Food and Agriculture Organization of the United Nations

Kachua 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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Kachua Upazilla

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Abbreviations

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

EWS	Early Warning System
F&A	Fisheries and Aquaculture
FAO	Food Agriculture Organization
FFWC	Flood Forecasting and Warning Center
FGD	Focus Group Discussion
FRSS	Fisheries Resources Survey System
FW	Fresh Water
GCM	General Circulation Model
GDP	Gross Domestic Product
GED	General Economic Division
GIS	Geographic Information System
GoB	Government of Bangladesh
HYV	High Yielding Variety
ICT	Information and Communication Technology
IFF	Integrated Fish Farming
IGA	Income Generating Authority
IPCC	Intergovernmental Panel on Climate Change
IUU	Illegal, Unreported and Unregulated
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
LSZ	Low Salinity Zone
MAM	March April May
MoDMR	Ministry of Disaster Management and Relief
MoEFCC	Ministry of Environment, Forest and Climate Change
MoF	Ministry of Finance
MoLJPA	Ministry of Law, Justice and Parliamentary Affairs
MoS	Ministry of Shipping
MoWCA	Ministry of Women and Children Affairs
MoWR	Ministry of Water Resources
MP	Muriate of Potash
MSL	Mean Sea Level
MT	Metric Tons
NCVA	Nationwide Climate Vulnerability Assessment
NGOs	Non-Government Organization
NRCC	National River Conservation Commission
NWRD	National Water Resources Database
ON	October November
PAs	Protected Areas
PES	Payment for Ecosystem Services
PL	Post Larvae
RAS	Recirculation Aquaculture Systems
RAWES	Rapid Assessment of Wetland Ecosystem Services

RHD	Roads and Highways Department
RSEMF	Rainfall Sensitive Environment for Migratory Fishes
RSERF	Rainfall Sensitive Environment for Resident Fishes
SGR	Specific Growth Rate
SLR	Sea Level Rise
SSP	Shared Socioeconomic Pathway
SPARRSO	Space Research and Remote Sensing Organization
SUFO	Senior Upazila Fisheries Officer
SW	South West
SWOT	Strength, Weakness, Opportunities and Threats
TDS	Total Dissolved Solids
TSE	Temperature Sensitive Environment
TSP	Triple Super Phosphate
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
UP	Upazila Parishad
WARPO	Water Resources Planning Organization
WSS	White Spot Syndrome
WQ	Water Quality
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, with putting particular emphasis on gender, need to be identified and analyzed at the national and local levels.

The current study evaluated the climate change vulnerability of Kachua Upazila of Bagerhat District of the Khulna Division of Bangladesh, as it is one of the most severely affected regions by catastrophic climatic events, both historically and in recent times. The land elevation of Kachua Upazilla mostly varies in between 3 to 12m and 53.45% area is lying below 3m. These low-lying areas are subjected to tidal flooding, flood, sea level rise which inundates, erode shorelines, and contribute to coastal flooding.

Being located in the south-western coastal region of Bangladesh, Kachua Upazila 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. Frequency of a 10 m high wave (surge plus tide) along Bangladesh coast occurs every 20 years, while a wave with a 7 m height occurs in every 5 years (Rahman, 2014). Cyclone Sidr (2007), Cyclone Aila (2009) and super Cyclone Amphan 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. Also, droughts and heat waves have adverse impacts on aquaculture and inland open-water fisheries in some areas in Kachua. Especially, tremendous rise in apparent temperature in the south-western region has caused fish farmers in Kachua Upazila to face numerous challenges, most importantly oxygen level drop in water and various viral, bacterial and fungal diseases. Although the lightning susceptibility of the South-West zone is comparatively less than other zones of Bangladesh, but 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 2.2°C and 0.9°C during winter and summer respectively in 2050s for SSP5-8.5 when compared to 1981-2010. Likewise, the minimum temperature will rise by 3.3°C and 2.2°C during winter and summer respectively in 2050s for SSP5-8.5 when compared to 1981-2010. Future rainfall projections show that rainfall will decrease during DJF, MAM, and ON 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. The permanent water bodies in Kachua are found to have decreased from 1990 to 2020 by 40% on average. The reasons behind these changes are many, including illegal encroachments and increase in urbanization leading to rise in human settlements that eventually resulted in the filling up of the permanent waterbodies. This would have a negative impact on the fisheries sector because of the disturbance caused to the habitats and breeding grounds of fishes and other aquatic animals.

The water quality tests undertaken found that nitrate TDS was higher than the standard for aquaculture. 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 Badhal and Gopalpur unions 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, Gazalia, Gopalpur and Badhal unions were found under high risk zone in both time slices.

The study further estimated that the magnitude of temperature induced stress on river seasonal migratory fishes will increase in the 2036-2065 and 2070-2100 under SSP1-2.6 scenario by 0.41% and 0.22% with increasing 1°C mean water temperature. However, this magnitude will decrease by 0.19% with increasing 1°C mean water temperature under SSP5-8.5 scenario. It was also noted that, the magnitude of the temperature induced stress on resident fishes increased in SSP1-2.6 scenario and decreased in SSP5-8.5 scenario with increasing minimum temperature. Sensitivity of capture fisheries was assessed through indictor-based analysis where it was found that Badhal and Gopalpur are highly sensitive to climate change induced hazard. Sensitivity assessment of culture fisheries show Badhal and Gopalpur to be highly sensitive to climate change induced hazards. Adaptive capacity assessment reveals that Gazalia union has high adaptive capacity for both capture fisheries and culture fisheries. Climate change induced hazard risk for capture fisheries impact chain analysis showed Gopalpur and Badhal union under high risk for the base period whereas, in 2050s, Kachua union will be in high-risk zone along with the high-risk union at the base period. For culture fisheries, Maghuia, Gazalia, Kachua and Dhopakhali unions are under high risk for the base period whereas, in 2050s, Gopalpur union will be in high-risk zone along with the high-risk union at the base period.

Most of the women in Kachua Upazila are involved in household related activities with only a few of them 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 Badhal, Gazalia and Maghia unions were highly sensitive while Rari Para had low sensitivity and rest of the unions had medium sensitive for Gender specific fisheries livelihood. Adaptive capacity assessment showed Dhopakhali and Gazalia unions have high adaptive capacity for gender-based livelihood. Risk assessment shows Maghia union at high risk for gender-based livelihood for both the base period and the 2050s time slice. In 2050s the Gopalpur union is found to be in high-risk zone while it was in the moderate-risk zone in the base period.

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

1 Introduction

1.1 Background

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

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

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

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

1.2 Study objectives

The overall goal of the study was to conduct a comprehensive Climate Change Risk and Vulnerability Assessment (CRVA) of 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 Kachua 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 Kachua 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 were used: Focused Group Discussions (FGDs), Community Survey and Key Informant Interviews (KIIs).

[1] FAO (2022). Draft National Level Climate Risk and Vulnerability Assessment for Fisheries and Aquaculture (F&A) Sector in Bangladesh.

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 Upazilla Fisheries Officer (SUFO), fish trader and Gher Owner were interviewed for KIIs. Three community surveys at Dhopakhali, Kachua and Gopalpur 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 Kachua with mostly groups of people from the fishing community to collect qualitative information regarding hazards, exposure, vulnerabilities, existing coping mechanism or adaptation practices, and challenges of gender for risk reduction, livelihood mapping, ecosystem vulnerability assessment etc. The primary focus of the FGDs is to customize of the impact chain, particularly for their project site and extract weights of identified elements by them. For FGDs, about 12 people, both male and female, aged between 25-65 years were chosen.

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

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

where, WT = Water Temperature and AT = Air Temperature

The mean of mean monthly temperature, mean of minimum monthly temperature, minimum of minimum monthly temperature, mean of maximum temperature, maximum of maximum temperature, and mean, minimum, and maximum monthly rainfall were considered as the major phenological drivers for river residents, seasonal migratory and advantageous visitor fish species according to Brown, C. J., (2016); Asch, R. G. (2015) and Weigel, B., (2021).

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 and T = Mean Water Temperature, 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 Bhairab river, fish ponds and ghers for laboratory tests to assess habitat condition. SWOT (Strength, Weakness, Opportunities and Threats) analysis was performed for numerous ecosystem services to facilitate the development of climate resilience action plan. The process involved Focus group discussion (FGD), Community surveys, and Key Informant Interviews (KIIs), where participants were simply asked to share their perceptions about the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of the four categories of ecosystem services (i.e. provisioning, regulating, supporting and cultural). Field observation findings were also used to validate the results. Respondent's answers were ranked by selecting the three most important themes within each of the four SWOT categories analysis (i.e. scores per respondent: 1=Less/Poor condition, 2=Medium/Good condition, 3=High/Better condition. A high score for Strength/Opportunities reflect Better/High Condition, but Less/Poor condition for Weakness/Threats. Scoring of different ecosystem services were 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 are 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 scrutinise and utilise datasets for relevant geo-spatial analysis of hazards, exposure, sensitivity, adaptive capacity, vulnerability and risk following the IPCC AR5 approach. Risk and vulnerability assessment was 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. Photos of the surveys are presented 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 description of the study area in the Kachua Upazila, highlighting the geographical setting, hydrology, climate, land cover, demography of fisheries communities, etc. Further, the prevailing aquatic ecosystem and its services are outlined.

2.1 Geographical features

Kachua Upazila is located in the Bagerhat District of the Khulna Division of Bangladesh. It shares boundary with the upazilas of Chitalmari to the North, Nazirpur to the East, Bagerhat Sadar to the West, and Morrelganj to the South. The land elevation of Kachua Upazila mostly varies between 3 to 12 m. It has been found that almost 54% area is lying below 3m, and 4% lies below 3m. These low-lying areas are subjected to floods, sea level rise, storm surges, cyclones etc. which cause inundation, erosion of shorelines, and also contribute to coastal flooding. The Upazila has a total area of 131.62 square kilometres. The Upazila is dominated mainly by rural settlement landuse, which covers almost 42.47% (5455 ha) of the Upazila. Freshwater aquaculture is observed to be the second most dominant land type among the other classes. This land type covers almost 25.41% of the total land cover. Crops cover around 2389.3 ha area and 18.60% of total land cover. 0.81% of total land uses are detected as rivers and khals respectively.

2.2 Hydrological system

The Baleshwar, Bhairab and Bishkhali are the primary rivers of Kachua Upazila. The Baleswar river enters Kachua from the northeast and flows along the eastern boundary of the upazila until the river exits it from the southeast. There are also some waterbodies, such as, lakes and ponds towards the southern portion of this upazila. The Bhairab River has played a dominant role in developing settlements in Kachua Upazila. This river system of the south-western zone was once dominant with the flow dynamics to be able to form the largest delta in the world. But for a number of years, the rivers in its lower course have been subject to tidal action due to a shortage of fresh water carriage, and nearly all of them are now carrying salt water. The **figure 2.1** shows the hydrological systems of the study area.

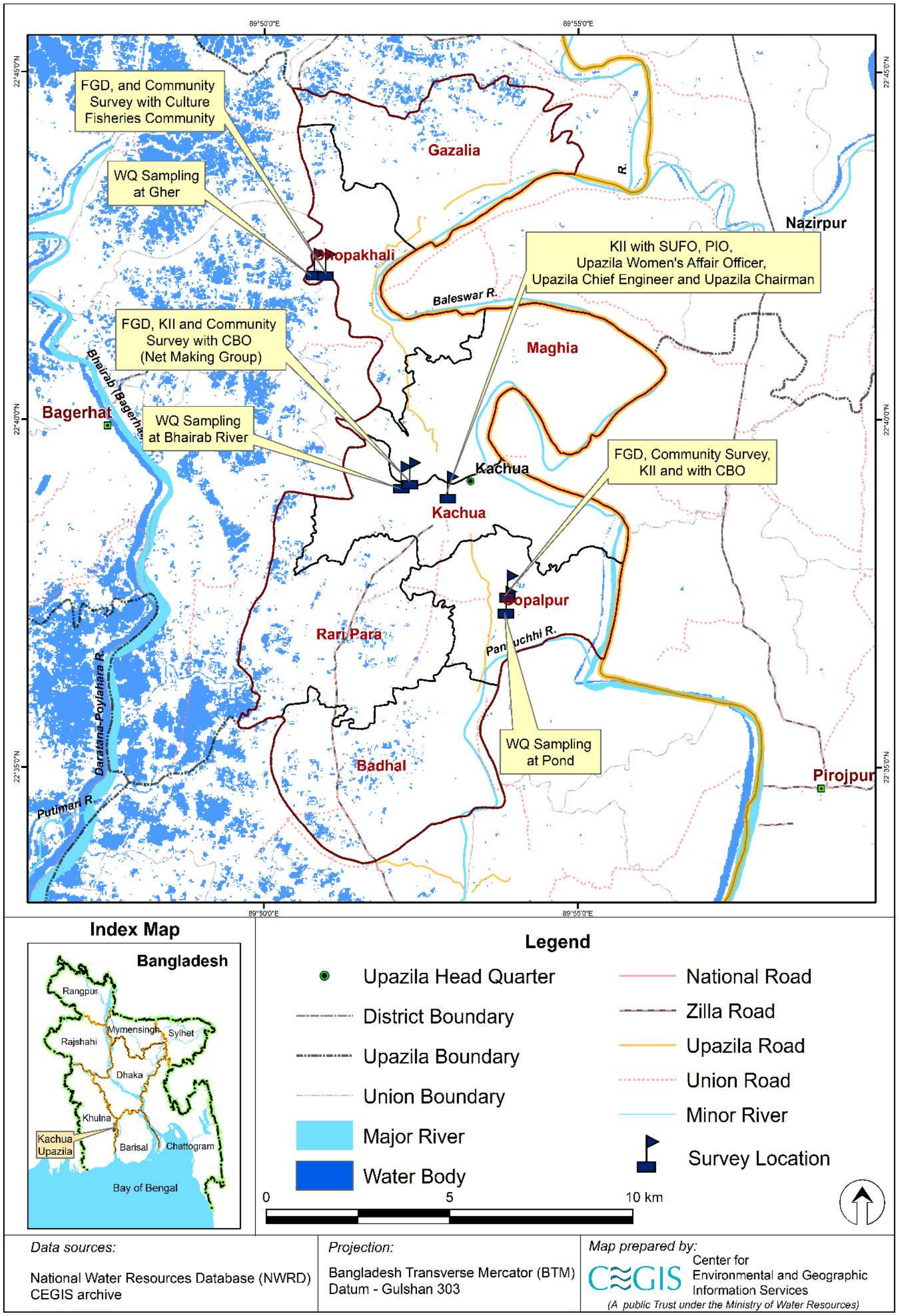


Figure 2.1: Hydrological system and locations of primary survey

2.3 Aquatic ecosystem and its services

The major aquatic ecosystem consists of river and fish pond. In Kachua, in addition to major rivers, there are Jalmahals, ponds and ghers. The aquatic ecosystem provides numerous services in the project area including provisioning, regulating, supporting, and cultural services. It usually provides significant amount of drinking water, fish, fuelwood, and medicinal plants as provisioning services; It regulates tidal floods, carries sediment, nutrients for aquatic plants and fauna, sequesters carbon, absorb heat, purify water naturally, transportation of freshwater, irrigation water for agriculture and flows for navigation purposes; supports diversified flora and fauna; Additionally, it allows tourism and earning revenue from this sector.

2.4 Fisheries resources

Kachua Upazila is very rich in fisheries resources due to having multiple rivers, connecting Khals and vast aquaculture area including shrimp farm and pond. The Upazila comprises a huge water area covering 1,909 ha of river and Khal, 2350 ha of shrimp farm including golda and bagda, 79 ha of crab fattening farmS area. These water bodies contribute about 260 MT of fish and fisheries products annually. The Upazila has 2,305 number of registered fishers who involved directly in fishing activities. Moreover, a good number of people including male and female are engaged in fishing activities in the nearer rivers and Khals. In addition to this, a good number of people are also involved in shrimp farms and trading related activities.

2.5 Demographic characteristics

The Upazila has a population of 97,011 (approximately) people; 49.25% male and 50.75% female. It has 7 unions, 78 mouzas/mahallas and 101 villages. The total number of households is 18,553. The density of population is 708 per sq.km. The average literacy in whole Upazila is 61.9%. Main occupation include agriculture, agricultural labour, wage laborer, forestry, fishing, commerce, service and transport. People in this area are dependent on both capture and culture fishing. According to Kachua Fisheries office, about 2394 fishermen involve in capture 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.

