Meghna fishers of Bangladesh: sources of vulnerability and their adaptation strategies

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Dedicated to

My

Beloved parents

Declaration

I hereby declare that the dissertation entitled "Meghna fishers of Bangladesh: sources of vulnerability and their adaptation strategies" submitted to the Department of Fisheries, University of Dhaka for the degree of Master of Science (MS) is based on self-investigation, under taken carried out under the supervision of Dr. Mahmud Hasan, Department of Fisheries, University of Dhaka, Dhaka-1000, Bangladesh.

I also declare that this or any part of this work has not been submitted for any other degree anywhere. All sources of knowledge used have been duly acknowledged.

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Abstract

Fishers communities are one of the poorest, least educated and vulnerable sub-population in Bangladesh. They have been playing a vital role in the fisheries sector of the country. Unfortunately, very little studies have been undertaken about the sources of their vulnerabilities and their adaptation strategies. This study was designed to asses these issues on the Meghna fishers communities of Sonargaon upazila in Narayanganj district and Gojaria upazila in Munshiganj district.

The livelihoods and vulnerability of the fishers were assessed by semi-structured household (HH) surveys, group discussions and FGDs as the primary tools. The purposive sampling technique was used to collect the data. The HH assets were found to be not sufficient enough to maintain the current living standards. Fishing was found to be the only income source for most of the fishers (94%). Water pollution of the river Meghna by the release of industrial effluents from cement industries, pulp and paper mills, jute and chemical industries was found to be the major source of vulnerability. Fishermen could not catch any fish for nearly 15 days after one discharge and no income in those days. Although those industries had Effluent Treatment Plant (ETP) but the owners did not operate them to reduce energy cost. Literacy rate among fishers was slightly lower (59%) than national literacy level. Literacy rate was found higher among the fishers of Gojaria upazila (65%) than Sonargaon (60%). 80% fishers of both upazila were Hindu. Most fishers (91%) were found as absolute landless. As an adaptation strategy, most fishers (52%) were found to borrow loan from NGOs in adverse condition. However, Only 27% fishers had their own savings.

This study revealed that the Meghna fishers communities of those study areas were mostly affected by anthropogenic activities rather than climate change variability. One of the major impacts of anthropogenic activities was the dropped fish catch over the last decade. All surveyed fishers were absolute or landless category. Landless fishers had higher asset holdings than did the absolute landless group. Similarly, total HH income was also higher in landless fishers than in the absolute landless group. However, total HH income from fishing was higher in absolute landless group than that of landless group. Since absolute landless fishers depend mostly on fishing that is why they claimed for maximum water pollution from neighboring industries. Besides water pollution, navigation of vessels and ships, illegal dredging, social conflicts, uses of current jal,

construction of the Meghna Bridge were the main anthropogenic activities that jeopardizing fishers lives. River bank erosion, increased temperature, flood, heavy current and rainfall were the sources of natural vulnerabity. Educated fishers had more adaptive capacity against vulnerabilities than uneducated ones. The present survey found out that livelihood diversification may be the best adaptation strategy against various types of vulnerabilities.

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List of symbols and Abbreviations

BBS	Bangladesh Bureau of Statistics
BOD	Biological Oxygen Demand
BRAC	Bangladesh Rural Advancement Committee (an NGO)
DO	Dissolve Oxygen
FAO	Food and Aquaculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GNP	Gross National Product
IPCC	International Panel on Climate Change
NGO(s)	Non-government Organizations
RRA	Rapid Rural Appraisal
SPSS	Scientific Package for Social Science
WMO	World Meteorological Organization
HH	Household
%	Percentage

Chapter 1

Introduction

1.1 Background

1.1.1 Fisheries sector of Bangladesh

Bangladesh is endowed with different types of water bodies such as rivers, lakes, haors and baors, beels, ponds, estuaries coastal belt, seashore which all together offer tremendous opportunities for fisheries development. From the very beginning of human civilization, fish is considered as one of the most important food items (Kabir et al. 2012) throughout the world including Bangladesh. The people of Bangladesh provided with 60% of total animal protein from fisheries sector (DoF 2015). One of the major sectors of Bangladesh agriculture is represented by this fisheries sector. This sector plays an important role in food security, nutrition, employment, export and the socio-economic development of Bangladesh. This sector has a contribution to national GDP (3.69%) and agricultural GDP (23.12%) (DoF, 2015). Bangladesh earns 2.01% foreign remittance from fisheries. It is the 2nd largest source of export earnings next to ready-made garments-RMG (Export Promotion Bureau, Bangladesh 2014). It involves 17.80 million full time and part time employment (11% of total population) and 1.40 million of women employment (8.5% of fisheries sector employment) (DoF, 2015).

Total river and estuary area of Bangladesh is 853863 ha. Annual fish production from these area is 1, 74,878 MT, which is 4.75 % of the total capture fishery (DoF, 2014-15). Bangladesh is top 5 aquaculture producing country in the world (FAO, 2015). Fisheries in Bangladesh fall broadly into four categories: Inland capture (open water), inland culture (closed water), marine industrial or trawl fishing or marine artisanal or small-scale fishing. Fish production (2013-14) from inland open water (capture) 99600 MT (DoF, 2015).

The country's total fish production has increased more than fourth times since 1980, reaching nearly 3300 thousands of tons in the fiscal year 2011-2012 (FAO 2014) (Figure 1). In case of capture fishery, total fish production shows the gross emerging trend during 1980 to 2010 but from 2010 to 2012, it showed a decreasing rate of capture fish production (FAO 2014).

