Anthropogenic and climatic impacts on the Kapotakkho river fisheries Bangladesh and adaptation strategies

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Abstract

Bangladesh has been identified as one of the most vulnerable countries due to climate change. On the other hand, anthropogenic impact on land and nature fuses impacts on the biophysical environment, biodiversity and distinctive resources. The river fisheries are also vulnerable due to climate and anthropogenic changes. Available researches on river fisheries have focused mainly on fish production, fish biodiversity, fishing gear and fishermen's livelihoods.

This study assessed the socio-economic status of fishers and present non-fishers (who were fishers before) and the impacts and adaptation strategies to anthropogenic and climatic changes in the Kapotakkho river fisheries of Chowgachaupazila of Jessore district, Bangladesh.

Data were collected through household interviews, semi-structure questionnaire, focus group discussions (FGD), oral history interviews and interviews with key informants between June and July 2016 from two fishing communities (Hazrakhana and Kalitola) of the Kapotakkho river. Secondary data (Climatic parameter; temperature, rainfall) were collected from Bangladesh metrological department (BMD), Agargaon, Dhaka-1207.

Socio-economic status of respondents was studied in term of age structure, religion, level of education, housing condition, homestead and cultivable savings. The socio-economic status of present day non-fishers was found better than that of fishers while occasional fishers and part-time fishers were found better than those of full-time fishers. On contrast, the socio-economic status of respondents was found better in 2016 than in 1998.

Both fishing communities are being exposed to the impacts of anthropogenic variables (dam construction, riverbank land use and urban runoff) and climatic variables (high temperature and low precipitation). However, volumes of water and fish habitat are being reduced. Quality of the waters was found deteriorated in 2016 than in 1998.

Fish abundance was found reduced in 2016 than in 1998. This study also identified that some fishes are locally extinct and/or going to be extincted from the surveyed river. It was also found that mean catch is reduced by 9.90-folds in 2016 than in 1998. Income from fisheries related activities were found reduced by reduction in fish catch which in turn affecting the livelihoods of the fishers thus affecting their socio-economic status.

To cope with the changing climate and man-made variability both fishing communities have taken multiple adaptation strategies. Some 88.3% respondents adapted adaptation strategies while rest did not. While 86.3% adopted diversification of livelihoods others increased fishing duration and use extra efficient fishing gears. Diversification of livelihoods included agriculture, fish trading; fish farming, small business and vehicle driving as prominent in both study sites. This has clearly demonstrated that agriculture is the most common adaptation strategy for fishers and non-fishers.

The socio-economic statusof the river Kapotakkho fishers and fisheries has been affected by a number of anthropogenic and climatic hazards, and are being traditionally adapted to those impacts which are not sufficient for sustainable livelihoods and fisheries. Over the next few decades this situation may worsen as predicted by the latest scientific research and an improved level of responsiveness would be required.

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List of Symbols and Abbreviations

BBS	Bangladesh Bureau of Statistics
DoF	Department of Fisheries
e.g.,	Example
FAO	Food and Aquaculture organization
FGD	Focus Group Discussion
FRSS	Fisheries Resources Survey system
GDP	Gross Domestic Product
GNP	Gross National Product
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometer
Kg	Kilogram
NGO (s)	Non-government Organization (s)
SPSS	Scientific Package for social sciences
UNDP	United Nations Development Programme
WMO	World Metrological Organization
%	Percentage
˚C	Degree Celsius
UNFCCC	United Nation Framework Convention on Climate Change
BRAC	Bangladesh Rural Advancement Committee (an NGO)
HH	Household

Chapter 1

Introduction

1. Introduction

1.1 Background

Bangladesh is one of the world's most important inland fishing nations having an extensive water resources in the form of ponds, natural depressions (*haors*[1] and *beels*[2]), rivers, oxbow lake (*baors*[3]). The major rivers of Bangladesh are the Padma, the Jamuna, the Meghna, the Brahmaputra, and the Surma. There are likewise a huge number of tributaries of these waterways with an aggregate length of around 24,140 km that are connected to the Bay of Bengal. In total 34% area (4.9 million hectare) of Bangladesh occupied by inland water body (Miah et al*.,* 2010).

Bangladesh is the fourth largest producer of inland water capture fisheries (FAO, 2016), one of the top ten in aquaculture production (FAO, 2013). Fisheries and aquaculture are important sources of food, food security and income from around the world, from the local to the global levels. Global fish production has grown steadily over the last five decades, with an increase in food fish supply at an average annual rate of 3.2 percent, exceeding world population growth by 1.6 percent (FAO, 2014). Annual per capita fish consumption has consistently grown in developing regions (from 5.2 kg in 1961 to 18.8 kg in 2013) and in food-deficit low-income countries (from 3.5 to 7, 6 kg; FAO, 2016). Total fish production in the last financial year 2014-2015 was 36,84,245 MT (FRSS, 2016). The fisheries sector in Bangladesh contributes about 3.65% to the national GDP (gross national production), almost a quarter (23.81%) to agricultural GDP (FRSS, 2016) and 2.01% to total exports (DoF, 2015). This sector provides about 60% of animal protein intake (DoF, 2014). Fisheries are an important source for economic growth and livelihood in rural area. Fishing is not just a livelihood activity but a way of life which determines the social identity and relationship (Coulthard et al*.,* 2011). In Bangladesh, fisheries sector support the livelihood of about 1,82,00,00 (more that 11% of the total population) people directly and indirectly (DoF, 2016).

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[1]Baor is the bend of river, which was cut off from the main river courses and become isolated water bodies, sometimes called as ox-bow lake.

[2]Beel is the large depression that contain water whole the year around and where it is connected with river.

[3] Collection of huge number of beels is called Haor.

1.1.1 Anthropogenic changes

Anthropogenic impact on the environment or human impact on the environment includes impacts on biophysical environment, biodiversity and other resources. Human activities have strongly altered the structure and function of their environments over centuries since the industrial revolution. The population growth of human has placed ever-increasing demands on both aquatic and terrestrial ecosystem. Literatures showed that aquatic habitats are adversely impacted by urbanization, deforestation, pollution, drainage of wetlands particularly of freshwaters and peat swamp (Shami et al., 2011). Rivers connect ocean and land through the transfer of water and sediment. Fluvial discharges to the oceans are influenced by both climatic (e.g., precipitation) and anthropogenic (e.g., dam construction).

1.1.2 Anthropogenic change of Bangladesh

Bangladesh is sensitive to the deviation of water from the Ganges through the Farakka barrage which negatively affects its ecology and economy. Due to reduction of the flow of the Ganges, Bangladesh has faced problems in agriculture, industry, fisheries, shipping, salinity and ecology, etc. in the south-western region. About one-third of Bangladesh's total area depends directly on the Ganges basin for subsistence. In these circumstances, the diversion of water in Farakka will have an impact, since it is an attempt to introduce a new ecological system against the normal course of nature. Water scarcity has brought much misery and hardship to the population of affected parts of southwestern Bangladesh, which has caused disruption of fishing and shipping, has brought unwanted salt deposits on rich agricultural land and affected agricultural production. Due to the deviation of the Ganges, the minimum discharge of the Padma river at the point of the Hardinge Bridge in Bangladesh fell far below. The level of groundwater in the highly affected area declined particularly in the Rajshahi, Kustia, Khulna and Jessore districts. The southwestern region has been facing the critical problem of the Bay of Bengal's salinity intrusion due to the drastic reduction of freshwater flows in the Gorairiver, which is the main distributor of the Ganges in this part of the country (Tiwary, 2006).

1.1.3 Climate variability and change

Climate variability refers to variations in the mean state and other statistics (such as standard deviation, the occurrence of extreme etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2007). According to IPCC (2007) variability in climate change had been regarded as natural internal process within the climate system but over the past few decades anthropogenic external forcing has compounded this variability in climate. Climate change is the change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i. e., decades to millions of years). It is unavoidably resulting in changes in climate variability and in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events (IPCC, 2012).

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a climate change that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which adds to the natural variability of observed in comparable periods. Global metrological organization referred to the average climatic period is 30 years.

Climate change issue, for example, increment in temperature, change in precipitation, increasing flood, change in storms and typhoon, increasing drought, changing in regular fluctuation and ascend in ocean level affect natural and human system in different ways (IPCC, 2007). Worldwide mean precipitation is anticipated to increment, with an expansion in tropical locales however a reduction in the subtropics (IPCC, 2007). More precipitation will bring about additional flooding however in ranges where mean precipitation will decline can bring about more serious danger of dry spell in those locales (IPCC, 2007). Atmosphere inconstancy and change not just made exceptional effect on common and human framework, additionally anticipated that in future it will accomplish more (Islam et al., 2014). Climate change is created by elements, for example, biotic procedures, varieties in sun powered radiations got by earth, plate tectonics and volcanic ejections. A worldwide temperature alteration is a critical reason for climate change.

1.1.4 Climate change in Bangladesh

Bangladesh has been distinguished as one of the most vulnerable countries on the earth because of environmental change (IPCC, 2007). It is regarded as one of the most vulnerable countries to the impacts of climate change where vulnerability is the degree to which a system is susceptible to, and unable to cope with against the adverse effects of climate change, including climate variability and extreme (IPCC, 2007). It is one of the developing countries prone to disasters. The country experiences disasters of one kind or another almost every year, such as tropical cyclones, storms, coastal erosion, monsoon wind, evaporation for monsoon rains, floods and droughts that cause great loss of life and goods and threaten development activities (Mamun et al., 2014).

There are four major seasons in Bangladesh, namely, winter (December to February), pre-monsoon (March to May), monsoon (June to early-October), post-monsoon (late-October to November). The average temperature of winter season is ranging from a minimum of 7.2-12.8°C to a maximum of 23.9-31.1°C. The minimum temperature occasionally falls below 5°C in the north. Generally, the southern districts are 5°C warmer than the northern districts. The average maximum temperature of the pre-monsoon season is approximately 36.7°C and occasionally erratic precipitation occurs from March to June. Pre-monsoon is relatively hot and the maximum temperature peak is in April. The monsoon is hot and humid and four-fifths of the average annual precipitation occurs during the monsoon. The normal rainstorm temperatures are higher in the western areas than in the eastern regions. The post-monsoon is a short life season characterized by a precipitation retreat and a gradual decrease in nighttime minimum temperatures (Agrawala et al., 2003).

According to the Met Office (2011) Bangladesh has experienced widespread warming (0.24°C per decade during the hot season of March to May and 0.19°C per decade during the cool season of December to February) and a small increase in total precipitation since 1960. This study also observed several temperature and precipitation extreme events in the last 5 decades. Although this study observed a long-term trend of temperature extremes, no evidence of a long trend of precipitation extremes (i.e., continuous wet or dry days) was observed. Between the years 1985-2009 an increased rate of sea surface temperature (0.0086°C to 0.0191°C annually) was found in the Bay of Bengal (Chowdhury et al*.,* 2012). Bangladesh could face more extreme weather events and related disasters in the future due to the increase in average temperature and rainfall values (Shahid, 2010).In Bangladesh, the average temperature and the annual average precipitation have registered an increasing tendency(Mamun et al., 2014).

The Long-term trend (1954-2007) of daily temperature and rainfall were analyzed from 17 stations of Bangladesh. From this analysis (Shahid, 2010) observed an significant increase in mean temperature in most of Bangladesh, except in northern Bangladesh. In southeastern coastal zone of Bangladesh, a maximum increase of 0.36°C decade–1 was found at Cox's Bazar. In southeastern hill region of Bangladesh, a maximum decrease in mean temperature –0.36°C decade–1 was observed at Rangamati. Shahid (2010) also observed a positive trend of annual and pre-monsoon rainfall as 5.53 and 2.47 mm/year respectively, over the period 1958-2007.

In coming decades, Bangladesh will experience a mixture of climate variability and change (some data are shown in Table 1). Greater variation in temperature and precipitation has been predicted compared to the past. General Circulation Models for Bangladesh predict a steady increase in temperature and precipitation, with temperatures increasing both in winter and summer, but more so in winter. In contrast, precipitation is predicted to decrease in winter and much increase in summer (Agrawala et al., 2003). The Met Office (2011) projects 3-3.5°C increase in temperature in Bangladesh, and 20% increase in precipitation in the north of the country and 5-10% increase in precipitation for the rest of the country by 2100 under A1B (higher) emissions scenario of IPCC. The temperature and rainfall would rise 2.4°C and 9.7% respectively at the end of the present century that have been projected by climate model (Agrawala et al., 2003).

Table 1 Future climate change scenarios for Bangladesh (Adapted from Agrawala et al., 2003)

Year	**Mean temperature change(°C)**			**Mean precipitation change (%)**		
	Annual	**December-February**	**June-August**	**Annual**	**December-February**	**June-August**
Baseline Average				2278mm	33.7mm	1343.7mm
2030	1	1.1	0.8	+3.8	-1.2	+4.7
2050	1.4	1.6	1.8	+5.6	-1.7	+6.8
2100	2.4	2.7	1.9	+9.7	-3.0	+11.8

Analysis of past flood record indicated that about 21% of the country is subjected to annual flooding and additional 42% is at risk of floods with varied, intensity. Every four or five year, a severe flood occurs during the monsoon season that submerging more than three fifths of the land (GoB, 2009).

Drought is climate variability recurring problem in Bangladesh of which 19 occurred between 1960 and 1991. In Bangladesh, the southwest and northwest regions are most vulnerable to drought. Climate models tend to show higher monsoon precipitation and annual precipitation, which could mean fewer droughts. Then again various atmosphere models gauge diminished yearly precipitation, and the models tend to demonstrate decreased precipitation in the winter months. So the possibility of increased drought cannot be ruled out (Agrawala, 2003).

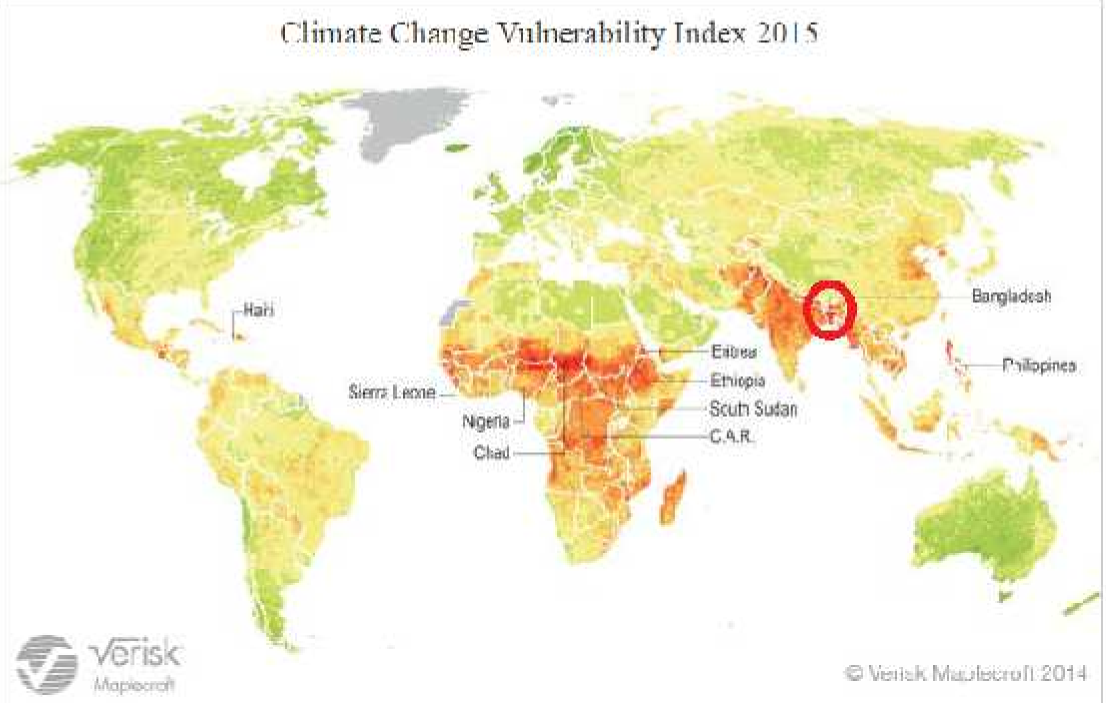
Bangladesh is also a global hot spot for typical cyclone. Nearly every year, cyclone hit the country's coastal region in the early summer (April-May) or late rainy season (September- October; Dastagir, 2015). There are some evidences that the peak intensity of regional typical cyclones may increase (Goodess, 2013) or may increase by 5% to 10% (IPCC, 2001) but there is still uncertainty whether the frequency of cyclone will change (IPCC, 2007).

1.1.5 Climate change of Bangladesh in the context of world

Climate change is one of the biggest challenges faced globally and an issue with significant on energy food and water security as well as health and safety of people across the world. Global warming is a significant cause of climate change. The world is nearly five times as dangerous and disaster prone as it was in the 1970s of because increasing drought due to climate change. In the first eight months of 2015, the world has seen more than 120 climate related disaster (World Bank, 2012). As the third series of the turn down the heat report prepared for the World Bank shows that globally warming of close to 1.5°C above pre-industrial times up from 0.8˚C is already locked into the earth atmosphere system by past and predicted greenhouse gas emission (World Bank, 2012).

According to the third Assessment Report of IPCC, South Asia is the most vulnerable region of the world to climate change impacts. People all over the world have to face the reality of climate variability. More than 5, 30, 000 people died as a direct result of almost 15,000 extreme weather events, occurred from 1993 to 2012 globally (World Bank, 2010).

In the context of world, the climate change vulnerability index, (Maplecroft, 2015) identified 32 extreme risk countries, which evaluates the sensitivity of populations, the physical exposure of countries, and governmental capacity to adapt to climate change over the next 30 years. It revealed that Bangladesh positioned first and which is alarming (Figure 1).