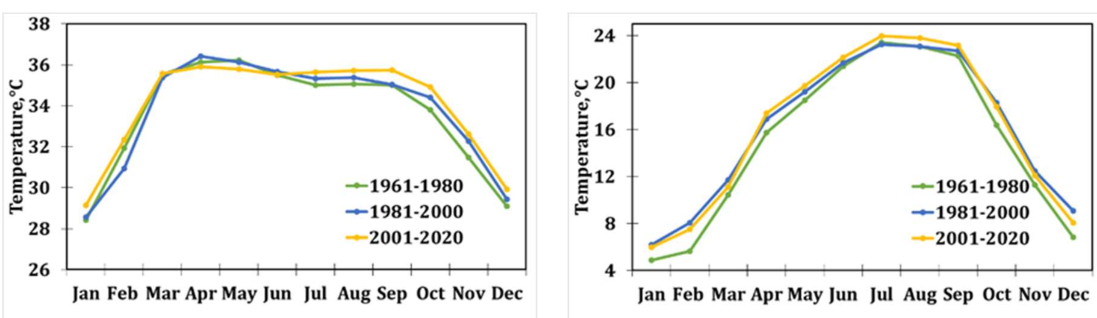
3.1 Climate change scenarios

3.1.1 Temperature

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

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

Future climate projections by CEGIS (2022) based on 1981-2010 data illustrate that, maximum temperature will rise 2.2°C and 0.9°C during winter and summer respectively in 2050s for SSP5-8.5. Likewise, minimum temperature will rise 3.3°C and 2.2°C during winter and summer respectively in 2050s for SSP5-8.5. Mean average maximum temperature of DJF, MAM, and JJAS and ON season will be 29.1^{0}C, 35^{0}C, 33.8^{0}C and 32.3^{0}C for 2050s and mean average minimum temperature of DJF, MAM, JJAS and ON season will be 17.3^{0}C, 25.5^{0}C, 28.1^{0}C and 24.4^{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

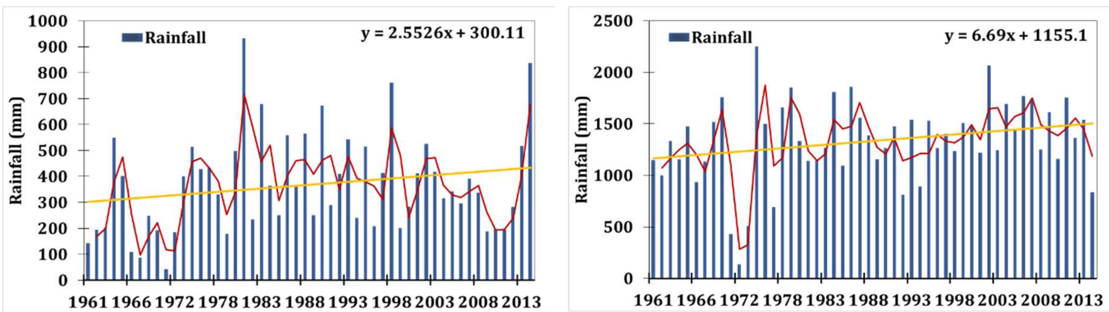
Figure 3.1: Average minimum (left) and average maximum (right) temperature of Khulna station

3.1.2 Rainfall variability

Rainfall data analysis (1961-2020) for the dry season (October to March) and wet season (April to September) represents that the annual average dry and wet period rainfall are about 358.6 mm and 1342.1 mm respectively. Wet season rainfall is increasing with higher rate (6.69 mm/year) than that of dry season

(2.5mm/year) **(Figure 3.2).** The area experiences distinct seasonal variations the winter season (DJF), which is generally dry and contributes only 2 percent of the total annual rainfall; the pre monsoon hot season (MAM), which perceives 17 percent of convective thunderstorms or northwester (locally known as Kalbaishakhi); and the rainy season, which receives 81 percent of the total annual rainfall. Rainfall can range from 3 mm to 846 mm during the rainy season, with June often having the highest amount of rainfall.

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

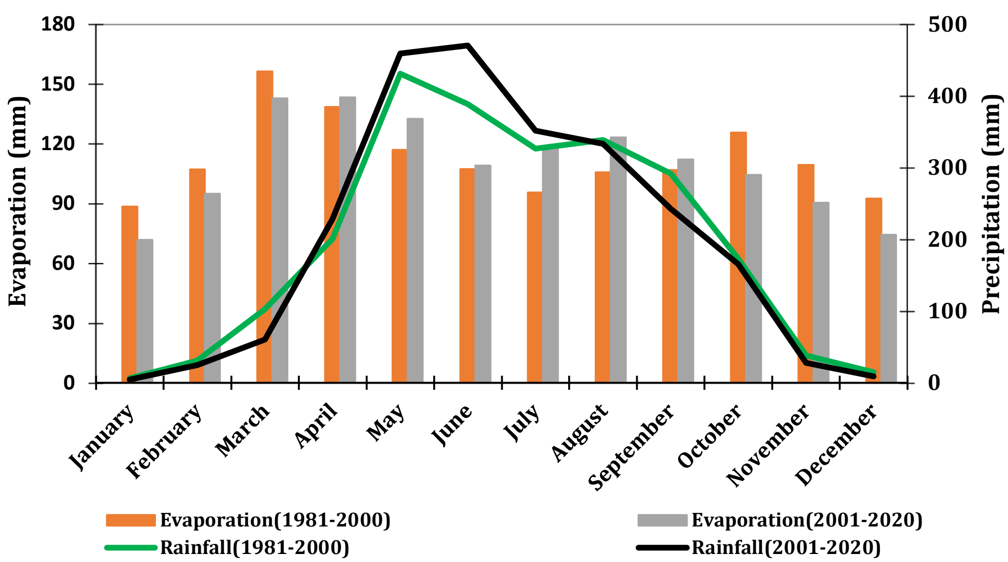


NWRD, BMD

Figure 3.2: Dry and wet season rainfall at Khulna station

3.1.3 Evaporation

Monthly variation analysis of evapotranspiration (**Figure 3.3**) shows increasing trend during pre-monsoon and monsoon but decreasing trend during post-monsoon and dry season 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 Khulna station

3.2 Climate hazards and its impacts

The Kachua Upazila is particularly vulnerable to cyclones, storm surges, tidal floods, drought, extreme hot days, severe cold days, lightning etc. Total 6 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, cyclone was ranked more impactful than flood, storm surge, drought, extreme hot days etc.

Table 3.1: Hazard ranked by local Community

Hazard	Ranking	Trends/Frequency	Intensity
		Increasing (↑)	High=3
		Decreasing (↓)	Moderate=2
		Static (↔)	Low=1
Flood/Tidal Flood	2	↑	2
Cyclone	1	↑	2
Storm Surge	3	↑	1
Drought	5	↓	2
Extreme Hot Days	4	↑	2
Severe Cold Days	6	↓	1

CEGIS Field Survey, 2022

The present study identified five major climatic hazards for fisheries and aquaculture as found in the Kachua Upazila. The fishers in the Upazila informed, major climatic hazards include heavy rainfall, tidal flood, extreme hot days, erratic rainfall and cyclone (**Figure 3.4**). Moreover, fishing activities are highly exposed to storm surge and cyclone.

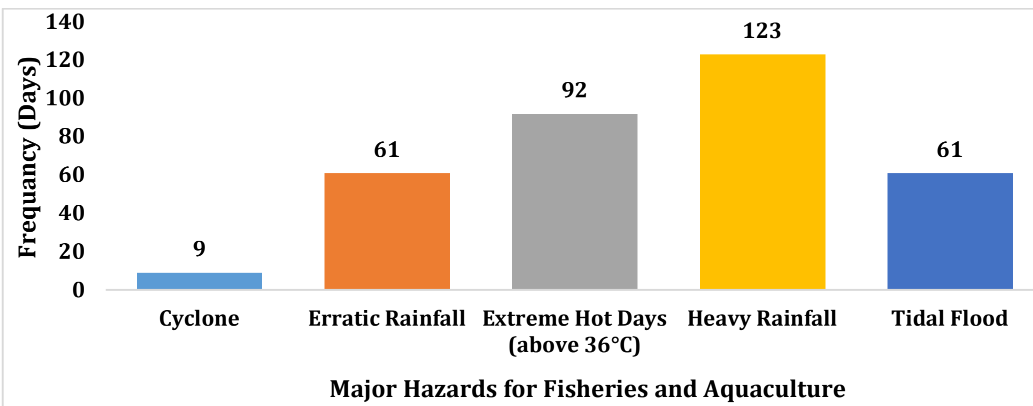


Figure 3.4: Frequency of climatic hazards on fisheries and aquaculture

CEGIS Field Survey, 2022

According to the hazard calendar developed by the fishing community, cyclones are the most devastating hazard of this region that has been increasing recently. Cyclones never occurred in the months of March and April in the past but they do now. The occurrence of floods has extended to the months mid-April to mid-June and mid-August to mid-November. Droughts have shifted to the months of January to mid-March whereas in the past they used to occur from mid-November to December. Severe cold days have extended to November and December at present.

Cyclone and storm surges

Being located in the south-western coastal region of Bangladesh, Kachua upazila in the Bagerhat district has faced numerous catastrophic severe cyclone events, especially in the last two decades, including Sidr, Fani, Mora, Aila, Rashmi, Roanu, Amphan and others. 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 Gopalpur, Maghia, Dhopkhali and Gazalia union of Kachua Upazila are mostly affected by SIDR equivalent cyclone under both SSP1-2.6 and SSP5-8.5. But in 2050s for SSP5-8.5 scenario inundation extent and impact will be higher in Maghia and Kachua union.

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. However, the formation of deep depressions and occurrence of super cyclones (> 222 km/hr) increased in the period 1990-2020 by 6% compared to the previous 30 years.

Cyclone Sidr resulted in damages and losses of $1.7 billion, or 2.6 percent of GDP in 2007. About half the losses were in the housing sector, followed by agriculture and infrastructure. Infrastructures including ponds, dighis, and ghers as well as privately owned fishing gear like boats and nets are among the damages to the fishery subsector. FAO (2007) reported that, around 90 percent of the shrimp enclosures along the prominent rivers in Bagerhat district were reportedly destroyed and flushed by tidal waves.

On May 25, 2009, Aila struck Bangladesh's southwest coastal regions, affecting 15 districts, 76 Upazillas, and 491 Unions. The 13-hour onslaught of Aila followed by eight to 10 feet high tidal surges destroyed 18,788 shrimp enclosures worth over 150 crore BDT and over 8000 fish farms worth over Tk 70 crore taka in Bagerhat district. 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 and 4633 fish farms in Bagerhat District were totally flooded with seawater due to this cyclone. According to DFO of Bagerhat, the total damages to fisheries sector was BDT 2.92 crore in Bagerhat district. The severe cyclonic storm Yaas in 26 May 2021 caused abnormal 6-8 feet tidal waves across the coastal districts, namely Bhola, Patuakhali, Satkhira, Khulna, Bagerhat, Jhalokathi, Barguna, Barisal and Pirojpur, resulting in breached embankments and inundation. The district fisheries department of Bagerhat reported that around 4,470 fish enclosures and over 400 ponds in Bagerhat have been inundated by tidal surges triggered by Cyclone Yaas. The frequency and impacts of such extreme events are reported to be increased under climate change scenarios. 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.

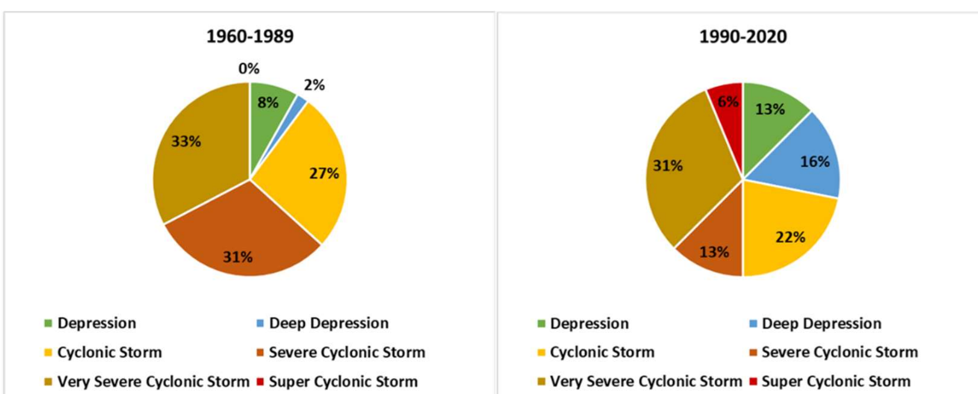


Figure 3.5: Distribution of high intensity cyclone along the Bangladesh coastline

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 Kachua Upazila 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 to 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 of the CEGIS Bay of Bengal model (2020) reveals that Kachua Upazila will be intruded by more than 4ppt surface water salinity by 2050s under extreme climate change scenario i.e. SSP5-8.5. As presented in **Figure 3.6** below only the Badhal union of Kachua Upazila is partially experiencing surface water salinity near 4ppt in the base period. By 2050 Rari Para and Badhal unions of Kachua will be fully experiencing salinity over 4ppt and the rest of the unions will be experiencing it partially. The 4ppt isohaline line will shift on average by 10.2 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.

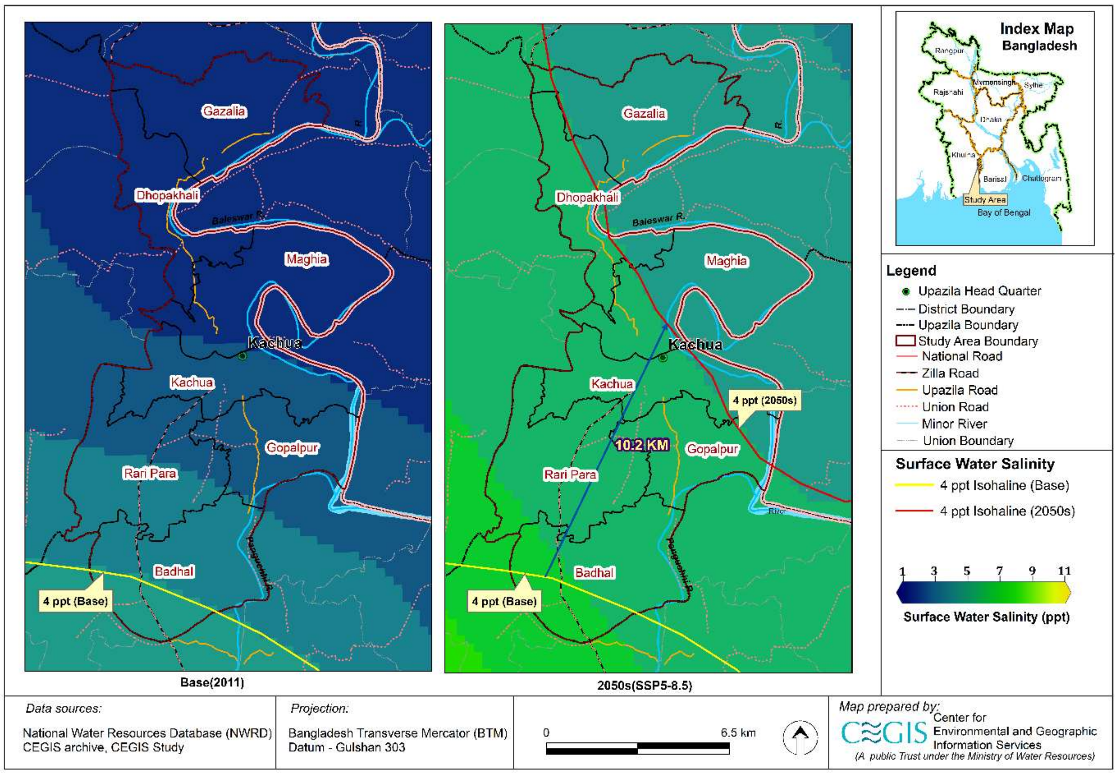


Figure 3.6: Salinity intrusion in Kachua Upazila

Heat wave

Heat wave frequency and severity are expected to increase in the future (Kirtman et al. 2013). About 39 heat waves in last 23 years (1989-2011) have been observed in Bangladesh (Hannah et al. 2017). With increased environmental temperature increase in bacterial decomposition, pH drop, 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 Kachua Upazila are facing numerous challenges, most importantly various viral, bacterial and fungal diseases (Islam et al. 2018).

Floods

Almost every year, many shrimp farms in Kachua get flooded. River bank erosion, mainly due to floods, is causing river siltation in Bhairab and Bishkhali River in Kachua 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.

Drought

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

Lightning

CEGIS (2022) analyzed 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 other zone of Bangladesh. Reportedly, lightning and thunderstorms in pre-monsoon are increasing all over the country, which are anticipated to affect the spawning and breeding of fisheries. Besides this, lightning damages infrastructure in fish-cultivated areas. There is some evidence that fishermen and fish farm owners get injured and die from 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 from low to high in **Table 3.2** where, red indicates high vulnerability, yellow indicates medium vulnerability and green indicates low vulnerability. During FGDs, hazards-wise effects on different aspects of the fisheries and aquaculture sector have also been identified based on the opinion of respondents. The following table shows the hazard-wise vulnerability matrix based on respondents' feedback in the FGD. The frequency and impacts of such extreme events are increased under climate change scenarios.

Table 3.2: Hazard wise impact matrix based on community perception

Sector	Impact	Flood	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 Kachua Upazila

A multi-hazard scenario for Kachua 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, Heat Waves, Sea Level Rise, Erosion, Lightning etc. are considered while assessing multi-hazard conditions. Multi-hazard conditions are assessed for two-time periods as such base period and 2050s. For future projection, due to limitation of resources only heat wave, drought, tidal flood, storm surge and cyclone are projected for 2050s and other hazards are considered constant as base period during multi-hazard mapping using geo-spatial techniques. The Kachua and Gopalpur unions of Kachua Upazila are found exposed to multiple climate hazards, with highest severity in the base period. The rest of the unions are found under moderate risk for multi-hazards in the base period. For future 2050s under extreme climate change scenario, Kachua, Gopalpur and Maghia unions will fall under high risk of multi hazards and rest of the union will be same as base period. **Figure 3.7** below highlight the multihazards outlook for 2050 based on 2011.

