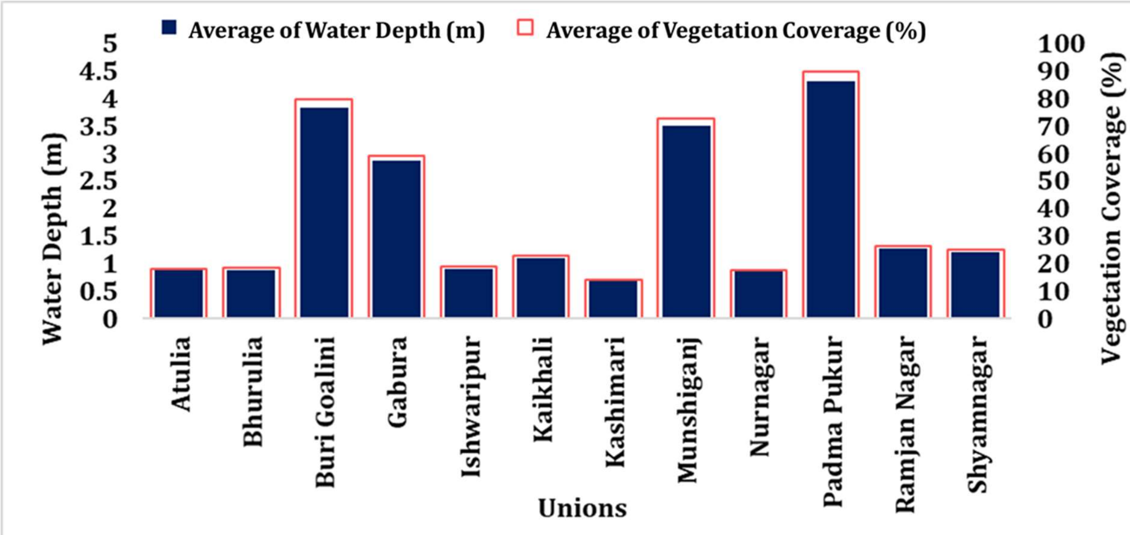



**Figure 4.13: Average water depth and vegetation coverage in the fish ponds and shrimp/prawn/fish farms in different unions of Shyamnagar Upazila**

*CEGIS Field Survey, 2022*

### *Growth coefficient and natural mortality*

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


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

*CEGIS Field Survey, 2022*

### *Production loss due to climate-induced disease*

The farms in different unions of Shyamnagar Upazila were estimated to lose about 7.88 MT of fish production in total (**Table 4.11**) due to climate-induced disease and other extreme events. During field survey, three climate induced diseases have been identified, among them antenna cut and White Spot Syndrome (WSS) are caused by extended days of 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) |
|---|---|
| Atulia | 0.21 |
| Bhurulia | 0.21 |

| | |
|---|---|
| Buri Goalini | 0.92 |
| Gabura | 0.69 |
| Ishwardipur | 0.22 |
| Kaikhali | 0.27 |
| Kashimari | 2.67 |
| Munshiganj | 0.84 |
| Nurnagar | 0.21 |
| Padma Pukur | 1.04 |
| Ramjan Nagar | 0.31 |
| Shyamnagar | 0.29 |
| **Total** | **7.88** |

*CEGIS Field Survey, 2022*

***Fish production***

The changes mentioned above in habitat condition and fish biology with growth co-efficient and natural mortality in respect of other climate change scenarios, total fish production in different unions of Shyamnagar Upazila would be about 7,573 MT 6,712MT, 6,961 MT and 8,160 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 scenarios**

| Union | Fish Production (MT) | | | | |
|---|---|---|---|---|---|
| | Base Year | SSP1-2.6 (2050) | SSP1-2.6 (2100) | SSP5-8.5 (2050) | SSP5-8.5 (2100) |
| Buri Goalini | 613 | 292 | 252 | 274 | 330 |
| Gabura | 3,936 | 1,575 | 1,410 | 1,433 | 1,659 |
| Munshiganj | 1,680 | 710 | 629 | 654 | 767 |
| Atulia | 1,399 | 599 | 529 | 553 | 651 |
| Bhurulia | 1,551 | 659 | 583 | 607 | 714 |
| Ishwaripur | 1,362 | 587 | 517 | 542 | 639 |
| Kaikhali | 1,560 | 654 | 580 | 601 | 703 |
| Kashimari | 1,346 | 588 | 517 | 545 | 645 |
| Nurnagar | 1,343 | 561 | 498 | 515 | 602 |
| Ramjan Nagar | 1,630 | 685 | 607 | 630 | 738 |
| Shyamnagar | 1,595 | 663 | 589 | 609 | 712 |
| **Total =** | **18,015** | **7,573** | **6,712** | **6,961** | **8,160** |

*Impact Chain Analysis, CEGIS (2022)*

***Livelihoods***

The shrimp farming communities apply specific strategies to continue fish farming in this area. From pond preparation to harvesting they have to do a lot of work. For shrimp farming, fry collection is one of the most important works, where fish or gher owner collect PL from the Sundarbans is the pre-monsoon months of April–June or buy them from the market. Every year cyclones hit this area and fry collectors often encounter problems. Besides, the cyclone and storm surge wash out the fish gher, due to which fish farmers encounter losses. Additionally, rise of temperature causes the death of shrimps in summer months and exert considerable negative effects on shrimp farms. The natural mortality rate of shrimp has been increasing with increasing number of total hot days and other climatic hazards. In this way, loss of production increases the vulnerability of small and poor farmers and make them more sensitive to climatic shocks.

Economic or financial capital has vital role for resilience in livelihoods. Monsoons generally limit the flow of the rural economy and access to informal jobs due to water logging, inaccessibility, and other adversities. In shyamnagar 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. Bangladesh, one of the poorest countries in the world, despite its impressive economic growth and consistent reduction in the rate of poverty, is still struggling with the poor and the extreme poor. There is an effort to combat poverty, both GoB and non-government organizations (NGOs) have been implementing a number of programs, such as, microfinance, vulnerable group development (VGD), and vulnerable group feeding (VGF), employment generation program, and other foods and cash transfers.

Fish farmers who are involved in gher, get earning opportunity because of the development of the fish processing center. The price they get from the Shirmp contribute to reduce the level of poverty. Besides, Govt. training on technology based aquaculture and cluster farming is providing opportunities in which capabilities of fish farmers are increasing along with earning opportunities to provide support for alleviating their poverty.

On the other hand, small farmers who are dependent on the aquaculture production, face problems in selling because of regularly occurred disasters. 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 do not let them to rid out of poverty cycle. In this aspect, choosing resilience and AIGs are becoming challenging for them to cope with the changing condition. Furthermore, fish farmers take loans from the local lenders with high interest that also contribute to their poverty condition and sometimes they are not able to repay the interest hence become more vulnerable.

Other than above assessments an indicator based sensitivity analysis (**Table 4.16**) was also made to identify sensitive unions of Shyamnagar Upazila. Total thirteen indicators were used to represent the sensitivity of ecosystem in Shaymanagar. According to the sensitivity analysis Munshiganj, Buri Goalini, and Gabura unions were found to be highly sensitive and rest of the unions were low sensitive 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 the Shyamnagar Upazila. One includes farm management and another is the disease control as discussed below.

***Aquaculture production system***

The present study found that the farm owners of all the unions take about 61 days (from November to December) for land preparation. Most of the farmers adopt semi-intensive culture technology. On average, they use about 247 Kg fertilizer and 123 Kg lime per hectare (ha) for their farm management (**Table 4.13**). They use fertilizers and lime for increasing primary productivity and maintaining pH level respectively. The stocking rate of these farms mainly depends on pond area and water depth. Vegetation coverage also has influenced on the pond 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 the Shyamnagar Upazila**

| Union | Land Preparation (Days) | Fertilization (kg/ha) | Lime (kg/ha) |
|---|---|---|---|
| Atulia | 61 | 240 | 130 |
| Bhurulia | | 230 | 120 |
| Buri Goalini | | 245 | 124 |
| Gabura | | 250 | 130 |
| Ishwaripur | | 235 | 125 |
| Kaikhali | | 245 | 140 |
| Kashimari | | 240 | 115 |
| Munshiganj | | 235 | 125 |
| Nurnagar | | 240 | 120 |
| Padma Pukur | | 235 | 110 |
| Ramjan Nagar | | 225 | 115 |
| Shyamnagar | | 235 | 125 |

*CEGIS Field Survey, 2022*

***Farm management against natural hazards***

The present study found that the local aquaculture farm owners have very limited adaptive capacity against the extreme climate induced events. They frequently take only two measures to tackle the extreme hot days, including pumping water and using coconut leaves over pond to make shade. During the drought period, fish farmers mainly use groundwater (**Table 4.14**). They use fine net surrounding their farm to protect their fish/shrimp from overtopping during tidal flood. In the study, a survey was conducted on 60 participants where 66% took no adaptive measures for heavy rainfall, cyclone, erratic rainfall, and wet days.