Rank	Country	Category
1	Bangladesh	Extreme
2	Sierra Leone	Extreme
3	South Sudan	Extreme
4	Nigeria	Extreme
5	Chad	Extreme

Rank	Country	Category
6	Haiti	Extreme
7	Ethiopia	Extreme
8	Philippines	Extreme
9	C.A.R.	Extreme
10	Eritrea	Extreme

Legend	
	Extreme Risk
	High Risk
	Medium Risk
	Low Risk
	No data

Figure 1 Climate change vulnerability index (adapted from Maplecroft, 2015)

The Global Climate Risk Index 2015 analyzed (1994-2013) climate data and reveled that which countries have been affected by the impacts of weather-related loss events (storms, floods, heat waves etc.). In the global climate Risk Index (CRI), Bangladesh ranked 6th position among 170 countries (Figure 2) that are most vulnerable to climate change from 1994 to 2013. Honduras, Myanmar and Haiti have been identified as the most affected countries which are followed by Nicaragua, the Philippines and Bangladesh(Kreftan et al., 2015).

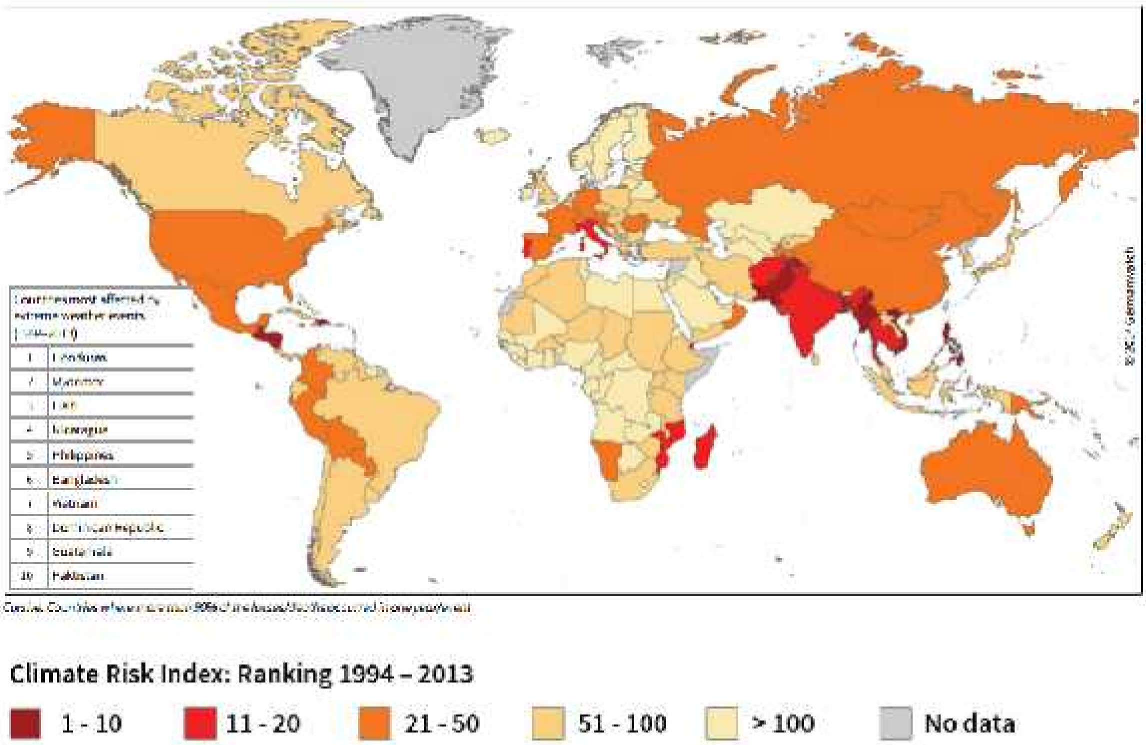


Figure 2 Climate change index ranked countries which are most affected by extreme weather events with range of year in 1994-2013 (Adapted from, Kreft et al., 2015).

1.1.6 Impacts of anthropogenic and climatic change on fisheries

Climate change places additional pressure on fishery systems that already experienced other tensions such as overfishing, habitat loss, pollution and disturbances (Brander, 2006). Climate change has direct repercussions (physiology and behavior and alteration of growth, reproductive capacity, mortality and distribution) and indirect (they alter the productivity, structure and composition of marine ecosystems from which fish depend on food). While some positive effects on fisheries have also been taken into account, for example the extension of the creation of high-yield supplements (Brander, 2010) and the decline in ice water mortality of some (IPCC, 2007a), most of the effects of environmental change are overwhelmingly negative (IPCC, 2007a). Environmental changes will tend to worsen non-climatic weights in fisheries, for example overfishing, pollution and loss of living space (Brander, 2006; Sumaila et al., 2011). Specifically, small-scale fishing groups in creative nations, which make up 90% of individuals under fisheries (FAO, 2012), will face mind-boggling and restricted effects, as anticipated by the Intergovernmental Panel on Climate Change (IPCC, 2007a).

Fish productivity, abundance and distribution may also be affected by climate change, which may increase the cost of access to fish catch (IPCC, 2007a, Cheung et al., 2009).

Fish species are highly dependent on the characteristics of their aquatic habitat that supports all their biological functions. Migratory fishes require different environments for their life cycle,such as reproduction, juvenile production, growth and reproduction, sexual maturation. Reservoirs or dams alter the regional hydrological regime, intensity, period and frequency of floods. The dam in a waterway may defer the movement of the fish upstream and, therefore, add to the decay and even termination of the species. The dams make the irregularity in the accessible space of the fish remarkable. They significantly modify angular movement courses (Antonio et al., 2007) and are mixed with the ecological trigger for gonadal development and fish generation which adversely affects the annual population recruitment.

Traditional fish drying is sensitive to variations in temperature and precipitation. Fish processing costs may also increase. As a result impacts on capture and processing will influence the employment, income and nutrition of households and communities dependent on fisheries through changes in local institutions and resource management. These impacts of fish species damage fishing methods and terrestrial property and infrastructure (Westlund et al., 2007; FAO, 2008). These impacts influence the economic return of livelihood strategies. This in turn can have an impact on the vulnerability and adaptability of households and communities. But all households within a community are not equally vulnerable. They can be differentially affected by variability and climate change based on their level of adaptive capacity (Adger, 2003) and sensitivity, which relates to their livelihood assets and strategies. Roncoli et al. (2001) found that poorer households are often less able to adapt. Dugan et al. (2010) showed that dams have a profound impact on fisheries in the Mekong basin and the livelihoods of fishermen for food and income.

1.1.6 Adaptation

1.1.6.1 The concept of adaptation

Adaptation is the action and adjustments made to maintain the ability to cope with induced stress as a result of current and future external change. Climate adaptation is the process by which people reduce the adverse effects of climate on their health and well-being and take advantage of the opportunities their climate provides (Fankhauser et al., 1999).

Adaptation is classified as maladaptation or effective or successful adaptation based on its failure or success. Adaptation can be reactive or anticipatory basing on timing and depending on the degree of spontaneity.Reactive adaptationmeans institutions, individuals, plants and animals actions, which are implemented after the fact. Anticipatory adaptationare carefully discussed to take in advance for reducing potential effects of climate change before fact (Fankhauser et al., 1999). Adaptation can also be unsuccessful, which does not necessarily mean that harm is done. It could mean that something just did not work. But there are instance of unsuccessful adaptation that result in people being worse off than before. Adaptation strategies is the long term strategies and by its nature not a single response.

Adaptive capacity relates to the force to react to challenges through knowledge, handling risks and impacts, developing new knowledge and formulating effective approaches (Azril et al., 2016). A strong adaptive capacity is vital for fishermen for several reasons. First of all, it will help them to absorb negative climate-change impacts. Second, it can emerge as the main influence on what impacts eventually emerged. Third, it is also the construct of vulnerability most amenable to affect social systems. For any adaptation planning, adaptive capacity should be closely considered (Azril et al., 2016). The strength of individuals to adapt can be affected by their characteristics and circumstances, and their capability to take benefit of other opportunities that become available. Adaptive capacity is context-specific which varies from community to community, among social groups and individuals, and over time (Barry Smit and Wandel, 2006). Community-based adaptation to climate change requires the recognition of multiple stimuli not only related to climate but also political, cultural, economic, institutional and technological forces (Barry Smit and Wandel, 2006).

1.1.6.2 Adaptation of fishing community to anthropogenic and climatic change

Climate change and anthropogenic change can have multiple impact on fishing communities, household members and their livelihood. To face the challenge of climate change, fishing communities need to adapt to cyclones, floods, variations in temperature and rainfall, sea level rise, El Nino, drought and land erosion, and their impacts. In addition to reducing exposures to these shocks and stresses, adaptation of fishing communities would need adjustment within livelihood assets, strategies (fishing, pre-harvest activities such as boats making, financing; postharvest activities such as processing and marketing) and transforming structures and processes. These adaptations may be adopted by the fishing communities themselves or by outsiders such as national governments.

Adaptation to changes in stock distribution, recruitment levels and variability and adult biomass and production can only be achieved by adjusting fishing effort to levels that are consistent with the yield levels that can be sustained by the changed populations. Literature shows that past adaptation strategies to climate variability in fishing communities are dominated by diversification or flexible livelihoods and migration. Livelihood diversification is an important adaptation option for buffering climate change impacts on certain kinds of livelihoods. Diversification of livelihoods to address climate variability has occurred outside and inside fisheries, where the households are involved in several income generating activities (Turner et al., 2007; Allison et al., 2009). Migration among fishers has occurred in response to climate-mediated fluctuations in fish abundance (Daw et al., 2009). In this type of migration the fishers usually only migrate for a short period leaving their families behind. However, a lot of other fishers might also have migrated in the past or may migrate permanently in future (either forcefully or voluntarily) with their households to adapt to climate impacts. Migration may help reduce vulnerability or enhance adaptation to climate variability and change. Migration may reduce exposure to climatic shocks and stresses for the people (Warner et al., 2008).

1.2 Rationale

The fisheries sector incorporates a variety of subsistence activities, from production and processing to marketing and auxiliary function. The world fisheries sector supports the livelihoods of approximately 660-820 million people. In the fisheries and aquaculture sector, many millions of people around the world find a source of income and livelihoods. Nearly 56.6 million people participated in the primary catch and aquaculture. Of them 36 percent were full-time, 23 percent part-time and the remainder were either occasional fisher (FAO, 2016).

Bangladesh's fisheries contribute significantly to GDP, foreign exchange gains, animal feed, animal feed and livelihoods. In the context of Bangladesh, we have growing evidence of the impact of climate change and anthropogenic change on livelihoods and the socio-economic status of fishermen. The revierine fisheries are more negligible compared to the coastal area of Bangladesh. These have the potential to make fishing communities and their livelihoods more vulnerable, but are only investigated in the context of the coastal zone. A detailed study on how fishing communities are vulnerable to past and current climate impacts can provide important insights to address the higher level of future impacts or reduce vulnerability to them. With this knowledge of the impacts and adaptation of communities dependent on the Kapotakkho river fisheries, it will be possible to develop appropriate policies and strategies to reduce impacts and improve sustainable adaptation for them. This will ultimately play a significant role in reducing the poverty of dependent people and the sustainable development of the country.

1.3 Problem statement

The Kapotakkhoriver is an important riverine fishery, located in the southwest region of Bangladesh. This river plays an important role for the migration and movement of fish. In the past the river had a high speed of water flow and abundant with amount of fish and composition of fish species. But at this point, the river is almost dry in the summer season. According to the local interviewee, the main reason for the decrease in water is the increase in temperatures, the decrease in rainfall over time, the breakage of the river bank, land use on the river bank, construction of dam and urban runoff. The reduction of depth and water flow resulted in the water registration system. At present due to the smaller flow of water, brackish water species move downstream. Fish species are less abundant at this time. Livelihoods that depend on the Kapotakkho river fisheries are more vulnerable at this time. Fishers are being faced many problems in adapting to climate change or anthropogenic. Fishermen are affected by social and economic problems. When they catch fish, they are hindered by local or political people. They do not have much money to adapt to climate change or anthropogenic. They lend money from different organizations and pay with high interest.

1.4 Research gap

Most studies on climate variability and change, and fisheries, have focused on documenting trend and fluctuation in fish abundance and distribution, and its impact on the marine ecosystem that are mainly focused on large scale industrial fisheries (Cushing, 1982; Kliashtorin, 2001; Yanez et al., 2001; Glantz, 2005; Kell et al., 2005). Risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural people in developing countries (Adger et al., 2003). A research about global assessment of potential impact of climate change on world food supply was conducted (Rosenzweig and Parry, 1994). With mounting evidence of the impacts of climate variability and change on aquatic ecosystem, the resulting impacts on fisheries livelihoods are likely to be significant, but remain a neglected area in climate adaptation policy (Allison et al., 2009). In the context of Bangladesh, there has an impact of climate change through typical cyclones, storm surge, coastal erosion and adaptation assessment

(Ali, 1999). There has a mounting evidence of impacts of climate change on livelihoods and socio-economic conditions of fisher folk on the coastal areas (Islam et al., 2014). The available researches on river fisheries has focused mainly on fish resource vulnerability and adaptation, fish migration and species assemblages, livelihood status of fishermen (Ali, 1999; Halls et al., 1998).

1.5 Research Aim and Objectives

The aim of this study was to investigate the socio-economic status, impacts of anthropogenic and climatic change on the fisheries and adaptation strategies of the river Kapotakkho in Chowhachaupazila of Jessore district, Bangladesh.

The specific objectives were:

1. to compare the socio-economic status of fishers between 1998 and 2016 of Kapotakkho river;
2. to assess the impacts of anthropogenic and climatic changes on fisheries of the Kapotakkho river between 1998 and 2016; and
3. to assess the adaptation strategies to overcome the impacts of the anthropogenic and climatic changes of the fishers of the Kapotakkho river.

Chapter 2
Materials and Methods

2.1 Selection of study sites

Site selection is very important component of the research design. In the materials and methods, the first aspect involved the identification of study area and sites to establish the relationship among livelihood status, socio-economic status of fisher folk, anthropogenic and climatic change and vulnerability. Chowgachaupazila in Jessore district were selected as a study site based on the criteria of the vulnerability due to anthropogenic and climatic changes and fisheries dependency on the Kapotakkhoriver.

2.2 Description of study river - The Kapotakkhoriver

The Kapotakkhoriver is one of the main arteries of the water system located in southwestern Bangladesh. It is an alluvial river flowing from north to south towards the more developed part of the Gangetic delta. The Kapotakkhoriver is an important outlet channel for flood spills and rains-running out of a vast area covering the district of Jessore, Satkhira, Jhenaidha. The Kopotakkhoriver flows through 20 upazilas, 10 municipalities and 95 unions under seven districts. The Kopotakkho began from the Mathabhangariver with a huge wind. A trench was burrowed to run the waterway along an abbreviated course maintaining a strategic distance from the wander and the Kopotakkho got disengaged from the Mathabhanga. Later, the Kopotakkho kept up its primary Bhairab release. The separation of the Mathabhanga from the ganges and again the detachment of the Mathabhanga, the Kopotakkho brought about an extremely contract stream. In the past, the continuous flow of fresh water from the Ganges river across the Mathabhangariver kept saline water away from the river upstream and pushed it downstream and discharged incoming sediments into the Bay of Bengal. But after having been disconnected from the Ganges, the Kapotakkhoriver has been subjected to tidal dominance, associated with increased sedimentation by the tidal process. Gradual sedimentation leads to a reduction in the cross-section of the river. From the rainstorm the waterway gets just nearby water and water permeated and loses its safety in many spots. In summer, the stream practically dries close Jhikargachha. The Kopotakkho, alongside its branches and branches, depletes around 3,315 km^2 of the areas of Kushtia, Jessore and Khulna. The waterway is traversable in Khulna region and there is a dispatch benefit on the stream. The aggregate length of the waterway is around 260 km.

Figure 3 Kapotakkhoriver at Chowgachaupazila in Jessore district

2.3 Description of study sites

Jessore is located in the northeastern region of Bangladesh. It is bounded by the districts of Satkhira and Khulna in the south and the districts of Jhenadha and Magura in the north. The main rivers flowing through this region are the Bharib, Chitra, Kopotakkho and Mukteshwari. Chowgacha is an upazila of the Jessore district. It is 23.2667˚N and 89.0250˚E. It is bounded by Mahashpur, Kotchanpur and Kalanjupazilas in the north, Jessoresadar and Kalanjupazilas in the east, Sarsha and Jhikargachaupazilas and Bagdah block of community development in the northern 24 Parganas district in West Bengal, India in the south and Maheshpurupazila in the west. The main city is on the bank of the Kopotakkhoriver. The area of Chowgachaupazila is 269.31 km^2 with 231,370 populations. The literacy rate of Chowgachaupazila is 25.5% against the national average of 32.4% literate, Bangladesh Census (2011).

2.3.1 Kalitola village

Kalitola village is located in Chowgachasadar of Jessore district, Bangladesh. The total population ofKalitola is about 600.The fishing community is located in west part of the sadar. The total fishers of kalitola are about 25. Physical infrastructure of Kalitola is poor. Most of the households head is male and their households depend on fishing. Some households are also involved in other activities such as fish trading, net making, agriculture and land laboar.

2.3.2 Hazrakhana village

Hazrakhana village is located in Chowgachaupazila of Jessore district, Bangladesh. It is 5 km away from Chowgachaupazila. From Chowgacha bazaar, it takes about 20 to 25 minutes to reach Hazrakhana by CNG. The total population of Hazrakhana village is about 1200. The fishing community is located in north, south, and middle part of village. The total fishermen of these three parts are 55. The households of the fishers are mostly made with soil, french and tin sheet. Some of houses are made with brick and cement.