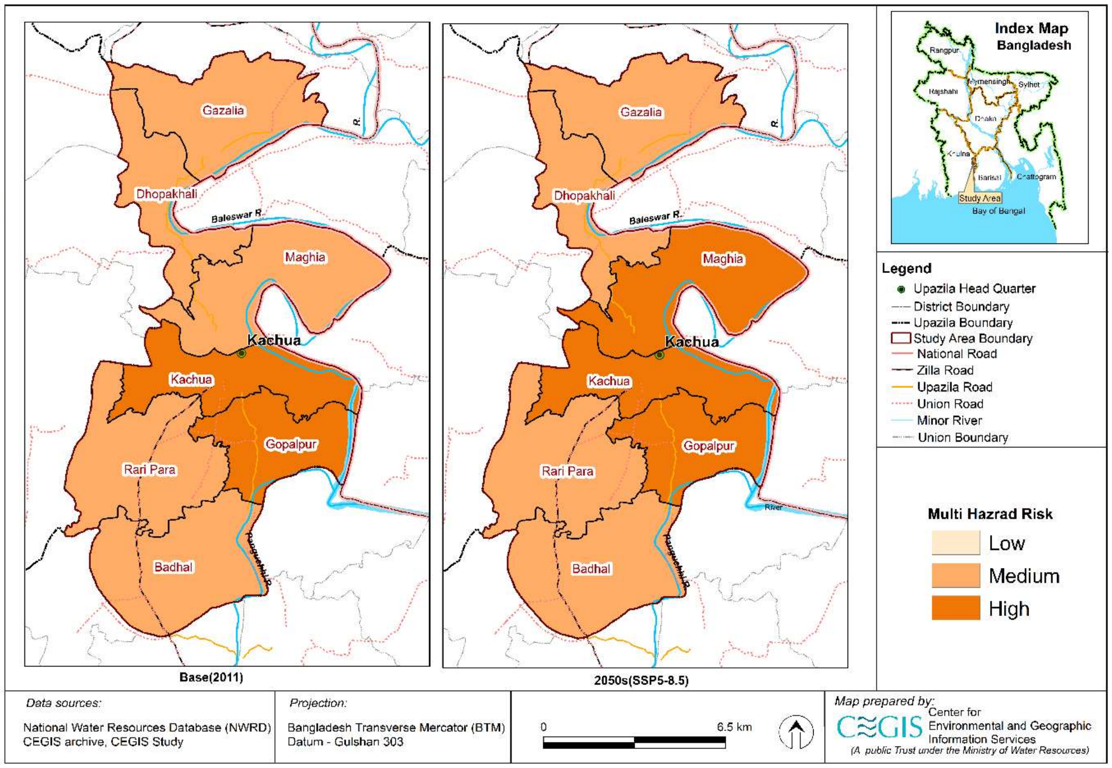


Figure 3.7: Multi-hazard map of Kachua Upazila

4 Climate Risk and Vulnerability

This chapter presents the critical outcomes of the study, which is climate risk and vulnerability for the Kachua Upazila covering all of its unions. Risk and vulnerability were assessed following 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 aquatic ecosystems in this region. Indicator-based assessment for the developed impact chains was also used to assess the ecosystem exposure to climate-change induced hazards in Kachua (Annex I). The exposure status of hazards to the aquatic ecosystem of different unions namely Badhal, Gazalia and Gopalpur were identified as high (**Table 4.2**).

4.1.2 Climate sensitivity of aquatic ecosystem

Climate change and its extreme variability make the habitat condition unfavorable and severely disrupt the ecosystem services. The study analysed the climate sensitivity of both River and Pond/gher ecosystem in terms of disruption of ecosystem services and hampered habitat conditions. The study area's rich and diversified aquatic ecosystem is found to be sensitive to climate change in various ways.

Change in habitat area

The change of perennial and seasonal waterbodies assessed provides information of the intra-annual behavior of such waterbodies. **Figure 4.1** shows the change in waterbody extent from 1990-2020. The permanent water bodies in Kachua are found to be decreasing from 1990 to 2020 by 40% on average. The reason behind this may be illegal encroachments and increase in urbanization leading to rise in human settlements that eventually resulted in the filling up of the permanent waterbodies. This would have a negative impact on the fisheries sector because of the disturbance caused to the habitats and fish breeding grounds and other aquatic animals. The seasonal waterbodies increased between 2000 to 2010 then it started decreasing slightly. Increasing trends of 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. Overall, this assessment revealed that increased saline or brackish water habitat and decreased freshwater habitat, therefore, adaptation in fish farming practices need to be planned accordingly.

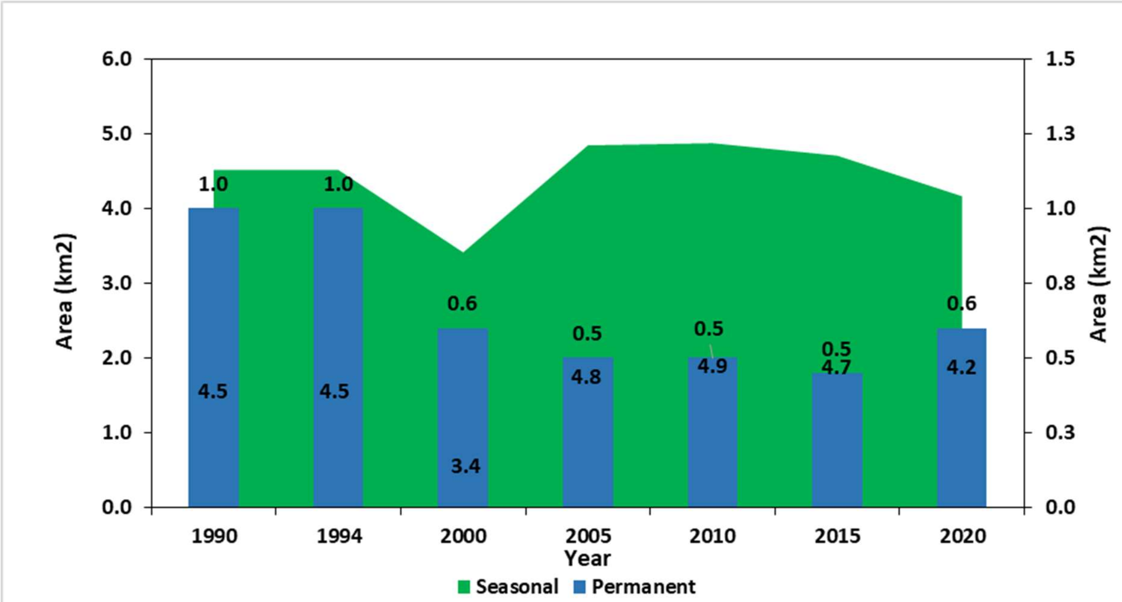


Figure 4.1: Waterbody changes in Kachua Upazila

Disruptions of ecosystem services

The aquatic ecosystem of the study area provides numerous ecosystem services as reported by the communities during FGDs and KIIs. Local people extract fish, fuelwood, and medicinal plants and plant parts along with grass from the river and pond ecosystems. Harvested rainwater in the pond after purification and boiling is generally used as the main drinking water source. Pond water is also used for domestic and household purposes. When the water remains sweet for six months during the monsoon period community people can use river water for consumptive and non-consumptive uses but face problems because of water pollution of the Baleswar River and several canals.

Aquatic ecosystem is diversified with fresh, brackish and saline water species 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. Besides fresh water species a number of saline tolerant aquatic/mangrove vegetation's observed on the torus and along the riverside toe of the Embankment Rivers because of tidal nature and saline intrusion. Mangrove vegetation provides shelter from larger predators due to the dense above-ground root network. 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. Ponds accumulate organic matter in their sediments and therefore bury or sequester carbon. About 16.6 million Mt of carbon is annually buried in aquaculture ponds globally. The plants surrounded by rivers, ponds, internal Khals and ditches also support the storage of rainwater in canopy, balance the fish production and its food system through oxygen supply and fish waste uptake by algal bloom and its photosynthesis in daytime, 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, the aquatic ecosystem in Kachua upazila also provides opportunities for cultural services such as recreation, aesthetic value and inspirational values. Community people usually gossip and spend their free time on the river bank and pond dyke for tranquility and relaxation. Observing the scenic beauty, serenity, unique and diversified animals and, landscape aesthetics people get both mental and physical health benefits.

All these 4 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 culture revealed that the river has more weakness and threats and low strengths-opportunities due to rapid urbanization and environmental pollution with a score of 0-15 representing low value, 16-30 representing medium value, and 31-45 representing high value. The results also show that both the river and pond ecosystem are in favorable conditions but the pond ecosystem has higher strengths-opportunities and lower weakness- threats because of their natural land-cover types.

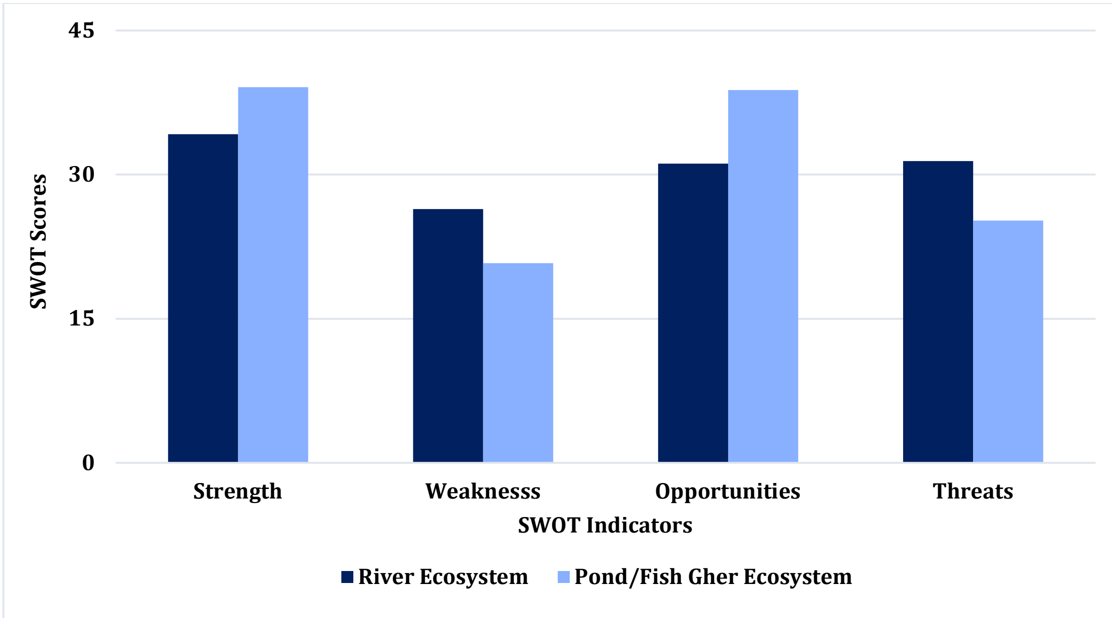
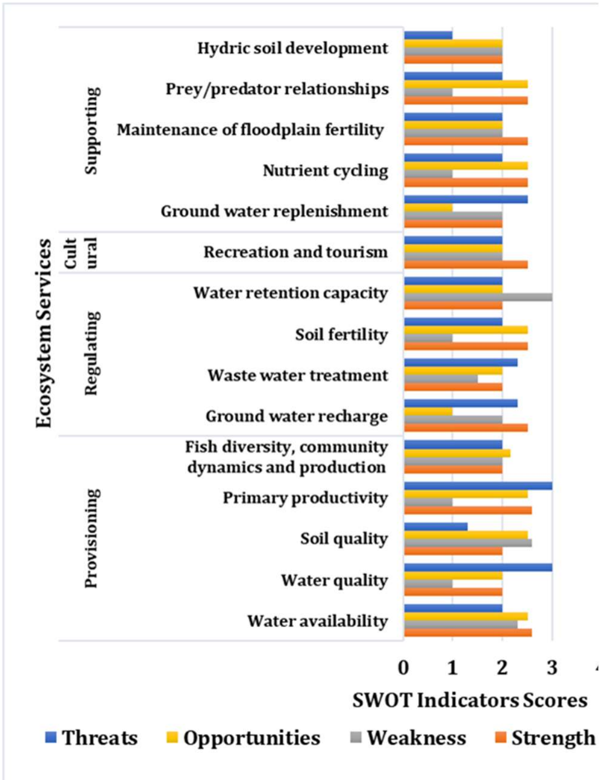
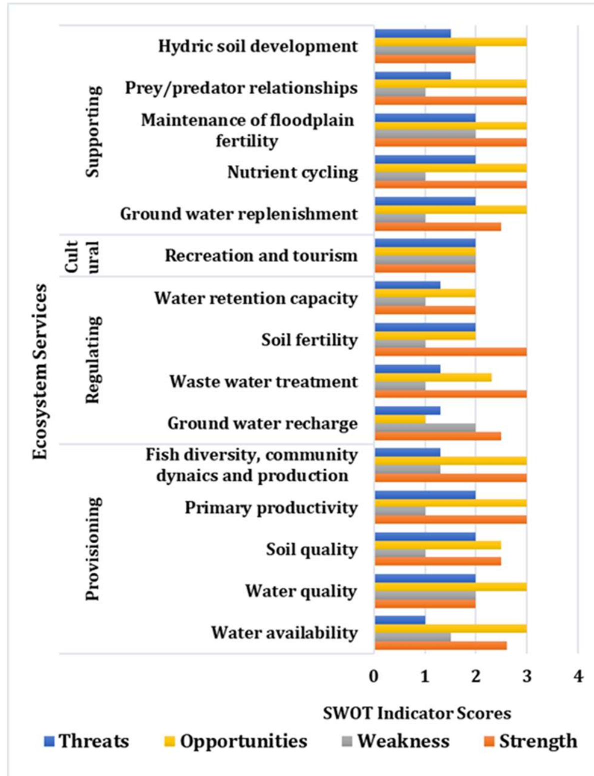


Figure 4.2: SWOT results of aquatic ecosystem services

To enhance the ecosystem services from both rivers and ponds/ghers ecosystem, identified weakness and threats will need to be addressed to increase the related benefits sustainably. Therefore, ecosystem approaches for aquaculture (EAA) or fisheries (EAF) follow to sustainably manage the fishery ecosystem and its climate sensitivity Integration of fishery ecosystem during structural or non-structural intervention design for adaptation and the resilient building is needed to be mainstream 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 Fish pond/Gher

Figure 4.3: SWOT outcome for river and fish pond ecosystem

Aquatic habitat condition

Similar to ecosystem services disruption by climate change, in situ and laboratory tests of water quality also indicated the ecosystem sensitivity of deteriorating due to climate change. DO, COD, EC, and TDS are found unsuitable and not within the thresholds reference value for rivers. Temperature, EC and TDS werefound to exceed the thresholds reference value of ECR'97 and different studies (marked in red color as shown in **Table 4.1** for fish gher but for fresh water pond water quality is found optimum except for dissolve oxygen.

The EC is an indicator of total salt concentration in water. EC values of river and fish gher water samples were 7360μS/cm and 9250μS/cm respectively (Table 4.1). Stone and Thomforde (2004) recommended that 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. Therefore, the present values of EC for river and fish gher 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. COD determine the amount of organic pollutants found in surface water. Chowdhury (2009) recommended that optimum COD level for aquaculture should be less than 200 mg/L. So, from the result observation it is seen that the COD level of river was not suitable for fish production and environment. Warm water fish requires a minimum DO level, at least 5 mg/l. The minimum amount of DO is 5 mg l-1for survival aquatic animals and level <4 mg/l causes killing of fish and other animals of water kingdom. Thirupathaiah et al. (2012) reported a range of DO in between 5.18 to 9.72 mg l-1 is good for survival of aquatic organism. Present study found DO in river and fresh water pond is 3.5 and 3.2 respectively which were not suitable for aquatic organism and biodiversity.

It was observed during the field visit and communities during surveys reported occurrence of frequent algal blooms due to increased water temperature and fish mortalities occurs especially during summer. In addition, During the pre-monsoon and winter seasons the rising trend of salinity level usually results in the disappearance of local species from the water bodies. Apart from climatic factors, farmers reported that water quality is deteriorating for overuse of pond and water levels decreasing due to drought that ultimately reducing habitat and production of fishes. Bed of the rivers and nearby canals have been silted up that reduced water carrying capacity of rivers. Excessive sediment loads are deposited in the rivers and their tributaries that cause floods during monsoon. These water quality condition will be exacerbated under climate change condition.

Table 4.1: Surface water quality in Kachua Upazila

Sample ID & Unit	Physical and Aggregate Properties of Surface Water Resource								
	pH	Temp	DO	EC	TDS	BOD	COD	Nitrate (NO_3^-)	Salinity
	-	^0C	mg/l	µS/cm	mg/l	mg/l	mg/l	ppm	ppt
River	8.2	30.1	3.5	7360	3640	1.52	440.7	2.1475	5.84
Fish Gher	8.1	34	6.8	9250	4590	2.4	162.55	1.5377	7.57
Pond	8.5	30.2	3.2	515	257	2.3	28.9	3.8927	0.29
Bangladesh Standard for Surface Water Quality (ECR'97)	6.5 – 8.5	20°C - 30°C	≥5.0	1200	2100	6 or less for fisheries		10	
Study reference value	(6.5-9)[2]	(25-32°C)[3]	(5.18-9.72)[4]	(30-5000 µs/cm)[5]	(< 160-200 mg/l)[6]	(<5 mg/l)[7]	(<200 mg/l)[8]		

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

The combined sensitivity analysis (**Table 4.2**) using the habitat extent, condition and ecosystem services related indicators found that Badhal and Gopalpur unions were highly sensitive ecosystem whereas Gazalia unions were found be as moderately sensitive ecosystem.

4.1.3 Adaptive capacity of aquatic Ecosystem

Rapid restoration and regeneration of plankton and vegetation, abundance of flora and animals, ideal soil nutrients, decomposition of leafs and plant materials, 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 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.

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[2] https://www.fisheriesjournal.com/archives/2020/vol8issue1/PartD/8-1-33-780.pdf

[3] Das, 1997.Das, B. 1997. Fisheries and Fisheries Resources Management. Bangla Academy, Dhaka, Bangladesh, 153-155p

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[8] Ahmed, G.; Uddin, M. K.; Khan, G. M.; Rahman, M. S. and Chowdhury, D. A. 2009. Distribution of trace metal pollutants in surface water system connected to effluent disposal points of Dhaka Export Processing Zone (DEPZ), Bangladesh: A statistical approach, Journal of Nature Science and Sustainable Technology, 3(4): 293–304.