**Table 4.14: Adaptive measures for farm management**

| Hazard | Adaptive Measures | Response (%) |
|---|---|---|
| Extreme Hot Days | ● Pumping water<br>● Use of water hyacinth to make shade | 17 |
| Longer Days of Water Unavailability | ● Using Groundwater<br>● Farmers irrigate water to the farm to maintain a water level of at least 1.0 meter in the dry season. | 3 |
| Flash Flood | ● Fish farmers fenced by Nylon net or bamboo made mat (Bana) around the fish farm to prevent fish from escaping<br>● The farmers heighten the pond dyke to prevent fish from escaping<br>● The farmers harvest fish at an early stage before flooding to some extent. | 14 |
| Heavy Rainfall<br>Cyclone<br>Erratic Rainfall<br>Wet Days | Fish farmers usually do not take any measure | 66 |

*CEGIS Field Survey, 2022*

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

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) is caused because of extended days of severe cold temperature. The local aquaculture farm owner frequently uses aqua medicine and liming for antenna cut and White Spot Syndrome and aqua-medicine, liming and salt for controlling WSS and EUS (**Table 4.15**). A considerable number of fish farmers (about 25%) who do not take measures for disease control because of lack of knowledge about diseases outbreak. Sometimes farmers reside distantly from the fish feed and medicine outlets thus taking timely necessary measures become difficult. The marginal farmers claimed that the price of medicine is too high to purchase. Their inability of purchasing necessary medicines compels them to rely on the natural cure of fish for the diseases. This in turn causes the farmers a capital loss.

**Table 4.15: Adaptive measures for disease control**

| Climatic Cause | Disease | Disease Control Measures | Response (%) |
|---|---|---|---|
| Extended days of extremely high temperature | Antenna Cut | Using Aqua-medicine and Liming | 14 |
| | WSS | | 43 |
| Extended days of severe cold temperature | EUS | Using Aqua-medicine, Liming and Salt | 7 |
| | | No measures | 36 |

*CEGIS Field Survey, 2022*

Union-wise adaptive capacity was also assessed (**Table 4.16**) through different indicator-based impact chain. These indicators mainly demonstrate the coping mechanism of the culture fisheries in hostile conditions induced by climate change. However, the culture fisheries scenario assessment in this study followed 17 adaptive capacity indicators. Although, due to study limitations, the study team could cover only three unions during the field visit. Study team assessed union-wise conditions by consulting with SUFOs, key informants, secondary data sources, and expert judgment. Set of indicator lists are attached (Annex I). From the adaptive capacity assessment of the culture fisheries in Shyamnagar, it was found that Bhurulia, Ramjan Nagar and Gabura unions are highly adaptive for culture fisheries whereas Nurnagar, Kaikhali, and Bhurulia unions are moderately adaptive and rest of the unions are low in adaptive capacity for culture fisheries.

### 4.3.4 Vulnerability

Vulnerability of culture fisheries (**Table 4.16**) of Shyamnagar Upazila was also obtained through validated impact chain analysis. Generally, high vulnerability occurs when for particular union sensitivity is high but adaptive capacity is low. From the assessment Munshiganj, Buri Goalini, and Gabura unions were found to be high in vulnerability zone. These unions had high sensitivity and low to moderate adaptive capacity. Kashimari and Padma Pukur unions were found to be in moderately vulnerable while rest of the unions were found to be in low vulnerability zone.

**Table 4.16: Summary of climate vulnerability assessment for culture fisheries in Shyamnagar Upazila**

| Union | CRVA Elements | | | | |
|---|---|---|---|---|---|
| | Multi Hazard | Exposure | Sensitivity | Adaptive Capacity | Vulnerability |
| **Atulia** | High | Medium | Low | Low | Low |
| **Bhurulia** | Medium | Low | Low | High | Low |
| **Buri Goalini** | High | High | High | Low | High |
| **Gabura** | High | Medium | High | Medium | High |
| **Ishwaripur** | Medium | High | Low | High | Low |
| **Kaikhali** | High | Low | Low | Low | Low |
| **Kashimari** | High | Medium | Low | High | Medium |
| **Munshiganj** | High | High | High | Low | High |
| **Nurnagar** | High | Low | Low | Medium | Low |
| **Padma Pukur** | High | Low | Low | Medium | Medium |
| **Ramjan Nagar** | High | High | Low | Medium | Low |
| **Shyamnagar** | Medium | Low | Low | Medium | Low |

### 4.3.5 Risk

Climate change-induced hazard risk for culture fisheries was obtained through impact chain analysis for the base and 2050s time period. Buri Goalini, Gabura, Ramjan Nagar, Padma Pukur and Munshiganj unions contain the highest number of aquaculture farms in Shyamnagar. However, these unions are also adjacent to the Sundarbans or the rivers thus face salinity intrusion which affects freshwater aquaculture negatively. During cyclone and flood events major portion of Shyamnagar 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. Due to climate change, in recent years Buri Goalini, Gabura, Kashmiri, Padma Pukur and Munshiganj unions have faced high amount of production loss. 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 process found Ramjan Nagar, Munshiganj, Buri Goalini, and Gabura unions to be in high-risk for the base period. In 2050s, Padmapukur union will be in high-risk zone along with the high-risk union at the base period. Nurnagar, Kaikhali, Kashimari, and Atulia unions were in moderate risk at the base period and will be continued to be the same in 2050s. Initially Ishwaripur union was in low-risk zone in the base period but due to increased impact of climate change it will be in moderate-risk zone in 2050s. Following **Figure 4.15** shows the risk of culture fisheries in Shyamnagar.

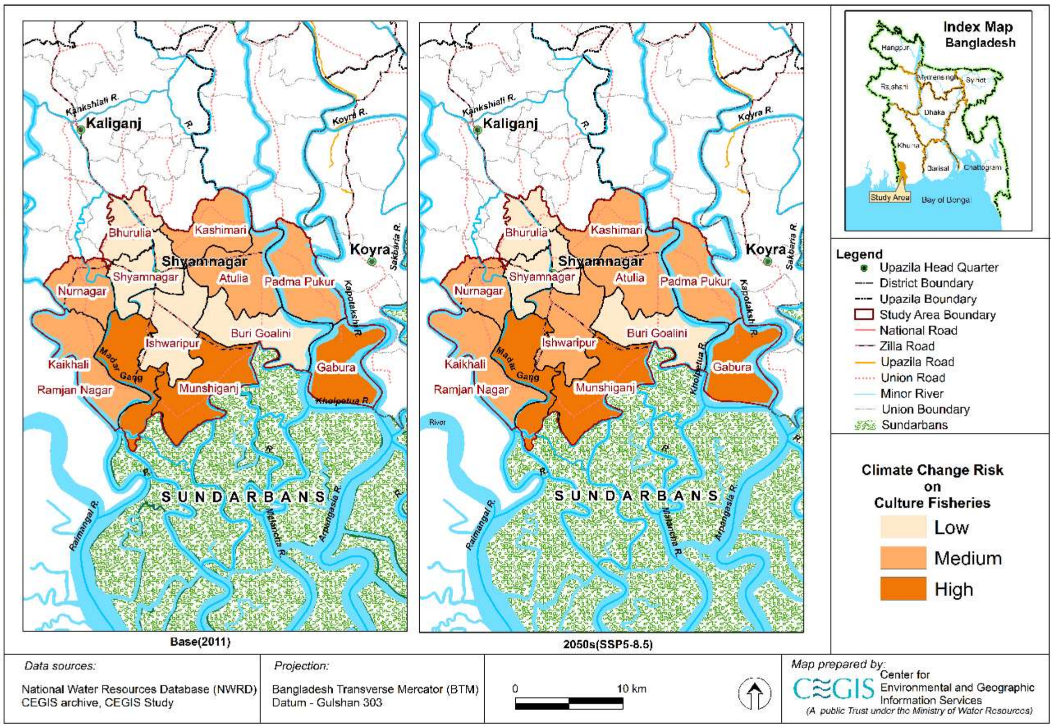



**Figure 4.15: Climate Risk for Culture Fisheries in Shyamnagar Upazila**

## 4.4 Gender

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 including the changing practice of social norms and protecting their rights are critical to integrate within the plan.

Shyamnagar Upazila is located in the coastal region, which has several social, financial, environmental and physical impacts due to climatic risks and hazards. Fisheries and aquaculture are also becoming more vulnerable because of cyclone, storm surge, extreme heat, flooding and salinity intrusion, and women's involvement in this sector has become more challenging. Women in this area involve in some of the activities related to capture and culture fishing. They are mainly involved in fry collection, net making, pond preparation, harvesting, and marketing. Although they have a huge involvement in fisheries and aquaculture, ownership of fish ponds and *ghers* is not adequate. Mostly women work with their male counterpart and working hour for women is higher than the male but contribution in decision making, access to market, income and wages are less which make them more sensitive to the climatic hazards. Even it becomes tough for them to take marketing decision though their experience and contributions play important role from pond preparation to harvesting. This section assesses the gender-based vulnerability considering the impacts on women, children, aged and disable people in terms of the exposure, sensitivity and adaptive capacity. In doing this, both quantitative and qualitative data collected from the field and analysed to identify the risks, risks mitigation action and future adaptation measures for developing a gender responsive future plan on fisheries and aquaculture.

This section analyzes gender segregated risks, mitigation and adaptation options to mitigate climate change impacts with the aim of highlighting policy and interventions to increase women involvement and resilience in fisheries sector.