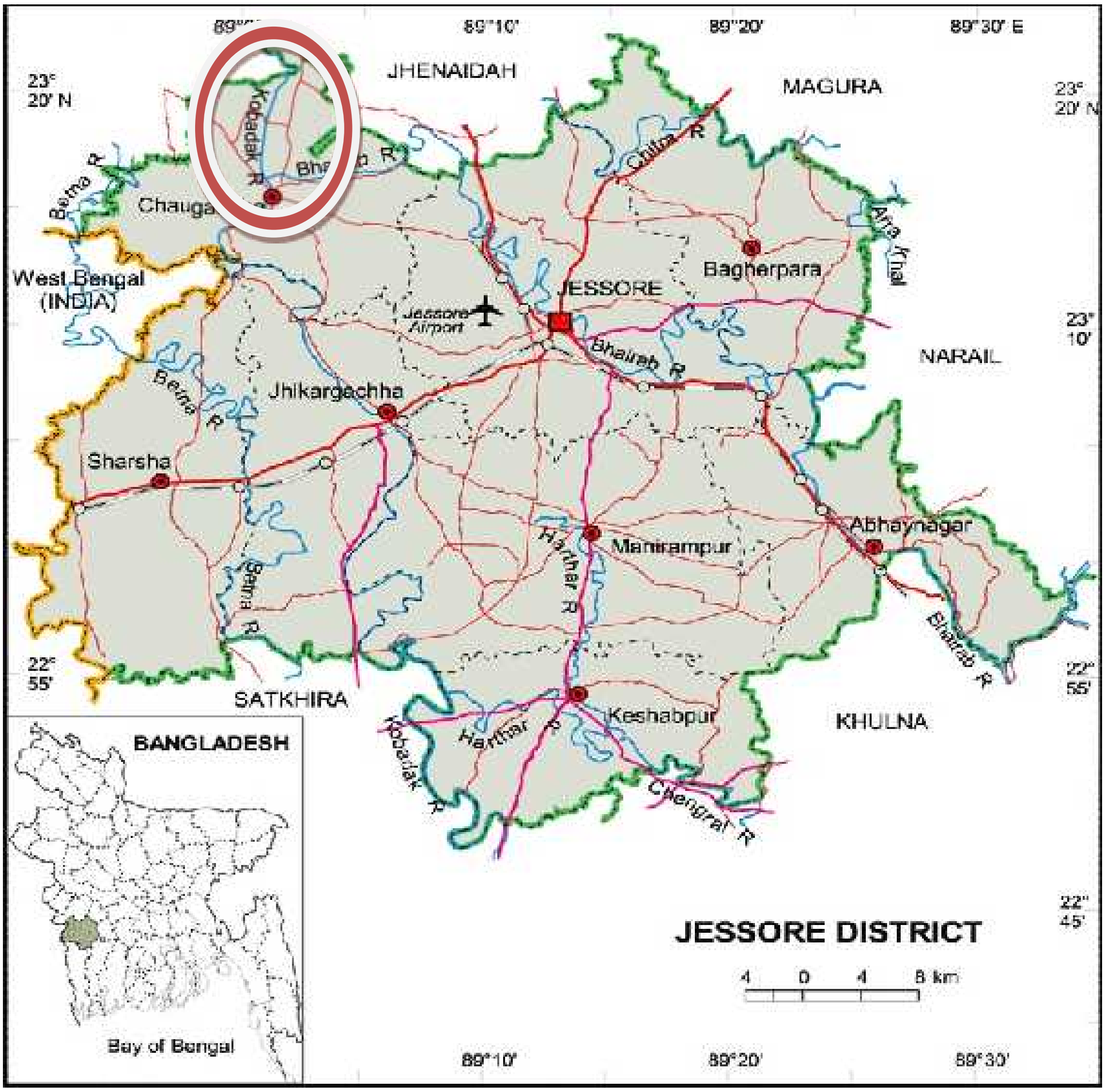


Figure 4 Map shows Kapotakkhoriver at Chowgachaupazila in Jessore district.

2.4 Fisheries in the study site

In the study, the household who directly depends on the Kapotakkho river fishing to support their family are considered as fishers and who does not depend on fishing to support their livelihood are considered as non-fishers. Depending upon the time of involvement in fishing, fishers are three types, such as full-time, part-time and occasional. Full-time fishers fish throughout the year, part-time fishers do not fish over the year round (3-9 months per annum), whereas occasional fishers are opportunistic and fish mainly for their subsistence (less than 3 month a year).

Both the study sites are located at the bank of Kapotakkhoriver in Chowgachaupazilla. So the fishers who are directly depend on Kapotakkhoriver for their livelihoods, are living nearby the river bank. The fishers are live is known as “Majhipara” or “Jelepara”.Some of the fishers have alternative livelihood options besides fishing such as fish trading, fish farming, agriculture, daily labor which supplement their fishing income. In the study site the non-fishers depend on off-farming activities such as agriculture, day labor, small business etc. rather than fishing.

There are two main fishing seasons: rainy season (May to September) and winter season (November to February). In these study sites, usual fishing duration is 6 to 8 hour per day. Both study sites have “Arat” nearby of the village. All the fishers are being bought their catches to the aratto sell. Some of fishers are being sold their catches to the Chowgacha and other markets.

2.5 Research process of this study

The study was designed in six steps (Figure 3). Basing on the research objectives, the study area was selected. Then, research indicators and criteria were identified through literature review and characteristics of the research site. After identifying indicators and preparing themes for group discussions and main modules for interview, data and information were collected. The fifth step was data analysis and the final step was writing the report.

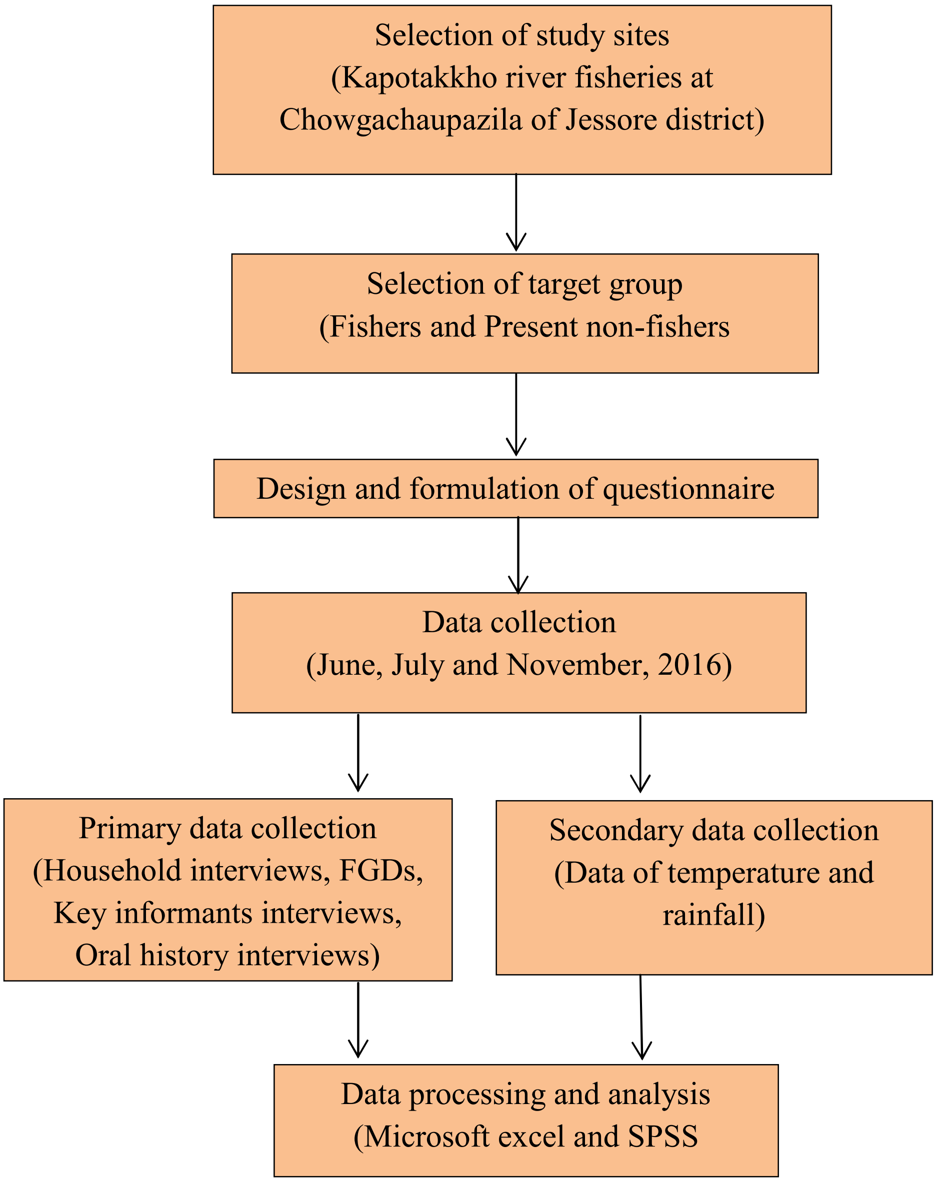


Figure 5 Flow chart of research process of the study in Jessore district

2.6 Scoping study to finalize the objectives

After selecting the specific fishing communities, a scoping study was made to each in order to introduce the research. Together with the fisher folk, I made contact with the member of the fishing communities. During scoping study, key information on climate and anthropogenic change and the livelihood of the fishing communities were gathered using key informant interview and focus group discussion.

2.7 Development of questionnaire

The semi structure questionnaire was designed according to (De vasus, 2002) and adapted for the specific context of Kapotakkhoriver fishing communities in Bangladesh. The questionnaire was designed to collect both qualitative and quantitative data. There were both open and close ended question. The response from close question allowed statistical analysis and open questions gather qualitative data eliciting more details and personal opinions on specific issues. The questionnaire was first developed in English then translated into Bangle. A pilot test with a small sample of respondents was done to verify the appropriateness of the question. Then the questionnaire was modified and rearranged following a pilot test. The final questionnaire developed in logical sequence so that the fishers could answer chronologically. The flow chart of development of questionnaire are given below,

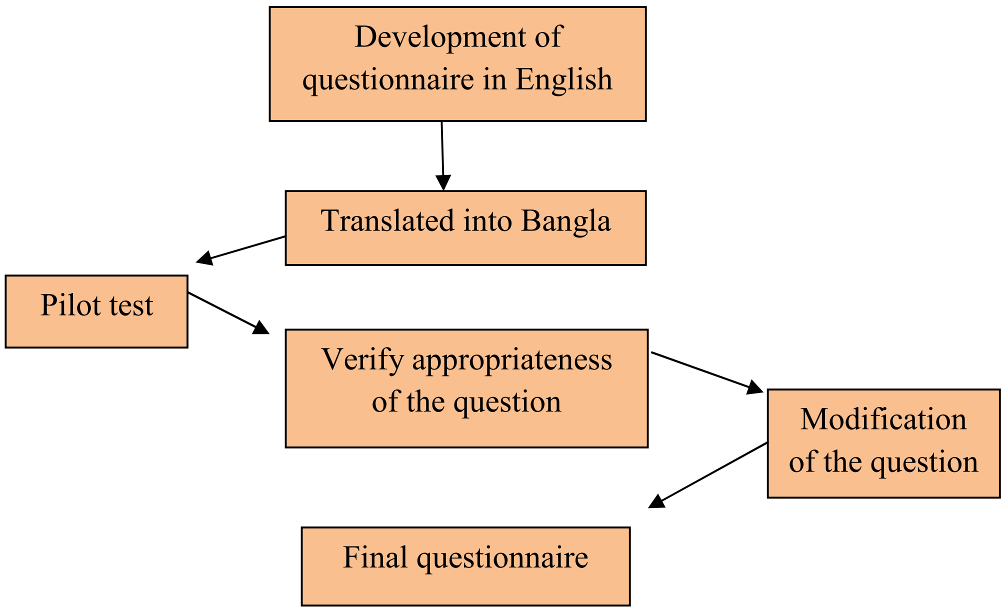


Figure 6 Process of questionnaire development for household interviews

2.8 Selection of respondents

To choose respondents for this study, the purposive sampling was applied. Single member for each household were selected. All of the members were male who are being involved in fishing and who are not being involved in fishing at this time. Male respondents were selected for sampling because they were directly involved with fisheries. For better information, almost all of the respondents were household member because the household head have a good sense of household vulnerability, security and livelihood (Jansen et al*.,* 2006).

2.9 Sample size determination

The sample size is an important feature of any research process. Sample size used in a study, is determined based on the expense of data collection, and the need to have adequate statistical power. Sample size was determined by according to Yamane formula (1973) as below,

Sample size, n= $\frac{N}{1+N\,(e)^2}$

Here,

N= Total number of fishers in both study sites

e = Deviation of sampling at the rate of 5%

So, Sample size= $70/1+70\ (.05)^2$

= 59.57

= 60

So the final sample size was 60 for household survey

2.10 Data collection

Both primary and secondary data were collected through mixed method approaches. The sources of primary data were household interviews, key informants interviews, focus group discussions. Data were collected from fishery dependent households from the fishing communities.

2.10.1 Primary data collection

2.10.1.1 Household interviews

Household interviews are the most important of the data collection process in this research. Interviews were conducted in all the sampled households using a pretest semi structured questionnaire (Appendix-B). Here the household comprise mainly married couple and their children. Information was collected on climatic and anthropogenic phenomena, its impact on fish species, fishers' folk and socio-economic status of the fishing communities.

2.10.1.2 Key informants interviews

A key informant interview is another approach of data collection for social science. Key informants interviews were therefore conducted at a later stage of the main data collection (Appendix-D). During the main data collection the goals of key informant interviews were to collect data on the issues in the research objectives or issues raised by respondents during the other data collection methods. Key informant interviews were conducted with the fisher's community (e.g., fisher's leader, stakeholder, experienced fishers) and other fisher's relevant authority (e.g.,upazila fisheries officer). During the reconnaissance study, the goal of key informant interviews were to develop the research objectives and methodology by exploring the research context and issue, introduced with local people and identify working facilities. A total of key 8 informants interviews were conducted during the data collection.

2.10.1.3 Transect walk

A transect walk is a participatory approach whereby the research team walks through village or community. A transect walk was done during the reconnaissance study. During the transect walk, some people of the both study sites helped me to introducing with water body and fishing communities of the study sites, which facilitated interactions between the community and the study sites.

2.10.1.4 Focus group discussion

FGD has become increasingly popular as a qualitative research method in participatory data collection in social science (Burgess, 1996; Goss, 1996; Longhurst, 2003). Like other participatory methods FGD has a direct interaction with the participants. In data collection FGD method has some drawback such as time consuming, costly, local power influence and limitation in generalizability from context specific information (Martin and Sherington, 1997). But it is helpful in sense in local community provides information directly and researcher can reach deeper of the study. FGDs were conducted in two stages for this study-during the reconnaissance study and the main data collection (Appendix-C). During the reconnaissance study, the goals of FGDs were to develop the research objectives and method by exploring the research context and issues as well as getting to know the study area and people. Then during the main data collection period, the FGDs were conducted to gather the data on livelihood vulnerability, coping and adaptation related to climate variability and change. Each FGD session was conducted within 3 hour and about 6-8 issue discussed. For an FGD, a group of 8-10 (Powell and Single, 1996) household heads were selected from each of the household clusters within a particular community. Homogenous group were insured to freely express their opinion. During FGDs there was no interfering of participants lecture. Overall the FGDs sessions were run ensuring that the focus was kept momentum maintained and that there was real participation and closure on question (Coldwell and Herbst, 2004).

2.10.1.5 Oral history interviews

Oral histories provide a more detailed perspective on social processes and can provide key insights into the lives of people that structured questionnaires cannot obtain. In this study oral histories were used to gather in-depth information on past and present impacts of climate variability and change on respondents' livelihoods, and their coping and adaptation strategies (Appendix-E). The location of interviews was important as it could have an effect on the power relationship between the research and the participants and the interview were conducted at respondent house and their convenient location. From the oral history we were provided about how past and current climate induced shock and stresses impacted (negatively or positively) on household's livelihood assets, capabilities, how those impacts differed, how they responded to those shocks and stress and their recommendation for future responses.

2.10.2 Secondary data collection

For this study, secondary data (temperature and rainfall) were collected from Bangladesh Metrological department (BMD), Agargaon, Dhaka-1207.

2.11 Data processing and analysis

After collection, both qualitative and quantitative data from various methods were synthesized and analyzed by using the software SPSS version 20. Descriptive statistics was used to present the data (Appendix-F).

2.11.1 Quantitative data analysis

Quantitative data were coded by MS excel 2007 and scientific package for social science (SPSS). Data were analyzed using descriptive statistics and compared mean. Data were presented in the form of graph and table to give graphical presentation of data.

2.11.2 Qualitative data analysis

The qualitative data were collected from open ended question from semi structure questionnaire, FGD and key informants interviews. Analysis of qualitative data consisted of three steps: preparing and organizing the data for analysis, reducing the data into theme through a process of coding and considering the code, and finally representing the data in table as a part of discussion (Creswell, 2007).When all the transcription were ready, coded were leveled on the text to assign units of meaning (Miles and Huberman, 1994). In the coding process it was kept in mind that not the words themselves but their meaning matters.

2.12 Ethical consideration

It is important to remember the power of relationship in a research process and how this affects the research. Ideally a survey will be technically correct, practically efficient and ethically sound (De Vaus, 2002). The ethical considerations were necessary to safeguard research participant the research process and the credibility of the research findings (Flick, 2009). Broadly, five main ethical issues were considerate for data participants: voluntary participants, informed consent, no harm, privacy and confidentiality anonymity (De vaus, 2002). The researcher has a responsibility not to abuse power, and to safeguard other participant's integrity, anonymity and generally treat all involved with respect. At the same time some of the information is very personal, it touches upon private feelings. Thus, to be sure that no one feels they have shared too much and to protect their privacy. I choose to leave out peoples real names in the analysis and presentation of the data. I do however mention the names of the local communities because it matters to the context of the data, and realize the double standards because it could be relatively easy to find out who the participants are. The data were not shared with anyone except the research team to comply with confidentially.