Apart from the systems inherent ability to cope with the nature, the field survey revealed that people generally use fencing and netting around ponds to prevent the escape of stocked fish as well as invasion of predator fish during floods. Local people harvest Rainwater with storage facilities for aquaculture in the dry season. Using rainwater for fish culture and pond-dike cropping increases water use efficiency. According to KIIs survey, pond-dike cropping can help to cope with increased water temperature. Plantation of suitable trees on pond-dikes can provide shade on water for fish and stabilize soil. Local people are practicing Ecosystem-based Adaptations (EbAs) in the pond ecosystem. To increase the primary productivity of the ponds local people normally use urea; triple super phosphate (TSP); murate of potash (MP); gypsum, and zinc sulphate (ZnSO4). Lime CaO, $Ca(OH)_2$ and $CaCO_3$ to improve pond biological activity, oxygen, maintain pH and remove turbidity.

Union wise adaptive capacity assessment (**Table 4.2**) based on different indicators (listed down in Annex I) demonstrates the overall status of coping mechanism of the ecosystems. It is found that aquatic ecosystem in Maghia has high adaptive capacity in compared to Dhopakhali, Rari Para, Badhal, Gazalia, Gopalpur and Kachua. 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 analyzing adaptive capacity and sensitivity of the system. From the assessment (**Table 4.2**) it was found that Badhal and Gopalpur unions are highly vulnerable to climate change induced hazards. These unions have high sensitivity and low adaptive capacity to cope with the hazards. On the other hand, the Gazalia union is found moderately vulnerable and ecosystems of the other unions are found low vulnerable to climate change induced hazards.

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

Union	CRVA Elements			
	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Badhal	High	High	Low	High
Dhopakhali	Low	Low	Medium	Low
Gazalia	High	Medium	Low	Medium
Gopalpur	High	High	Low	High
Kachua	Low	Low	Low	Low
Maghia	Low	Low	High	Low
Rari Para	Low	Low	Medium	Low

4.1.5 Risk of aquatic ecosystem

Climate change risk (**Figure 4.4**) on ecosystem in Kachua has been calculated for both base period and 2050s following the CRVA framework (attached in Annex I). At present, Kachua and Gopalpur unions are highly exposed to multi-hazard risk while in future Maghia union will also be under high multi-hazard risk. These various hazards affect the aquatic ecosystem negatively throughout the year in these unions. Both the permanent and seasonal waterbody in Kachua Upazila have been reported to increase in the past years and then decrease slightly. The increase in waterbody may be due to the increase of shrimp farming or SLR while the decrease in waterbody extent in recent years are due to illegal encroachment and filling up of waterbodies. 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. 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, Gazalia, Gopalpur and Badhal unions are found under high risk in both time slices. Kachua union will be under medium risk in 2050s but in base period it was found to be under low risk zone. Dhopakhali, Maghia and Rari Para unions are at low risk in both time slices.

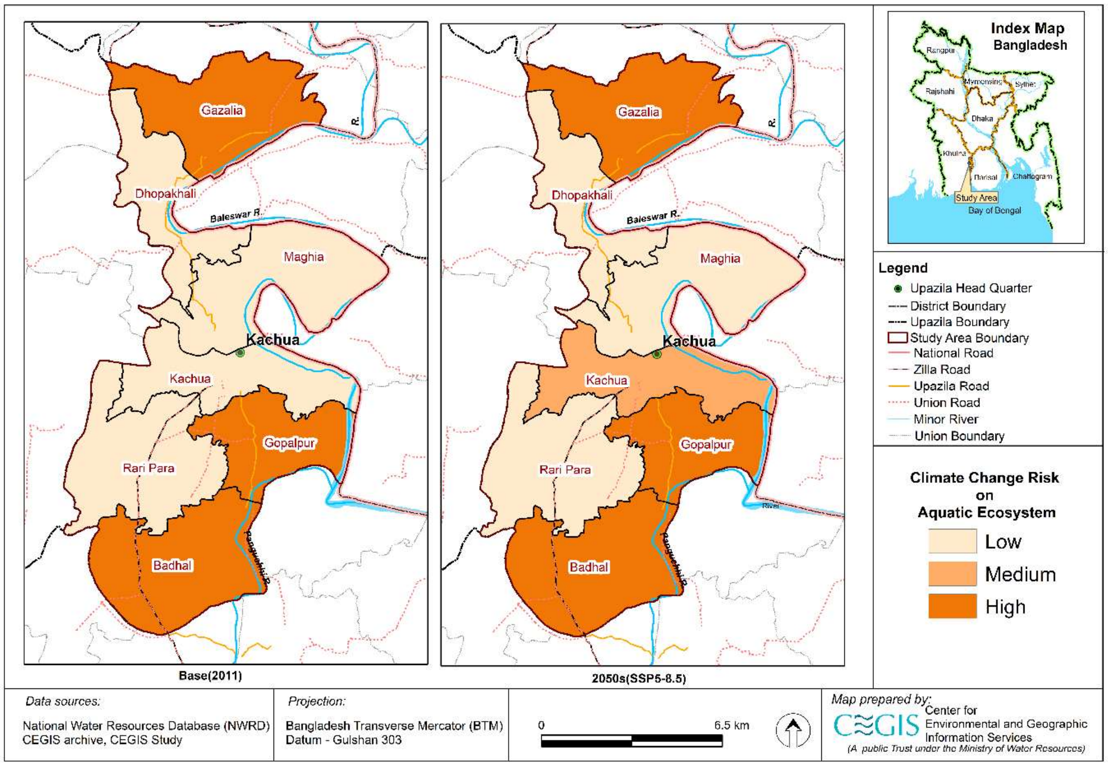


Figure 4.4: Climate risk of aquatic ecosystem in Kachua Upazila

4.2 Capture fisheries

4.2.1 Exposure

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

Fish habitat area

The Upazila possesses a riverine habitat of about 105 ha, union-wise distribution of the riverine habitat is given in the **Table 4.3** below.

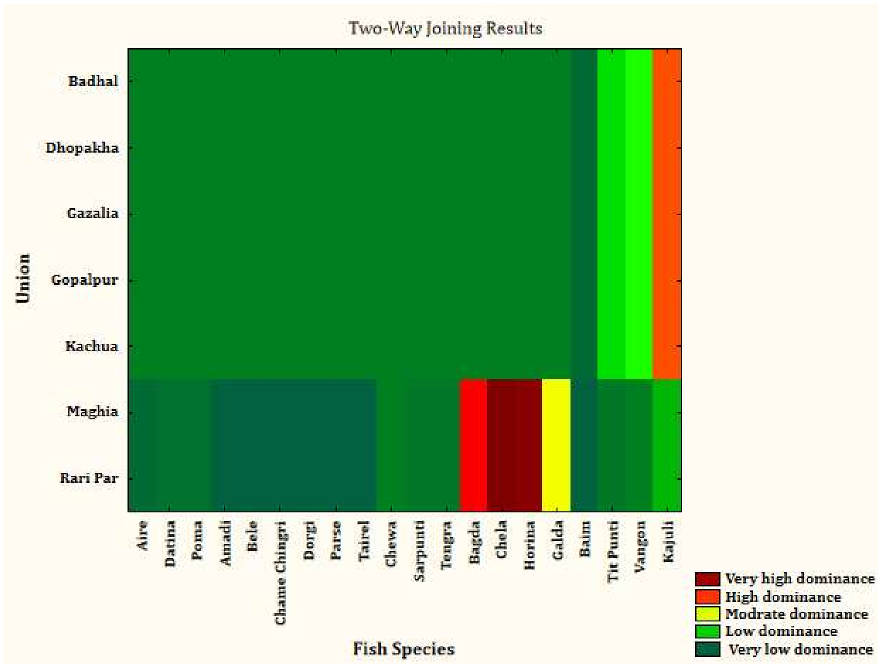
Table 4.3: Area of riverine habitat in different Unions of Kachua Upazila

Unions	Water area (ha)
Badhal	30
Dhopakhali	15
Gazalia	10
Gopalpur	17
Kachua	17
Maghia	16
Total Area	**105**

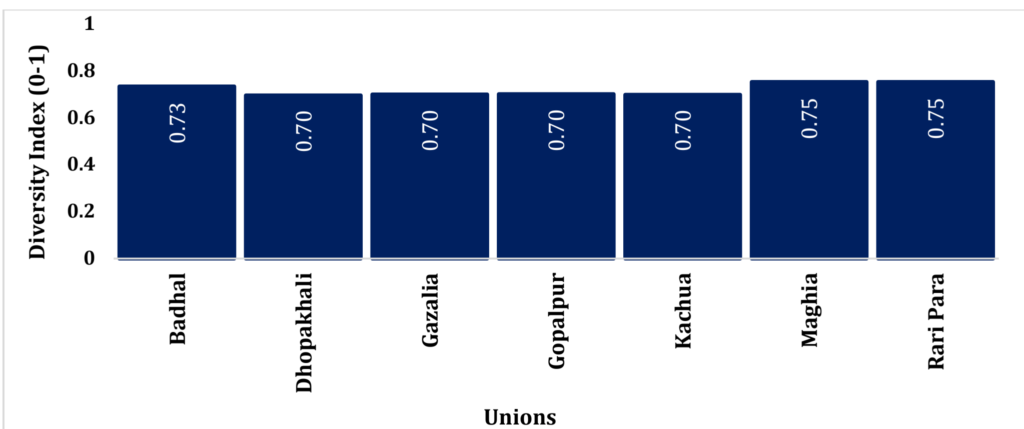
CEGIS estimation based on LandSat8 image, 2019

Fish diversity

The riverine ecosystem is characterized by the Low Salinity Zone (LSZ), having less than 10ppt mean salinity, which can support stenohaline fish species (short range salinity tolerance). 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 Kachua Upazila. The present study found that the instantaneous catch is highly dominated by Chela and Horina in Maghia and Rari Par Union (**Figure 4.5-A**). The colors in the following figure denote the composition of fish species. Very high dominance where the composition has 80%-100%, similarly 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 and biodiversity index (species evenness) of the instantaneous catch of different unions of the Kachua Upazila

CEGIS Catch Assessment Survey, 2022

This study also analysed the Shannon-Weiner Index (Bio-diversity Index) in order to assess the species evenness in the riverine ecosystem (**Figure 4.5-B**). The values of this index range from 0 to 1. The fractal intervals of the index values can be used to characterize the various magnitude of evenness in distribution, i.e., the value of 0.61-0.8 indicates high evenness (maximum number of species are in similar composition. The index showed that the fish species in all the unions are evenly distributed in the Upazila.

Livelihoods

According to Upazila records, the total number of registered fishermen in the region is 2,394 whereas only 58 women are involved in fishing. According to Upazila records, the total number of registered fishermen in the region is 2,394. The study found that most of capture fishermen catches fish from open water bodies (i.e. sea, river, canal etc.) and on average fisher households earned between BDT. 10,000-13,0000 monthly. The field findings also reveal that most women were involve in household related activities with only 2.7% women involved in fry collection, culture fishing etc activities. However, women's income from capture fish is very low as they mostly catch fish for family consumption and usually sell only after surplus. Fishermen have reported that less fish is being caught than in last years. The reasons behind catches and disruption of income from fish is attributed to decreasing of navigability of water, lack of rainfall, raising salinity and temperature, water contamination etc. They also reported that fishermen loss their lives, fishing gears because of the climate induced hazards.

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 Badhal, Dhopakhali and Maghia are highly exposed to climate change induced hazards, may be due to high presence of river ecosystem within these upazilas. 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. This was achieved by ensuring the 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 fish’s 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.

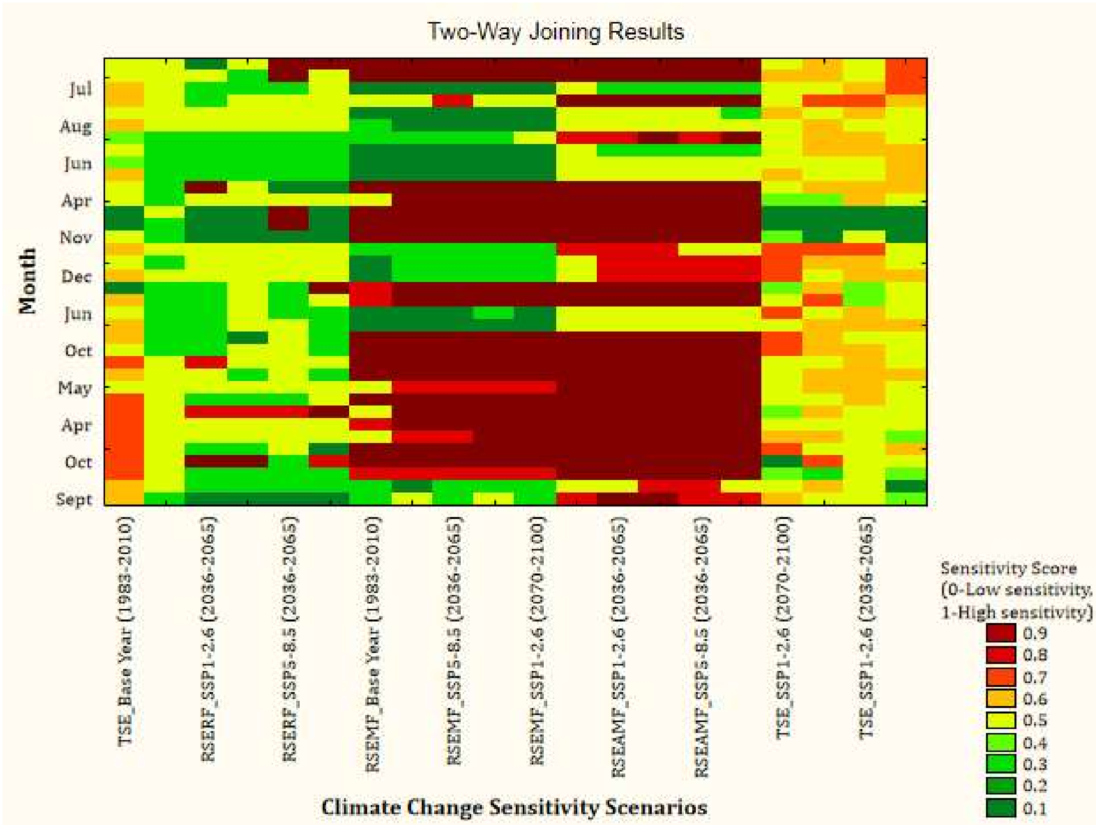


Figure 4.6: Habitat sensitivity to natural mortality in the SSP1-2.6 and SSP5-8.5 scenarios

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

Fish breeding/spawning

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

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

Species	Locality	Breeding season	Spawning Season
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 • September- October	• May-June • October- November
Tengra	Pond	June-September	July and August
Bagda	Estuary (Sundarbans)	January	February- April
Galda	Estuary (Sundarbans)	January	February- April

Species	Locality	Breeding season	Spawning Season
Aire	River	June-September	July and August
Datina	River	December-April	Jan-March

Literature review and CEGIS Field Survey, 2022

It is indicated from various studies that maximum fluctuations 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 magnitude of breeding/spawning success in case of Galda, Sarpunti, Bata and other available inland fishes might be significantly increased in 2036-2065 average year, but decreased in 2070-2100 average year under both SSP1-2.6 and SSP5-8.5 scenarios (**Figure 4.7**). There would be no significant change in breeding magnitude in case of Bagda, Boal/Aire and Hilsa Shad (**Figure 4.7**).

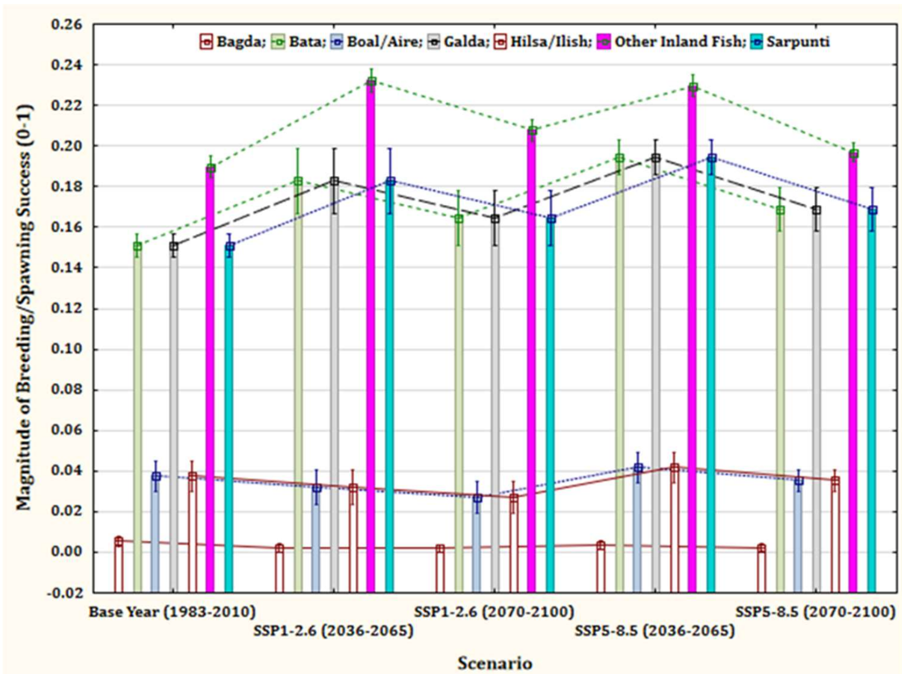


Figure 4.7: Magnitude of breeding/spawning success of the available fish species

CEGIS Field Survey, 2022

Fish migration

The rivers in the unions of the Kachua Upazila can provide necessary ecological demand for feeding, breeding/spawning and nursing of fries and juvenile fishes of different migratory fish species. The river residence fishes migrate longitudinally to the upstream or laterally to the Khals for spawning, feeding or escaping from predators. According to the local fishermen and Upazila Fisheries Officials, major longitudinal migratory fishes in the rivers are Pangas (*Pangasius pangasius*), Vetki (*Lates calcarifer*), Ramchos (*Polynemous paradiseus*), Poma (*Otolithoides pama*), Tular Dandi (*Sillaginopsis panijus*) and Tirel (*Eleutheronema tetradactylum*). The lateral migration occurs mostly for small fishes like Tengra (*Mystus bleekeri*), Guli (*Mystus gulio*), Parse (*Liza Persia*), and small shrimp/prawn are mostly limited between river and Khal. This study analyzed the magnitude of the migration extent for available fishes from the instantaneous catch among the unions of the Upazila (**Figure 4.8**). The values ranging from 0 to 1 are divided into five (05) fractile intervals. The value of less than or equal to 0.2 indicates very strict migration (available in only one particular habitat condition), 0.21- 0.4 indicates strict migration (favor to migrate to one particular habitat condition, but migrate adventitiously to other habitat condition), 0.41-0.6 indicates moderate migration extent (frequently migrate to different habitat conditions, but in limited unions), 0.61-0.8 indicates wide migration extent (frequently migrate to different habitat conditions among the unions), and above 0.8 indicates very wide migration extent (very frequently migrate to different habitat conditions among the unions). It has been found that Chela has the very high migration extent) among the observed fish species (**Figure 4.8**). It has predicted that the migration rate for Hilsa, Aire, Bata, Sarpunti and Galda would be increased in SSP5-8.5 (2036-2065) scenario (**Figure 4.8**). On the other hand, migration rate of Bagda would not be changed with the future climate change scenarios.