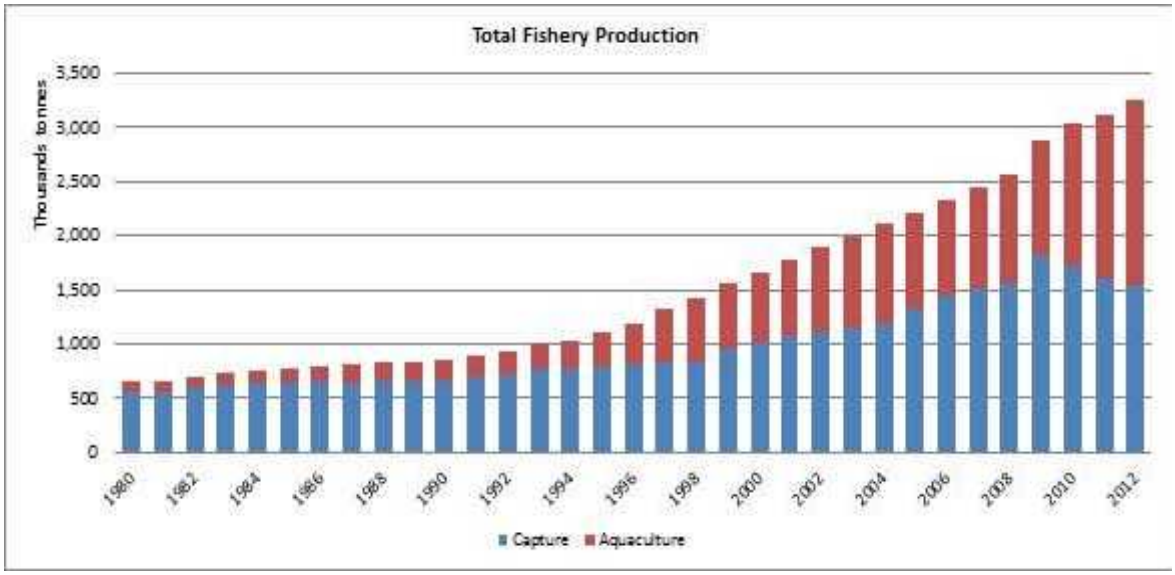

Figure 1 Bangladesh total fish production (1980 to 2012).

According to DoF (2014-2015), total fish production of Bangladesh is 3684894 MT whereas total inland fisheries production is 3085048 MT which is 83.72% of the total fish production (DoF 2014-15). Whilst it is conspicuous that inland water catch is the main source of fish production of Bangladesh.

1.1.2 River systems of Bangladesh

Predominantly, Bangladesh is known as "land of rivers" (Bundell and Maybin, 1996). Open water capture fisheries specially riverine and estuarine systems conjointly have an enormous contribution to the fisheries sector of Bangladesh. There are about 230 rivers and estimated total length of rivers, streams and canals altogether cover more than 24000 km. The watercourse of the country is obviously not evenly distributed. They increase in number and size from the northwest of the northern region to the southeast of southern region. Bangladesh has predominantly four major river systems; the Brahmaputra-Jamuna, the Ganges-Padma, the Surma-Meghna and the Chittagong region river system.

Bangladesh is fortunate with having an extensive water resources in the form of ponds, natural depressions (haors and beels), lakes, canals, rivers and estuaries covering an area of 4.56 million ha (DoF, 2005). The rivers are the blessing of the country. It is one of the main sources of fishes and fish is one of the most important foods of our country. A large number of people are dependent on catching and selling fish to earn their livelihoods. However, the biodiversity of these rivers are greatly reducing. The causes of disquiet are accountable for this: river regulation and water diversion, descent of water quality (pollution or eutrophication), overexploitation and mortification of shattering of habitats

(Allan and Flecker, 1993; Coares-Pereira and cowx, 2004; Prenda et al., 2006). Rivers are also seen as a curse sometimes. Devastating floods, river bank erosion affects on normal people's lives and assets.

1.1.3 The Meghna river fisheries

The Meghna River is one of the biggest inland depressions of marshy characters and also one of the richest wet land areas of Bangladesh with enormous biodiversity. It is specially famous for its great estuary that discharges the flows of the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna itself. The present deltaic Meghna, being the combination of Padma and Meghna, is the largest river in Bangladesh. The downstream of Surma River from Ajmiriganj is often referred to as Meghna. Most of the fishers of the Meghna river is professional fishermen rather than seasonal. Eight types of fishing net were found to be operated by the fishermen and there are 16 species of fish were caught by the different types of gear of the fishermen on the river Meghna (Mondal et al. 2013). During the peak season the monthly income of fishermen were sufficient and the range was 5000 to 30000 BDT. But during the lean period their income become low and even zero (Mondal et al. 2013). Various kinds of fish species are found in the Meghna river. They are Lal Chewa (*Pseudapocryptes elongatus*), Iar (*Sperata aor*), Poa (*Otolithoides pama*), Gura echa (*Macrobrachium malcomsonii*), Riksha (*Polynemus paradiseus*), Haoa (*Pseudeutropius atherinoides),* Tengra *(Mystus vittatus*), Cherkuti (*Engraulis sp*.), Bata (*Cirrhinus reba*) and Bashpata (*Brachypleura novazeelandiae*) (Mondal et al. 2013).

Table 1 Contribution of Meghna to annual inland fish production of Bangladesh.

Meghna	Annual fish production (MT)
Lower Meghna (across 5 districts)	62785 (45.44% of total river production)
Upper Meghna (across 7 districts)	6351 (4.60 % of total river production)

(*Source: Fisheries statistical yearbook of Bangladesh 2008-2009)*

1.1.4 Fishing communities

Fishing communities are often considered as the poorest group of peoples in developing countries. According to the Magnuson-Stevens Fishery Conservation and Management Act (which governs U.S. marine fisheries), fishing communities are "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs". Dyer and Mc Goodwin (1999, 214) explained fishing communities as particularly vulnerable to the combination of natural and technological

disasters because fishing utilizes resources in a natural environment under little human control.

Fishermen are those who catch fish for a living. Fishermen community is a distinctive group of people who geographically located in areas near river or sea. They have their own lifestyle and culture. Fishermen in rural Bangladesh usually live a community life in neighborhoods or villages around the water bodies. They are ranked very low category in in the social hierarchy. They cooperate closely with one another not only in fishing, or in the cooperative utilization of fishing grounds, but also in economic activities, such as marketing and purchasing, and in social life and family affairs. They have lived communally for many generations, creating in the process their own history, distinct traditions, and patterns of daily life. Traditionally, most of the fishermen of our country is Hindu. Hindu fishermen are formed into separate and distinct castes. They are also identified separately from other occupational groups. Muslims do not admit caste system but they are grouped into distinct sects or functional classes with restrictions on eating and marrying, similar to the Hindu caste divisions. Fishermen of Bangladesh depend on both fishing and crop cultivation for their living. Mostly are primarily dependent on fishing. They use simple and traditional fishing equipment. For fishing in the inland waters the fishermen use non-motorized boats and traditional nets. The income of the fishermen varies not only in accordance with the types of fishing practices but also with the variations in fishing seasons cause this variations in seasons cause changes in the yields of fishing. Fishermen do some non-fishing economic pursuits like cultivation, wage-labor, net making and mat making during off-peak seasons, as well as in their leisure times. Women of the fishing community also participate this kind of non-fishing activities for some additional income. In Bangladesh the community life of fishermen has changed gradually due to decrease in fishing grounds and fishery resources for various man made and climatic change. The members of the fishing communities have tended to leave their traditional occupation in search for other jobs.