### 4.4.1 Exposure

Women are not involved in capture fishing directly but work as supporting staff during the preparation stage. However, some women sometimes catch fish near the house to meet their family's needs. Besides, women are engaged to support her husbands during net preparation. Furthermore, women who are solely responsible for maintaining family expenses sometimes go to near river area to collect shrimp fry. Women have to face challenges because of exposure elements to move and collect fish fry. It becomes very tough to go to fish market because of muddy and slippery roads in the rural area. Participation of women in capture fisheries is quite less than that of male fishers.

Regarding culture fisheries, women are mostly involved in supporting the male members and working in the fish pond/gher. Besides, they are responsible for household activities, collection of water, fish feeding, regular supervision, medication, pond drying, marketing etc. It is found that a total of 737 (8%) women involved in fish farming related activities. Following **Table 4.17** shows union-wise people engagement in fish related occupations by sexes, in which on an average 3% female are found to be engaged in this relevant occupation of which 0.36% have own fish farm/gher in Shyamnagar Upazila. Women involvement in fish related occupation is highest in Kashimari union (4%) among all the unions of Shamnagar Upazila. A considerable percentage of population of these occupational household are dependent, having the age group of 0 to 14 years old and 60+ age groups.

**Table 4.17: Ownership of fish ponds/gher in Shyamnagar by Union**

| Name of the Unions | Male (% of fish related occupants) | Female (% of fish related occupants) | Dependent members (%) |
|---|---|---|---|
| Atulia Union | 97 | 3 | 41.8 |
| Ishwaripur Union | 97 | 3 | 40.9 |
| Kaikhali Union | 97 | 3 | 42.9 |
| Kashimari Union | 96 | 4 | 44.9 |
| Nurnagar Union | 97 | 3 | 40.5 |
| Padma Pukur Union | 97 | 3 | 41.9 |
| Buri Goalini Union | 97 | 3 | 41.8 |
| Bhurulia Union | 97 | 3 | 39.6 |
| Munshiganj Union | 97 | 3 | 39.9 |
| Ramjan Nagar Union | 97 | 3 | 41.0 |
| Shyamnagar Union | 97 | 3 | 44.3 |
| Gabura Union | 97 | 3 | 39.0 |

*Field Data, 2022*

Based on the indicators of exposed elements by combining all data of exposed elements it is found that Atulia, Burigoalini and Ramjan Nagar unions are highly exposed to the climatic hazards in comparison with other unions (**Table 4.19**). Besides, Kashirmiri union is less exposed than all other unions. Rest of the unions are found moderately exposed to the risks of cyclone, storm surge and other hazards occurred in this area.

### 4.4.2 Sensitivity

Poverty conditions, mobility, gender-based risks, health, and physical condition are the most sensitive receptors for the regular occurrence of floods, erosion, cyclone, extreme heat, drought, siltation, and wave action where women, children, aged, and physically challenged people are highly exposed to these disasters. All these hazards are not equally affecting the exposed communities; it depends on the resistance capacity and accessibility to the support service for the community people.

In the fishers and fish farm households, with lessening income, poverty is increased which causes lack of vitamins and minerals intakes which is also a sensitive issue caused by the effects of climate change. In gender aspect, female income is quite lower than their male counterparts as women are less involved in economic activities, and have less access to the necessary support services, during disaster and post-disaster phase. Following **Figure 4.16** Shows the monthly income level of fish farmers in Shyamnagar Upazila. The average monthly income of male fish farmer ranges from BDT. 15000-25000 and female fish farmers earn considerably an average of BDT. 5500-10000 per month. Respondents from the different unions in Shyamngar Upazilla stated that their average income is not enough to maintain social life and dependency on their male counterparts is inevitable. Therefore, poor conditions and fewer income opportunities continue that make them more sensitive to the changing climatic conditions.

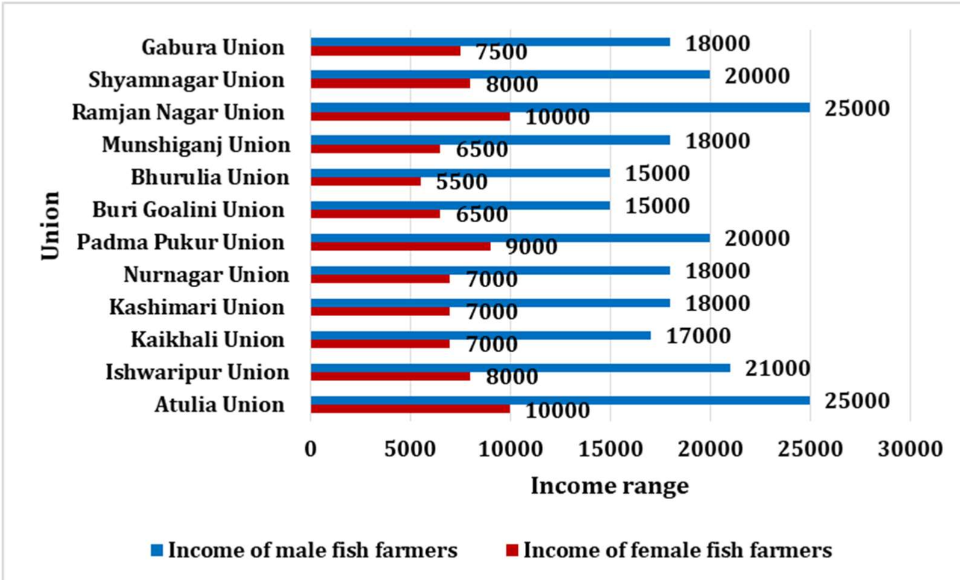



**Figure 4.16: Monthly average Income of women fish farmers by Union**

On top of that, women's labor wages are much less than men's. Usually, women labor is used in fish pond preparation, fry collection, feeding and harvesting. Women used to get 250 Taka (in average) per day, 7500 tk per month for these laboring activities whereas male laborers get about 350 Taka (in average) per day, 10500 tk per month. Nationally, this variation is calculated in monthly income where male earns BDT 13600 whereas female counterparts earn BDT 12300 per month (Source: BBS, 2018), which shows insignificant variation in compared to the study area. It is observed that most of the unions in Shyamnagar Upazilla have some issue of less income opportunities for women which are reasons to be more sensitive to the changing climatic condition. Also, poverty condition couldn't support to build resilient infrastructures, pond management and buying drinking water. Besides, water collection from far away increase accidental risks for women. The following **table 4.18** shows the indicators and its impact that are analyzed for identifying the sensitivity of Gender.

**Table 4.18: Impacts of hazards on gender**

| Indicators | Impacts |
|---|---|
| **Housing and homesteads** | The natural disaster causes huge negative impact every year in Shyamnagar. Floods, storm surges, cyclones, heavy rainfall, heat wave and salinity have increased in the region. As a result, it causes damage to houses, crop fields, crops, fisheries and more. Many families are even forced to migrate every year due to the impacts of the disasters. |
| **Impact on pond management and homestead vegetation** | Women work in nearby ponds and have less control over the resources, especially ownership of the ponds. Due to Hazard conditions, their pond based activities are disrupted. Besides, women, who control homestead-based livelihoods, lose income when crops are washed away. Most of the homesteads are now fallow and unsuitable for cultivation. In this regard, they have to buy vegetable from the market with a high price. Thus, family expenditure is increased in manifolds. Finally women face chronic nutritional deficiency. |
| **Limited access to market** | There are many unions in the Shyamnagar Upazila where the communication system is poor. It was noted that during disaster period, the communication system especially roads are damaged which disrupts transportation and communication and limits accessibility towards markets. Therefore, fishers cannot sell the produced fish in the local market, even at low price. In this regard, women suffer a lot and have limited ways to recover from this vulnerable condition. |
| **Loss of income, savings and employment** | Climate change related disasters are adversely affecting people's lives and environment. Women who are involved in fishing, fish farming and related work are adversely affected by natural disaster almost every |

| Indicators | Impacts |
| --- | --- |
| | year. They lose their income, fish ponds/gher are washed away, ponds are damaged and there is lack of money to recover due to disasters. Besides, during the disaster, job opportunities are limited. |
| **Sickness and disease** | The frequency of sickness has increased over the years. Women who are involved in catching fish, are exposed to saline water conditions for a long time which sometimes causes different types of skin diseases and diarrhoea. It was noted that during the menstruation period, women fishers face severe gynaecology related diseases. In most cases, they need to go to cities for treatment, which is a financial burden for them. Women and new born babies also face huge problems due to malnutrition, food insecurity and increased poverty condition. |
| **Social security** | Women who engage in outside work face social insecurity and are often subjected to physical and human harassment. Besides, various social taboos lead to neglect and disrespect of women who work outside. Moreover, flood shelters have limited separate facilities for women, aged, and physically challenged people, but they are not properly maintained. |

Sensitivity analysis (**Table: 4.19**) showed Munshiganj, Gabura,Buri Goalini, Nurnagar unions to be highly sensitive in comparison with other unions of the Shyamnagar Upazila for gender specific fisheries livelihoods.

### 4.4.3 Adaptive capacity

Following **Table 4.19** shows the status of people's contribution or access toward the adaptive indicators. It is found that about 40% women responded that they know about the climate change. But they have less capacity in reducing the saline water from the drinking water. According to respondents, about 7% women responded that they know how to reduce the salinity from drinking water. Besides, they confessed that they have received training on alternative livelihoods but not enough. About 13% women received training on Alternative Income Generating Activities (IGA). Women fishers have no adequate opportunity to take loans from banks or NGOs. As a result, it's very uncertain for them to carry out a business by their own. It was found that about 73% people get early warnings during natural disasters. And it is really shocking that only 73% people have their access to shelter from natural disasters. During these natural disasters, the local people were badly affected and became helpless. Their crops, livestock, and home were damaged by storms and cyclones. Moreover, they have good score on other adaptive capacity indicators. It means that they require more training and education on climate change, alternative livelihoods and credit facilities to be more adaptive and responsive for being resilient and fighting against climate change.