Fish migration may be affected by various climatic factors such as, salinity intrusion, erratic rainfall, changes of flooding seasonality, temperature fluctuation, etc. Salinity intrusion may be posing threats to freshwater fish assemblages and their habitats. The migration length may be decreased in the riverine ecosystem due to salinity intrusion because of sea level rise. During the rainy season, fish migrates from one place to another for spawning and breeding purposes. The timing of rainfall is a crucial factor for gonadal development as it triggers successful spawning and breeding among freshwater species. Climate change may have altered the timing of rainfall, impacting fish spawning time that may result into decreased fertilization rate. Fish migration occurs for quality habitat and available food. Food availability i.e., phytoplankton, zooplankton, benthos-particle is one of the major determiners for fish migration and this mainly depends on temperature. The primary productivity decreases following temperature fluctuations which hampers fish migration rate in the riverine ecosystem. On the other hand, excess rainfall causes floods, leading into water turbidity and siltation, which may block the migration route.

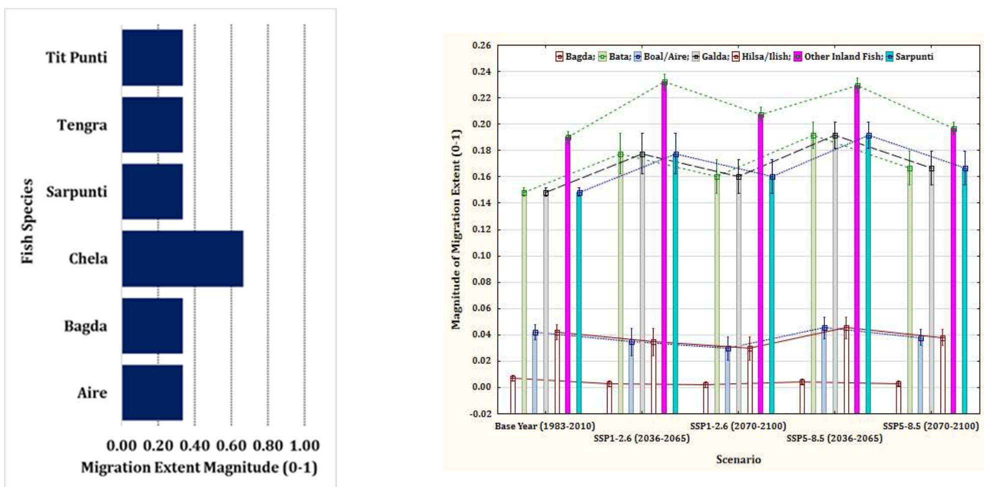


Figure 4.8: Migration extent of different migratory fish species

CEGIS Field Survey, 2022

Growth coefficient and natural mortality

Higher growth coefficient (>0.5) was found in case of Baim, Galda, Harina and Titpunti, whereas maximum fish species have lower growth coefficient (<0.3) (**Figure 4.9**). It has also been found that Aire is facing higher mortality rate, losing more than three generation cohorts per year in the studied riverine system and other fishes were found to loss two generation cohorts per year. It has been predicted that the growth rate of the available inland fishes might be fluctuated in the future climate change scenarios (**Figure 4.9**).

Fish production

The above-mentioned changes in habitat condition, fish diversity, fish migration and fish biology in respect of different climate change scenarios, riverine fish production in different unions of the Kachua Upazila would be about 290 MT, 295MT, 304 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)
Badhal	4	4	4	4	4
Dhopakhali	2	2	2	2	2
Gazalia	2	2	2	2	2
Gopalpur	2	2	2	3	3
Kachua	2	2	2	3	3
Maghia	2	2	2	2	2
Rari Para	0	0	0	0	0

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 a 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. Kachua field finding indicates that fish farmers also relied upon alternative sources to balance their financial demands, including shop keeping, small business, labor, part-time jobs, auto-rickshaw driving, etc. Additionally, they receive alternative income training from various government and private institutions. Besides, many take loans from various NGOs and banks to improve their livelihoods.

As a part of the risk assessment, sensitivity of fisheries sector in Kachua was also assessed (**Table 4.7**). According to the assessment, Badhal and Gopalpur Unions are highly sensitive to climate change induced hazard. Only Rari Para union was found to have a moderate sensitive and rest of the unions were found to have low sensitivity to climate induce hazards for capture fisheries. Generally, cyclone intensity increases from April to May and September to November. Because of these extreme climatic events, fishing season reduces which has considerable impacts on the fishermen's income by reducing fishing days. Dependency on the fishing makes the livelihoods of fishermen highly sensitive to climate change as fishing and fish processing have a high exposure to cyclones and flooding. This climate sensitivity poses serious impacts particularly on low income fishermen.

4.2.3 Fishers adaptive capacity

Mechanized boat

The fishers in the upazila 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 having narrow scope of coping the hazardous situation. However, the fishers usually undertake various initiatives to cope with such environmental stressed 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 Kachua Upazila is shown in **Figure 4.11**.

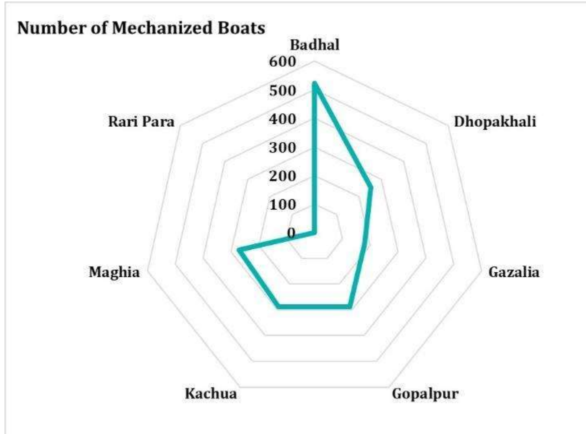


Figure 4.11: Availability of mechanized boats

CEGIS Field Survey, 2022

Fishing gear

The fishers in the Upazila use various types of fishing gear to catch maximum fish within the shortest time for strengthening their economic capability and reduce socio-economic vulnerability. During the field investigation, different types of fishing gears and catch have been observed under this study. 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.)
Vesal Jal	66	22	12	0.55	77	19	20	1.05

CEGIS Field Survey, 2022

Similar to exposure and sensitivity assessment, adaptive capacity was assessed for Kachua Upazila through indicator-based impact chain analysis. This assessment (**Table 4.7**) reveals that Gazalia has high adaptive capacity while Dhopakhali and Gopalpur have moderate adaptive capacity for capture fisheries and the rest of the unions have low adaptive capacity.

4.2.4 Vulnerability

The study assessed vulnerability of Capture fisheries of Kachua 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**) Gopalpur union was found to be in high vulnerability. This union had high sensitivity and low to moderate adaptive capacity. Badhal and Rari Para unions were found to be in moderate vulnerability while rest of the unions were found to be in low vulnerable zone.

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

Union	CRVA Elements			
	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Badhal	High	High	Low	Medium
Dhopakhali	High	Low	Medium	Low
Gazalia	Low	Low	High	Low
Gopalpur	Low	High	Medium	High
Kachua	Low	Low	Low	Low
Maghia	High	Low	Low	Low
Rari Para	Low	Medium	Low	Medium

4.2.5 Risk

The study also assessed the risk associated to capture fisheries for base and 2050s time period. At present, Kachua and Gopalpur unions are highly exposed to multi-hazard risk while in future Maghia union will also be under high multi-hazard risk. This affects capture fisheries activities negatively throughout the year in these unions. Panguchhi and Baleswar rivers run through Badhal, Gopalpur, Kachua, Maghia, Dhopakhali and Gazalia unions which create capture fisheries opportunity in these unions but also leave them exposed to flood, erosion, sea level rise etc. Due to lack of proper early warning system, fishermen often get caught up in heavy rainfall and storm while fishing in these rivers and lose their boats, nets, fishing gear, catch and even their lives. Their conventional fishing boats and other equipment are not adequate to cope with the changing climatic threats. Additionally, salinity ingression is a major issue in Badhal and Rari Para union which is projected to move inward and affect Gopalpur, Kachua, Maghia and Dhopakhlai in future due to their proximity to the sea. This also hampers the freshwater fisheries activities in those unions. Due to rising temperature, the water temperature is also rising, affecting the water quality adversely. Lack of oxygen in the water lead to hampered growth rate and increased mortality of fish. Moreover, the fishermen in the region lack for appropriate freezing, storage and transportation facility hence often loose a considerable amount of their catch.

From the risk assessment of capture fisheries, Gopalpur and Badhal were found to be in high risk in the base period. In 2050s, Kachua union will be in high risk zone along with the high risk unions at the base period. Gazalia and Rari Para unions are in low risk zone while Dhopakhali and Maghia are in moderate risk zone in both time slices. The income and livelihoods of high risk unions will face more losses and damages due to recurrent climatic extreme event. **Figure 4.12** below shows the risk of capture fisheries in Kachua Upazila

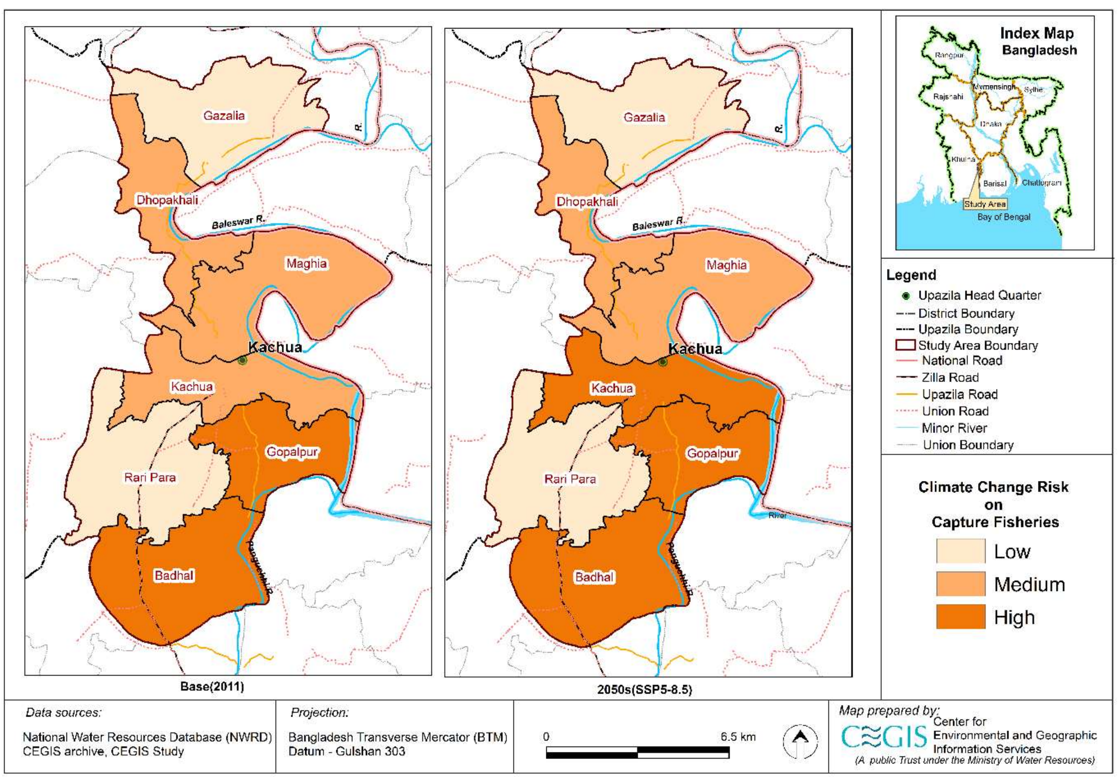


Figure 4.12: Climate risk of capture fisheries in Kachua Upazila

4.3 Culture Fisheries

4.3.1 Exposure

The aquaculture farm includes Pond, Bagda Gher, Golda Gher, Borrow pit and Crab Fattening Farm. The habitat assessment of the aquaculture farms and cultured fish species are briefly described in respect of the exposure indicators in the following sections.

Habitat

There are 3,263 ha of aquaculture farm including shrimp/prawn/fish farm in Kachua Upazila. Among the shrimp/prawn/fish farm, some are the Bagda Gher where Bagda (*Peneus monodon*) along with other shrimp and fish are cultured all the year-round, and the Golda Gher where Golda (*Macrobrachium rosenvergii*) and white fish (major carp, tilapia, etc.) are cultured in mix way in the wet season. Major carp, exotic carp and other fast-growing fish species are cultured in the ponds following poly-culture technology. The small sizes ponds hold water mostly for 36-40 weeks in a year and are cultured fish by following extensive culture method. The aquaculture status of different unions in Kachua Upazila is shown in **Table 4.8**.

Table 4.8: Status of aquaculture farm area in different Unions of Kachua Upazila

Unions	Water area (ha)
Badhal	909
Dhopakhali	188
Gazalia	1,052
Gopalpur	26
Kachua	132
Maghia	51
Rari para	905
Total Area	**3,263**

CEGIS estimation based on LandSat8 image 2019

Cultured fish species

Similar composition of the cultured fish species was found in the Kachua Upazila as found in the Kachua Upazila (**Table 4.9**).

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

Species name	Species composition (%)
Bagda	14.8
Catla	1.5
Golda	16.6
Grass carp	0.3
Mirror carp	4.4
Mrigal	5.3
Pangas	7.3
Perse	8.8
Rui	17.2
Sarpunti	4.8
Silver Carp	2.2
Tengra	3.7
Tilapia	13.1
Total	**100**

CEGIS Field Survey, 2022

Livelihoods

Recently, the trend of shrimp farming has been gradually increasing in this region instead of rice farming. The average monthly income of shirmp farmer is about BDT. 15,000-20,000. Women who are actively involved in fish culture, earns lower tham men. Having with the social challenges, those who are involve in capture fish and own fish farm earn an average of BDT. 9000-13000 monthly. With favorable weather condition, this income can increase but it depends on how many ponds owned by shrimp farmers or Gher. Earlier it was seen that there was not much surplus after paying household needs from only paddy farming but now farmers are getting more profit from shrimp farming. Additionally, road communication become somehow developed and this is also increasing the possibilities of higher income generation for shrimp farmers.

Fish farmers in this region were faced various types of problem during culture period such as economical, technical, social and environmental problem. Majority of the farmers indicated seasonal flood, cyclone and storm surge as the most vital hazards that lead to the increase in the vulnerability of fish farmers as a whole due to lack of money for pond management, insufficient water in dry season, non-availability of fish fry, and fish disease.

The study further made an assessment to understand the culture fisheries exposure to climate induced hazards in Kachua Upazila and eleven exposure indicators were selected (Annex I) and mapped following the impact chain analyses. **Table 4.15** below shows the exposure status of Kachua Upazila and from the assessment, its revealed that Dhopakhali, Gazalia and Maghia unions are in highly exposed zone and Kachua was found to be moderately exposed for culture fisheries.

4.3.2 Sensitivity

Habitat condition

Pond water quality starts to degrade when temperature reaches higher than 33 °C and results in slow growth and reduce fish feeding efficiency (A. Adey et. Al., 2015, M. Shahjahan, 2021) of fish. Temperature higher than 36°C is the lethal limit for most of the 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 of the 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). It has been found that pH, temperature and BOD are almost in optimum range in all unions in Kachua Upazila (**Table 4.10**). It has also been predicted that extreme temperatures coupled with erratic rainfall patterns have direct impacts on fish physiology, growth, feeding behavior and mortality in aquaculture. Moreover, excessive rainfall will breach the dyke of fishpond or shrimp farm and increase the natural mortality due to reduction of pH.

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

Unions	PH	TDS (gm/l)	Water Temperature (°C)	DO (mg/l)	BOD (mg/l)
Badhal	8.18	1243	30.9	6.58	3.14
Dhopakhali	8.19	1270	30.9	6.47	3.52
Gazalia	8.18	621	30.9	8.11	2.71
Gopalpur	7.47	244	30	7.18	1.2
Kachua	7.42	704	30	5.18	7.6
Maghia	7.79	288	30	4.95	0.81
Rari Para	8.18	1368	30	6.59	3.09
Acceptable Range of Fish Community including Crustaceans	Growth Limit: 6.8-8.5 Lethal Limit: 3.8	300-2100	Lethal Limit: 36 °C Optimum Range: 25-30°C 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 Kachua Upazila (**Figure 4.13**). Moreover, water depth (>1.5m) was found to be optimum level for aquaculture production in all unions. The farms in all the unions have more than 25% submerged vegetation coverage, and expected to produce high abundance of methanotrophs, which can act as a biological sink for the greenhouse gas methane.