In Bangladesh, industrial development and rapid urbanization over the last decade have provoked some serious concerns in environment (Hasan et al., 2015). Most of the rivers of our country are gradually getting polluted. Currently Meghna fishers is mostly vulnerable because of pollution from industries, for example, large untreated effluent discharge from adjacent cement, paper, jute, super broad, oil, sugar, food processing, salt and chemical industries. Along with industrial wastes, the river is also exposed to

domestic and agro-chemical wastes which are responsible for huge pollution of the water and the sediment.

1.1.5 Fishing communities of the river Meghna

The river Meghna is being contaminated and industries are the major supplier of this wastage. Discharge from the factories severally affecting the ecosystem of the river Meghna. Fish catch is being declined at an alarming rate. This causes lower catch of fish for the fishermen who dependent on this river for their livelihoods. These fishermen are most vulnerable communities of our country because of various natural hazards and anthropogenic changes. Most of them are living below poverty line and their livelihood standards are worsening over times. Fishermen are mostly illiterate and they have low ability to involve with others job rather than fishing. When the fish catches decline, they fall on a great danger. River bank erosion is a common phenomenon in the river Meghna. Most of the fishermen lost their homestead land twice or more in a year. Fishermen experience fever, skin diseases, cold, typhoid, diarrhea due to using polluted water of the river. The river Meghna is very prone to flood. The areas besides the river get flooded by the river in monsoon period and fishers who live on the bank of the river are mostly affected by flood. The fishers normally use Thella jal, Ber jal, Jhaki jal, Dhormo jal, Borshi etc to catch fish, reported by Bhuyan et al.(2016). In fishermen community, women play role in making diverse types of fishing materials, rearing children, household activities and sometimes in harvesting fish (Bangladesh Hydro Medit, 2014). Though both male and female work hard but their financial condition stay same or turn out to be more awful than past.

1.1.6 Vulnerability

Vulnerability is the possibility to experience adverse impacts. Hilhorst and Bank off (2004) defined, “Vulnerability is the key to an understanding of risk that attempts to break from the all-too-technocratic attitudes that have characterized relationships between human societies and their environments over previous centuries.” The concept of vulnerability often considered to have its roots in the study of natural hazards (Hewitt, 1983). In the early twentieth century, Dewey put forward the idea that humanity lives in a hazardous world that results in human insecurity and, therefore, that environmental hazards are not independent from society but are shaped and defined by human actions (Dewey, 1929). Vulnerability is the susceptibility to injury or attack, the state of being vulnerable or exposed and adaptation strategies to this vulnerability mean the adjustment

of a system to moderate the adverse effects. Vulnerability in fisheries community arises due to various anthropogenic activities and climate change. Many fisheries worldwide have declined sharply in recent decades due to overfishing (Pauly et al., 1998), and many major fishing grounds are concentrated in zones that are further threatened by pollution, mismanagement of freshwater and habitat and coastal zone modification.

1.1.7 Vulnerabilities in fishing community

Vulnerabilities of fishing communities can be categorized in two types; vulnerabity due to anthropogenic activities and vulnerability due to climate changes.

Water pollution is the main problem for the fishers of the river Meghna. This pollution affects the livelihoods of the people living along the Meghna coast particularly the fishers, by causing deaths of large number fishes and other aquatic organisms. Dredging the river bed, construction of the Meghna bridge, navigation of vessels and ships on river and social conflict among the local fishers are also some other problems which impede the improvement of the Meghna fishers livelihood. Some other natural phenomenon rooted at climate change like increasing temperature, strong wind action and heavy current of the water also implicating heavy loss of catches of the fishers whose livelihoods are entirely dependent on the river. The diversity of the fish composition is decreasing for these various types of anthropogenic pollution and climate changes. A successful adaptation process is necessary to minimize this loss and for improving their livelihoods. Fishing communities can be affected by land use by agricultural and forestry, using of river water changes the water flow rate (Canalization, dams, water abstraction), disposal of effluent have for population growth as the demand of food. Some are responsible for chemical input in water and some changes the water physical characteristic. They both are responsible for water quality changes. Changed water quality has a great impact on aquatic plants, invertebrates, fish communities and the fishing communities dependent on them.

1.1.8 River water pollution

Anthropogenic activities such as industrial and vehicular emission, energy production, agricultural operations, sewage discharge and waste disposal are the main sources of pollutants.

This pollutants exert adverse effect on biota at the cellular, organism, population and community levels, eventually altering the functioning of the ecosystem as a whole(Jana 1994). Jana also said that “organic pollutants can bring about change in the physic-

chemical characteristics of water and also cause changes in the biotic component of the ecosystem, resulting in loss of bio-diversity." Chemical pollution of water modifies the biota and affects the aquatic system. Pollution prevents the normal functioning of water. Acute toxicity caused by water pollution leading to death of organism, settling on substance and depletes the amount of dissolve oxygen which also leads to death of organisms.

1.1.9 Water pollution in the river Meghna

Large number of industries and urbanizing infestations along with mechanical fishing effort and fuel transportation on the lower Meghna than upper which are the prior key factors to the water quality degradation. A larger number of settlements, towns, ports and industries have sprung up on both the banks of the Meghna towards its downstream. Narshingdi, Chadpur, Barisal and Bhola are the district towns that stand on the banks of the Meghna. Kuliarchar, Bhairab bazaar, Chandpur, Ramdashpur, Kalupur and Daulatkhan are important river ports and business centers. The Ashuganj thermal power plant and the Fenchuganj fertilizer factory are located on the banks of the river also. All these settlements make the downstream prone to water pollution as well as aquatic diversity loss.