**Table 4.19: Status of adaptive capacity of women involved in fishing and fish farming**

| Adaptive capacity indicators | Status (%) |
| --- | --- |
| Understanding on Climate Change Impact | 40 |
| Knowledge of Fisheries Techniques | 73 |
| Knowledge of Pest and Diseases in Fish | 60 |
| Receive Early Warning Message Regularly | 73 |
| Watching Television or Social Media | 73 |
| Having Cell Phone | 73 |
| Having Smart Phone but no Internet | 23 |
| Having Smart Phone with Internet | 73 |
| Watching Television Once in a Week | 73 |
| Accessibility to Shelter during Cyclone/Floods | 73 |
| Knowledge on Hygiene during menstrual and pregnancy period | 73 |
| Knowledge on Drinking Water Boiling or Chlorination | 73 |
| Training Received on Climate Change | 27 |
| Training on Alternative Livelihood | 13 |
| Training on Climate Change Impact and Adaptation | 73 |
| Knowledge on Reducing the salinity from drinking water | 7 |
| Training on Climate Resilient Housing, Pond management and Infrastructures | 33 |

Adaptive capacity assessment (**Table 4.20**) showed Buri Goalini and Gabura unions had high adaptive capacity for gender-based livelihood. Only Shyamnagar union showed low adaptive capacity and rest of the unions had moderate adaptive capacity for gender specific fisheries livelihoods.

### 4.4.4 Vulnerability

Using impact chains developed for South-West region, vulnerability for gender-specific livelihood was also assessed for Shyamnagar Upazila (**Table 4.20**). Vulnerability assessment showed Munshiganj, Buri Goalini and Nurnagar unions were highly vulnerable. While Kaikhali, Padma Pukur,and Gabura unions were in moderately vulnerable zone. Unions with high vulnerability have low adaptive capacity and high sensitivity level. Rest of the unions were found at low vulnerability levels.

**Table 4.20: Summary of climate vulnerability assessment for F&A based gender in Shyamnagar Upazila**

| Union | CRVA Elements | | | |
|---|---|---|---|---|
| | Exposure | Sensitivity | Adaptive Capacity | Vulnerability |
| **Atulia** | High | Low | Medium | Low |
| **Bhurulia** | Medium | Low | Medium | Low |
| **Buri Goalini** | High | High | High | High |
| **Gabura** | Medium | High | High | Medium |
| **Ishwaripur** | Medium | Low | Medium | Low |
| **Kaikhali** | Medium | Low | Medium | Medium |
| **Kashimari** | Low | Low | Medium | Low |
| **Munshiganj** | Medium | High | Medium | High |
| **Nurnagar** | Medium | High | Medium | High |
| **Padma Pukur** | Medium | Low | Medium | Medium |
| **Ramjan Nagar** | High | Low | Medium | Medium |
| **Shyamnagar** | Medium | Low | Low | Low |

### 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 Shyamnagar, 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 Munshiganj, Bhurulia, Nurnagar, Kaikhali, Kashmiri and Buri Goalini 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 Munshiganj, Buri Goalini, and Gabura unions are in high risk for gender-based livelihood for both time periods. Initially Atulia union was in moderate risk at the base period but in 2050s due to increased impact of climate change induced hazard it showed high risk. Nurnagar, Kaikhali, Ramjan Nagar and Padma Pukur unions were found to be in moderate risk. Rest of the unions were found to be in low-risk zone. Following **Figure 4.17** shows the risk on gender (women) engaged on F&A based livelihood in Shyamnagar Upazila.