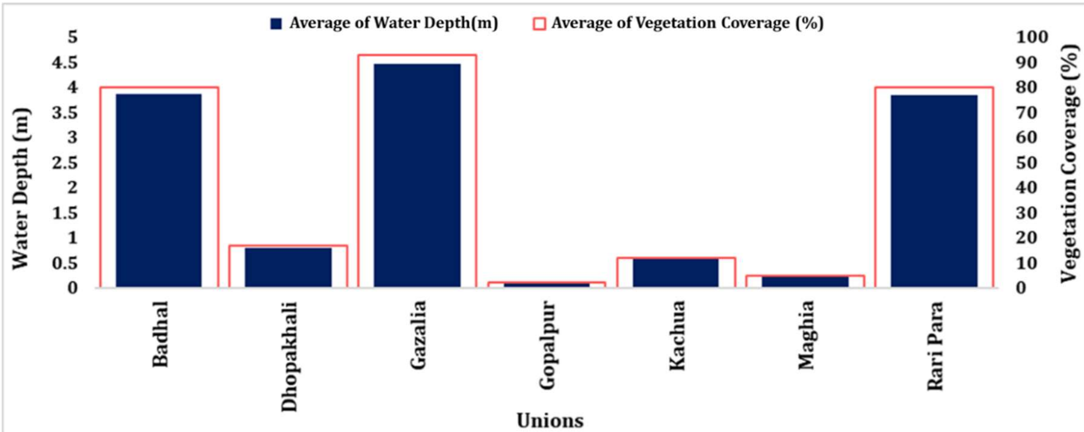


Figure 4.13: Average water depth and vegetation coverage in the fish ponds and shrimp/prawn/fish farms in different unions of the Kachua Upazila

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. The highest growth rate was found in case of Silver Carp (about 0.15cm per day). However, the highest mortality has also been found in case of Bagda (**Figure 4.14**). From the survey, this mortality is mainly as a result of viral infection accelerated by increasing temperatures.

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

CEGIS Field Survey, 2022

Production loss due to climate-induced disease

The highest production loss due to climate-induced disease was found in the farms in Gazalia and was estimated to lose about 17MT production, followed by farms in Maghia (about 14MT), Dhopakhali (about 9MT) and Kachua (about 8MT) (**Table 4.11**).

Different unions of kachua Upazila were estimated to lose about 808 MT of fish production in total (**Table 4.11**) due to climate-induced disease and different extreme events. During field survey, three climate induced diseases have been identified, 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 happened because 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)
Badhal	228
Dhopakhali	47

Unions	Fish production loss (MT)
Gazalia	264
Gopalpur	6
Kachua	23
Maghia	13
Rari Para	227
Total	**808**

CEGIS Field Survey, 2022

Fish production

The above-mentioned changes in habitat condition and fish biology with growth co-efficient and natural mortality in respect of different climate change scenarios, total fish production in different unions of the Kachua Upazila would be about 3,492 MT, 2,713MT, 3,321 MT and 3,568 MT in SSP1-2.6 (2050), SSP1-2.6 (2100), SSP5-8.5 (2050) and SSP5-8.5 (2100) scenarios respectively as shown in **Table 4.12**.

Table 4.12: Aquaculture fish production under different climate change scenario

Union	Fish Production (MT)				
	Base Year	SSP1-2.6 (2050)	SSP1-2.6 (2100)	SSP5-8.5 (2050)	SSP5-8.5 (2100)
Badhal	-	-	-	-	-
Dhopakhali	610	682	530	648	697
Gazalia	1,075	1,202	934	1,143	1,228
Gopalpur	-	-	-	-	-
Kachua	540	603	469	574	616
Maghia	899	1,005	781	956	1,027
Rari Para	-	-	-	-	-
Total	**3,124**	**3,492**	**2,713**	**3,321**	**3,568**

Impact Chain Analysis, CEGIS (2022)

Livelihoods

According to BBC 2012, about 70 percent of people in this region are involved in agriculture. Field findings found that the agricultural sector is suffering every year due to adverse weather condition, climate change, increasing natural calamities etc. Salinity intrusion is a major reason for turning away from agriculture, as it disrupts agricultural production. As a result, most of the people in this region are interested in fish farming particularly shrimp farming. However, due to extreme weather conditions and various natural calamities, the farmers are not able to profit as expected in shrimp farming. Due to frequent cyclonic storm surge, the ponds get washed away, damaged its bank and fish production. Small farmers who cultivate small areas or take leases are the most affected. Many of them tried to support their families through a subsistence economy. Now, if the fish ponds are damaged due to extreme weather conditions, they have no other means of livelihood. As a result, it becomes difficult for them to make a living in this situation.

Other than above assessments an indicator-based sensitivity analysis (**Table 4.15**) was also made to identify sensitive unions of Kachua Upazilla. Total thirteen indicators were used to represent the sensitivity of ecosystem in Kachua. A list of indicators is attached to the (Annex I). According to the sensitivity analysis Badhal and Gopalpur unions are found to be highly sensitive while Rari Para union is moderately sensitive and the rest of the unions are low in terms of sensitivity for culture fisheries.

4.3.3 Adaptive capacity

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

Aquaculture production system

The present study found that the farms owners in all the unions take about 61 days (from November to December) to prepare land for aquaculture. They use about 247kg of fertilizer and 123kg of lime per hectare for their farm management (**Table 4.13**). Stocking rate of these farms mainly depends on the farm area and water depth. Vegetation coverage also have an influence on the farm management. Union wise fertilizer and lime use in the Upazlia is given in the **Table 4.13**.

Table 4.13: Aquaculture production system in different unions of Kachua Upazila

Union	Land Preparation (Days)	Fertilization (kg/ha)	Lime (kg/ha)
Badhal	61	257	125
Dhopakhali		245	130
Gazalia		255	128
Gopalpur		245	115
Kachua		250	125
Maghia		235	125
Rari Para		242	115
Average		**247**	**123**

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 happened 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 4.14**).

Table 4.14: Adaptive measures for disease control

Climatic Cause	Disease	Disease Control Measures	Response (%)
Extended days of extreme high temperature	Antenna Cut	Using Aqua-medicine and Liming	10
	WSS		47
Extended days of severe cold temperature	EUS	Using Aqua-medicine, Liming and Salt	6
		No measures	35

CEGIS Field Survey, 2022

Union-wise adaptive capacity was also assessed (**Table 4.15**) through different indicator-based impact Chains. These indicators mainly demonstrate the coping mechanism of the culture fisheries in hostile 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. The study team assessed union-wise conditions by consulting SUFOs, key informants, secondary data sources, and expert judgment. A set of indicator lists are attached (Annex I). From the adaptive capacity assessment of the culture fisheries in Kachua it was found that Gazalia union is highly adaptive for culture fisheries whereas Dhopakhali and Rari Para unions are moderately adaptive for culture fisheries.

4.3.4 Vulnerability

Vulnerability of culture fisheries (**Table 4.15**) of Kachua Upazilla 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 Badhal and Gopalpur unions were found to be in high vulnerability. These unions had high sensitivity and low adaptive capacity. Rari Para union was found to be in moderate vulnerability while rest of the unions were found to be in low vulnerable zone.

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

Union	CRVA Elements				
	Multi Hazard	Exposure	Sensitivity	Adaptive	Vulnerability
Badhal	Medium	Low	High	Low	High
Dhopakhali	Medium	High	Low	Medium	Low
Gazalia	Medium	High	Low	High	Low

Union	CRVA Elements				
	Multi Hazard	Exposure	Sensitivity	Adaptive	Vulnerability
Gopalpur	Medium	Low	High	Low	High
Kachua	Medium	Medium	Low	Low	Low
Maghia	Medium	High	Low	Low	Low
Rari Para	Medium	Low	Medium	Medium	Medium

4.3.5 Risk

Climate change induced hazard risk for culture fisheries was obtained through impact chain analysis for base and 2050s time period. Gazalia, Rari Para and Badhal unions contain the highest number of aquaculture farms in Kachua. However, these unions also faced highest amount of production loss. As these unions are adjacent to the rivers, they face inundation and salinity intrusion which affects freshwater aquaculture negatively. These unions face salinity intrusion which affects freshwater aquaculture negatively. During cyclone and flood events major portion of Kachua Upazila gets inundated due to its low lying topography and lack of proper cyclone and flood protection infrastructure. Fish farmers often elevate the banks of their ponds to prevent saline water intrusion during flood. Lack of proper storage and transportation facility result in considerable production loss. The increasing 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 found Gazalia, Dhopakhali, Maghia and Kachua unions to be in high risk for the base period. In 2050s Gopalpur union will be in high risk zone along with the high risk union at the base period. Badhal and Gopalpur unions were in moderate risk at the base period and Badhal union will be continued to be the same in 2050s. Rari Para union is in low risk zone in both time slices. **Figure 4.15** shows the risk of culture fisheries in Kachua.

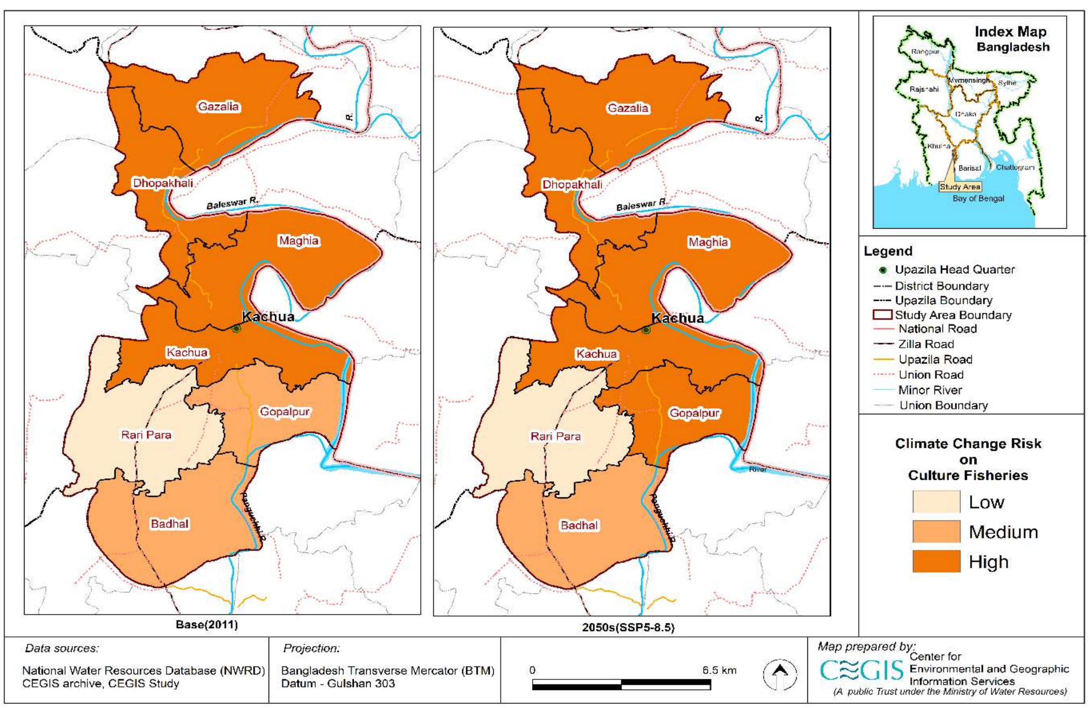


Figure 4.15: Climate risk for culture fisheries in Kachua Upazila

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.

Being a coastal area high vulnerability in terms food insecurity, income, water, health, and poverty are prominent in this region (BBS et al. 2009; GoB 2006). The areas face various natural risks and hazards resulting in social, economic and physical impacts. The fisheries and aquaculture sector is one of the major source of livelihood in this area. This sector becomes vulnerable due to cyclone, storm surge, extreme heat, flooding and salinity Intrusion. Women in this area are actively involved in catching fish, net making, and pond preparation, harvesting, and marketing. Their contribution in fisheries and aquaculture sector hugely makes an impact to their family earning though their ownership pattern is not visible.

Mostly women work with their male counterparts—with the working hours for women even higher than for men. However, their contribution in decision making process and access to market, income and wages is far more less which makes them more susceptible to the impacts associated with climatic hazards.

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

4.4.1 Exposure

The impact of climate change has increased the number of various hazards that have adverse effects on fisheries and aquaculture. In fisheries and aquaculture sector, exposure determines the risks to be exposed of fisheries resources (i.e. ponds, Gher, Fishing Gear) and vulnerable communities who are become affected due to the climate change. The study area is located in Kachua Upazila covers 7 unions where majority people are involved in fish farming.

Women are mainly involved in supporting fish farming and fishing along with household work. In terms of women's involvement in fishing, it is found that very few women are involved in fishing. Following the table shows that very negligible number of women are involved in fishing and related activities in each union of Kachua upazila. It is depicted that Maghia union has the highest number of women involved in fishing among the 7 unions of Kachua Upazila and Gazila union has no women fisherman.

Capture fisheries

People in this area dependent on both capture and culture fishing. According to Kachua Fisheries office, about 2394 fishermen involve in capture fishing whereas 58 female fishermen have been found. Following **table 4.16** shows the union wise distribution people who are involve in fisheries sector at Kachua Upazila. It is found that most of capture fishermen catches fish from open water bodies (i.e. sea, river, canal etc.) Field findings show that about BDT. 10,000-13,0000 earned by the capture fisher's household monthly. But according to the fishermen, now fish is not caught as before due to unavailability of fish. The reason behind this the decreasing of navigability of water, lack of rainfall, raising salinity and temperature, water contamination etc. As a result, they also involve alternative sources (i.e. cow rearing, poultry, gardening, agriculture etc.) for earning and maintaining expenses.

Aquaculture

Shrimp farming is currently a very lucrative business in the region rather than rice cultivation (Akber et al., 2017; Hossain and Hasan, 2017). The average monthly income of Shrimp farmer is about BDT. 15,000 - 20,000 (monthly) from shrimp farming or gher. If the weather is favorable, then this income can increase but it depends on how much water bodies owned by shrimp farmers. Respondents stated that there was not much surplus after meeting the household needs from only paddy farming earlier but now the farmers are getting more profit from shrimp farming. Additionally, road communication become developed that also increasing the possibilities of income for Shrimp farmers. Although, fish farming is affected almost every year due to natural calamities which adversely affects their income. The Dependency rate (The dependent population ratio is the ratio of the population defined as dependent (the population aged 0-14 and 60 and over) divided by the population 15-59, multiplied by 100. Considering it, the dependency ratio has been calculated, which includes both male and female.) of those household areas also depicted in the **Table 4.16**.

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

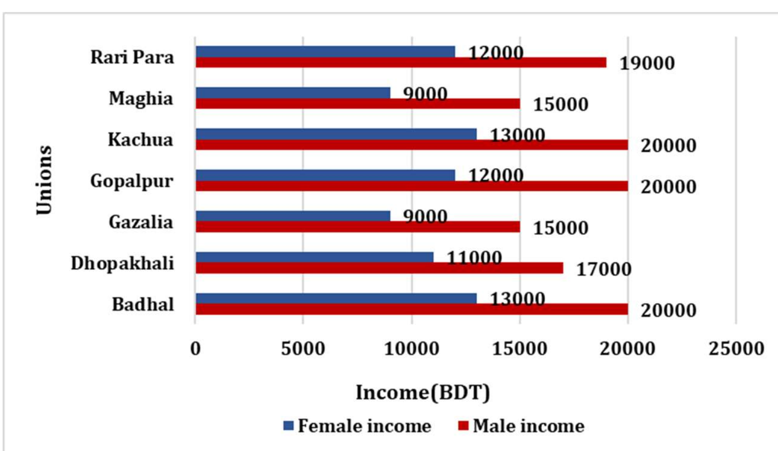
Name of the Unions	Male (% of fish related occupants)	Female (% of fish related occupants)	Dependent members (%)
Badhal	98.7	1.3	40.5
Dhopakhali	95.4	4.6	44.0
Gazalia	100.0	0.0	45.7
Gopalpur	99.2	0.8	42.0
Kachua	98.3	1.7	40.2
Maghia	96.6	3.4	42.6
Rari Para	98.4	1.6	39.9

CEGIS Field Survey, 2022 and BBS, 2022

4.4.2 Sensitivity

Poverty condition, mobility, health and physical condition become more sensitive due to the regular occurrence of cyclone, storm surge, salinity intrusion, extreme heat and flood. Women's mobility is being constrained to the home. When the disaster strikes, everyone did not have the same ability to move.

With the less income, poverty increases especially women headed households and lack of essential vitamins and minerals tend to be more sensitive because of the effects of climate change. **Figure 4.16** below shows the monthly average income of women fish farmer who owned the fish ponds/Gher in Kachua. Due to social challenges, men fish farmers on an average earn between BDT. 15000-20000 monthly and women who have own fish farms earn considerably on an average BDT. 9000-13000 monthly. Moreover, natural disaster disrupts farming every year, cause extensive damage to fish and ponds, to a reduction income. As a result, their families do not run properly with this low income as it becomes very tough for them to bear the routine family expenses. They have to take a loan to get rid of the situation and their financial condition worsens every month by paying off the loan. Besides, in this kind of adverse situation, even if women want to work outside to maintain the balance of livelihood, there are less opportunities and they have to face various social barriers. Therefore, poor condition and less income opportunity continuing that make them more sensitive to the changing climatic conditions.