1.1.10 Climate

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years (IPCC, 2007). The classical period for averaging these variables is 30 years (WMO, 2002). According to American Meteorological Society (2008), Climate (from Ancient Greek "klima", meaning "inclination") is commonly defined as the weather averaged over a long period. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2015).

1.1.11 Climate change

Climate change is a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use(IPCC, 2015).According to

United Nations Framework Convention on Climate Change (UNFCCC, 2002), climate change is defined as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC, 2015). A region's climate is generated by the climate system, which has five components: atmosphere, hydrosphere, cryosphere, lithosphere and biosphere (IPCC, 2011). This figure is a schematic diagram of changing climate system.

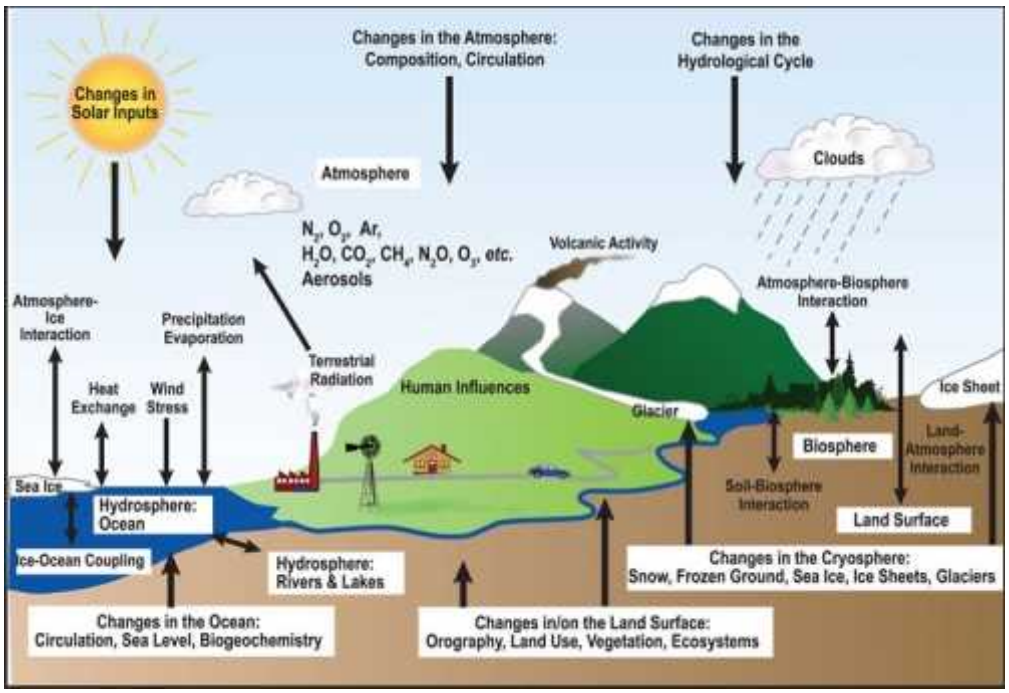

Figure 2 A schematic view of changing climate system (Source: IPCC 2007).

1.1.12 Causes of climate change

Both natural factors and human activities are responsible for climate changes. The greenhouse effect is a natural process through which various gasses and water vapor in the atmosphere affects the earth's climate. The earth's climate is driven by this continuous flow of energy from the sun, mainly in the form of visible light. As the earth is much cooler than sun, it does not give out energy as visible light. Instead, it emits heat in the form of infrared or thermal radiation. Green house gasses in the atmosphere block

this infrared radiation from escaping from the surface to space. This is illustrated in the figure 3. Since the beginning of industrial revolution, one of the major green house gasses, carbon dioxide has increased over 30%. Other green house gasses such as methane and nitrous oxide are also produced by human activity. Global warming that may also cause more evaporation and a further increase in the greenhouse layer due to increased water vapor (Williams, 2002).

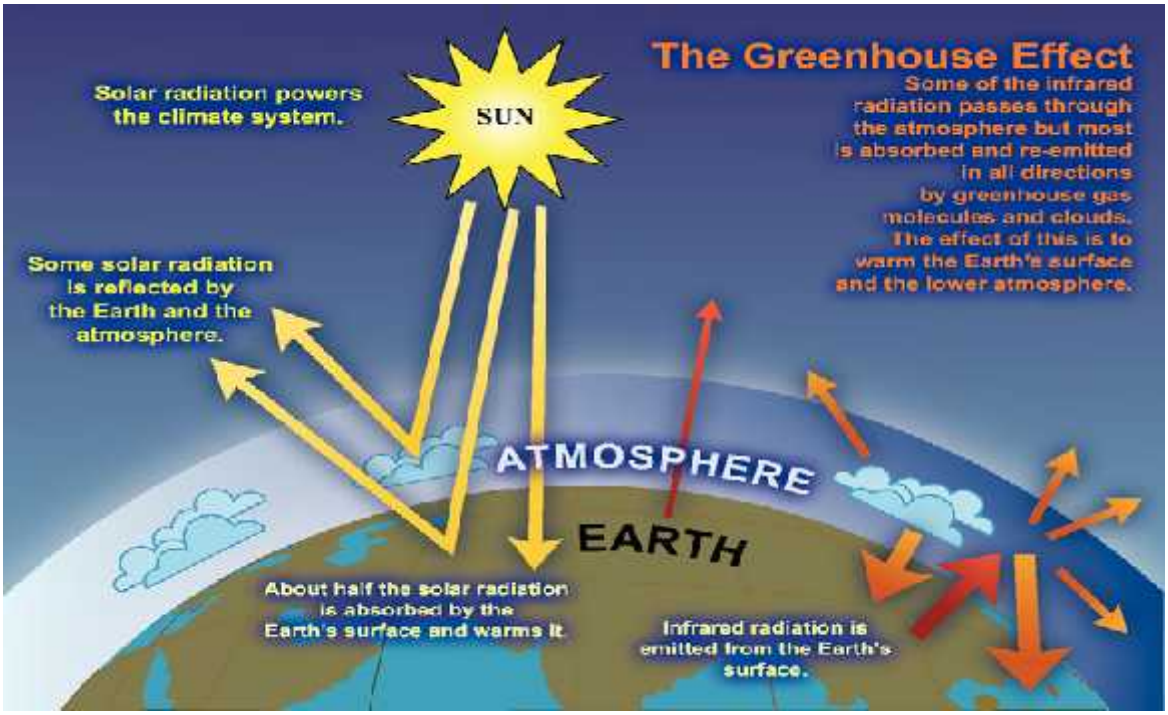

Figure 3 An idealized model of the natural greenhouse effect (Source: IPCC Fourth Assessment Report: Climate Change 2007)