Chapter 3
Findings of the survey and Discussion

3.1 Human capital

3.1.1 Category of the respondents

Generally the fishers depended on fishing for their income, nutrition and their livelihood. The income of fishermen varied with their capability and quantity of the capturing fish. Of the total, 60% were fisher and 40% non-fisher (Table 2). However, only 18.3% fishers were found fulltime fishermen. Occasional fishermen (30%) were nearly 3-times than part-time fishermen (11.7%; Figure 7). Occasional and part-time fishers rely mostly on agriculture, fish farming, small business and livestock rearing for their livelihood.

Table 2 Number and percentage of fishers and non-fishers in the study area

Category of fishers	Number	Percentage (%)
Fisher	36	60
Non-fisher	24	40

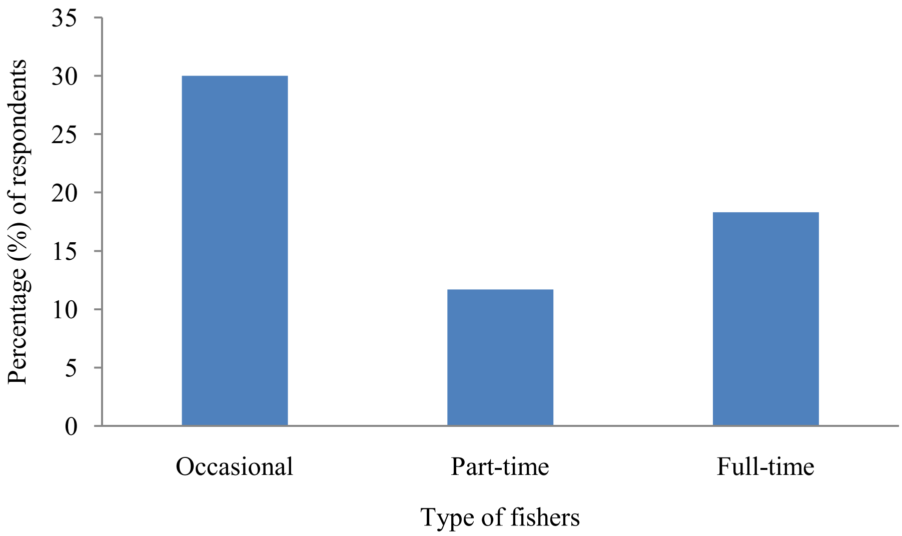


Figure 7 Type of fishers in the Hazrakhana and Kalitola village in Chowgachaupazila of Jessore district

3.1.2 Age structure of the respondents

The age structures of fishers are important to understand the potential productive human resource. Different categories of age group were considerate to examine the age structure. In this study, the maximum and minimum ages of fishers were 85 and 28 years old respectively. It was found that most of the fishers were to the age group 40 to 49 year (Figure 8). This study also found that the percentage of young and old fishers, respectively, less than 30 years and greater than 70 years were very low. The numbers of part-time and full-time fishermen were very low at the age of less than 40 years old. The number of non- fishers at the age structure of 40 to 60 were relatively higher than fishers (Table 3). This study found that young generation lost their attention towards fishing due to the decreasing catch. Ali et al. (2009) reported that the majority of fish farmers (50%) belong to the age group 31-40 in the district of Mymensingh, related to this study. Bhaumik and Saha (1994) also reported that the age structure of fishers in the Sundarbans ranged from 20 to 70 years, which was in agreement with the present findings.

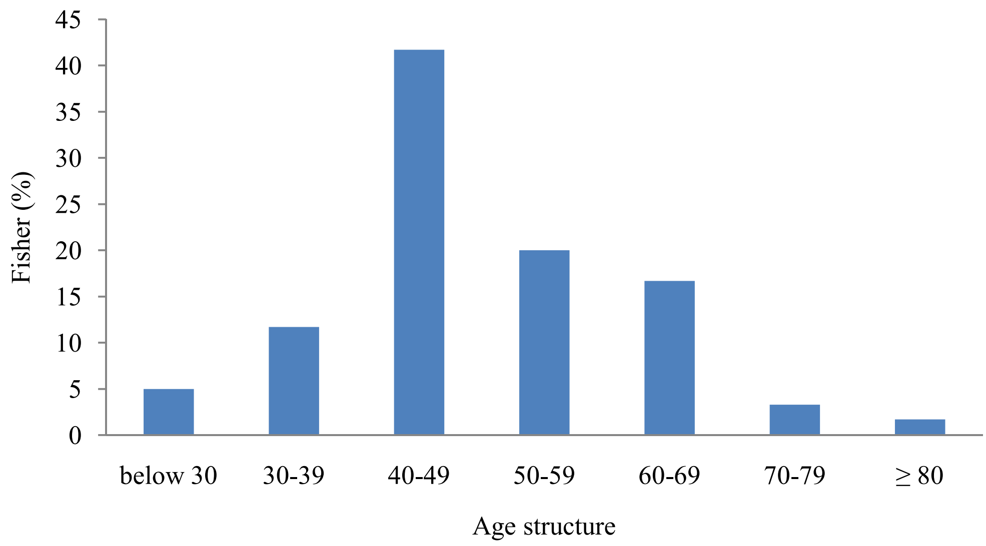


Figure 8 Age structure of fishers in the Hazrakhana and Kalitola village of Chowgachaupazila of Jessore district

Table 3 Distribution of HH by age structure and category of fishers in the study sites

Age structure of the fishers	Category of the fishers				
	Occasional	Part-time	Full-time	Non-fisher	Percentage (%)
Below 30	2	0	0	1	5.0
30-39	4	0	1	2	11.7
40-49	6	3	4	12	41.7
50-59	4	2	2	4	20.0
60-69	2	1	3	4	16.7
70-79	0	1	1	0	3.3
≥ 80	0	0	0	1	1.7

3.1.3 Religion and Marital status

This study found from household interviews that average 97.15% fishers from both study sites were Hindu, followed by 2.85% Muslim (Figure 9). Most of the respondents (96%) in both study sites were married. BBS 2011 showed that in Bangladesh 89.7% people were Muslim and 9.2% people were Hindu. Here the study showed higher involvement of Hindu community in fishing in the study area. Another study by Bijoya et al. (2013) conducted in the Turag river area in Bangladesh reported that approximately 60% of Birulian fishermen and 89% of Boroibari fishermen were Hindus. Sultan et al. (2015) reported that 54% of the fishermen were Muslims and 46% of them were Hindus in the Pairariver, south of Bangladesh. Bhuyan et al. (2016) noted that 63% of the fishermen were Hindus while the rest belonged to Muslims (27%) in the Narsingdi district. Khan et al. (2013) on the Tistariver, reported that most of the fishermen were Muslims in that area. The implications of the Hindu community were high in this sector because fishing was a traditional occupation for the Hindu lower caste community in Bangladesh.

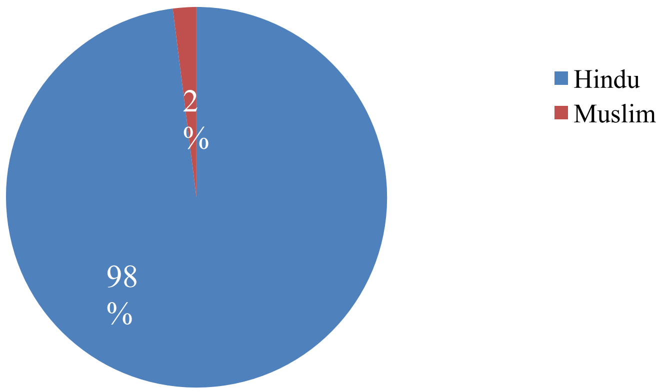


Figure 9 Level of religion of the respondents in the Hazrakhana and Kalitola village of Chowgachaupazila of Jessore district

3.1.4 Gender

In this study, it was found that all of the respondents were male. No female fishers were found in any of the study area. Farauque and Ahsan (2014) noted that no involvement of female in the Padma river fishing in Rajshahi district. Ahmed et al. (2009) reported that women have less freedom both socially and economically than men restrict their activities. Sultan and Thampson (2006) also reported that women are often excluded from fishing.

3.1.5 Education level of respondents

In reality, it is true that education is not an essential subject for fishing in the river. But be aware and well-known with the latest technology and appropriate use of it, education is must. Human resource development is a function of education. In this study, of the total, 33.3% of respondents were totally illiterate, 46.7% had a literacy level of 1-5 class. Only 18.3% of respondents were literate between classes of 6 and 10. Only 1.7% of respondent had higher secondary education (Figure 10). Most fulltime fishers were literate (45.5%) than those of non-fishers (16.7). Among non-fishers, most (33.3%) had secondary education followed by fulltime fishers (18.2%; Table 4). Absolute landless were illiterate (38.9%) followed by primary (50.0%; Table 5). From the reconnaissance study, it was found that due to the fisher's poor socio-economic status, they could not get the opportunity to take education. The levels of literacy are generally low. This low level of education implies that fishers have limited option for off- farm or other activities. They are also less able to participate in the community and develop social capital for reducing vulnerability. In the study of Sultan et at. (2015) found that the education level of most of the fishermen were primary (46%), followed by secondary level (14%). Tasnoova et al. (2008) reported that 60% of Rice-Fish Alternate farmers and 50% of Rice-Cum-Fish farmers were educated until they graduated and above the level of education.

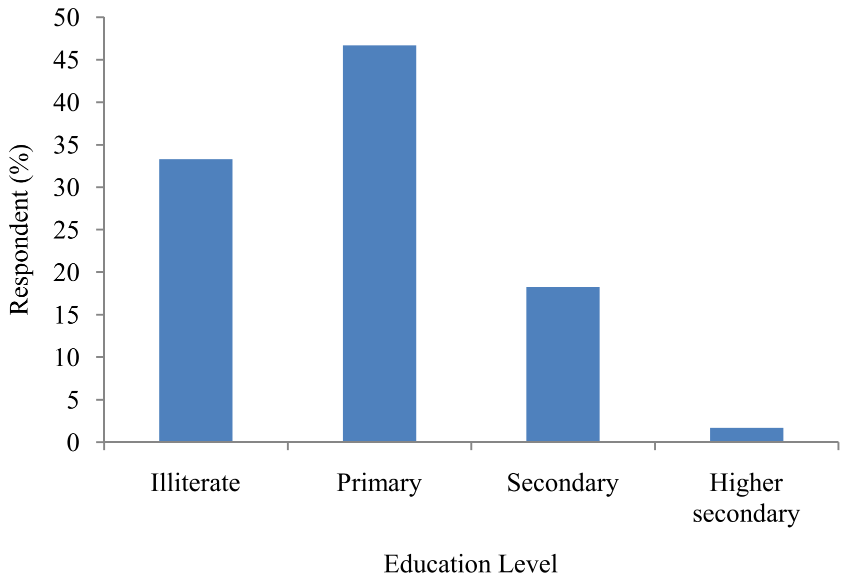


Figure 10 Level of education of respondents of the study sites (Hazrakhana and Kalitola village) of Chowgachaupazila of Jessore district

Table 4 Distribution (%) of HH members by level of education and category of fishers

Category of education	Education level of respondents (%, percentages of respondents are shown in bracket)			
	Occasional	Part-time	Fulltime	Non fisher
Illiterate	7 (38.9)	4 (57.15)	5 (45.5)	4 (16.7)
Primary	9 (50.0)	3 (42.9)	4 (36.4)	12 (50.0)
Secondary	1 (5.6)	0 (0.0)	2 (18.2)	8 (33.3)
Higher secondary	1(5.6)	0 (0.0)	0 (0.0)	0 (0.0)

Table 5 Distribution (%) of HH member by land class and level of education

Category of education	Land class (%, of Respondents are shown in bracket)		
	Absolute landless	Landless	Marginal
Illiterate	5 (35.7)	12(32.4)	3 (33.3)
Primary	7 (50.0)	18 (48.6)	3(33.3)
Secondary	1 (7.1)	7 (18.9)	3 (33.3)
Higher secondary	1(7.1)	0 (0.0)	0 (0.0)

3.1.6 Health status of respondents

Health is another important indicator of human capital. Of the two fishing communities, 80% fishermen claimed that their health conditions were good in 1998 than in 2016 (Figure 11). From the household interview, fishermen claimed that their health were good because they ate good food and the environmental conditions were good. But in recent time, they suffered different types of diseases. In 2016, it was found that nearly 42% fishers had joint pain. Some also complained of diabetic (10%), blood pressure (20%), fever (8.2%) and gastric (19.8%; Figure 12). But in this time they claimed that they eat adulterate food and vegetable. Farmer mix different types of chemical when they culture vegetable. On the other hand, fishermen claimed that weather (increasing temperature) is another reason of their bad health condition. In South and Southeast Asia, dengue outbreaks correlated with temperature and rainfall with different delays in time

(Su, 2008; Hsieh and Chen, 2009; Shang et al., 2010; Sriprom et al., 2010; Hashizume et al., 2012). In the Himalayan region, other studies found that the outbreak of vaccine-preventable Japanese encephalitis has been associated with precipitation (Partridge et al., 2007; Bhattachan et al., 2009). Another study was conducted in Western and Southern Asia that projected the impact of climate change on malaria risk, which will differ between areas (Husain and Chaudhary, 2008; Garg et al., 2009; Majra and Gur, 2009).

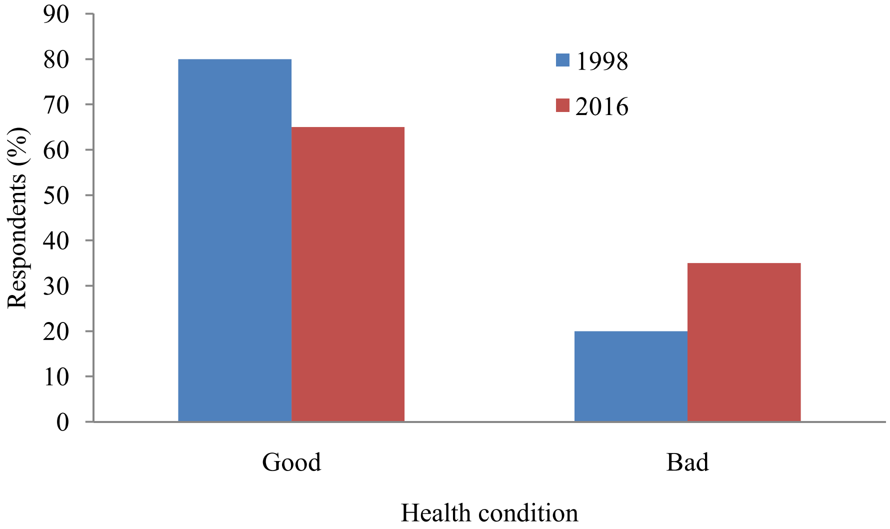


Figure 11 Health conditions of respondents between 1998 and 2016

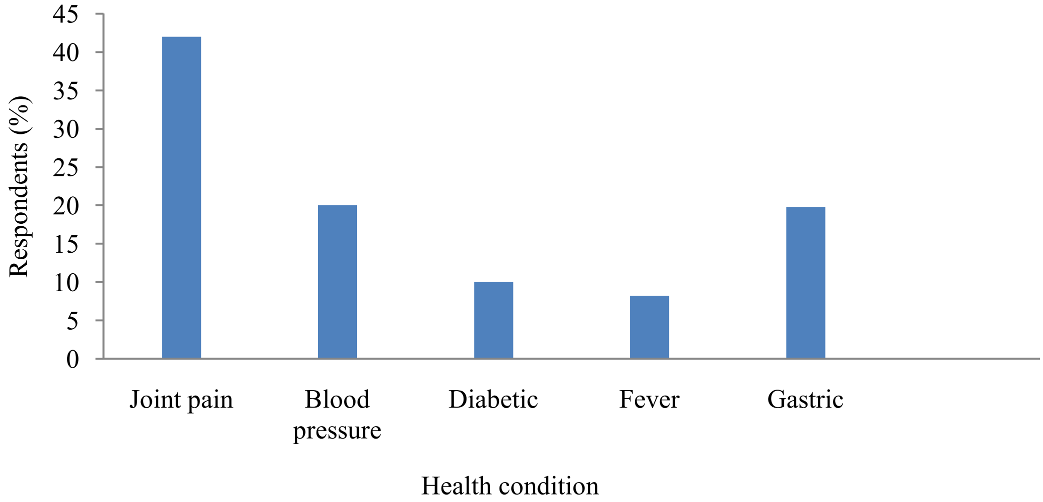


Figure 12 Health conditions of fishers in the study sites in 2016

3.2 Natural capital

3.2.1 Land holding class

Sampled household were classified into six groups based on the land holdings except homestead.

Basis of land classification: Land owned (ha) = Cultivate land + pond/*gher*+ fallow land; Total land owned (ha) = land owned + homestead land; Absolute landless (1) = No cultivate land (excluding homestead); Landless (2) = Land owned 0-≤0.2; Marginal (3) = Land owned >0.2-≤0.6; Small (4)= >0.6-≤1.0; Medium(5) = >1.0-≤2.0; Large (6)= >2.0 (IFAD, 2002).

Non-fishers were poorer than fishers in terms of land ownership. Non-fishers (35.7%) and occasional fishers (35.7%) were more absolute landless than part-time (7.1%) and full-time fishers (21.4%). On the other hand non- fishers were 7 times (77.8%) more marginal than full-time (11.1%) and occasional fishers (11.1%; Table 6).