Literature review and CEGIS Field Survey, 2022

Figure 4.16: Monthly average income of fish related activities

Additionally, the women's labor wages are much lower than men's while a male laborer is paid Tk. 350 to Tk. 450 for working a whole day whereas women are paid Tk. 250 to maximum Tk. 300 (in average). In fish farming, women are involved in all kinds of work such as pond preparation, feeding and fertilizing, where they often spend more time than men. Despite all this, their low income, less working opportunities and poverty makes them more sensitive to the changing climatic condition. In this way, women, disable and aged people who have less access to resources decision making suffer a lot and become more sensitive because of disaster. In addition, physical and health condition play significant role to be more sensitive in the disaster-prone area. In this way, gendered condition become sensitive in the Kachua Upazilla. Following the **Table 4.17** shows the different indicators and its impacts on gender that will make more sensitive.

Table 4.17: Impacts of hazards on gender

Indicators	Impacts
Housing and Homesteads	Disasters cause damage to houses. High salinity disrupts homestead vegetable production. Besides, fruit trees and medicinal plants cannot be grown in homestead.
Impact on Pond management and Homestead Production	Women have the less control over the resources, especially ownership of the ponds—and their pond-based activities disrupted following climate hazards. Women who earn homestead-based livelihoods are more affected by climate change related disasters. Their crops are destroyed, lack work opportunities and experience shortage of loans or other facilities to recover from the situation—which consequently make them face chronic nutritional deficiencies.
Limited Access to Market	There are many unions in the Kachua Upazila where the communication system is very poor. Both the waterway and roadway communication affected adversely due to disasters occurs in this area. Boat is their only mode of communication as there are no/ lack of road facilities. But due to shortage of boats, they cannot keep connection with the market all the time, particularly after the communication system is broken during the hazard. Market access became limited due to damaged road and transport system to buy or sell their goods. Women are forced to trade within the village or accept lower prices offered by male buyers from other areas. Due to which they cannot sell the produced fish even in the local villages at a low price. In this regard, women suffer a lot and have limited ways recover this vulnerable condition.
Loss of Income, Savings and Employment	Both men and women who are involved in fishing, fish farming and related work are adversely affected by natural disasters as heavy rainfall, cyclone almost every year. During disaster period, the female fishermen cannot go for fishing in the river and women as well. Women are involved in different fisheries activities as net making, pond preparing, feeding the fishes etc, During the flood saline water enters in the pond and make the water unhabitable for fish. It does a great loss for the women fish farmers. They cannot sell their products properly due to the disasters which make them vulnerable. Women lose their income, fish ponds/gher are washed away, ponds are damaged and lack of money to recover due to disasters. Besides, during the disaster, the job opportunities are reduced.
Sickness and Disease	The frequency of sickness has increased both for men and women. Women who are involved in catching fish, are exposed in saline water for conditions long time. It was nooted that during menstruation period, women fishers face severe gynecologic related diseases. In most cases, they need to go to cities for treatment, which is financial burden for them. Women and newborn babies also face huge problems due to malnutrition, food insecurity and increase poverty condition. There is a health center situated in the upazila headquarter and others at the union level called union health center which are not adequate for all the people. It becomes more problem due to shortage of medical officers and modern equipments.
Social Security	Women who engage in outside work facing social insecurity. They are often subjected to physical and human harassment at the work place. Besides, there are various taboos in our society which lead to neglect and disrespect of women who work outside. Moreover, cyclone shelters have

Indicators	Impacts
	limited separate facilities for women, aged people and disable people but it is not properly maintained.

Women are playing different role in their families in maintaining household chores and fish farm related activities. In previous time women played only one role for their families as caregiver. Two other burdens have added with their role- producer and breadwinner. Many development interventions implemented in this area, but few of them can address women vulnerabilities, because the target-oriented programs. It is very much required to provide accessibility to service from different service providers. Therefore, mainstreaming the gender in climate change adaption plan and development process is very urgent.

According to the **Table 4.19** the unions named Badhal, Gazalia and Maghia are highly sensitive due to the moderate condition of domestic violence, moderate accessibility to income opportunities, post harvesting loss and working hour. Thus, Badhal, Gazalia and Maghia unions are found as highly sensitive in comparison with other unions of the Kachua Upazila according to the results on sensitivity indicators on Gender.

4.4.3 Adaptive capacity

The **Table 4.18** indicates the specific scoring against each adaptive capacity indicators where respondent gave their perception/views during an FGD meeting. The table shows that the respondents in this region know about each indicator. The highest number of respondents around 92% said that they have access to the Cyclone Centre during cyclone and floods periods. However, they have low knowledge to reduce salinity from drinking water where the score is zero. About 33% women received training on poultry farming, aquaculture, animal husbandry and homestead vegetation for involving in Alternative Income generating Activities (IGA).

It is difficult for women fisherman to adapt during disaster and post-disaster period as they do not have adequate access to take loans as they do not have direct ownership of fish ponds, inadequate mortgage, communication skill and unable to provide required documents. As a result, they carry out businesses by their own which is always tough for them following any disaster. The FGD findings depicted that about 83% respondents of the FGD have good understanding of climate change impact, local fisheries techniques and disaster early warnings.

Based on the adaptive capacity score card it can be stated that women of this area 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 will be very helpful for other livelihoods to be responsive against the climate change risks and vulnerabilities.

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

Adaptive capacity indicators	Status (%)
Understanding on Climate Change Impact	83
Knowledge of Fisheries Techniques	83
Knowledge of Pest and Diseases in Fish	58
Receive Early Warning Message Regularly	83
Watching Television or Social Media	83
Having Cell Phone	50
Having Smart Phone but no Internet	33
Having Smart Phone with Internet	67
Watching Television Once in a Week	75
Accessibility to Shelter during Cyclone/Floods	92
Knowledge on Hygiene during menstrual and pregnancy period	58

Adaptive capacity indicators	Status (%)
Knowledge on Drinking Water Boiling or Chlorination	50
Training Received on Climate Change	50
Training on Alternative Livelihood	33
Training on Climate Change Impact and Adaptation	42
Knowledge on Reducing the salinity from drinking water	0
Training on Climate Resilient Housing, Pond management and Infrastructures	33

4.4.4 Vulnerability

Vulnerability for gender specific livelihood was also assessed for Kachua Upazila using impact chains developed for Southwest region (**Table 4.19**). During the assessment women were asked different issues in relation with climate change and vulnerability. Women and children have the more sensitivity than male in climate induced hazards. Vulnerability assessment showed Badhal and Maghia unions were highly vulnerable. While Dhopakhali and Gazalia unions were in moderately vulnerable zone. Unions with high vulnerability have moderate to low adaptive capacity and high sensitivity level. Rest of the unions were found to be in low vulnerability level.

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

Union	CRVA Elements				
	Multi Hazard	Exposure	Sensitivity	Adaptive	Vulnerability
Badhal	Medium	Low	High	Medium	High
Dhopakhali	Medium	High	Medium	High	Medium
Gazalia	Medium	Low	High	High	Medium
Gopalpur	Medium	Low	Medium	Low	Low
Kachua	Medium	Medium	Medium	Low	Low
Maghia	Medium	High	High	Low	High
Rari Para	Medium	Medium	Low	Low	Low

4.4.5 Risk

Union wise risk on gender-based livelihood due to climate change induced hazard for two time periods. In Kachua, 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 Maghia, Gazalia and Dhopakhali the wage rate of women is shockingly lower 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 Maghia union is in high risk for women livelihood for base period. In 2050s Gopalpur union will be in high-risk zone along with Maghia. Initially Gopalpur union was in low risk at the base period but in 2050s due to increased impact of climate change induced hazard it showed high risk. Dhopakhali, Kachua and Badhal unions are found to be in moderate risk while Rari Para and Gazalia are in low-risk zone in both time slices. **Figure 4.17** depicts climate change risk on gender (women) engaged in F&A activities.

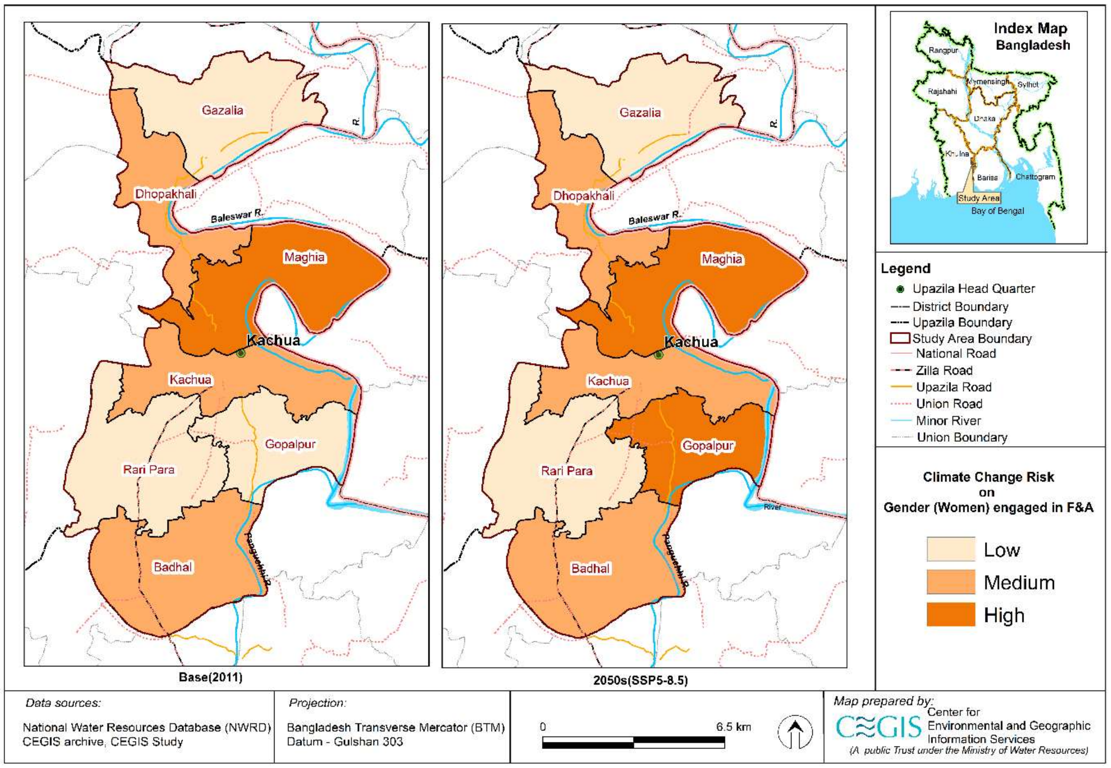


Figure 4.17: Climate risk of gender (women) engaged in F&A in Kachua Upazila

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 Kachua 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 Kachua 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 Kachua 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 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 • 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 fisher's community	• Improve financial stability of fishermen to recover any losses incurred from damages • Ensure sustainability of income and livelihoods	DoF, BFRI, MoF, MoDMR, MoEFCC, Insurance companies	Within 3 to 5 years
		• Provide climate resilience funds for repair or purchase of boats of gears	• Improve financial stability of fishermen to recover any	DoF, BFRI, MoF, MoDMR, MoEFCC, LGIs, NGOs	Within 3 years

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	**Risk**	**Adaptation or Risk Reduction**	**Motivation**	**Critical stakeholder(s)**	**When to Implement**
			losses incurred from damages		
		• 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 • 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 • 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
		• 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

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	**Risk**	**Adaptation or Risk Reduction**	**Motivation**	**Critical stakeholder(s)**	**When to Implement**
		• 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 production losses and plan accordingly for fisheries risk reduction	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**
		• 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 • 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
		• 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 • 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
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

Cyclone, Storm surge, Salinity Intrusion, Flood, Tidal Flood, Wave action					
ID	**Risk**	**Adaptation or Risk Reduction**	**Motivation**	**Critical stakeholder(s)**	**When to Implement**
		• 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 • 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 • 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 • 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 • 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 • 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 • 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 • 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 • 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 • 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 • 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 • 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	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**
			• Reduce gender indiscrimination and inequality		
		• 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 • Control of disease outbreak • Increase in fish production • 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 • Reduce disease outbreak • 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 • 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 • 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	• Safeguard fish species and production • Secure income	DoF, BFRI, LGIs, Knowledge Institutes, Academia	Within 3 years and continue

Cyclone, Storm Surge, Sea Level Rise, Salinity Intrusion, Flood, Tidal Floods & Wave action					
ID	**Risk**	**Adaptation or Risk Reduction**	**Motivation**	**Critical stakeholder**	**When to Implement**
		• Introduce IoT based water quality monitoring such as salinity/pH/DO/water temperature in the aquaculture farms	• Risk informed decision making by fishermen themselves • Reduce habitat and production loss	DoF, BFRI, LGIs, Knowledge Institutes, Academia, Fishing Communities	Within 3 years and continue
		• Pond rehabilitation to improve water quality with Urea, TSP, lime etc.	• Improve habitat condition • 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 • 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. • 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 • 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,	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**
				Training and Knowledge Institutes, Private Sectors	
		• 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 • 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 • Reduce aquatic ecosystem vulnerability	BWDB, MoS, DoE, NRCC, DoF, WARPO	Annual and periodic

Drought, Lightning, and Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
		• 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
		• 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 • 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 • 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 • 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 • 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	

Drought, Lightning, and Heat Stress					
ID	Risk	Adaptation or Risk Reduction	Motivation	Critical stakeholder	When to Implement
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 • 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 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 • 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 • Reducing gender base violence during and post disaster period		
		• Construction of separate market shed for women	• Ensure accessibility to the market and Growth Centre • 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 • 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 • Ensuring sustainability of income and livelihood		
		• Training on cow fattening and multi farming approach	• Ensuring support in livelihood during disasters • 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 • 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 assesses the key risk and vulnerabilities of F&A sector, specifically livelihoods of fishers with special focus on gender and aquatic ecosystem in the project area of Kachua Upazila through comprehensive assessment. Blended participatory appraisal techniques such as FGDs, KIIs and representative community surveys; scientific analysis based on latest available data and information are utilized for the assessment. The assessed risk and vulnerabilities are mapped through geo-spatial analysis following indicator-based approach of the approved CRVA framework for the F&A sector in Bangladesh. Impact chains for capture fisheries, culture fisheries, aquatic ecosystem and gender-based F&A livelihoods are used to prioritize indicators, collect data through participatory and scientific approach and then doing weighted aggregation of multiple indicators using geo-spatial tools. The risk and vulnerability maps are prepared with severity of risk or vulnerabilities for each of the unions of the Kachua Upazila. For the analysis of climate sensitivity of aquatic ecosystem, in situ and laboratory tests of rivers and ponds/ghers are performed followed by the SWOT analysis of ecosystem services.

Cyclone, coastal flooding, saline water intrusions, river bank erosion, sea level rise and drought have severely affected the people living in this region. This upazila faces cyclone accompanied with high storm surge almost every year which inundates ponds and fish farms. Fish farmers in Kachua 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. 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, which has an impact on the production of fish in aquaculture and in open water systems in some localities of Kachua. The migration, reproduction, and growth of fish and other aquatic species are now also being impacted by this.

From risk assessment, Gapalpur and Badhal union are found to be under high risk for capture fisheries and Gazalia, Dhopakhali, Maghia and Kachua unions were found to be in high risk for culture fisheries at base period. In 2050s, Kachua union will be in high-risk zone along with the high-risk unions at the base period for capture fisheries. Gopalpur union will be in high-risk zone in 2050s along with the high-risk union at the base period for culture fisheries. The SWAT analysis shows that pond ecosystem has higher strengths-opportunities and lower weakness- threats because of their buffer areas are characterized by natural land-cover types and less land-use changes. The results also draw attention to the weaknesses of the river ecosystem, which are more threatened by urbanization and environmental pollution.

A climate resilience action plan has been prepared following the principles of climate resilience framework, ecosystem approaches to fisheries and ecosystem approached to aquaculture. Community preferences of actions for the climate risk reduction are taken into account for the resilience action plan. Key stakeholders are mapped to implement the action plan. Necessary capacity development initiatives and institutional management measures are suggested to boost the motivation of stakeholders for implementing the local led resilience action plan of the Kachua upazila smoothly. Different ecosystem-based adaption options, technical/financial incentives and alternative livelihoods generation for fishermen, required policy reforms or nonstructural solutions like human skill development and capacity building of institutions are considered under this plan. Special emphasis is given to create an enabling environment for women's participation in climate adaptation process for the F&A, and raise women's voices at from micro level to macro level, create gender-specific disaster risk reduction policies and promote women's empowerment through capacity building to combat pre, during and post disaster period. The implementation of the locally led climate resilience action plan would contribute significantly to reducing risk and vulnerabilities of climate change and building resilience for F&A based livelihood, women fishers and climate sensitive aquatic ecosystem. The fisheries and aquaculture production would be revamped in the region and sustainable economic development will be achieved.