1.1.13 Climate change and the river Meghna fishers

Bangladesh is most likely to suffer adverse impacts from anthropogenic climate change. Threats include sea level rise (approximately a fifth of the country consists of low-lying coastal zones within 1 meter of the high water mark), droughts, floods, and cyclones (approximately 130,000 people were killed in the cyclone of April 1990) (Huq, 2001). Specially, the areas beside the Meghna River face flooding, erosion, rising water level of the river and cyclonic storm surges. Greater variability in rainfall increases the chance of floods and droughts.

In human systems, Adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2015). Where adaptive capacity is

the combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities (IPCC, 2015). Successful adaptation is any adjustment that reduces the risks associated with climate and various anthropogenic change without comprising social, economic and environmental sustainability. Successful adaptation processes can be divided into three dimensions: 1) the ability of, and mechanisms used by individuals and communities to cope with climate change shocks, i.e., to maintain function and withstand shocks, with a focus on informal institutions and social networks; 2) the ability of those communities to self-organize, and formal institutions; 3) adaptive capacity, which is related to the existence of mechanisms for the evolution of novelty or social learning (Oshber et al., 2010).

1.1.14 Climate change in Bangladesh

Bangladesh is inherent tropical monsoon climate with high seasonal variation like heavy rainfall, fluctuation of temperature and high humidity. The monsoon climate brings high natural disasters in this continent every year that adversely affect the country and causes a serious damages and valuable losses of life and property. Bangladesh is one of the significant examples of vulnerable countries in the world due to climate change (BCCSAP, 2008). The effect of climate change visualized throughout the country including long time summer with hot temperature that has occurred drought in the northern part of the country and extreme cold winter and heavy rainfall that has caused flood, cyclone and storm surge in most part of the country. The seasonal pattern of Bangladesh has dramatically changed that reduces the number of season. According to IPCC (2007), global temperature will rise between 1.8˚C and 4.0˚C by 21st century. The IPCC also forecast that global warming will increase in sea level rise of between 0.18 and 0.70 meters which could increase coastal flooding and saline intrusion into aquifers and rivers. Rainfall is predicted to become both higher and more erratic, and the frequency and intensity of droughts are likely to be increase, especially in the drier northern and western part of the country (BCCSAP, 2008). The figure 4 mentioned below shows the areas of Bangladesh affected by various types of natural hazards.

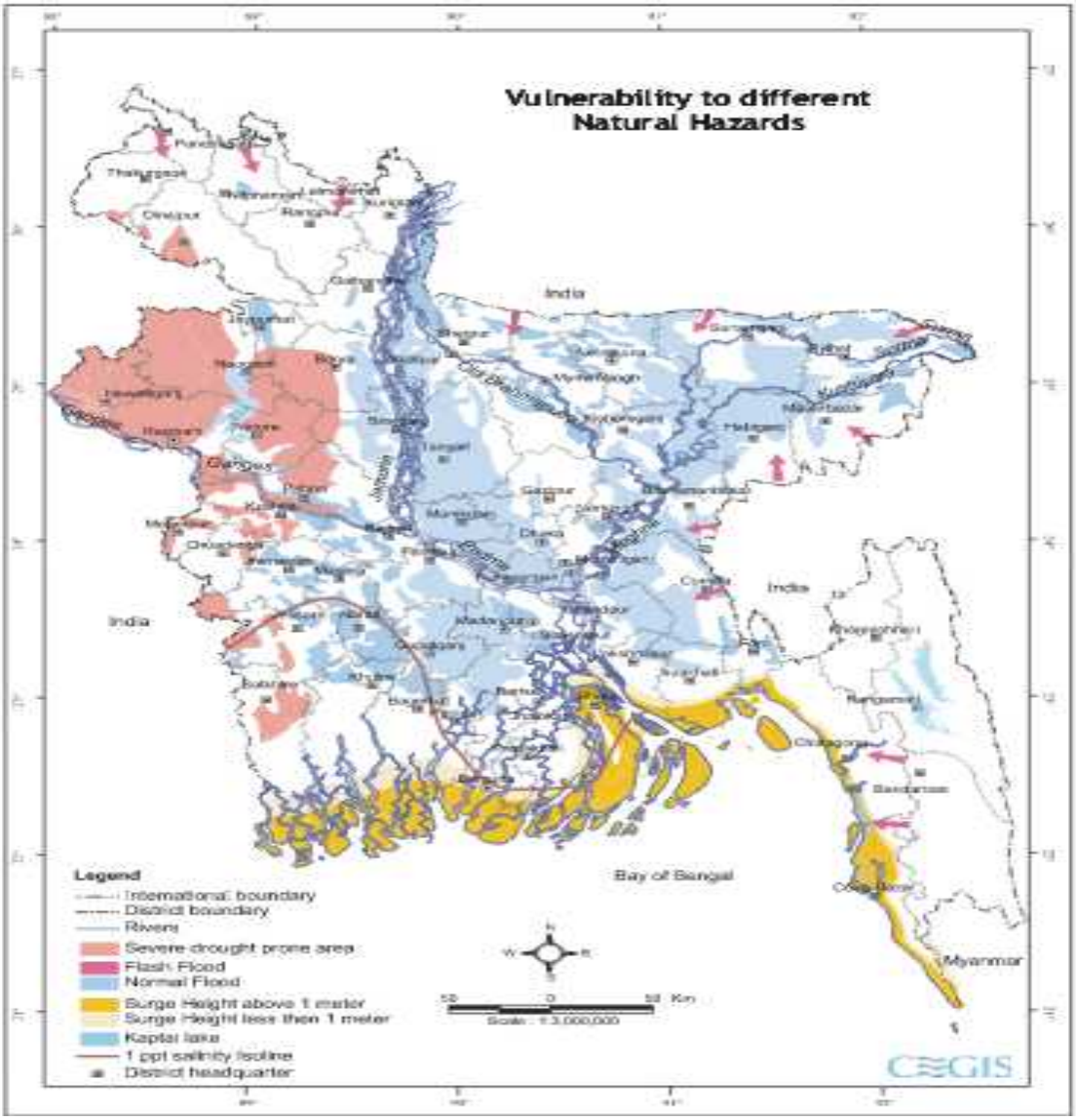

Figure 4 Areas affected by different types of climate related disaster (Source: CEGIS, Dhaka).