Table 6 Distribution of HH by land class and category of fishers surveyed of Chowgachaupazila in Jessore district, Bangladesh

Category of fishers	Land class (%, Percentage of respondents are shown in bracket)				
	Absolute landless	Landless	Marginal	Small	Medium
Occasional	5 (35.7)	12 (32.4)	1(11.1)	0	0
Part-time	1(7.1)	6 (16.2)	0 (0.0)	0	0
Full-time	3 (21.4)	7 (18.9)	1 (11.1)	0	0
Non-fisher	5 (35.7)	12 (32.4)	7 (77.8)	0	0

3.2.2 Homestead land

Homestead land increased 1.88-folds in 2016 than in 1998 (Figure 13). The homestead lands of fishers (occasional, part-time, full-time) were 2 times (28.6%) greater than non-fishers (14.3%) at the range of 11-15 decimal. The homestead lands of occasional fishers were 33.3% at the range of 6-10 decimal. The homestead lands of non-fishers were 37.5% and 27.3% at the range of 16-20 and > 20 decimal, respectively (Table 7). In this study, it was found that the homestead land of non-fishers were greater than fishers in decimal. On the hand, the homestead land of occasional and part-time fishers were greater in decimal than fishers.

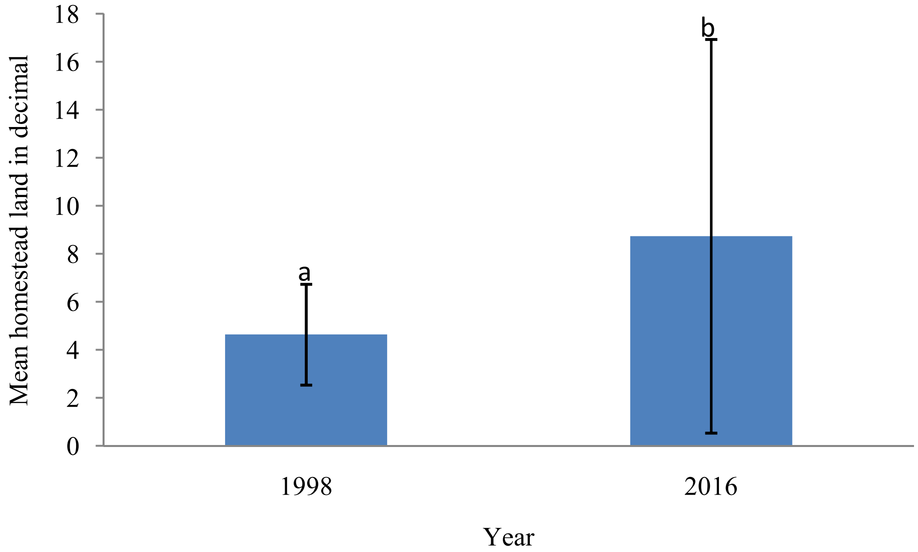


Figure 13 Mean homestead land in decimal in 1998 and 2016 by the respondents. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Table 7 Distribution of HH by homestead land in decimal in 2016 and category of respondents

Category of respondents	**Homestead land in decimal in 2016 (%, respondents)**				
	0-5	6-10	11-15	16-20	>20
Occasional	25	33.3	28.6	25	27.3
Part-time	0.0	3.3	28.6	12.5	27.3
Full-time	0.0	16.7	28.6	25	18.2
Non-fisher	75	46.7	14.3	37.5	27.3

3.2.3 Cultivable land

Cultivable land of the fishers rose 2.34-times in 2016 than did 1998 (Figure 14). In this study, occasional fishers (33.3%), part-time (6.7%), full-time (26.7%), and non-fishers (33.3%) had no cultivable land. The cultivable land of occasional fishers (33.3%), followed by part-time fishers (33.3%), followed by full-time fishers (33.3%) at the range of 1-9 decimal. The fishers and non-fishers had no land at the range of 21-30 decimal.

On the hand the full-time fishers and part-time fishers had no cultivable land at the range of 31-40, 41-50 and above 50 decimal, respectively. But the occasional fishers and non-fishers had 42.9, 25, 33.3 decimal land and 57.1, 75, 66.7 decimal land at the range of 31-40, 41-50 and above 50, respectively (Table 8). So it can be concluded that in the land category, non-fishers had greater land than fishers. On the contrarily, occasional fishers had greater land than part-time and full-time fishers.

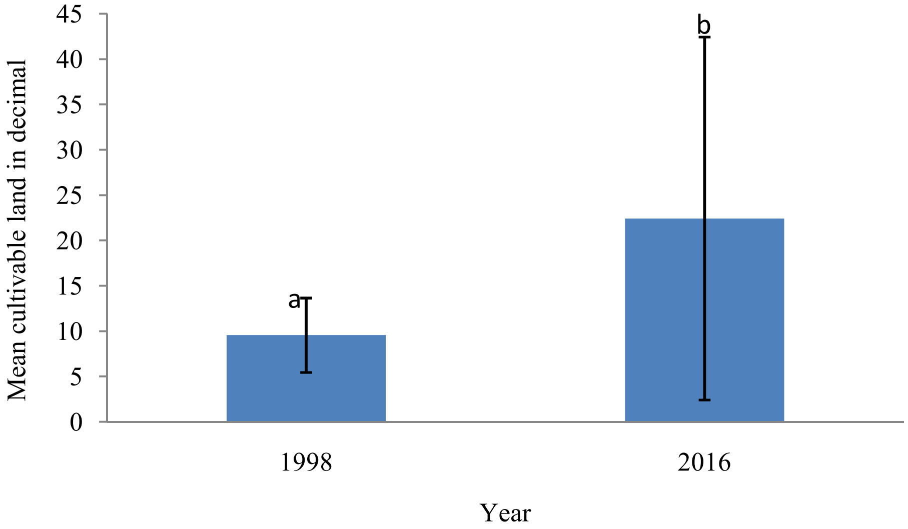


Figure 14 Mean cultivable lands in decimal in 1998 and 2016 by the respondents. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Table 8 Distribution of HH by cultivable land in 2016 land in decimal and category of respondents

Category of respondents	**Cultivate land in decimal in 2016 (%, Percentage of respondents are shown in bracket)**						
	No land	1-9	10-20	21-30	31-40	41-50	>51
Occasional	33.3	33.3	31.8	0.0	42.9	25	33.3
Part-time	6.7	33.3	18.2	0.0	0.0	0.0	0.0
Full-time	26.7	33.3	13.6	0.0	0.0	0.0	0.0
Non-fisher	33.3	0.0	36.4	0.0	57.1	75	66.7

3.3 Financial capital

3.3.1 Savings

Most of the respondent did not have any savings or bank account in 1998. But percentage of savings rose nearly 43.1-times in 2016 than in 1998 (Table 9). The percentages of part-time fishers at a range of 100 Tk/month of savings were two times higher than the others. The percentage of non-fishers have greater savings rate than fishers. Only non-fisher have a saving rate at 1000 Tk/month and 1500 Tk/ month (Figure 15). Based on land classes the savings rate at a range of 100 Tk/month of landless fishers were 1.22-times and 3.65-times than absolute landless and marginal fishers,respectively (Figure 16).

Table 9 Level of savings of respondents between 1998 and 2016

Year	Saving of respondents (%)	
	Present	Absent
1998	1.7	98.3
2016	73.3	26.7

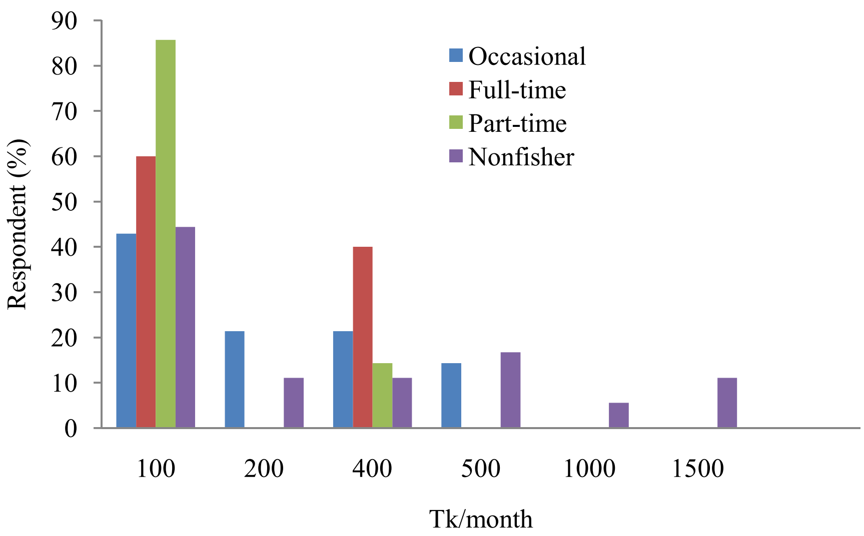


Figure 15 Savings (Tk/month) of respondents based on category of fishers in 2016

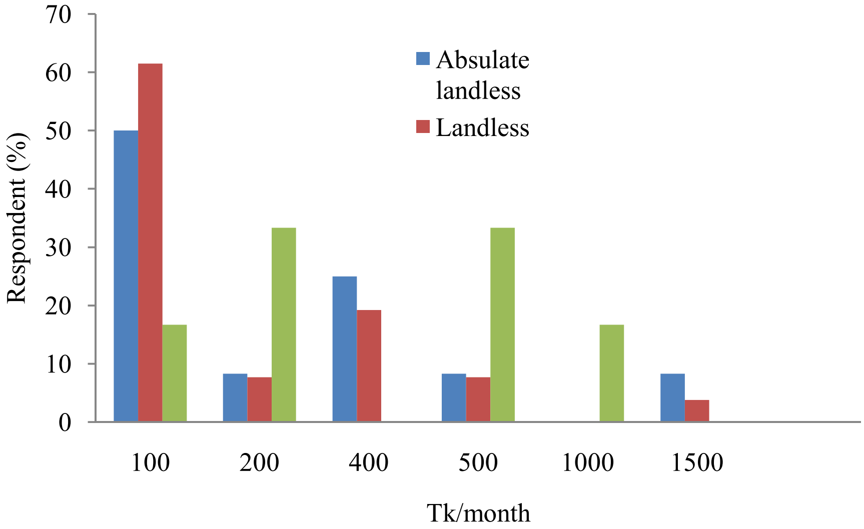


Figure 16 Savings (Tk/month) of respondents based on land class in 2016

3.3.2 Income

Income from fisheries related activities in 2016 was nearly 1.75-folts higher than the income of 1998 (Table 10). But income from non-fisheries activities rose nearly 3.39-times in 2016 than in 1998. Increase in income from non-fisheries could be due to reduced catch in 2016 than did 1998.

Table 10 Level of income from fisheries and non-fisheries activities between 1998 and 2016

Year	Type of income (% respondents)	
	Fisheries related activities	Non-fisheries activities
2016	53.66 ± 33.54	74.33 ± 24.99
1998	93.66 ± 11.99	22. 00 ± 12.07

3.3.3 Credit access

In this study, it was found that almost all respondents (80%) received loans from NGOs (ASA, GRAMEEN). Mainly the occasional and part-time non-fishermen received loans for activities outside of agriculture. The interest rate was reported as high by fishermen. Kostori (2012) and Halder et al. (2011) mentioned the high interest rate of the NGO loan. Zaman et al. (2006) revealed that poor fish farmers had no access to bank loans because of the lack of mortgage assets. On the other hand, another study found that only 34% of the farmers obtained bank loans for fish farming while the majority (53%) of the farmers spent their own money (Quddus et al., 2000).

3.4 Physical capital

3.4.1 Ownership of house

Ownership of house is another important indicator to define the socio-economic status. Around 100% respondent of study site had their own houses and land both study sites but in Kalitola study site some respondent built their house in land of government.

3.4.2 Housing condition

The nature of house is an indicator of the social status of the people. In general, economically solvent person always try to build their houses with bricks or in permanent nature but the poorer people of the society cannot do it. It is also the indicator of one's economic capability and choice. Housing condition (paved, semi paved) of both study sites increased in 2016 than in1998. But house which made from soil, straw reduced in 2016 than in 1998 (Figure 17). Housing condition (non paved, semi paved) of fishers were 2-times higher than non-fishers. The percentage of housing condition (Paved) of non-fishers was greater than fishers (Figure 18). On the other hand, the percentage of housing condition of occasional and part-time fishers was better than that of full- time fishers (Figure 19).

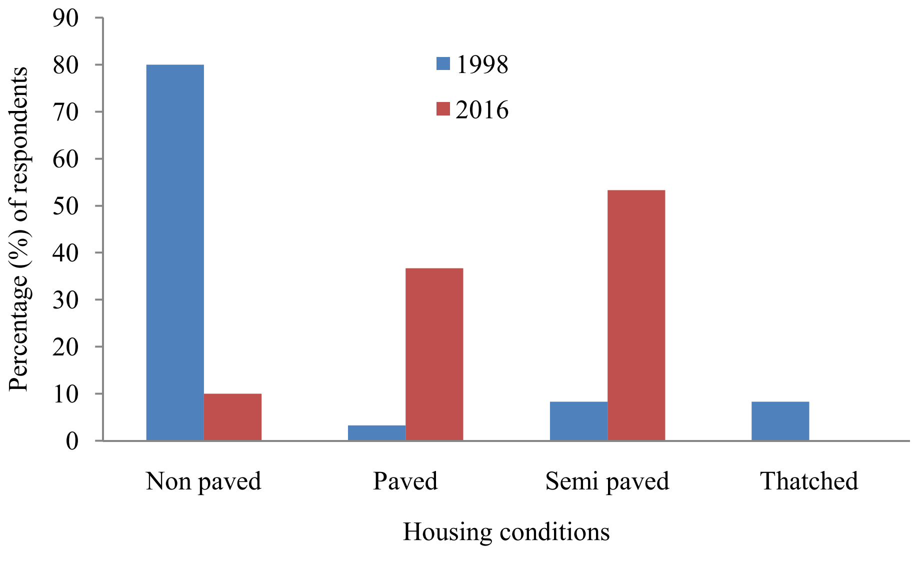


Figure 17 Housing conditions of respondents between 1998 and 2016

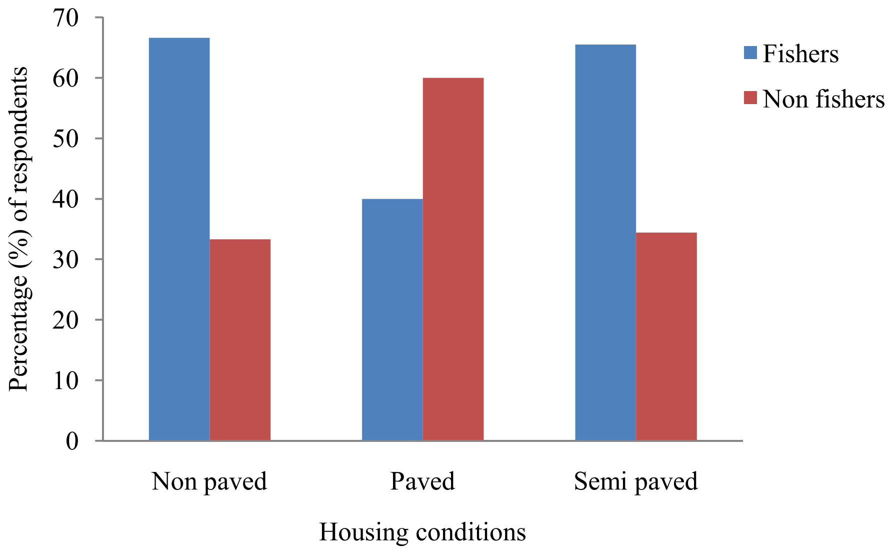


Figure 18 Housing conditions of fishers and non-fishers in 2016

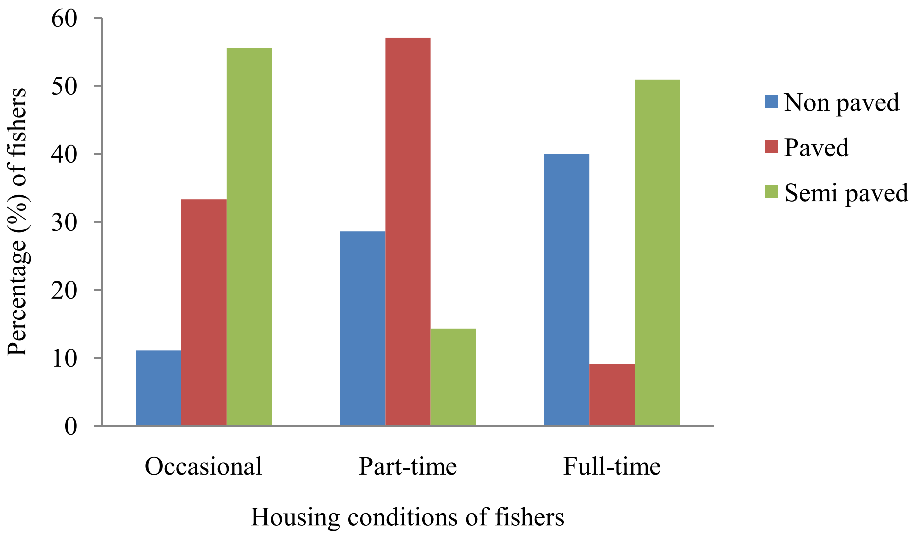


Figure 19 Housing conditions of fishers in 2016

3.5 Social capital

3.5.1 Social relation among fishers

It was found that the social relation between fishers was same as previous. Around 30% fishers claimed that their social conflict was increased (Figure 20). Akter et al. (2016) found that the relationship of the fish farmers with neighbors and local leaders was quite good of Kaharoleupazila of Dinajpur district, Bangladesh.