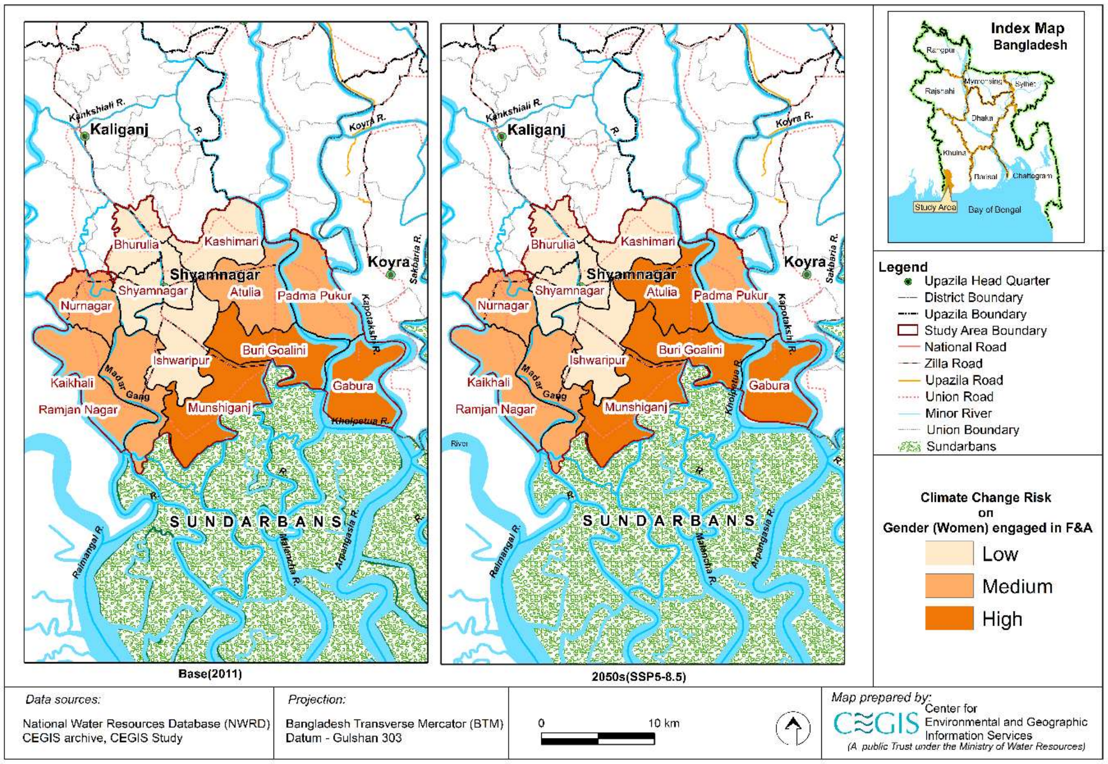



**Figure 4.17: Climate risk of gender engaged in F&A in Shyamnagar Upazila**

# 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 Shyamnagar 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 Shyamnagar 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 Shyamnagar 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 | • Develop and strengthen EWS and its dissemination for F&A | • Protect fishers' life, livelihoods and ensure social security through pre-informed early warning messages | DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, NGOs, Electronic, web and print media | Within 3 years |
| | | • Introduce index-based risk recovery mechanism or insurance scheme for the fishing communities | • Improve financial stability of family to recover sudden loss of family member | DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies | Within 3 years |
| | | • Training for emergency disaster response and risk management | • Increase adaptive capacity and know how to respond on disaster | DoF, BFRI, MoDMR, LGD, DSS, MOWCA, Training and Knowledge Institutes | Within 3 years |
| | | • Awareness raising program and behavioral change | • Protect fishers' life, livelihoods and ensure social security | 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 | • Develop and strengthen EWS and its dissemination for F&A to facilitate emergency safeguard of boats or fishing gears | • Safeguard the fishing gears and boats against hazards<br>• Reduce economic loss of the fishermen | DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, Electronic, web and print media | Within 3 years |
| | | • Introduce index-based risk recovery mechanism or insurance scheme for fishers community | • Improve financial stability of fishermen to recover any losses incurred from damages<br>• Ensure sustainability of income and livelihoods | DoF, BFRI, MoF, MoDMR, MoEFCC, 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** |
| | | • Provide climate resilience funds for repair or purchase of boats of gears | • Improve financial stability of fishermen to recover any losses incurred from damages | DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs, NGOs | Within 3 years |
| | | • Repair fishing and gears before every monsoon | • Protection of boats or gears and economic loss through proactive adaptation | Fishing communities | Within 3 years and continue |
| | | • Construction of storage areas for fishing tools | • Ensure support to prevent fishing gear and safety equipment damages during disasters | DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs, NGOs | Within 3 years |
| | | • Awareness raising program and behavioral change | • Enhance adaptive capacity and resilience | 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 | • Regular dredging of all large, medium and small rivers, beels | • Revitalization of rivers, beels and restoration of fisheries habitat<br>• Reduce aquatic ecosystem vulnerability | BWDB, MoS, DoE, NRCC, DoF, WARPO | Annual and periodic |
| | | • Maintaining connectivity of khals, beel and rivers | • Revitalization of rivers, beels and restoration of fisheries habitat<br>• Reduce aquatic ecosystem vulnerability | BWDB, MoS, DoE, NRCC, DoF, WARPO | Within 3 to 5 years |
| | | • Restoration of fish habitats and breeding grounds | • Increase productivity of fisheries | DoF, BFRI, DoE, MoS, NRCC, WARPO | Within 3 to 5 years |
| | | • Delay fishing activities until river/beel water become clean | • Reduce production losses | DoF, BFRI, MoLJPA, LGIs | Within 3 years and continue |
| 4 | Overall fishing activities may be hampered due to extreme weather, cyclone/floods or wave actions | • Awareness raising and capacity building for enhancing coping mechanism | • Increase adaptive capacity and resilience, income generation activities and improve living standard | 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** |
| | | • Arrangement of opportunities and skill development for alternative livelihoods generation | • Increase adaptive capacity and resilience, income generation activities and improve living standard | DoF, BFRI, LGIs, DSS, MoWCA, MoDMR, MoEFCC, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Introduce index based risk recovery mechanism or insurance scheme for fishermen community | • Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies | Within 3 to 5 years |
| | | • Strengthen flood management measures | • Reduce disruptions in fishing activities and economic losses | BWDB, LGED, DoF, WARPO | Within 3 to 5 years |
| | | • Climate sensitive zoning, plan and regulate fishing activities accordingly | • Reduce disruptions in fishing activities and economic losses | 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 | • Integrated coastal zone and mangrove management | • Protection of fish biodiversity and increase fish production combating impacts of climate change | DoF, BFRI, BFD, WARPO, BWDB, LGED, LGIs, MoDMR, MoEFCC, DSS, DYD | Within 3 years and continue |
| | | • Stock enhancement of threatened fish species | • Enhance resilience of fish species, increase adaptive capacity of fisheries ecosystem and reduce production losses | DoF, BFRI, LGD, Knowledge Institutes, Academia | Within 3 years and continue |
| | | • Research and monitoring of movement of salinity front, migration extent and diseases of major fish species | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | DoF, BFRI, Knowledge Institutes, Academia, DoE | Within 3 years and continue |
| | | • Increase freshwater flow from upstream of coastal rivers | • Reduce salinity and disruptions in migrations | MoWR, NRCC, LGED, MoS, WARPO, JRC | Within 3 to 5 years |
| | | • Innovate and release stress tolerant fish species | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce | DoF, BFRI, LGIs, Knowledge Institutes, Academia | 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 |
| | | | production losses and plan accordingly for fisheries risk reduction | | |
| | | • Conservation of freshwater sanctuaries, beel nursery and breeding ground | • Spawning and breeding of healthy fisheries and enhance fisheries production, boost income | 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 | • Provide subsidies and skill development for alternative livelihoods ensuring women's participation | • Reduce gender vulnerability, income loss and living standard<br>• Enhance adaptive capacity and resilience to combat disproportionate impacts on gender | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Training on gender and youth inclusive CC&DRR and EWS for fish farmers | • Enhance adaptive capacity and resilience to combat climate disasters | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Introduction of zero interest or low interest based credit facilities to recover disaster risk | • Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies, Bangladesh Banks and Private Sectors | Within 3 years and continue |
| | | • Introduce index based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards<br>• Reduce gender indiscrimination and inequality | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies | Within 3 to 5 years |
| | | • Provide climate resilience funds specially focusing on marginal women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs | 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** |
| 7 | Aquatic habitat degradation and decreased water quality due to flood and salinity | • Monitoring of water quality after the disaster and refrain from fishing activities | • Information about the habitat condition and plan fishing activities accordingly | DoF, BFRI, Knowledge Institutes, Academia, DoE, LGIs, MoLJPA | Within 3 years and continue |
| | | • Regular dredging of rivers and beels | • Allow natural cleansing of water and improve water quality | BWDB, MoS, DoE, NRCC, DoF, WARPO | Annually |
| | | • Conservation and expansion of coverage of different indigenous aquatic plants | • Allow natural cleansing of water and improve overall habitat condition | DoF, BFRI, DoE, BFD, LGIs, LGD | Within 3 years and continue |
| | | • Conservation of freshwater sanctuaries, beel nursery and breeding ground | • Spawning and breeding of healthy fisheries and enhance fisheries production, boost income | DoF, BFRI, NRCC, WARPO, LGIs, DoE, MoLJPA | Within 3 years and continue |
| | | • Ensure proper and smooth drainage of water after the floods through effective and integrated water management and operational infrastructures with fish pass | • Reduce chances of water quality degradation after floods | 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 | • Development of climate proofed post-harvest storage management, communication infrastructures and marketing facilities in gender inclusive way | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD | Within 3 to 5 years |
| | | • Rehabilitation of post-harvest storage management, communication infrastructures and marketing facilities in climate resilient way | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD | Within 3 to 5 years |
| | | • Climate sensitive planning and extend F&A post-harvest storage facilities and relevant infrastructures | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | 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 | • Regular dredging of all large, medium and small rivers, beels | • Revitalization of rivers, beels and restoration of fisheries habitat<br>• Reduce aquatic ecosystem vulnerability | BWDB, MoS, DoE, NRCC, DoF, WARPO | Annual and periodic |
| | | • Maintaining connectivity of khals, beel and rivers | • Revitalization of rivers, beels and restoration of fisheries habitat<br>• Reduce aquatic ecosystem vulnerability | 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 | • Coverage of selective aquatic vegetation in the water body e.g. water hyacinth, improve habitat suitability and biochemical treatment of water | • Establishment of selective fish sanctuaries with brush shelters. | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |
| 3 | Post-harvest storage management may get disrupted due to extreme heat and crisis of ice/cold storage facilities | • Development and rehabilitation of climate proofed post-harvest storage management, communication infrastructures and marketing facilities in gender inclusive way | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD | Within 3 to 5 years |
| | | • Climate sensitive planning and extend F&A post-harvest storage facilities and relevant infrastructures | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | 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 | • Development of stress tolerant species, improve habitat suitability and enhance aquatic biodiversity | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |

| Drought, Lightning, Heat Stress | | | | | |
|---|---|---|---|---|---|
| ID | Risk | Adaptation or Risk Reduction | Motivation | Critical stakeholder | When to Implement |
| 5 | Loss of fishermen lives due to lightning | • Strengthening Gender inclusive ICT based EWS for the Fisheries and aquaculture sector | • Protect fishers' life, livelihoods and ensure social security through pre-informed early warning messages | DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, Electronic, web and print media | Within 3 years |
| | | • Installation of lightning arresters or resting sheds nearby to large open waterbodies | • Protect fishers' life, livelihoods and ensure social security | DoF, BFRI, LGED, LGD, MoDMR | Within 3 years |
| | | • Awareness raising and capacity building for enhancing coping mechanism | • Increase adaptive capacity and resilience, income generation activities and improve living standard | DoF, BFRI, MoDMR, DSS, MoWCA, LGD, Training and Knowledge Institutes | Within 3 years and continue |
| | | • Introduce index-based risk recovery mechanism or insurance scheme for fishermen community | • Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies | Within 3 to 5 years |
| 6 | Loss of livelihoods, shifting occupation and increased poverty with disproportionate impact on women | • Provide subsidies and skill development for alternative livelihoods ensuring women's participation | • Reduce gender vulnerability, income loss and living standard<br>• Enhance adaptive capacity and resilience to combat disproportionate impacts on gender | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Training on gender and youth inclusive C&DRR and EWS for fish farmers | • Enhance adaptive capacity and resilience to combat climate disasters | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Introduction of zero interest or low interest-based credit facilities to recover disaster risk | • Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies, Bangladesh Banks and Private Sectors | Within 3 years and continue |