1.1.15 Livelihood

Livelihood is a means of living. The livelihood comprises the capabilities, assets (stores, resources=tangible; claims access=intangible) and activities required for a means of living the livelihood is sustainable when it can cope with, and recover from, stress and shocks; maintain or enhance its capabilities and assets, and provides sustainable livelihood opportunities for the next generation (Chambers and Conway, 1992).

1.1.16 Adaptation strategies of fishermen to vulnerabilities

IPCC (2014) defined "adaptation to climate change" as "the process of adjustment to actual or expected climate and its effects". It also said that "In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities".

Adaptation strategies are not single response; these are those actions that taken over time but in some case short-term response can overlap and develop into long-term strategies over time (Berkes and Jolly, 2002). Fishermen of our country are vulnerable due to various man-made and climatic changes. They have to adapt themselves in various ways to adjust with these vulnerabilities. According to Vogel (2005), adaptation is not a new word to the fishers who have to face couple of climate hazards in every year. There have been many examples in fishing communities where they have success in some extent to adapt themselves against various types of vulnerabilities. By changing fishing patterns, increasing the efficiency of fishing vessel or changing the duration of fishing, they have to survive against the changes of their surroundings. In ecology, adaptation refers to the ability of an organism to adapt to changes in its environment.

1.2 Rationale

The population of Bangladesh depends on wild fish for food and generation of income. A large portion of rural family are engaged in part-time or full-time in fishing from the rivers and beels (Hughes et al., 1994).

The Meghna estuary is the largest estuarine ecosystem of Bangladesh and supports diverse fisheries community (Hossain et al., 2012). According to DoF (1991-1992), it alone contributes 11.30% of the total inland open water fish harvest (1369.60 kg/ha). This estuary is the meeting place of fresh water from rivers and salt water from the sea and as such dynamic environment characterized by the large fluctuation of environmental conditions (James et al., 2007). It is the breeding and nursery ground of a wide variety of fishes. Ilish (*Nenuacosa toil*), Chewa (*Pseudapocryptes elongatus)*, Kachki (*Corica soborna*), Chapila *(Gudusia chapra)*, Bele (*Awaous grammepomus*), Icha (*Macrobrachium lamarrei*) some commonly found fish species in the Meghna river. Rohu (*Labeo rohita*), Catla (*Gibelion catla*) are rarely fond now. Some species of fish like Tekchanda, Soto pungus, Fewoa are now vanished totally. The Chandana ilish (*Nenuacosa toil*) was once widely available in the Meghna River, though its numbers are decreasing over duration due to over-catching, netting fries or jatka and smuggling across the border. Once the Hilsha was known as ‘Shad” in foreign country, but now it is known as ‘Hilsha’. Hilsha is our national fish for its delicious taste and flavor. Contribution of Hilsha to our national economy is 1% and 12% of the national fish production. Five lakh fishermen are directly involved in netting Hilsha, while it is the main source of livelihood of more than 2 million people of our country. The total annual

fish production of the Meghna river is 104461 MT (Mia et al., 2015).It has been observed that within 8years (1984-1992), the fish production has decreased by 23.38% in the Meghna (Consultancy report, 1995) due to various man-made and climate change variability. If this declination continues, soon in the following years, the fishers' livelihood and fish habitat on this river will be affected a lot. To get rid of this problem, there is a need to identify the sources of vulnerability and the successful adaptation process to reduce the losses.

1.3 Problem statement

The fisheries community along the bank of the Meghna is now mostly vulnerable for anthropogenic causes due to rapid urbanization and industrial development on the bank of the river. Most of the industries are using it as a dumping ground for garbage. They release chemically polluted water at least twice in the river Meghna. Because of the harmful effect of this chemical water, the biodiversity of the river Meghna getting disrupted. From larvae to large fish all get killed after release of this water within two days. Besides fish, other aquatic organisms like various types of algae, small plants and other aquatic animals all are also died by this polluted water. Some important species of fish are now totally vanished from the river. The color of the river gets changed after the release of the chemical water, a very bad odor also found near the water body. Thousands of locals who are dependent on the river allege that they were unable to use the water as the dumping caused the pollution levels to rise very quickly. The fish habitat becomes vulnerable to the presence of high amount of pollutants and increased temperature-salinity. Change in the climatic condition lowers the amount of catch and adversely affect the livelihoods of the fishers. Dredging which takes place on river bed and bottom causes another type of problem to fisheries community along the river Meghna. Due to increase of the depth of the water body, netting is getting difficult cause most fishes move to the deeper and cooler water to hide. River bank erosion is another effect of this dredging activity. Movement of the steamer and launch create large wave in the near shore area which destructs the boat, torn the fishing net, even responsible for the death of the fishermen. Social conflict between Hindu and Muslim fishermen, among fishermen of the different area, between fishermen and local and political leader of that fishing area are also some common occurrence. Hindu fishermen are not allowed to catch fish every area of the river. Some dominant Muslim fishermen and local leader attack them when fishing in the non-permitted area. In some areas, Hindu fishermen have

to give a percentage of their profit to the Muslim fishermen. Muslim fishermen use fishing trap to catch fish which torn the net while netting. The construction of Meghna Bridge hinders the movement of fish from lower area to the upper area of the river. In winter, it reduces the spread of current in the nearby area while in rainy season it creates vortex of the water due to the presence of large amount of water which torn the net sometimes. Some natural causes like increasing the frequency of the flood per year, strong wind action, increasing the temperature and river bank erosion hinders the development of the fishermen livelihood condition.