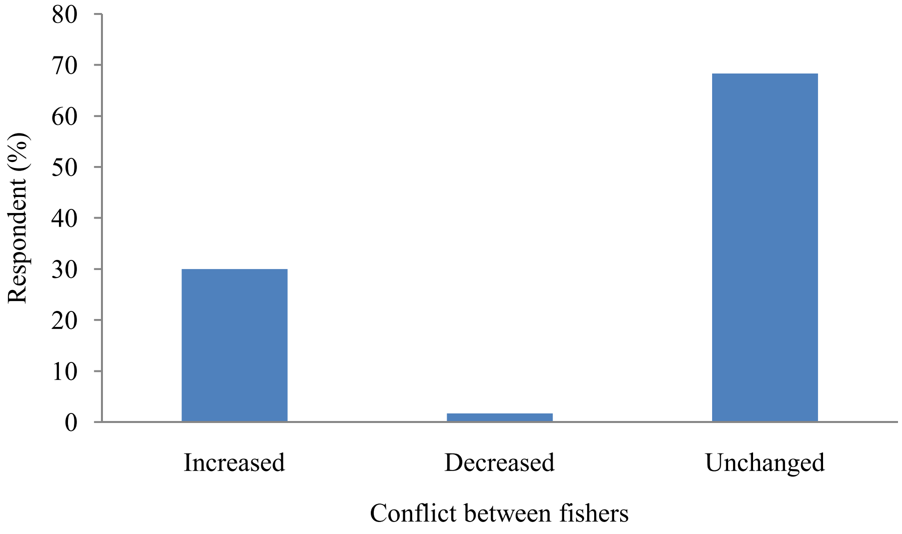


Figure 20 Social relations among fishers in the study sites

3.5.2 Social relation among fishers and other people

The social relation among fishers and other local people was same in 2016 as previous in 1998 (Figure 21). Only 3.3% respondents said that their social relation was decreased and 45% respondents claimed that their social relation among fishers and local people was increased.

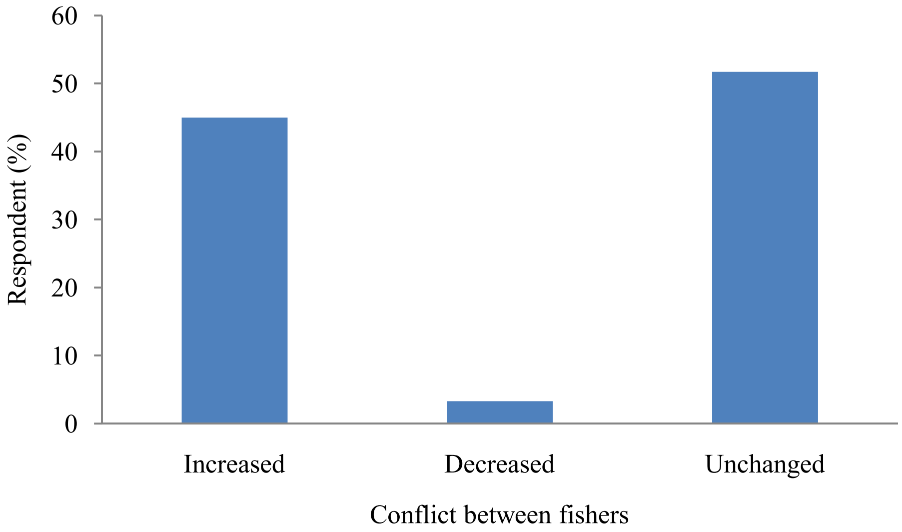


Figure 21 Social relations among fishers and other local people .

3.6 Anthropogenic variable of the study sites

3.6.1 Land use on riverbank and urban runoff

From this study, it was found that the impact of land use on the river bank such as growing paddy, culture vegetable etc. and urban runoff on the river basin and their results indicates degradation in the river quality. From the household interviews, it was found that local people of the study sites threw the urban and household wastage in the riverbank of the river. On the other hand, from the FGDs, it was found that the river bank broke down during agriculture and mixed with river water and degraded water quality and reduced water depth. Land uses on the river bank have an impact on annual or long-term runoff and also have a significant impact on hydrology and the environments. From the FGDs, It was found that the normal flow of the river blocked due to stacking at various points in this area. This study was supported by the study of Arienzo et al. (2001) on Sarno river basin in southern Italy. Okamura and Feist (2011) also found that the flow and regimes are altered in areas which are largely dominated by humans (urban and agriculture) and where habitat for native freshwater species is most likely adversely altered.

3.6.2 Dam

Nearly 30% respondents reported that water quantity was reduced due to constructing Farraka barrage. As a result, the numbers of fish species were reduced. Dams interrupt stream flow, and generate hydrological changes along the integrated continuum of river ecosystems that ultimately can be reflected in their associated fisheries (Vannoteet al., 1980; Junk et al., 1989). Dams have an effect on fish by creating barriers to movements that fragment fish populations (Santos et al., 2006; MacDougall et al., 2002; Morita et al., 2002; Garcia et al., 2010), changes in connectivity with the floodplain (Aarts, 2004; Hirzinger, 2004; Koel, 2004), and the alteration of flow patterns (Galat et al., 2000; Lytle et al., 2004). Fish yields were reduced in the Black Sea and the Azov Sea to reservoirs in the Danube, Dnieper and Dniester rivers in Europe (Tolmazin, 1979).

Dudgeon (2000) noted the ecological impacts of dams on populations of migratory species (i.e., diadromous fauna requiring a migration between fresh and salt water and potomadromous fauna migrating long distances within fresh water) that was rejected. Larinier (2000) noted that migration through turbines from hydroelectric dams also causes mortality, especially of adult fish. Frissell (1993) also found that the physical barrier is the main conspicuous migration with the consequent decline of the anadromous species in the upstream areas. Another study found that endemic species are intrinsically more at risk of loss than non-endemic species when faced with potential habitat alterations because endemic species are restricted in their habitat extension (Scott and Helfman, 2001). On the other hand, Hess et al. (1982) found that the reservoirs produced plankton that when discharged through the dams on the Missouri river was beneficial for the respective downstream fisheries.

3.7 Climate of the study area

3.7.1 Temperature

Temperature is one of the most important indicators to identify the change in climate change. Around 90% people of both study site said that temperature is increasing and the rest of respondents said that temperature was same as previous. For analysis, temperature data in the study area available for thirty four years from 1980-2014 was considered. Temperature analysis revealed that average annual maximum temperature, average annual minimum temperatures in the study area, all are in increasing trend. From the analysis of temperature data of the study area, it resulted that average maximum temperature has increased 0.5°C to 0.6°C from 1980 to 2014. The average maximum temperature of 1980 to 1995 was 31.44°C where the average maximum temperature of 1995 to 2014 was 31.99°C. Among the data average maximum temperature was lowest in the year 1981 (30.61°C and height in the year 2009 (32.92°C; Figure 22).

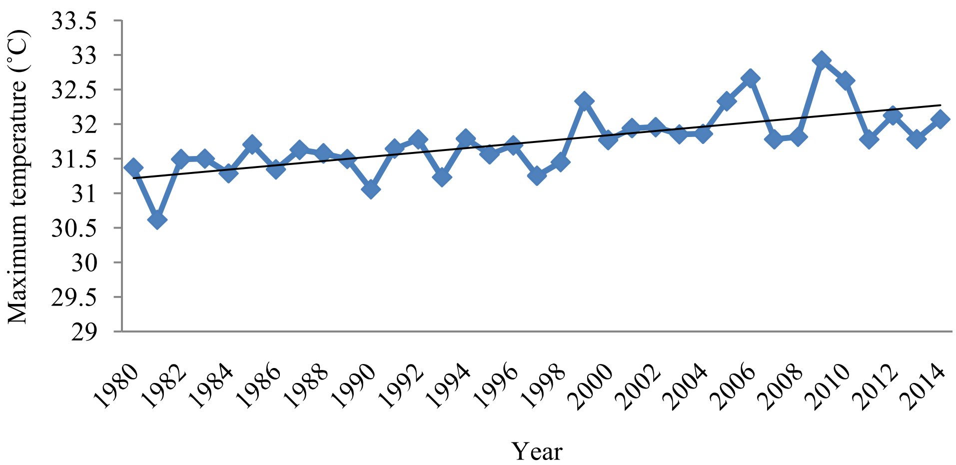


Figure 22 Average annual maximum temperatures (Degree Celsius) of Jessore district (Source: Bangladesh Metrological Department).

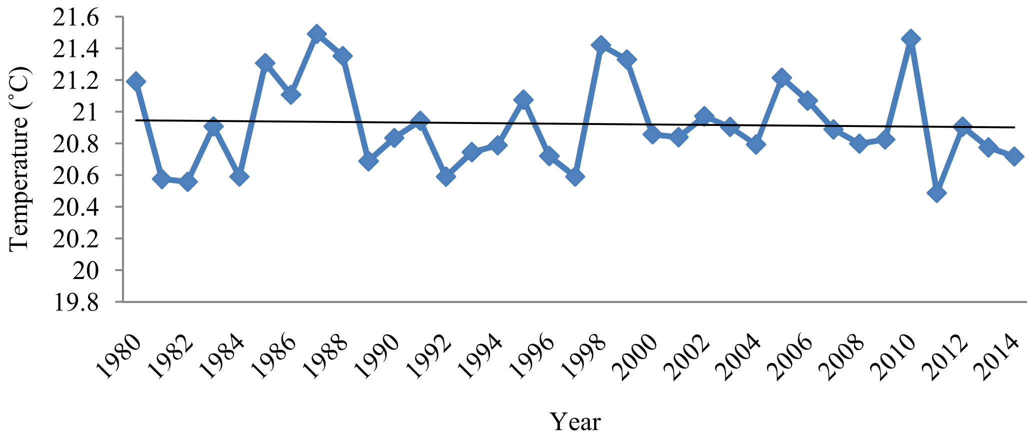


Figure 23 Average annual minimum temperature (Degree Celsius) of Jessore district (Source: Bangladesh Metrological Department).

3.7.2 Rainfall

Rainfall is very important factor to determine the climate change. People of developing countries like Bangladesh who are solely dependent on natural resource can be at the most vulnerable zone because of the change of the rainfall. Thirty four years of rainfall data (1980-2014) were collected from BMD. These data were used for assessing pattern of rainfall over the year. Here the Figure 24 resulted that annual rainfall was similar from 1980 to 2014. After the year 2005 there was no significant increase of rainfall amount than before. Figure 25 shows the monthly rainfall record from 1980-2014 in the study area. Analysis of average monthly rainfall, Figure 25 showed that the degree of rainfall was high in June to September.

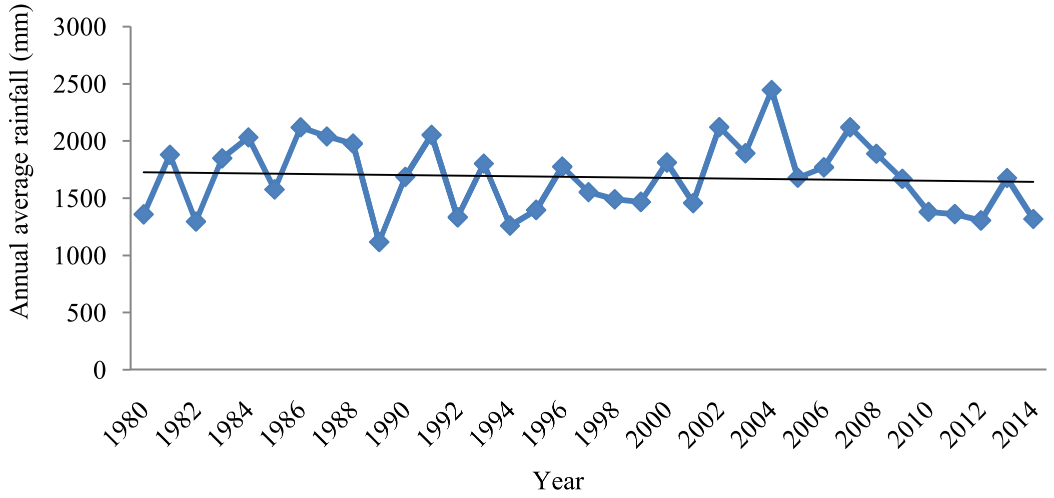


Figure 24 Average annual rainfalls (mm) in the study area, Jessore district (Source: Bangladesh Metrological Department).

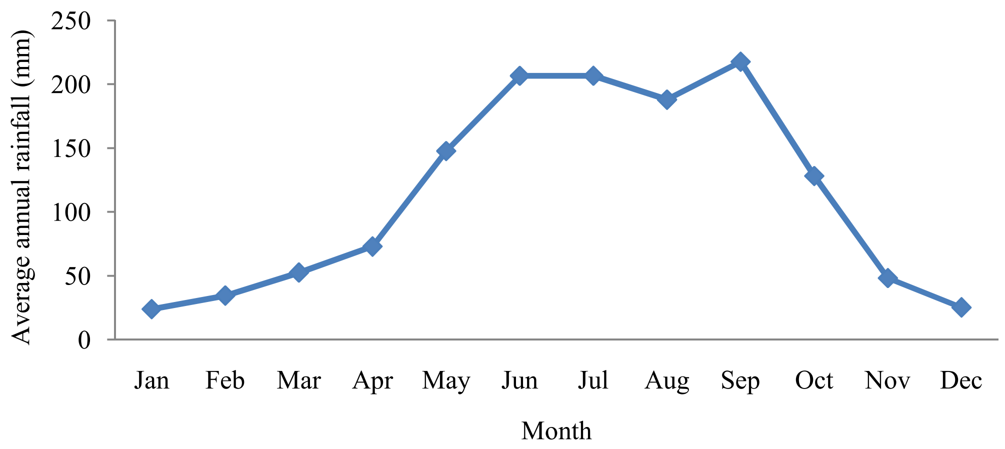


Figure 25 Monthly average rainfalls (mm) from 1980 to 2014 in the study area, Jessore district (Source: Bangladesh Metrological Department).

3.8 Anthropogenic and climatic impacts on fisheries

3.8.1 Impact on water body

Change of river geometry results in water logging and long-term logging condition creates adverse impact on water body. Survey of the study area indicated that water of river area was covered by water hyacinth. Above 30% of the river stretch was covered by water hyacinth. Nearly 98.3% respondents claimed that water quantity was reduced. Some respondents claimed that after constructing Farakkha barrage, the water quantity was reduced. According to the opinion of nearly 95 % respondents, water flow was reduced in the Kapotakkhoriver. On the other hand 56.7% respondents said that the turbidity of water was decreased, followed by increased (6.7%) which was followed by unchanged (36.7%).

Arnell (1999) reported that climate change intensifies the global hydrological system and has a major impact on regional water resources. Due to climate change, the major impacts of declining water quality include increased pollutants from different sources due to heavy rainfall, increased water withdrawals from low-quality sources, poor infrastructure hydraulics during floods and rainwater overload (IPCC, 2014). Jimenez (2003) also noted that few studies have evaluated the potential effect of climate change on water quality, and most of them refer to developed countries. Precipitation is the main input signal to freshwater systems, not properly simulated in current climate models. Therefore, quantitative projections of changes in river flow at the basin scale remain largely uncertain (Milly et al., 2005; Nohara et al., 2006).

Table 11 Level of water characteristics in the study site

Characteristics of water body	**Respondent percentage (%) year in 2016**		
	Increased	Decreased	Unchanged
Water quantity	0.0	98.3	1.7
Water flow	0.0	95.0	5.0
Water turbidity	6.7	56.7	36.7

3.8.2 Impact on fish species

Nearly 91.3% respondents claimed that fish habitat reduced in 2016 than in 1998. The fish species available over the study area in 2016 and in 1998 are shown in Table 12. This study found that, some fishes were already extinct or not available in 2016 such as *Macrobrachiumrosenbergii*,*Wallagoattu, Puntiussarana, Mastacembelusarmatus, Ompokpabda, and Mystustengra.*

Table 12 Available fish species in study area

Fish available in 1998	Fish available in 2016
1. *Labeorohita,*	1. *Channastriata,*
2. *Gibeliancatla,*	2. *Channapunctatus,*
3. *Cirrhinuscirrhosus,*	3. *Clariasgariepinus,*
4. *Mystestengra,*	4. *Channamarulius,*
5. *Heterophonestusfossilis,*	5. *Labeorohita,*
6. *Notopterousnotopterous,*	6. *Ctenopharyngodonidella,*
7. *Macrobarchiumrosenbargi,*	7. *Anabas testudineus,*
8. *Mastacembelusarmatus,*	
9. *Ompokpabda,*	
10. *Labeobata,*	
11. *Puntiuspuntio,*	
12. *Channamarulius,*	
13. *Anabas testudineus,*	
14. *Clariasgariepinus,*	
15. *Channastriata,*	
16. *Nandusnandus,*	

3.8.3 Impact on fish catch

From this study, it has been found that catch of fish reduced by 9.90-folds in 2016 than in 1998 (Figure 26). From the household interviews, almost 80% respondents reported that higher temperature decreased the fish catch in the Kapotakhhoriver. From household interview, almost 95% fishers reported that reduced rainfall is the main cause for fish yield reduction. Almost 30% fishers reported that rainfall pattern create breeding problem for local indigenous fish. Naturally fishes contained ripe eggs at the month

March to mid-April and spawn immediately after rain started. But due to climate change rain pattern has changed and rain has become little late. So the naïve fish species could not breed properly and the amount of them has decreased. This study also found that easily operating fishing gears and other equipment's that intensify river fishing may also responsible for yields reduction due to the low level of water

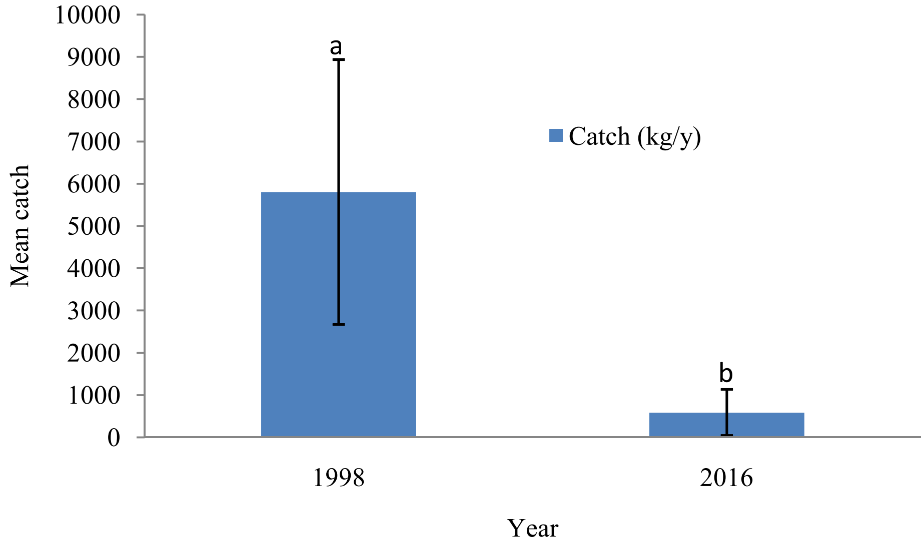


Figure 26 Fish catch (kg/y) harvested in 1998 and 2016 by the respondents. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; $p<0.05$).