| Drought, Lightning, Heat Stress | | | | | |
|---|---|---|---|---|---|
| **ID** | **Risk** | **Adaptation or Risk Reduction** | **Motivation** | **Critical stakeholder** | **When to Implement** |
| | | • Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards<br>• Reduce gender indiscrimination and inequality | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies | Within 3 to 5 years |
| | | • Provide climate resilience funds specially focusing on marginal women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards | 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 | • Construction of climate proofed dykes or wave control structures or use of nets | • Reduce production losses and income losses | DoF, BFRI, LGED, LGIs, BWDB | Within next 3 years |
| | | • Plantation of native species, fruit trees or vegetable farming and mangroves as natural barrier over the pond dykes | • Reduce production losses and income losses<br>• Boost vegetable and fruit production and income | DoF, BFRI, LGED, LGIs, BFD, DAE | Within next 3 years |
| | | • Strengthening Gender inclusive ICT based EWS for the Fisheries and aquaculture sector | • Protect fisheries related infrastructures and assets through pre-informed early warning messages | DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, Electronic, web and print media | Within 3 years |
| 2 | Fishing and fishing assets (boats, nets and gear) may get damaged due to storm surge, floods or flash floods | • Strengthening Gender inclusive ICT based EWS for the Fisheries and aquaculture sector | • Protect fisheries related infrastructures and assets through pre-informed early warning messages | DoF, BFRI, FFWC, MoDMR, BMD, SPARRSO, LGED, LGIs, Electronic, web and print media | Within 3 years |
| | | • Construction of storage areas for fishing tools | • Protect fisheries related infrastructures and assets<br>• Reduce economic losses and income | DoF, BFRI, LGED, LGIs, RHD, Private Sectors | Within 3 years |
| | | • Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards<br>• Reduce gender indiscrimination and inequality | 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** |
| | | • Provide climate resilience funds specially focusing on marginal women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards | 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 | • Development of stress tolerant species, improve habitat suitability and enhance aquatic biodiversity | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |
| | | • Deepening of the ponds/shrimp farms to retain water >1.0 meter | • Improvement of habitat condition<br>• Control of disease outbreak<br>• Increase in fish production<br>• Increase of income | DoF, BFRI, LGIs, Academic Institutes, private sectors | Within 3 years and continue |
| | | • Application of aerator for oxygenation, aqua-medicine use in the aquaculture farms | • Reduce/neutralize environmental effects<br>• Reduce disease outbreak<br>• Increase fish production | DoF, BFRI, LGIs, Academic Institutes | Within 3 years and continue |
| | | • Identify and select simultaneous cultures of fish or shellfish along with other culture systems in light of integrated fish farming (IFF) | • Fish production increase<br>• Income increase | DoF, BFRI, LGIs, Knowledge Institutes, Academia, private sectors | Within 3 years and continue |
| | | • Facilitate in development and extension of stress-tolerant functional aqua-feed | • Improve habitat condition<br>• Facilitate boosting fisheries nutrients | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |
| | | • Heighten dikes of freshwater retention ponds to halt salinity ingression due to storm surges | • Safeguard fish species and production<br>• Secure income | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |
| | | • Introduce IoT based water quality monitoring such as salinity/pH/DO/water temperature in the aquaculture farms | • Risk informed decision making by fishermen themselves | DoF, BFRI, LGIs, Knowledge Institutes, Academia, Fishing Communities | 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** |
| | | | • Reduce habitat and production loss | | |
| | | • Pond rehabilitation to improve water quality with Urea, TSP, lime etc. | • Improve habitat condition<br>• Facilitate boosting fisheries nutrients | 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 | • Extension of resilient climate technology for combating climate-related stresses in Aquaculture<br>• Development of stress tolerant species of commercially important fish and species diversification | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |
| 5 | Pond habitats degradation due to siltation after floods or storm surge | • Excavation or re-excavation of dighi, pond, reservoir or construction-relevant infrastructure for freshwater harvesting | • Good quality, healthy and improved pond ecosystems to increase productivity and profit.<br>• Protect ecosystem to increase production and reduce vulnerability of the local community. | DoF, BFRI, BFD, WARPO, BWDB, MoS, DoE | Within 3 to 5 years |
| | | • Restoration of fish habitats and breeding grounds | • Improve the fish habitat condition | 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 | • Provide subsidies and skill development for alternative livelihoods ensuring women's participation | • Reduce gender vulnerability, income loss and living standard<br>• Enhance adaptive capacity and resilience to combat disproportionate impacts on gender | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Training on gender and youth inclusive C&DRR and EWS for fish farmers | • Enhance adaptive capacity and resilience to combat climate disasters | 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** |
| | | • Introduction of zero interest or low interest-based credit facilities to recover disaster risk | • Improve financial stability of fishermen to recover any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies, Bangladesh Banks and Private Sectors | Within 3 years and continue |
| | | • Introduce index-based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards<br>• Reduce gender indiscrimination and inequality | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies | Within 3 to 5 years |
| | | • Provide climate resilience funds specially focusing on marginal women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards | 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 | • Regular dredging of all connected river reaches with fish farms or ponds | • Revitalization of rivers, beels and restoration of fisheries habitat<br>• Reduce aquatic ecosystem vulnerability | BWDB, MoS, DoE, NRCC, DoF, WARPO | Annual and periodic |
| | | • Digging or excavation of ponds/dighi or reservoirs to store more water | • Reduce salinity and disruptions in migrations | MoWR, NRCC, LGED, MoS, WARPO, JRC | Within 3 to 5 years |

| Drought, Lightning, and Heat Stress | | | | | |
|---|---|---|---|---|---|
| **ID** | **Risk** | **Adaptation or Risk Reduction** | **Motivation** | **Critical stakeholder** | **When to Implement** |
| | | • Identification of vulnerable fish farms in respect of water availability and arrange for irrigation measures | • Reduce climate risks due to drought | 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 | • Development of stress tolerant species<br>• Improve habitat suitability and enhance aquatic biodiversity | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | 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 | • Extension of resilient climate technology for combating climate-related stresses in Aquaculture<br>• Development of stress tolerant species of commercially important fish and species diversification | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | 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 | • Development of stress tolerant species, improve habitat suitability and enhance aquatic biodiversity | • Innovate stress tolerant technologies, halt outbreak of diseases, reduce production losses and plan accordingly for fisheries risk reduction | DoF, BFRI, LGIs, Knowledge Institutes, Academia | Within 3 years and continue |
| 5 | Post-harvest storage management during extreme heat | • Development and rehabilitation of climate proofed post-harvest storage management, communication infrastructures and marketing facilities in gender inclusive way | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD | Within 3 to 5 years |
| | | • Climate sensitive planning and extend F&A post-harvest storage facilities and relevant infrastructures | • Reduce post-harvest losses and economic losses<br>• Reduce recurrent cost of government for O&M | LGED, RHD, LGD, DoF, BFRI, MoEFCC, MoDMR, private sectors, MoWCA, DSS, DYD | Within 3 to 5 years |
| | | • Construction of sheds over the ponds or ghers | • Protection of fisheries and reduce production losses | DoF, BFRI, LGD, LGED, LGIs, Private Sectors | |
| 6 | Loss of livelihoods, shifting occupation and increased poverty & internal | • Provide subsidies and skill development for alternative livelihoods ensuring women's participation | • Reduce gender vulnerability, income loss and living standard | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and | Within 3 years and continue |

| Drought, Lightning, and Heat Stress | | | | | |
|---|---|---|---|---|---|
| **ID** | **Risk** | **Adaptation or Risk Reduction** | **Motivation** | **Critical stakeholder** | **When to Implement** |
| | displacement with disproportionate impact on women | | • Enhance adaptive capacity and resilience to combat disproportionate impacts on gender | Knowledge Institutes, Private Sectors | |
| | | • Training on gender and youth inclusive C&DRR and EWS for fish farmers | • Enhance adaptive capacity and resilience to combat climate disasters | DoF, BFRI, LGIs, DSS, MoWCA, DYD, MoDMR, MoEFCC, MoF, Training and Knowledge Institutes, Private Sectors | Within 3 years and continue |
| | | • Introduction of zero interest or low interest based credit schemes to recover from disaster risks | • Improve financial stability of fishers to recover from any losses incurred from damages due to climate hazards | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, NGOs, Insurance companies, Bangladesh Banks and Private Sectors | Within 3 years and continue |
| | | • Introduce index based risk recovery mechanism or insurance scheme for fishermen community specially focusing on women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards<br>• Reduce gender indiscrimination and inequality | DoF, BFRI, MoF, MoDMR, MoEFCC, MoWCA, DSS, DYD, Insurance companies | Within 3 to 5 years |
| | | • Provide climate resilience funds specially focusing on marginal women | • Improve financial stability of women to recover any losses incurred from damages due to climate hazards | 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 | • Arrangement for awareness building on Climate change and its impacts | • Improving Capacity on CCA | DoF, MoWCA, NILG, MoLGRDC and MoSW with relevant organizations/ institutes, CBO, NGOs, CSOs | Before and After Disaster |
| | | | • Improving knowledge on CCA | | |
| | | | • Ensure empowerment and access to resources | | |
| | | • Training on optimum usage of resources for homestead and livelihoods development | • Improving knowledge on CCA | | |
| | | | • Resilient Livelihoods and Infrastructures | | |
| | | • Training on safety and security management of livelihood and homestead for pre, during and after disasters | • Improving Capacity on CCA | | |
| | | | • Ensure empowerment and access to resources | | |
| | | • Training on handling the necessary tech-based devices for ensuring early warning | • Ensure empowerment and access to resources | | |
| 2 | Lack of infrastructure dedicated for women | • Training on Understanding the necessity of using civic facilities during disaster | • Understanding the necessity of using civic facilities during disaster | DoF, MoWCA, MoLGRDC, MoSW, NILG with relevant | Before and After Disaster |

| ID | Risk | Adaptation or Risk Reduction | Motivation | Critical stakeholder | When to Implement |
|---|---|---|---|---|---|
| | | • Training on management of civic facilities in emergencies during disaster | • Capacity building on the management of these civic facilities in emergencies during disaster | organizations/ institutes, CBO, NGOs, CSOs | |
| | | • Building cyclone shelter with separate accommodation, hygiene and WASH facilities for women | • Ensure mobility and accessibility to the cyclone and flood centre<br>• Reducing gender base violence during and post disaster period | | |
| | | • Construction of separate market shed for women | • Ensure accessibility to the market and Growth Centre<br>• Ensuring safety - security during and post disasters | | |
| 3 | Disasters hampering income generating activities | • Creation of alternative IGAs and training on IGAs for livelihood management due to impact of disaster | • Ensuring support in livelihood during disasters<br>• Ensuring sustainability of income and livelihood | MoWCA, DoF, DDM, MoSW, DYD, NILG, CreLIC, CBOs, NGOs and CSOs. | During and after Disaster |
| | | • Training on IGAs with diseases management of livestock and poultry products | • Ensuring support in livelihood during disasters<br>• Ensuring sustainability of income and livelihood | | |
| | | • Training on cow fattening and multi farming approach | • Ensuring support in livelihood during disasters<br>• Ensuring sustainability of income and livelihood | | |
| 4 | Violence and accidental occurrences towards women | • Required training for emergency response team from Community, NGOs and GOs Level<br>• Training on handling the gender sensitive issues during disaster and post disaster | • Stopping violence and accidental occurrence during and after disaster period | MoWCA, DoF, DDM, MoSW, DYD, NILG, CreLIC, CBOs, NGOs and CSOs. | During and after Disaster |
| 5 | Inadequate lead time in early warning | • Instant and direct dissemination of early warning to women staying at home | • Safe evacuation before disaster | DoF, BMD, FFWC, DDM | Before and during Disaster |

| ID | Risk | Adaptation or Risk Reduction | Motivation | Critical stakeholder | When to Implement |
|---|---|---|---|---|---|
| | | | • Protection of livestock and property | | |
| | | • Transmitting early warning through digital medium i.e mobile SMS, megaphone announcement etc. | • Safe evacuation before disaster | | |
| | | | • Protection of livestock and property | | |

# 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 Shyamnagar 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 Shyamnagar 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 Shyamnagar 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 increases 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 Shyamnagar Upazila. Fish and/or other aquatic species migration, reproduction, and growth are also being impacted by the drought conditions usually experience in the area.