1.4 Research gap

Hasan et al. (2015) published a paper about Status of Heavy Metals in Water and Sediment of the Meghna River. Fishers' local knowledge on impact of climate change and anthropogenic interferences on Hilsha fishery in South Asia is reported by Jahan et al. (2015). Hossain et al. (2012) has demonstrated the relationship between fish diversity and DO and salinity of the Meghna River estuary. They found changing climate reduces species diversity. Huq et al. (eds.) reported the vulnerability and adaptation to climate change in Bangladesh. Hasan et al., (in press) demonstrated the impact of climate change and variability on fisher livelihoods of coastal communities in Dhalchar, Bhola district, Bangladesh. Rahman et al. (2012) worked on livelihood status and the potential of alternative income generating activities of fisher's community of Nijhum Dwip under Hatiya upazila of Noakhali district in Bangladesh. Mia et al. (2015) published a paper about socio-economic condition of the fishermen of the fisher's community of Meghna river of Ashuganj upazila in Brahmanbaria district, Bangladesh. Islam et al. (2004) reviewed the impact of pollution on coastal and marine ecosystems including coastal and marine fisheries and approaches for management. Chakraborty et al. (2013) analyzed the cause and impact of water pollution of Buriganga river. Heavy metals in water, sediment and some fishes of Buriganga river are studied by Ahmed et al. (2010). Whitehead et al. (2014) published a paper on socio-economic status of fishermen of district Rampur, Utter Pradesh. In 2011, vulnerability in small scale fishing community is reported by Mia et al. Sindermann (1980) researched on the pollution effects on fisheries potential management activities. However, the sources of vulnerability of the fishers related to natural and anthropogenic climate change has never been reported. The successful adaption strategies under this circumstance are also not identified.Therefore, there is a need for

assessing the successful livelihood adaptation to the vulnerability mostly causes for anthropogenic and climate change of the Meghna River estuary in Bangladesh.

1.5 Objectives

The overall objective of the study is to identify the sources of vulnerability of the Meghna fishers' community and their adaptation strategies. The specific objectives are to:

1. identify the sources of vulnerability of the Meghna fishers;
2. assess the current livelihood status of the Meghna fishers;
3. identify the successful adaptation strategies against current pollution and climate change.

Chapter 2
Materials and Methods

2.1 Selection of study sites

Study sites were selected based on the sources of vulnerability analysis of the Meghna fisheries resulting from anthropogenic and climate changes. Sonargaon of Narayanganj district and Gojaria of Munshiganj district were selected as study sites. This research founded out the sources of vulnerability currently were being faced by the fishers living on the banks of the river Meghna of these two upazila and identified their adaptation strategies.

2.1.1 The river Meghna

The river Meghna is one of the most famous rivers in Bangladesh and endures country's important multi-species commercial fishery (Flura et al. 2016). It is one of the three rivers that form the Ganges delta, the largest delta on earth fanning out to the Bay of Bengal (Chowdhury, 2012). About 26 km from Madna downstream, one of the two channels of the Surma-Meghna is known as the Dhaleshwari. Dhanu and down to the confluence of the channel from Ajmiriganj is referred to as the Surma. The Meghna starts from the downstream of this point.

The Meghna is divided with its two distinct parts. The Upper Meghna is comparatively smaller than lower Meghna. It starts from Kuliarchar to Shatnol. Below Shatnol, the Lower Meghna starts. Because of its wide estuary mouth, the lower Meghna is one of the largest rivers in the world. It is 160 km where the length of Surma-Meghna is 670 km. Among all rivers inside Bangladesh, the Meghna is the widest river. It is 12 km wide at the Bhola point. The lower Meghna is almost a straight line in its path. There are many towns, ports and industries have been developed on both the banks of the Meghna.

Figure 5 Map of the river Meghna.

2.1.2 Selection of fishing communities

Fishing communities were selected depending on some criteria, for example, those areas had to be exposed on some anthropogenic and climate change vulnerabilities, community's level of dependency on the Meghna fisheries and the willingness of the fishermen to help to continue this study. Based on scoping study and consultation with local people, two villages of one upazila in Narayanganj and three villages of Gojaria, Munshiganj were selected as study sites.

2.1.2.1. Justifications of selection of the fishing communities

Presences of traditional fishing communities, ease of communication were the reasons to select the fishing communities. Besides, fishermen were interested to communicate and improve their livelihood. There were many industries near the study areas and if they cause any damage to the fisher's lives was also one of the main concerns.

2.2 Description of the the study sites

The present investigation was conducted on Loshkordi, Vabanipur and Ismanichar at Gojaria upazila in Munshiganj district and Baiday para, Shatviya para at Sonargaon upazila in Narayanganj district.

Narayanganj district is a sub-division of former Dhaka zila. It was upgraded to zila on 15th February, 1984 (Bangladesh population and housing census, 2011). The previous name of this district was "Ganj". It is one of the oldest cities of Bangladesh. The zila is bounded by north by the Gajipur and Narsingdi zilas, on the east by Brahmanbaria and Comilla zilas, on the south by Munshiganj and Dhaka zila is on the west of this zila. In Narayanganj district, total population size was 2948217 (Bangladesh population and housing census 2011). Total number of HH size was 675652. It is 684.37 sq. km in area. Population density per square km is 4308. Literacy rate is 57.1 %. There are 5 upazila under this district and 1204 villages. The zila lies between 23°33′ and 23°57′ north latitudes and between 90°26′ and 90°45′east longitudes. The zila consists of 5 upazilas, 41 unions, 619 mauzas, 1204 villages, 6 paurashavas, 54 wards and 282 mahallas. The upazilas are Araihazar, Bandar, Narayanganj Sadar, Rupganj and Sonargaon.

Munshiganj was known as "Bikrampur". It is situated at the central Bangladesh and it is border of the Dhaka district. Total land area is 235974 acres (954 $km^{2)}$. The land area under river is 26242 acres (106 km^2). It has 14 rivers of 155 km passing through (Rahman 2015). Munshiganj district, formerly a subdivision under Dhaka district, was established in 1984. It consists of 6 upazilas, 67 union parishads, 662 mouzas, 906 villages, 18 wards, 73 mahallas and 2 municipalities. The six upazilas are Lohajang, Sreenagar, Munshiganj, Sirajdikhan, Tongibari and Gazaria upazila. Population size is 1445660 and the population density is 1400/ sq. km (Census 2011). This upazila is bounded on the north by Dhaka and Narayanganj districts, on the south by Madaripur and Shariatpur districts, Comilla and Chandpur districts on the east, Dhaka and Faridpur districts on the west. This district is endowed with the Padma, Meghna, Dhaleshwari, Ichamati and Shitalakshya.