Bhuiyan et al. (2008) reported that as a consequence of temperature change the water temperature has increased that caused reduction of water flow and as a result spawning and nursing ground of fishers have been drastically affected in the recent year. Ali (1999) and Allison et al. (2009) reported that higher water temperature can change sex ration, alter the spawning time, and migration which has possible impact on timing and level of productivity of freshwater system. According to IPCC (2001) climate shifts e.g. 1°C increase in sea temperature may produce major changes in main fish stocks as well as primary and secondary production. It is clear that climate shift such as increase in water temperature alters the rate of operation of some key chemical processes in water and alter the habitats. Johnson (2012) reported that in Alaska increased stream temperature as a result of high temperature and lower water levels in fresh water systems can reduce the productivity of spawning and rearing waters. According to Oreily et al. (2003) fish production has declined in Lake Tanganyika in the recent past largely due to increasing temperature. Jain et al. (2003) reported that the effect of higher temperature on fish are decreasing the availability of dissolved oxygen (DO) as a result of diminishing solubility in water, increasing metabolism, respiration and oxygen demand, militating against desirable fish growth and also higher temperature affects the spawning and hatching of eggs in natural environment. So temperature change has negative impacts on the fish production as well as fish catch. Again non-fisheries activities such as agriculture production can also negatively impact by variation of temperature and reduced rainfall in various part of the world especially in Africa (Lobell et al., 2008; Thornton et al., 2011). Also, changes in intense precipitation events impact the rate at which materials are flushed to rivers and groundwater, and changes in flow volumes affect dilution of loads. Reduced fish catch means reduced income for fisheries which affect their livelihood.

3.8.3.1 Trend in fish catch

According to the 55 % respondents in the study site, trend in fish catch decreased slowly. Nearly 30% respondents claimed that fish catch was decreased moderately (Figure 27). Reduced water level and high temperature affected fish spawning, nursing grounds and migration (Ali, 1999; Bhuiyan et al., 2008; Allison et al., 2009) that results in reduced fish catch. Again impacts on fish stock and fishing activities can in turn have adverse effect on fisheries ancillary activities such as reduced fishing may reduce employment and nutritional intake in the fishing communities and beyond. Decreased catches may increase the risk of malnutrition or under nutrition for communities highly dependent on fish for a source of protein (Ogutu-Ohwayo et al., 1997). Reduced fish catch means a reduced supply of fish for processing which may result in market instability.

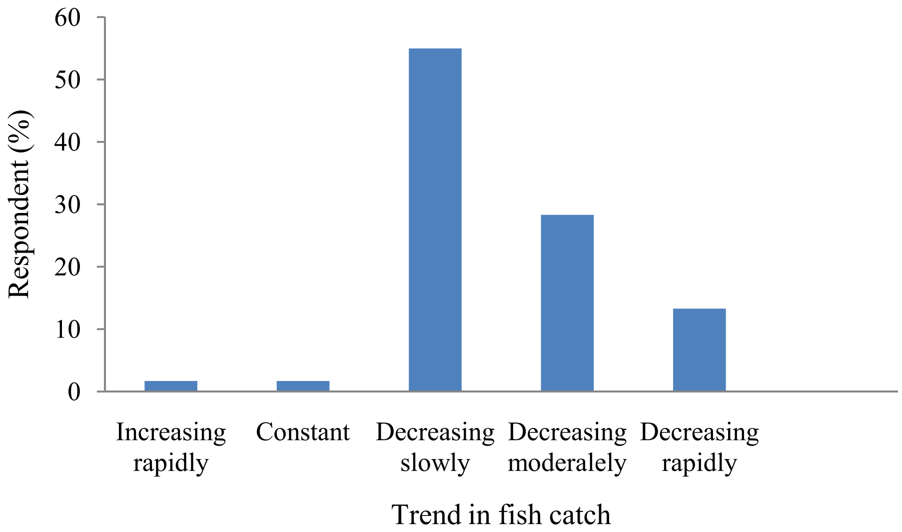


Figure 27 Trend in fish catch in the study sites

3.9 Adaptation strategies

Some 88.3% respondents took adaptation strategy and 11.7% did not. Reconnaissance visit revealed that livelihoods in Kalitola and Hazrakhana have been influenced by climatic and anthropogenic changes. Nearly 87% respondents reported their suffering due to climatic and anthropogenic changes. Climate variability and changes such as changes in rainfall, temperature, riverbank erosion and drought and anthropogenic changes such as construction of dam, dumping of urban runoff impacted their livelihoods by reducing the availability of fish that means a reduction in fish catch, increased risks of health and decline in income from fisheries related activities. As a result, the respondents adapted strategies to cope with these impacts and support their livelihoods.

3.9.1 Livelihood diversification

Livelihood diversification was found as one of the important adaptation strategies in this study sites. HH survey revealed that nearly 86.3% respondents adapted diverging livelihoods and rest increased their fishing hours (Figure 28). The livelihood diversification strategies were agriculture, selling farm labor, driving vehicles, small business, intensive fish farming, and fish trading. Few full-time fishers adapted intensive fish farming and fish trading (Figure 29).

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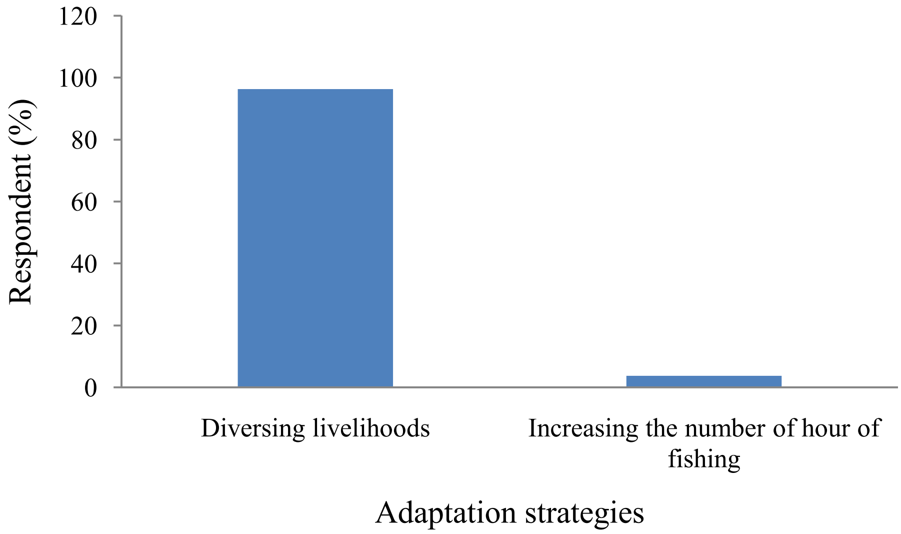

Figure 28 Adaptation strategies of the respondents in study sites

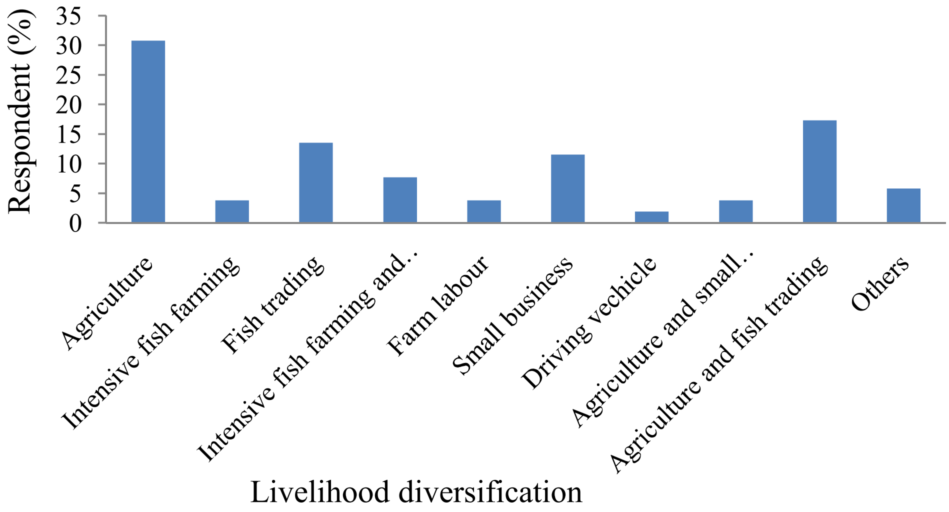

Figure 29 Diversification of strategies by the respondents in study sites

Andersson and Ngazi (1998) identified that 89% respondents were found engaged in several production strategies such as combined use of marine (for fishing mainly, but also seaweed farming and collection of aquatic organisms) and terrestrial (for agriculture) ecosystems in Tanzania which is more or less similar to this study. Hill (2005) has shown that households with a member employed in the local ecotourism industry still engaged in some fishing as a complementary activity and a source of protein in Mozambique. Ireland et al. (2004) also studied that respondents adapted over 100 different coastal livelihood income generating opportunities, with a large proportion relying on the use of surrounding environment or natural resources in Western Indian Ocean (Comoros, Mauritius, Mozambique and Tanzania).

The vulnerability of fishery dependent peoples resulting from fluctuation in fishing incomes can be reduced by diversifying their livelihoods, which helps them adapt to change better living (Turner et al., 2007; Westlund et al., 2007). According to Coulthard (2005) diversification in specialized activities 'outside fishing' such as agriculture or rural service-type enterprises alongside traditional fishing pursuits is also encountered. In case of small-scale fisheries, Salas and Gaertner (2004) found that being "generalists" allowed small-scale fishers to switch between target species with changes in their circumstances.

Hazell and Norton (1986) reported that develop portfolios of income generating activities with low covariate risk among their components was the main purpose of diversification.

Another study was conducted in Loas found that 90% of the inland fisheries catches are from households whose livelihood is not primarily dependent upon fishing (Lorenzen et al.*,* 2000). Holvoet (2007) noted that vulnerable households were targeted with food processing activities mainly sale of fruits and sandwiches and processing of cassava and fish. Coulthard (2005) reported that diversification occurred both within fishing and outside fishing but was limited by status and cultural background in India (Tamil Nadu). Coulthard (2005) also reported that fishermen of South Indian fishing community bound by their caste, specialized skills and status were and unable to diversify their fishing techniques. Smith et al. (2005) noted that specialization was relatively rare in the inland fishing because of limits of scale such as fishing space, effective demand and labor needs, and under-investment.

Table 13 Level of diverging strategies based on category of fishers

Adaptation strategies	**Category of fishers (%)**			
	Occasional	Part-time	Full-time	Non-fisher
Agriculture	33.3	28.6	00.0	33.3
Farm labor	5.6	00.0	00.0	4.2
Small business	5.6	00.0	00.0	20.8
Driving vehicles	00.0	00.0	00.0	4.2
Fish farming	5.6	00.0	00.0	4.2
Fish trading	16.7	14.3	33.3	8.3
Intensive fish farming and fish trading	11.1	14.3	33.3	0.0
Agriculture and fish trading	11.1	42.9	00.0	16.7
Agriculture and small business	00.0	00.0	00.0	8.3
Others	11.1	00.0	33.3	00.0

3.9.2 Agriculture

Agriculture was found as the major adaptation strategy and positioned at first category. This study found that among non-fishers, 33.3% HH adapted only agriculture and 16.7% adapted agriculture and fish trading as strategy. On the other hand, occasional fishers (33.3%) and part-time fishers (28.6%) were converted fishing to agriculture farming as their adaptation strategy (Table 13). Some respondents have their own land for agriculture. In contrast, HH had no cultivable land, leased in cultivable land from others and grew vegetable.

3.9.3 Small business

According to the respondents, small business was found another important type of adaptation strategy. Among non-fishers, 20.8% respondents adapted small business as strategy. Among fishers, only occasional (5.6%) took adaptation strategy as small business (Table 13). In this study, it was also found that 8.3% non-fishers adapted to agriculture and small business as strategy.

3.9.4 Driving vehicles

Driving vehicles was also found as another type of adaptation strategy. Only non-fishers (4.2%) adapted driving vehicles as strategy (Table 13). Respondents drive different types of vehicles such as small van, motor bike, battery driven auto and CNG driven autorickshwa.

3.9.5 Intensive fish farming

In this study, intensive fish farming was found as another adaptation strategy. Among the non-fishers only 4.2% respondents and among the fishers, only occasional fishers (5.6%) adapted to intensive fish farming as strategy (Table 13). Some respondents farm fish in their own pond while some farmed in leased in ponds and/or farmed fish together.

3.9.6 Fish trading

Fish trading was found as an important adaptation strategy. In this study in both sites, it was found that among fishers, occasional part-time and full-time fishes adapted to fish trading 16.7%, 14.3% and 33.3%, respectively. On the other hand, among non-fishers around 8.3% respondents adapted to fish trading. In this study, it was also found that occasional fishers, part-time fishers and full-time fishers of both sites adapted to fish trading 11.1%, 14.3% 33.3%, respectively (Table 13).

3.9.7 Change in duration for fishing

Change in time duration for fishing is another adaptation strategy in the community. According to the fishers in both study sites, due to decreasing fish catch they increased the duration of fishing for better income. After adapting this strategy, the fishers spent additional 4-5 hrs a day for fishing.

3.9.8 Change in gears and nets for fishing

According to the respondents of the communities, most of the fishers previously used few types of nets and gears. But now a day they have been using efficient net and fishing gears because of decreasing fish catch.

3.9.9 Others adaptation strategies

In this study, it was found that dropped rainfall and increased temperatures and anthropogenic changes negatively affected the fishers overall livelihoods. Therefore, fishers had to adapt to selling livestock or reduced household consumption, borrowing loan from friends or relatives.

3.9.10 Adaptation of previous fishers and present non-fishers

In this study found nearly 40% HH were non-fishers but all of the non-fishers were fishers in previous (see section 3.1). The socio-economic status of present non-fishers was better than their previous socio-economic status when they earned money to support their livelihood only by fishing. Of natural capital, the non-fishers had a greater area of homestead and cultivable land than their fishers condition (see section 3.2). Of financial capital, present non- fishers had better savings than their previous condition in terms of saving (TK/month; see section 3.3). In ownership of physical capital, the housing conditions of present non-fishers were better (Most of them were paved) than their previous housing condition (most of them were Non paved; see section 3.4). One of the respondents said that

"I earn more money by doing agriculture and small business than previous when I earned money by fishing. Now I can fully support my family and can sent my children to school"

Finally this may be concluded that the socio-economic status of present non-fishers is better than the previous.

3.9.11 Adaptation of present fishers and previous fishers

Current study found 60% fishers (see section 3.1) at present in which almost all of them were occasional and part-time fishers and a few were full-time. But all of them were full-time fishers in 1998. Occasional and part-time fishers adopted different types of adaptation strategies. Due to adopting adaptation strategies, the socio-economic status of occasional and part-times fishers has improved than full-time fishers. However, the socio-economic status of present occasional and part-time fishers was better than their previous condition when they earned money only from fishing. In ownership of natural capital, present amount of natural and financial capitals were greater than their previous condition. Likewise, the area of homestead and cultivable land were greater of occasional and part time fishers (see section 3.2). Financial capital (saving) has proven that, all most all fishers had not any savings in their previous conditions. But currently the savings of part-time and occasional fishers were better than full time fishers in terms of savings per month (TK/month; see section 3.3). Ownership of physical capital (housing condition) denotes present paved housing that was not in 1998. But housing of occasional and part-time fishers was better than full time fishers and most of them were paved and semi paved (see section 3.4). Thus this can be said that by adapting different strategies, the socio-economic status of occasional and part-time fishers got better than full time fishes between present and previous but the status of full-time fishers was not better than their previous.

3.9.12 Future adaptation strategies

Predictions or estimates of possible future adaptations are an essential element of the impact of climate change and vulnerability assessment. The extent to which a future risk of climate change is dangerous depends on effectiveness of adaptations in that system.

Met Office (2011) projects 3-3.5°C increase in temperature in Bangladesh by 2100 under A1B (higher) emissions scenario of IPCC.Hasan et al. (2013) found that the mean temperature of ensemble simulations will increase about 1.1ºC, 2.4ºC, 3.7ºC by 2020's, 2050's and 2080's, respectively. In future, country will be more industrialized which may emit more greenhouse gases. Therefore, the earth will encounter several degrees more increased warmer condition if greenhouse gases continue to increase (Stern, 2006).

Hasan et al. (2014) found that precipitation will decrease in almost all parts of the country in winter season and concluded that up to 45% reduction of precipitation will be observed during winter by 2050s under the RCP 8.5 scenario. Due to reducing precipitation, the water volume of the river in the southeast region will be decreased. As a result, the fishes will move to downstream. In addition, anthropogenic changes such as urban runoff, land use on the river bank will be increased due to increasing population. So the climate and anthropogenic changes together will be continuously affecting fishing and thus livelihood strategies. If it continues, fishers will have to seek alternate livelihood strategies to support their family.