Climate change induced hazard risk for capture fisheries impact chain analysis showed Kashmiri, Atulia, Padma Pukur, Buri Goalini, Gabura and Munshiganj unions under high risk for the base period whereas, in 2050s, Kaikhali and Ramjan Nagar unions will be in high-risk zone along with the high-risk union at the base period. For Culture Fisheries, Munshiganj, Ramjan Nagar and Gabura unions were found to be in high risk for the base period and continue to do so in 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 fewer land-use changes. The results also draw attention to the weaknesses of the pond/fish gher ecosystem, which is more threatened by urbanization and 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 Shyamnagar Upazila smoothly. Different ecosystem-based adaption options, technical/financial incentives, and alternative livelihood generation for fishermen required policy reforms or non-structural 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 Shyamnagar 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 CO2 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 Aphanomyces 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** | • Understand context of CRVA, define objectives and possible outcome<br>• Define scope (sector, topic), extent (geographic level or vertical level) and timeframe (current and future)<br>• Assess resources and stakeholders' involvement requirement<br>• Stocktake available information<br>• Prepare implementation plan | • Capture and Culture Fisheries<br>• CRVA on Fisheries Livelihood and Ecosystem<br>• Base (2000s) and Future (2050s and 2085s)<br>• Climate Change Scenarios (SSP1-2.6 and SSP5-8.5)<br>• Up to district level<br>• Separate assessment for selected 6 regions<br>• National level stakeholders<br>• Review and stocktake | • Capture and Culture Fisheries<br>• CRVA on Fisheries Livelihood and Fish Ecosystem<br>• Base (2000) and Future (2050s and 2085s)<br>• Climate Change Scenarios (SSP1-2.6 and SSP5-8.5)<br>• Up to union level<br>• Separate assessment for each project site or Upazila<br>• Local level stakeholders, community and gender<br>• Review and stocktake |
| 2 | **Developing Impact Chains** | • Identify climate impacts and risks affecting the system<br>• Determine hazards (climate signal and direct impacts) and intermediate impacts<br>• Determine vulnerability (i.e. sensitivity and lack of adaptive capacity which are contributing to risk)<br>• Determine exposures or elements at risk | • Brainstorming among study team experts based on draft NCVA impact chain<br>• Develop initially conceptualized impact chain for selected 6 regions and as per defined scope for F&A<br>• Identify recommended adaptation measures including Ecosystem based Adaptation (EbA) considering gender inclusion ad sustainable livelihoods<br>• Share with relevant stakeholders and client | • Bring the national level impact chain for the respective region under which project site located<br>• Conduct FGDs, KIIs and Community Survey<br>• Update or modify the impact chain including the weight through Budget Allocation Approach<br>• Identify recommended adaptation measures including EbA considering gender inclusion and sustainable livelihoods |

| Steps | Activities | Agenda | National Level | Local Level |
|---|---|---|---|---|
| | | • Brainstorm adaptation measures to reduce the risk | • Get feedback and assign weights of identified CRVA elements through Budget Allocation Approach<br>• Finalise the impact chain for next step | • Compile Field based Outcome<br>• Brainstorming among study team experts<br>• Finalise the impact chain for each project site |
| 3 | **Identifying and Selecting Indicators** | • Select indicators for hazards<br>• Select indicators for vulnerability and exposure based on functional relationship with risk<br>• Identify proxy indicators, if any<br>• List all indicators and discard redundant or repeated indicators for same CRVA components | • Compiling data and information availability<br>• Selecting indicators of CRVA components based on data and information availability at desired level from secondary sources<br>• Identify proxy indicators<br>• Deduct redundant data | • Compiling data and information availability from FGDs, KIIs and Community Survey, Water Quality test<br>• Selecting indicators of CRVA components based on data and information availability at desired level from both secondary and primary sources<br>• Identify proxy indicators<br>• Deduct redundant data<br>• |
| 4 | **Data Acquisition and Management** | • Data collection, database construction and linking relevant data to chosen indicators | • Data collection and processing<br>• Gender disaggregation which are possible<br>• Threshold or intensity identification from trend, frequency and indices analysis<br>• 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.<br>• Land cover or water bodes change assessment<br>• Inventory preparation with unit for each indicator | • Data collection and processing<br>• Gender disaggregation which are possible<br>• Threshold or intensity identification from trend, frequency and indices analysis through both secondary sources and using feedback from local stakeholders and community<br>• 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.<br>• Land cover or water bodes change assessment<br>• Inventory preparation with unit for each indicator |
| 5 | **Normalisation of Indicator Data** | • Transfer different data sets into unit-less values on a common scale (i.e., 0 to | • Normalisation of indicator data based on functional relationship | • Normalisation of indicator data based on functional relationship |

| Step s | Activities | Agenda | National Level | Local Level |
|---|---|---|---|---|
| | | 1) based on functional relationship and standard normalisation formula | | |
| 6 | **Weighting and Aggregating of Indicators to CRVA Components** | • Assign weights to the various indicators<br>• Arithmetic aggregation indicators to CRVA components | • Assign weights derived from Impact Chain Finalisation workshop<br>• Geo-spatial weighted arithmetic aggregation using GIS<br>• Estimate total score of each CRVA components i.e. for hazard, exposure and vulnerability | • Assign weights derived from FGDs, KIIs and based on National level impact chain of that region<br>• Geo-spatial weighted arithmetic aggregation using GIS<br>• Estimate total score of each CRVA components i.e. for hazard, exposure and vulnerability |
| 7 | **Aggregating of CRVA Components** | • Assign weight and arithmetic aggregation of vulnerability components (i.e., adaptive capacity and sensitivity)<br>• Assign weight and arithmetic aggregation of CRVA components i.e., among hazards, exposure and vulnerability<br>• Estimate the total CRVA score and normalise the score again to single value (0 to 1) | • Assign weight among CRVA components derived from impact chain finalisation workshop<br>• Geo-spatial weighted arithmetic aggregation using GIS<br>• Estimate total score and normalise the CRVA score | • Assign weights derived from FGDs, KIIs and based on National level impact chain of that region<br>• Geo-spatial weighted arithmetic aggregation using GIS<br>• Estimate total score and normalise the CRVA score |
| 8 | **Presenting the Outcomes of CRVA** | • Summarise and present the findings of CRVA in maps using GIS and graphs (spider, pie or bar chart)<br>• List down possible adaptation measures to reduce climate risk and vulnerability | • CRA maps for current and future for each selected region showing spatial variation up to District Level<br>• Separate maps for Capture and Culture Fisheries highlighting gender perspectives<br>• CRV map for fishery ecosystem<br>• List of potential recommendations for adaptation measures<br>• Validating the outcome of CRVA with stakeholders | • CRV maps for current and future for each project site or Upazila showing spatial variation up to Union level<br>• Separate maps for Capture and Culture Fisheries highlighting gender perspectives<br>• CRV map for fishery ecosystem<br>• List of potential recommendations for adaptation measures<br>• Validating the outcome of CRVA with stakeholders |

| Steps | Activities | Agenda | National Level | Local Level |
|---|---|---|---|---|
| | | | • Update (if necessary) and publish the finalised CRV maps | • Update (if necessary) and publish the finalised CRV maps |

*Selected Indicators of Impact Chain*

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

| | Factor | Indicator |
|---|---|---|
| Hazard | 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 Shyamnagar Upazila