Although, the study consulted with multiple respondents from the fisheries and fisheries related communities residing in 2-3 vulnerable unions and organization in the Kachua Upazila, consultations and validation in each of the unions would improve the study outcome. 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. Further, comprehensive assessment of such kind of information may improve the study outcome further making it more specific and local evidence based, which may be undertaken in future considering the very basic 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 • Define scope (sector, topic), extent (geographic level or vertical level) and timeframe (current and future) • Assess resources and stakeholders' involvement requirement • Stocktake available information • Prepare implementation plan	• Capture and Culture Fisheries • CRVA on Fisheries Livelihood and Ecosystem • Base (2000s) and Future (2050s and 2085s) • Climate Change Scenarios (SSP1-2.6 and SSP5-8.5) • Up to district level • Separate assessment for selected 6 regions • National level stakeholders • Review and stocktake	• Capture and Culture Fisheries • CRVA on Fisheries Livelihood and Fish Ecosystem • Base (2000) and Future (2050s and 2085s) • Climate Change Scenarios (SSP1-2.6 and SSP5-8.5) • Up to union level • Separate assessment for each project site or Upazilla • Local level stakeholders, community and gender • Review and stocktake
2	**Developing Impact Chains**	• Identify climate impacts and risks affecting the system • Determine hazards (climate signal and direct impacts) and intermediate impacts • Determine vulnerability (i.e. sensitivity and lack of adaptive capacity which are contributing to risk)	• Brainstorming among study team experts based on draft NCVA impact chain • Develop initially conceptualized impact chain for selected 6 regions and as per defined scope for F&A • Identify recommended adaptation measures including Ecosystem based Adaptation (EbA) considering gender inclusion ad sustainable livelihoods	• Bring the national level impact chain for the respective region under which project site located • Conduct FGDs, KIIs and Community Survey • Update or modify the impact chain including the weight through Budget Allocation Approach

Steps	Activities	Agenda	National Level	Local Level
		• Determine exposures or elements at risk • Brainstorm adaptation measures to reduce the risk	• Share with relevant stakeholders and client • Get feedback and assign weights of identified CRVA elements through Budget Allocation Approach • Finalise the impact chain for next step	• Identify recommended adaptation measures including EbA considering gender inclusion and sustainable livelihoods • Compile Field based Outcome • Brainstorming among study team experts • Finalise the impact chain for each project site
3	**Identifying and Selecting Indicators**	• Select indicators for hazards • Select indicators for vulnerability and exposure based on functional relationship with risk • Identify proxy indicators, if any • List all indicators and discard redundant or repeated indicators for same CRVA components	• Compiling data and information availability • Selecting indicators of CRVA components based on data and information availability at desired level from secondary sources • Identify proxy indicators • Deduct redundant data	• Compiling data and information availability from FGDs, KIIs and Community Survey, Water Quality test • Selecting indicators of CRVA components based on data and information availability at desired level from both secondary and primary sources • Identify proxy indicators • Deduct redundant data •
4	**Data Acquisition and Management**	• Data collection, database construction and linking relevant data to chosen indicators	• Data collection and processing • Gender disaggregation which are possible • Threshold or intensity identification from trend, frequency and indices analysis • 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. • Land cover or water bodes change assessment • Inventory preparation with unit for each indicator	• Data collection and processing • Gender disaggregation which are possible • Threshold or intensity identification from trend, frequency and indices analysis through both secondary sources and using feedback from local stakeholders and community • 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. • Land cover or water bodes change assessment

Steps	Activities	Agenda	National Level	Local Level
				• 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 1) based on functional relationship and standard normalisation formula	• Normalisation of indicator data based on functional relationship	• Normalisation of indicator data based on functional relationship
6	**Weighting and Aggregating of Indicators to CRVA Components**	• Assign weights to the various indicators • Arithmetic aggregation indicators to CRVA components	• Assign weights derived from Impact Chain Finalisation workshop • Geo-spatial weighted arithmetic aggregation using GIS • 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 • Geo-spatial weighted arithmetic aggregation using GIS • 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) • Assign weight and arithmetic aggregation of CRVA components i.e., among hazards, exposure and vulnerability • 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 • Geo-spatial weighted arithmetic aggregation using GIS • Estimate total score and normalise the CRVA score	• Assign weights derived from FGDs, KIIs and based on National level impact chain of that region • Geo-spatial weighted arithmetic aggregation using GIS • 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) • 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 • Separate maps for Capture and Culture Fisheries highlighting gender perspectives • CRV map for fishery ecosystem	• CRV maps for current and future for each project site or Upazilla showing spatial variation up to Union level • Separate maps for Capture and Culture Fisheries highlighting gender perspectives • CRV map for fishery ecosystem

Steps	Activities	Agenda	National Level	Local Level
			• List of potential recommendations for adaptation measures • Validating the outcome of CRVA with stakeholders • Update (if necessary) and publish the finalised CRV maps	• List of potential recommendations for adaptation measures • Validating the outcome of CRVA with stakeholders • 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 Kachua 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 Kachua 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 Kachua Upazilla

Indicators excluded in CRVA

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

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	Availability 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 concentration
	Resistance to Temperature	Aquatic species growth/avoidance rate in higher temperature
	Provisions for Nature Conservation	Number/Area of reserved wetland/sanctuary/ECAs
	Monitoring and Enforcement	Number of monitoring/patrolling/enforcement program
	Water Resources Management	Presence/Number of functional water resources management structures (regulator, sluices, culverts etc.)
	Availability of fish pass/fish friendly structure/fish pass	Number/Density of Fish Pass
	Weak ecosystem management practices	Number of Awareness Program on CC

Annex II: SWOT Analysis of Aquatic Ecosystem

SWOT scoring and outcomes for River ecosystem

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Provisioning	Water availability	2.6	2.3	2.5	2	The strength of water availability received high score due to good condition of availability of optimum water in the dry season and good water retention time and diversified water use when water stays sweet after monsoons. Weakness scores medium condition because poor connecting of surrounding hydrological system, connectivity obstructed due to high siltation and lack of sandy river bed materials which. There are good opportunities to increase water availability through dredging or re-excavation practices, high opportunities for law enforcement of IUU fishing and support alternative livelihoods so, the opportunities scored high. Plan of upstream development due to rapid urbanization and overuse the water are the main threats that scored medium.
	Water quality	2	1	2	3	Water quality received a moderate score for strength as the Optimum Physio-Chemical Parameters (Temperature, DO, TDS, pH) from the field test are average for water quality and water can be used for multipurpose when the water salt concentration changes to low levels. As the physio-chemical parameters is average than threshold range, so the weakness of water quality is scored medium. However, EbA interventions for dust management and the presence of law enforcement are good opportunities for water quality improvement but the presence of functional ETP is absent and co-management is poor so, the opportunities received medium scores. Extreme heat and drought due to climate change are the main threats to water quality. Moreover, chemicals and pesticides used in surrounding crop field, fish gher and waste dumping from the surrounding infrastructures causes the water quality more vulnerable so threats scored high here.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Soil quality	2	2.6	2.5	1.3	The strength of soil quality is scored medium as the optimum soil nutrients is in good condition due to the vegetation coverage. The weakness of the soil quality scored high due to high presence of ordinary peat soil which is a very soft soil with low shear strength and high compressibility exists in an unconsolidated state a. Soil is also polluted by anthropogenic activities. Opportunities for soil quality improve assigned high scores because of increasing vegetation coverage and land use practice. There are high threats to soil quality as chemicals and pesticides used in surrounding crop field and fish gher and household discharge and waste dumping.
	Primary productivity	2.6	1	2.5	3	Availability of plankton, good sediment retention, export and floodplain fertility provide good strength scores for primary productivity. Weakness for primary productivity scored 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 get high scores because of increasing forest, vegetation coverage and EbA interventions. However, Threats scored high due to overmuch unsustainable harvest of the ecosystem resources.
	Fish diversity, community dynamics and production	2	2	2.16	2	This indicator received average score for strengths as water for integrated use for fishery, crop and nature is sufficient and water quality and soil quality is average for fisheries. Moreover, primary productivity is medium. Weakness is scored medium due to average water retention capacity and less time needed to regenerate primary productivity. Presence of green coverage is good, fishing ban period is strictly maintained, community involvement, EbA activities is active, which are good opportunities and received medium score. Frequent climate extreme event are the main threats to fish diversity, community dynamics and production. However, Disruption of environmental flow of the ecosystem due to infrastructure and upstream development is the main threats and received moderate score

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Regulating	Ground water recharge	2.5	2	1	2.3	The strength for ground water recharge is high because of silty clay soil type and adequate vegetation coverage. Poor sandy soil type is the main weakness for ground water recharge 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 rapid urbanization, unsustainable use of forest and poor management of domestic waste which is scored high.
	Waste water treatment	2	1.5	2	2.3	The strength of waste water treatment received moderate score due suitable condition of aquatic vegetation and presence of molluscs. Weakness scored medium condition because of average dense turbidity. Presence of co-management, awareness of the role of ecosystem for climate resilience and law enforcement are good opportunities for this indicator and received medium scores. Rapid urbanization, unsustainable use of forest and poor management of domestic waste are the main threats which is scored high.
	Soil fertility	2.5	1	2.5	2	Strength for soil fertility scored high as existing biodiversity makes the soil fertile by decomposing organic materials which provide suitable habitat. So, the weakness gets poor score. Opportunities for soil quality improve assigned good scores because of increasing forest and vegetation coverage and sustainable management and increasing awareness of the people. Presence of embankment and agro-chemicals use in the surrounding ghers, moderate water management structure, moderate deforestation are the main threats to soil fertility which scored medium.
	Water retention capacity	2	3	2	2	Water retention and conveyance capacity is good and strength for this indicators scored medium though siltation is the main weakness and received highest score. There are average opportunities for dredging and new hydrological connection so it scored medium. Presence of embankment and moderate deforestation disrupt water retention so the threats scored medium.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Cultural	Recreation and tourism	2.5	2	2	2	High resource availability, scenic beauty provides satisfying score for cultural services but the main weakness is recreation and tourism are not so planned and lack of sustainable management which received moderate score. There are good Opportunities for community based livelihood and received average score. The main threats are environmental pollution and overexploitation of resources which received an average score.
Supporting	Ground water replenishment	2	2	1	2.5	The strength for ground water replenishment is moderate because of silty clay soil type and good vegetation coverage. Lack of sandy soil type is the main weakness and scored medium here due to low water holding capacity. As this is a natural ecosystem so there are few opportunities for groundwater recharge which received less score. Main threats are management of domestic waste and unplanned urbanization which is scored highest.
	Nutrient cycling	2.5	1	2.5	2	Nutrient cycling gets highest score due to existing biodiversity which makes the soil fertile by decomposing organic materials and enrich nutrients to the soil. So, the weakness gets poor score. Opportunities for nutrient cycling received highest score because of increasing forest and vegetation coverage and sustainable management. Disasters, rapid urbanization, encroachments are the main threats for nutrients cycling which received moderate scores.
	Maintenance of floodplain fertility	2.5	2	2	2	The strength of this indicator received maximum score because floodplains are highly fertile as sediment is rich in organic matter and nutrients. Floodplains are home to some of the most biologically rich habitats on Earth. They provide opportunities of spawning grounds for fish and critical areas of rest and foraging for migrating waterfowl and birds. So, opportunities received a good score. Weakness and Threats received average score as stream bank erosion, and siltation which can undermine the stability of nearby infrastructure or disperse or degrade quality soils necessary for nutrient cycling and vegetative viability

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Prey/predator relationships	2.5	1	2.5	2	Strength and opportunities for this indicator are high for multitrophic interaction and high species & genetic diversity as both fresh and brackish water species is supporting the ecosystem. So, weakness for this indicator received negligible score. Frequent climate extreme events and deforestation due to urbanization are the main threats for Prey/predator relationships which received a medium score
	Hydric soil development	2	2	2	1	The strength of this indicator is moderate because of good vegetation coverage. Clay soil type is the main weakness and scored medium here due to low water holding capacity. Opportunities received good score due to the natural ecosystem support. Presence of embankment and infrastructure are the main threats to hydric soil development which gets poor scores.
Total	**Total Service=15**	**34.2**	**26.4**	**31.16**	**31.4**	

SWOT scoring and outcomes for Pond/Fish farm ecosystem

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
Provisioning	Water availability	2.6	1.5	3	1	The strength of water availability received highest score as availability of optimum water in the dry season and good water retention time and water use is for domestic purpose is medium. Weakness scored low as fish pond is connected with surrounding hydrological system which support water availability in dry season, pond bed materials is silty clay which can holds certain amount of water. There are high opportunities to increase water availability by rainwater harvesting, re-excavation practices and community based management. Overuse of ponds is the main threat that received lowest scores.
	Water quality	2	2	3	2	The strength for water quality received average score as the Optimum Physio-Chemical Parameters (Temperature, DO, TDS, pH) from the field test are moderate for water quality and water can be used for multipurpose. Weakness for water quality is scored medium as the physio-chemical parameters is average but algal bloom occurs due to climate change. However, EbA interventions,

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
						increase vegetation coverage and community based management are good opportunities for water quality improvement so the opportunities received high scores. Heat and drought due to climate change are the main threats to water quality deterioration but has limited impact. Moreover, chemicals and pesticides used in surrounding crop field and fish gher deteriorate water quality so, threats received moderate score.
	Soil quality	2.5	1	2.5	2	The strength of soil quality is scored high as the optimum soil nutrients is in suitable condition due dominance of herbs, shrubs and trees. The weakness of the soil quality scored low due to good litter decomposition and vegetation coverage, so the soil is less polluted. Opportunities for soil quality improve assigned high score due to increasing suitable crops and vegetation coverage. There are medium threats on soil quality as chemicals and pesticides used in surrounding crop field and fish gher.
	Primary productivity	3	1	3	2	Presence of superior aquatic vegetation and plankton provides high strength scores for primary productivity. Weakness for primary productivity scored low as comparatively few time needed to restore plankton and aquatic vegetation after disasters because of soil fertility. Opportunities for primary productivity get high score for increasing awareness to plant suitable tree, vegetation coverage and EbA interventions. However, moderate threats on productivity due to unsustainable harvest of the ecosystem resources received medium score.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Fish diversity, community dynamics and production	3	1.3	3	1.3	This indicator received highest scored for strengths as water for integrated use for fishery, crop and nature is sufficient and water quality and soil quality is suitable for fisheries. Moreover, primary productivity is high. Weakness is scored low due to good water retention capacity and less time needed to regenerate primary productivity. Presence of green coverage is sufficient, community based activities is active, awareness on the role of ecosystem for climate resilience increase which are the good opportunities and received high score. Frequent climate extreme event and disruption of environmental flow of the ecosystem are the main threats for fish diversity, community dynamics and production which received low score
Regulating	Ground water recharge	2.5	2	1	1.3	The strength for ground water recharge is high because of silty clay type and high vegetation coverage. Clay soil type is the main weakness which influence ground water recharge and scored medium here due to low water holding capacity compare to sandy soil. 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 low.
	Waste water treatment	3	1	2.3	1.3	The strength of waste water treatment received high score due improved condition of aquatic vegetation and abundance of molluscs. Weakness scored low condition because of high aquatic vegetation and low dense turbidity. EbA interventions, community based management and awareness raising are good opportunities for this indicator and received good scores. High dependence of vegetation, management of domestic waste and unplanned urbanization are the main threats which scored low for this indicator.
	Soil fertility	3	1	2	2	Strength for soil fertility score highest due to abundance of flora and fauna. So, the weakness gets lowest score for high abundance of flora and fauna. Opportunities for soil quality improve assigned good score by increasing suitable tree and vegetation coverage, sustainable management and increase awareness on the role of ecosystem for climate resilience. Re-excavation, overuse of

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
						resources and agro-chemicals use are the main threats for soil fertility which scored medium.
	Water retention capacity	2	1	2	1.3	Water retention and conveyance capacity are good and strength for this indicators scored medium. Siltation during flood is the main weakness and received low score. There are good opportunities for re-excavation and connecting with new hydrological system so it scored medium. Threats scored medium due to low deforestation and moderate water management structure.
Cultural	Recreation and tourism	2	2	2	2	Existing biodiversity, scenic beauty provides average satisfying score for cultural services and the main weakness is unsustainable management of the ecosystem and scored average. Opportunities received medium score for social relations and inspirational values. The main threats are environmental pollution and over exploitation of resources and received moderate score for threats.
Supporting	Ground water replenishment	2.5	1	3	2	The strength for ground water replenishment is high because of low sandy soil type and high vegetation coverage. Silty clay soil type is the main weakness and scored low here due to moderate water holding capacity. There are few opportunities for ground water recharge by increasing vegetation and modifying soil texture which received highest score. Main threats are management of domestic waste and unplanned urbanization which scored moderate.

Ecosystem Service Type	Indicators	Strength	Weakness	Opportunities	Threats	Remarks
	Nutrient cycling	3	1	3	2	Nutrients cycling gets high score due to rich of biodiversity which makes the soil fertile by decomposing organic materials. So, the weakness gets lowest score due to improve nutrients cycling. Opportunities for nutrient cycling received high 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	3	2	3	2	The strength for this indicator received high score because floodplains are sometimes 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 high 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	3	1	3	1.5	Strength and opportunities for this indicators are high for multitrophic interaction, species and genetic diversity. Weakness for this indicator received low score due to abundance of flora and fauna. Frequent climate extreme event are the main threats for Prey/predator relationships which received average score.
	Hydric soil development	2	2	3	1.5	The strength of this indicator is medium because of good vegetation coverage. Silty clay soil type is the main weakness and scored medium here due to medium water holding capacity. Opportunities received high score due to community based management and EbA interventions. Rapid urbanizations is the main threat for hydric soil development which scored low.
Total	**Total Service=15**	**39.1**	**20.8**	**38.8**	**25.2**	

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

FGDs at Kachua Upazila

FGD with CBO at Gopalpur-1

FGD with CBO at Gopalpur-2

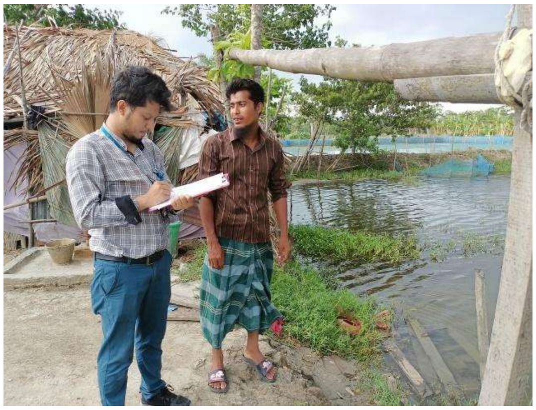
FGD with CBO (Net Making Group) at Kachua-1

FGD with CBO (Net Making Group) at Kachua-2

FGD with CBO (Net Making Group) at Kachua-3

FGD with Culture Fisheries Community at Dhopakhali

KII, Community Survey and Water Quality Sample Collection



KII with Boatman at Kachua

WQ Sampling at Bhairab Canal

KII with SUFO at UP

KII with Pond Owner at Gopalpur

Community Survey with Gher Owner at Dhopakhali

KII with Gher Owner at Dhopakhali