I suggest some future adaptation strategies such as change in land use such as dry land farming, small business, day labor at industry, changes in fishing technique (Figure 30). Because many of the respondents have cultivable land, they can grow vegetables or can lease in cultivable land to grow vegetable and paddy. Due to increasing temperature, they can be growing paddy and vegetable which tolerate high temperature. Due to reducing catch, modern fishing technique can be adopted which can help them to catch more fish. On the other hand, they can earn money by selling labor or by doing different small business. These future adaptation strategies will help fishers to cope with future environmental changes and support their livelihoods. It is, therefore, important to have a better understanding of the adaptation process and better information on the conditions under which adaptations of various types are expected.

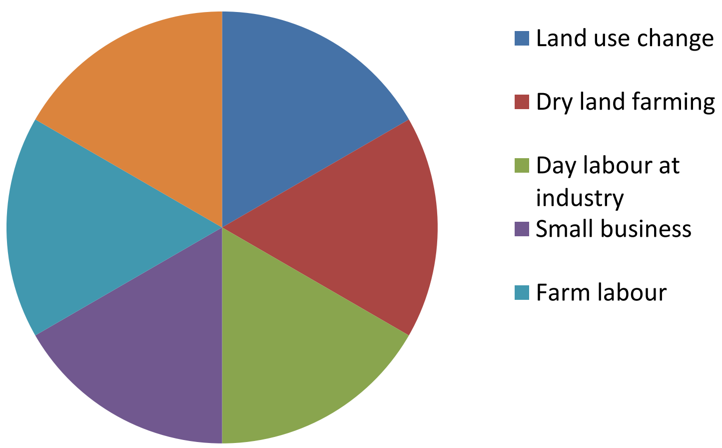

Figure 30 Future adaptation strategies

Chapter 4
Conclusions and Recommendations

4.1 Conclusions

This study assessed the impacts of anthropogenic and climatic change and adaptation strategies of fishers and present non-fishers of the Kapotakkho river of Jessore district, Bangladesh. Following a mixed method approach, the data were collected. This study assessed the socio-economic status of fishers and present non-fishers. The socio-economic status of non-fishers was better than fishers. Sustainable and increased income from fisheries and off-farm activities might be one of the productive ways to improve socio-economic status. Based on the findings of the study, it can be said that the fishers of the Kapotakkhoriver have been impacted by several anthropogenic and climatic shocks and stresses. High temperature and low rainfall can have direct impacts on the water body of the Kapotakkhoriver. In contrast, anthropogenic impacts such as constructing dam, urban runoff can have direct impacts on river fisheries and livelihood status of fishers all over the country. Due to reducing catch, the income from fisheries related activities is reduced. As a result, fishers earn money from different types of activities. The full-time fishers are more vulnerable than others. They fully depend on fishing and do not earn money from off-farm activities. This study assessed that occasional and part-times have coped with climatic and anthropogenic changes and adapted different strategies such as agriculture, fish farming, fish trading, small business, driving vehicles.

4.2 Recommendations

Climate and anthropogenic changes have the potential to make fishers livelihood more vulnerable. This thesis focuses mainly on the fishers of the Kapotakkhoriver of two study sites in Chowgachaupazila of Jessore district, Bangladesh. Taking into the account fishers of the river Kapotakkho may provide some new insights of the impacts of climate and anthropogenic changes and their adaptation strategies to overcome the impacts. The findings of such a study will also contribute to an understanding of this issue in other parts of the Bangladesh with similar environmental, socio-economic and livelihood conditions.

Wider scale (country) studies on these issues may help generalize the findings. Cross nation comparative case-studies may also help countries to learn from each other. Government with the support of national and international organizations have to work on the issue of climate and anthropogenic changes by updating knowledge and developing technical skills of the human resources to mitigate the effects of climate change.

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Appendices

Appendix A

Some definitions used by different agencies in the livelihood study

Household (HH): A co-resident social unit sometimes may have permanently non-family members in residence (Ellis, 2000).

Off farm income: Off farm income refers to non-agriculture income sources (Ellis, 2000).

Capital: Tangible or intangible assets that are held by a person or household for use or investment; wealth, in weather form, capable of being used to produce more wealth; any source of benefit or assistance.

Financial capital: The financial and liquid economic resources (e.g. savings, credit, remittance, pension, sources of credits etc.; Ellis, 2000).

Physical capita: Basic infrastructure (e.g. transportation, shelter, energy, communications, and water system), production equipment, and other means that enable people to pursue their livelihoods.

Human capital: The skills, knowledge, capacity of labor and good health, which are important in pursuing livelihood strategies.

Natural capital: The natural resource stocks from which resource flows useful for livelihoods are derived (e.g. land, water, wildlife, biodiversity, and environmental resources.

Social capital: The quantity and quality of social resources (e.g. networks, membership in groups, social relations, and access to wider institutions in society) upon which people draw in pursuit of livelihoods. The quality of the networks is determined by the level of trust and shared norms that exist between network members.

Livelihood strategies: A livelihood comprises the capabilities, assets (stores, resources, claims and access), and activities required for a means of living (Chamber and Conway, 1992). Most specifically, livelihoods can be seen to consist of a range of on-farm and off-farm activities that together provide a variety of procurement strategies for food and cash.

Appendix B

Semi-structure Questionnaire

Respondent and household information

1. Name of the village:
2. Name of the respondent:
3. Religion: Islam/Hindu/Others………..
4. Age (years):
5. Gender: Male/Female
6. Years of education:
7. Marital status:

Fishing activities of the respondent

1. How many years are you involve in fishing? From..............to..............=...........................
2. How many months in the last year did you do fishing?.......................

Livelihood and socioeconomic condition

1. Have there any difference in your housing condition compare two year? Yes/ No

   If yes, then answer

1.1 Housing condition

Household condition in 1998 year	Please tick the correct on	Household condition in 2016 year	Please tick the correct one
Non paved			
Paved			
Semi Paved			
Thatched			

2. Have you seen any difference in your wealth in between two years? Yes/ No

If yes, then answer

2.1 Land of fishermen between 1998 and 2016 year

Land in 1998 year	Quantity Acre	Land in 2016 Acre	Quantity Acre
Household land			
Cultivatable land			
Yard			

3. Have you seen any difference in your savings in between two year? Yes/ No

If yes, then answer

3.1 Savings of fishermen

Year	Savings as deposit	Local informal loan	Savings as insurances
1998			
2016			

4. Health condition of fishermen

Was the health condition of fishermen good? Yes/ no

If no then why ………

Answer the following table

Sickness in 1998 year	Frequency (0-low,1-medium,2-high)	Sickness in 2016 year	Frequency (0-low,1-medium, 2- high)

5. Have you experience any difference of your income between year (1998 and 2016)? Yes/ No

If yes, then answer

Income of fishermen in year of 1998

Fisheries related activities	% of income	Quantity Tk/year deducting expense	Non fisheries related activities	% of income	Quantity Tk/ year deducting expense
Fishing			Agriculture		
Fish farming			Small business		
Fish marketing			Driving vehicles		
Fish trading			others		
Net mending					

5.2 Income of fishermen in year of 2016

Fisheries related activities	% of income	Quantity Tk/year deducting expense	Non fisheries related activities	% of income	Quantity Tk/ year deducting expense
fishing			Agriculture		
Fish farming			Small business		
Fish marketing			Driving vehicle		
Fish trading			others		
Net mending					

3. Social relation of fishermen compare two year (put √ mark)

Criteria	Increased	Decreased	Unchanged
Conflicts between fishers			
Conflict between fishers and other people			
Good relation among fishermen			
Helping hand			

5.1Personal security compare two year

Criteria	Increased	Decreased	Unchanged
Not to be derived of freedom			
Free from of all forms of violence			
Not to be tortured by anyone			
Others lease mention			

Anthropogenic Impact on Fisheries

1 Has there any anthropogenic impact on the fisheries of Kapotakkho River? Yes/No

If yes, please explain…………

Impact on fisheries

1. Do you think, has anthropogenic change any impact on water quality? Yes/ No
2. If yes, then (compare between 1998 and 2016)

Serial no	characteristics	Increased	Decreased	Unchanged
1.	Water quantity			
2.	Water flow			
3.	Water turbidity			

2. Do you think, reduced water have an impact on fish species? Yes/ No
3. Have you seen any difference of fish catch? Yes/ No

   If yes, then answer

4. What is the trend in fish catch?

Increasing rapidly / increasing moderately / increasing slowly / constant/decreasing slowly / decreasing moderately / decreasing rapidly

5. Which fish species have you caught?

Serial no	Name of fish species before water flow (in 1998)	Name of fish species after reduced water flow (in 2016)
1.		
2.		
3.		
4.		

6. Quantity of fish catch

Serial no	Time period of catch	catch (Kg/ year)
1.	Production (in 1998)	
2.	Production (in 2016)	

7. What are the impacts on fish (compare between year 1998 1nd 2016)? (put √ mark)

Serial no	characteristics	Increased	Decreased	Unchanged
1.	Growth of fish (kg)			
2.	diseases			
3.	Habitat of fish			

Adaptation strategies

1. Have you taken any adaptation strategies against the impacts of dam or reduced water flow, on reduced catch, fisheries dependent wellbeing etc? Yes/No.

If yes, please explain

2. What are the adaptation strategies?
   i. Permanent migration
   ii. Temporary migration
   iii. Diversifying livelihoods
   iv. Increasing the number of hours spent in fishing
   v. Using more efficient fishing gears
   vi. Using mechanized boat for fishing
   vii. Tree plantation
   Others

3. Rely on friends/family/neighbors. In what form?

4. Receive assistance from the government. In what from?

If No, then why………………?

5. If you have increased your fishing duration, then answer below,

Time spent in fishing (hrs/day)		Changed in duration
Before	Present	

6. If you have used more efficient fishing gear, then mention below:

Gear used for fishing		Remarks
Before	Present	

1. What is your livelihood diversification strategy?
    1. Nothing
    2. Agriculture
    3. Intensive fish farming
    4. Fish marketing
    5. Farm labour
    6. Driving vehicle
    7. Small business
    8. Others
2. Please rank two livelihood diversification strategies based on your opinion.

Adaptation strategies	Rank

3. Do you think that staying in fishing occupation is a right (successful) decision? If yes explain, if no explain.

4. Do you think that leaving fishing occupation (or diverting to current occupation) is a right (successful) decision? If yes explain, if no explain.

Appendix C

Checklists for focus group discussion (FGD)

1. Highlight main change that has taken place in this community. How have these events affected socio-economic status of fishermen and fisheries?
2. How assets and wellbeing activities are vulnerable to changes pattern compare of year 1998 and 2016?
3. How do the community adapt to these changes in the weather pattern?
4. What things prevent the community from implementing these adaptation strategies?
5. Are there any beliefs or social norms that prevent the community from taking certain decisions to respond to changes?
6. What institutions (organizations) do you as a community rely on for help? What kinds of help?

Appendix D

Checklists for Key informant interviews

1. What is your perception about the climatic variability and change?
2. What is your perception about the anthropogenic change?
3. From your knowledge and experience, what are the climatic variability and anthropogenic changes that affected the fishers?
4. What are the overall impact of those changes on the fisheries and fishers?
5. What are the adaptation strategies to the impacts of climatic and anthropogenic changes?

Appendix E

Common checklist for oral history interviews

1. How environmental factor impact on Kapotakkho river fisheries and socio-economic status of fishers?
2. What was the past climatic history in this locality?
3. How anthropogenic factor impact on Kapotakkho river fisheries and socio-economic status of fishers?
4. What was the past climatic history in this locality?
5. How you response of those impact?
6. How do you adapt to those changes?

Appendix F

Analysis of data of the study site

Category of respondents

Fisher types	Frequency	Percentage (%)
Occasional	18	30.0
Part-time	7	11.7
Full-time	11	18.3
Non-fisher	24	40
Total	60	100

Category of respondents based on land class

Fishing of respondent (month/year)	Land Class							Percentage (%)
	Absolute landless	Landless	Marginal	Small	Medium	Large	Total	
Occasional	5	12	1	0	0	0	18	30
Part-time	1	6	0	0	0	0	7	12
Full-time	3	7	1	0	0	0	11	18
Non-fisher	5	12	7	0	0	0	24	40
Total	14	37	9	0	0	0	60	100

Age interval of respondents of the study area

Maximum (85), Minimum (28), Range (57), Mean (48.28), Standard deviation (11.439).	Age Interval	Frequency	Percentage (%)
	below 30	3	5.0
	30-39	7	11.7
	40-49	25	41.7
	50-59	12	20.0
	60-69	10	16.7
	70-79	2	3.3
	80 and above 80	1	1.7
	Total	60	100.0

Descriptive analysis of education level of respondents

Education level	Frequency	Percentage (%)
Illiterate	20	33.3
Primary	28	46.7
Secondary	11	18.3
Higher secondary	1	1.7
Total	60	100.0

Involved year of fishing

<table>
<tr><td rowspan="7">Maximum (50),
Minimum (8),
Range (42),
Mean (24.62),
Standard deviation (11.936).</td><td>Year of fishing</td><td>Frequency</td><td>Percentage (%)</td></tr>
<tr><td>below 10</td><td>10</td><td>16.7</td></tr>
<tr><td>10-19</td><td>12</td><td>20.0</td></tr>
<tr><td>20-29</td><td>13</td><td>21.7</td></tr>
<tr><td>30-39</td><td>13</td><td>21.7</td></tr>
<tr><td>40 & above 40</td><td>12</td><td>20.0</td></tr>
<tr><td>Total</td><td>60</td><td>100.0</td></tr>
</table>

Descriptive study of household in 1998

Types of House	Frequency	Percentage (%)
Non paved	48	80.0
Paved	2	3.3
Semi Paved	5	8.3
Thatched	5	8.3
Total	60	100.0

Descriptive study of household in 2016

Types of House	Frequency	Percentage (%)
Non paved	6	10.0
Paved	22	36.7
Semi Paved	32	53.3
Thatched	00	00
Total	60	100.0

Compare of quantity of fish catch in 1998 and 2016 (t- test)

Quantity of fish catch (Kg/Year)	Paired Difference (1998-2016)							
	Mean	Standar ddeviati on	Mean	Standard deviation	95% CI (lower, upper)	t	df	Sig. (2-tailed)
In 1998	5802.22	3133.479	5216.25	3119.362	(4160.81,6271.69)	10.033	35	.000
In 2016	585.97	545.145						

Compare percentage of income from fisheries related activities in 1998 and 2016

Percentage of income from fisheries related activities	Paired Difference (1998-2016)							
	Mean	Standard deviation	Mean	Std.Deviation	95% CI (lower, upper)	t	df	Sig. (2-tailed)
In 1998	93.66	11.991	40.00	33.110	(29.549,50.451)	7.736	40	.000
In 2016	53.66	33.541						

Compare percentage of income from non-fisheries related activities in 1998 and 2016

Percentage of income from non-fisheries related activities	Paired Difference (1998-2016)							
	Mean	Std.Deviation	Mean	Std.Deviation	95% CI (lower, upper)	t	df	Sig. (2-tailed)
In 1998	22.00	12.071	-52.333	29.330	(-68.576,-36.091)	-6.911	14	.000
In 2016	74.33	24.990						

Compare Percentage of income from fisheries related activities in 1998 and 2016

Percentage of income from fisheries related activities	Paired Difference (Fisheries2016-Non-fisheries 2016)							
	Mean	Std. deviation	Mean	Std. deviation	95% CI (lower, upper)	t	df	Sig. (2-tailed)
In 2016	36.67	20.941	-27.000	41.285	(-42.416,-11.584)	-3.582	29	.001
In 1998	63.67	20.381						

Compare the household land in 1998 and 2016

Household land in decimal	Paired Difference (Household land between year 1998 and 2016)							
	Mean	Standard deviation	Mean	Standard deviation	95% CI (lower, upper)	t	df	Sig. (2-tailed)
In1998	4.64	2.181	-4.100	7.847	(-6.330,-1.870)	-3.695	49	.001
In 2016	8.74	8.243						

Compare the cultivate land in 1998 and 2016

Cultivate land in decimal	Paired Difference (Cultivate land between year 1998 and 2016)							
	Mean	Standard deviation	Mean	Standard deviation	95% CI (lower, upper)	t	df	Sig. (2-tailed)
In 1998	9.55	4.106	-12.87	18.806	(-19.769,-5.973)	-3.811	30	.001
In 2016	22.42	20.061						

Social relation among fishers

Criteria	Frequency	Percentage (%)
Increased	18	30.0
Decreased	1	1.7
Unchanged	41	68.3
Total	60	100.0

Social relation between fisher and other local people

Criteria	Frequency	Percentage (%)
Increased	27	45.0
Decreased	2	3.3
Unchanged	31	51.7
Total	60	100.0

Adaptation strategies of respondents based on land class

Adaptation strategies	Land Class							Percentage (%)
	Absolute landless	Landless	Marginal	Small	Medium	Large	Total	
Permanent migration	0	0	0	0	0	0	0	0
Temporary migration	0	0	0	0	0	0	0	0
Diversifying livelihoods	12	31	9	0	0	0	52	96
Increasing the number of hours spent in fishing	0	2	0	0	0	0	2	4
Using more efficient fishing gears	0	0	0	0	0	0	0	0
Using mechanized boat for fishing	0	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0	0
Total	12	33	9	0	0	0	54	100
Percentage (%)	22	61	17	0	0	0	100	

Adaptation strategies of respondents based on category of fishers

Adaptation strategies	Fishing of respondent (month/year)					Percentage (%)
	Occasional	Part-time	Fulltime	Non-fisher	Total	
Permanent migration	0	0	0	0	0	0
Temporary migration	0	0	0	0	0	0
Diversifying livelihoods	18	7	3	24	52	96
Increasing the number of hours spent in fishing	0	0	2	0	2	4
Using more efficient fishing gears	0	0	0	0	0	0
Using mechanized boat for fishing	0	0	0	0	0	0
Others	0	0	0	0	0	0
Total	18	7	5	24	54	
Percentage (%)	33	13	9	44	100	100

Appendix G Photographs of primary data collection

Conducting key informant interview

Conducting household interview

Conducting focus group discussion