Indicators excluded In CRVA

| | Factor | Indicator |
|---|---|---|
| Culture Fisheries | 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 |
| Capture Fisher | Number and composition of fish species (Hilsha, Brackish water species) | Number/abundance of species |
| | Endangered and Threaten species | Number/abundance of endangered/threatened species |
| | Fish migratory route | Change in migratory route |

| Factor | | Indicator |
|---|---|---|
| ies | Regional fish species | No of Species |
| | 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 Shyamnagar 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 conc |
| | 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 occuring |
| | Fish Growth | Fish Growth Rate |
| | | Fish Size |
| | Mortality Rate | Mortality Rate |
| | Low resistance to Salinity | Fish Growth/Avoidance rate in higher salinity conc |
| | 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) |
| | Community Composition | No of Species/Abundance of species |

| Factor | | Indicator |
|---|---|---|
| | 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 Shyamnagar 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 Biofloc | Practice/Coverage of RAS and Biofloc |
| | 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 |
| | Fishing Ban season | Number of adequate ban days |
| | Subsidies for fishermen | Avaialbility of subsidies (PES/BPP) program |
| | Number of markets | Number of Fish Market |

| Factor | | Indicator |
|---|---|---|
| | 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 conc |
| | 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 | 2 | 1.75 | 1.75 | The strength of water availability received high score due to better condition of availability of optimum water in dry season and water retention time. Weaknesses scored medium condition because of good surrounding hydrological system and low sandy bed materials but the main delicacy is channel connectivity is being lost due to siltation. There are good opportunities to increase the water availability through dredging or re-excavation practices and community-based management. Moderate level of encroachment and intermediate obstacles are the main threats which scored medium but the overuse or extraction of water is low due to high salinity. |
| | Water quality | 1.6 | 2 | 1.75 | 2.5 | Water quality received medium score for strength as the Optimum Physio-Chemical Parameters (Temperature, DO, TDS, and pH) from the field test is optimum for water quality but due to high salinity water cannot be used for multipurpose so, for salinity increases, Weaknesses of water quality is scored medium. However, EbA interventions for dust management and presence of law enforcement 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 for water quality. Moreover, chemicals and pesticides used in surrounding crop field and fish gher causes the water quality more vulnerable so threats scored highest here |

| Ecosystem Service Type | Indicators | Strength | Weakness | Opportunities | Threats | Remarks |
|---|---|---|---|---|---|---|
| | Soil quality | 2 | 2.66 | 2.66 | 1.5 | The strength of soil quality is scored medium as the optimum soil nutrients are in good condition due to the nearby mangrove forest. The weaknesses of the soil quality scored high due to presence of ordinary peat soil which is a very soft soil with low shear strength and high compressibility exists in 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 on soil quality as chemicals and pesticides used in surrounding crop field and fish gher. |
| | Primary productivity | 2.33 | 1 | 2 | 1 | Availability of high plankton because of the nearby Sundarbans, adequate sediment retention, export and floodplain fertility provides high strength scores for primary productivity. Weaknesses for primary productivity scores low as less time 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 set medium score by increasing forest, vegetation coverage and EbA interventions. However, negligible threats on productivity scored low due to low harvest of the ecosystem resources because of presence of law enforcement. |
| | Fish diversity, community dynamics and production | 2.66 | 1.3 | 1.5 | 2.2 | This service scored highest 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 medium 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 the good opportunities and received medium score. Frequent climate extreme event are the main threats for fish diversity, community dynamics and production. However, Limited access to climate and hydrology information also a big threat and received highest score |
| **Regulating** | Ground water recharge | 1.5 | 2 | 1 | 1.3 | The strength for ground water recharge 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 ground water recharge. Main threats are management of domestic waste and unplanned urbanization which is scored moderate. |

| Ecosystem Service Type | Indicators | Strength | Weakness | Opportunities | Threats | Remarks |
|---|---|---|---|---|---|---|
| | Waste water treatment | 2 | 1.5 | 2 | 2 | The strength of waste water treatment received good score due suitable condition of aquatic vegetation. Weakness scores medium condition because of average dense turbidity. EbA interventions for dust management and law enforcement are good opportunities for this indicator and received medium scores. Management of domestic waste and unplanned urbanization are the main threats which scored medium. |
| | Soil fertility | 3 | 1 | 1.6 | 1.6 | 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 score because of increasing forest and vegetation coverage and sustainable management. Presence of embankment are the main threats for soil fertility which scored medium. |
| | Water retention capacity | 2.5 | 3 | 1.5 | 1.5 | Water retention and conveyance capacity is good and strength for this indicator scored high though siltation is the greatest weakness and received maximum score. There are average opportunities for dredging and new hydrological connection so it scored medium. Presence of embankment disrupt water retention so the threats scored average. |
| **Cultural** | Recreation and tourism | 3 | 1.5 | 2 | 1.5 | High resource availability, scenic beauty and sustainable management provides satisfying score for cultural services but the main weakness is ecotourism is not so planned and scored moderate. Opportunities received good score for community-based livelihood. The main threats are environmental pollution by the tourist and receives average score. |
| **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 natural ecosystem so there are few opportunities for ground water recharge which received less score. Main threats are management of domestic waste and unplanned urbanization which is scored moderate. |

| Ecosystem Service Type | Indicators | Strength | Weakness | Opportunities | Threats | Remarks |
|---|---|---|---|---|---|---|
| | Nutrient cycling | 3 | 1 | 3 | 1 | Nutrients 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 score. |
| | Maintenance of floodplain fertility | 2.5 | 2 | 2 | 1.5 | The strength for 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 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 indicators 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 event are the main threats for Prey/predator relationships which received poor score |
| | Hydric soil development | 1.5 | 2 | 2 | 1 | The strength for 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 for hydric soil development which gets poor score. |
| **Total** | **Total Indicators= 15** | **34.89** | **25.96** | **28.26** | **23.35** | |

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

| Ecosystem Service Type | Indicators | Strength | Weakness | Opportunities | Threats | Remarks |
|---|---|---|---|---|---|---|
| **Provisioning** | Water availability | 1.3 | 3 | 3 | 3 | The strength of water availability received medium score due to vulgar condition of availability of optimum water in dry season and low water retention time but water use is significant. Weakness scored very high because of lack of surrounding hydrological system, low sandy bed materials and ground water table depletion. There are good opportunities to increase the water availability through rainwater harvesting, re-excavation practices and community based management. Overuse of pond and climatic hazards are the main threats which received high scores. |
| | Water quality | 2 | 3 | 2 | 2.3 | The strength for water quality received medium scored as the Optimum Physio-Chemical Parameters (Temperature, DO, TDS, and pH) from the field test is moderate for water quality and water is used for multipurpose. Weakness for water quality is scored very high due to salinity intrusion 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 for water quality deterioration. Moreover, chemicals and pesticides used in surrounding crop field and fish gher causes the water quality more vulnerable so threats scored highest here. |
| | Soil quality | 1 | 2.5 | 1.6 | 2 | The strength of soil quality is scored poor as the optimum soil nutrients is not in good condition due to lack of vegetation. The weakness of the soil quality scored high due to presence of ordinary peat soil which is a very soft soil with low shear strength and high compressibility exists in unconsolidated state. Soil is also polluted by anthropogenic activities. Opportunities for soil quality improve assigned medium score by 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. |

| Ecosystem Service Type | Indicators | Strength | Weakness | Opportunities | Threats | Remarks |
|---|---|---|---|---|---|---|
| | 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 by increasing suitable tree, vegetation coverage and EbA interventions. However, moderate threats on productivity due to unsustainable harvest of the ecosystem resources. |
| | Fish diversity, community dynamics and production | 1 | 2.3 | 1.6 | 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 and more time needed to regenerate primary productivity. The presence of green coverage is not sufficient but community-based activities is active which are 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 highest here. |
| **Regulating** | Ground water recharge | 1 | 3 | 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 high 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 water treatment | 1 | 2 | 2 | 1.6 | The strength of waste water treatment received poor score due 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 |

| Ecosystem Service Type | Indicators | Strengt h | Weaknes s | Opportunitie s | Threat s | Remarks |
|---|---|---|---|---|---|---|
| | | | | | | received good scores. Management of domestic waste and unplanned urbanization are the main threats which scored medium for this indicator. |
| | Soil fertility | 1 | 3 | 1.8 | 1.6 | Strength for soil fertility score loWest due to lack of flora and fauna. So, the weakness gets highest score. 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 over use are the main threats for soil fertility which scored medium. |
| | Water retention capacity | 1 | 2 | 2 | 2 | Water retention and conveyance capacity is very poor due to climate change and strength for this indicators scored low. Siltation due to flood is the greatest weakness and received average score. There are good opportunities for re-excavation so it scored medium. Presence of poor embankment and low vegetation disrupt water retention so the threats scored average. |
| **Cultural** | Recreation and tourism | 1 | 1 | 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 low. Opportunities received low score for poor community based livelihood. The main threats is environmental pollution and over exploitation of resources and received moderate score for threats. |
| **Supporting** | 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 is 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 is scored moderate. |

| Ecosystem Service Type | Indicators | Strength | Weaknesss | Opportunities | Threats | Remarks |
|---|---|---|---|---|---|---|
| | 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 | 1 | 2 | 2 | 2 | The strength for this indicator received medium 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. |
| | Prey/predator relationships | 1.5 | 2 | 1 | 2 | Strength and opportunities for this indicators 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 for 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 Indicators=15** | **16.8** | **36.8** | **27** | **30.4** | |

# Annex III: Photo Album of FGDs, KIIs, Community Survey and In-situ Test

***FGD at Shyamnagar Upazia***

FGD at Shyamnagar, Gabura with CBO (Women)

FGD at S, Gabura with CBO (Women) 2

FGD at Mothurapur with Capture Fisheries Group

FGD at Mothurapur with Capture Fisheries Group 2

FGD at Barsha Resort, Kolbari with Culture Fisheries Group

FGD at Barsha Resort, Kolbari with Culture Fisheries Group 2

***Community Survey and Water Quality Sample Collection***

KII with SUFO at UP

KII with Fishermen at Shyamnagar

KII at Shyamnagar

KII with Shrimp fry collector

KII with Fish Farm owner

Community survey with Gher owners