2.2.1 Sonargaon upazila

Sonargaon upazila was known as "Baidayer bazaar" before. It was declared as a upazila on 19th November, 1917 and later it was also changed as "Sonargaon upazila" on 13th march, 1983. The area of total upazila is 17167 sq. km. It is located between 23°32' and 23°46' north latitudes and between 90°31' and 90°41' east longitudes. The upazila is bounded on the north by Rupganj and Araihazar upazilas of Narayanganj zila on the east by Araihazar upazila and Homna upazila of Comilla zila, on the South by Bandar upazila of Narayanganj zila and Gojaria upazila of Munshiganj Zila and on the west by Narayanganj Sadar and Rupganj upazila. It is crisscrossed by three main river the

Meghna, Shitalakshya, Old Brahmaputra (moribund). According to Bangladesh Population Census 2001, it had 1 municipality, 11 union, 351 mouza, 487 village, population density 1780 per sq. km., literacy rate in urban area is 62.8% and rural area 46.7% and total population was 305562.

38.19% (rural 38.13% and urban 42.03%) of dwelling households of the upazila use sanitary latrines and 57.21% (rural 57.24% and urban 55.30%) of dwelling households use non-sanitary latrines; 4.60% of households do not have latrine facilities. According to Cultural survey report of Sonargaon Upazila 2007, Sources of drinking water were Tube-well (93.36%), tap (2.03%), pond (0.60%) and others (4%,77), 63% of the dwelling households have access to electricity and average literacy rate 47%; male 51.5%, female 42.1%. BRAC, PROSHIKA, ASA, VARC and Thengamara Mahila Sabuj Sangha are the active NGOs of this upazila.

According to Bangladesh Population Census 2001, Baiday bazaar union in Sonargaon upazila was 2366 acre in which 10250 males and 9547 females. However, literacy rate was 43.95%.

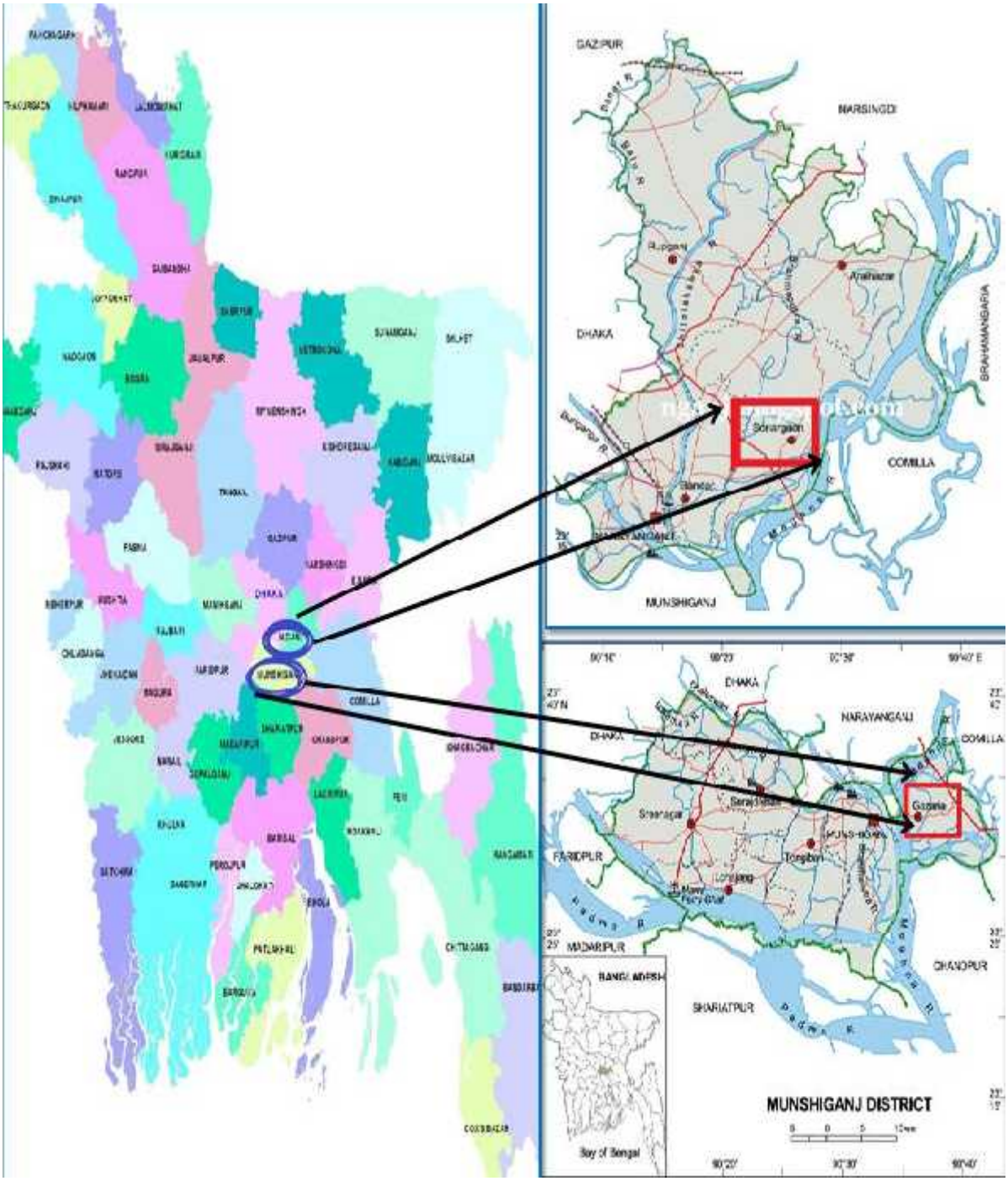

Figure 6 Map of the study areas: a) Sonargaon upazila of Narayanganj district and b) Gojaria upazila of Munshiganj district.

2.2.1.1 Baiday para

There were 30 numbers of households in that village who were involved in fishing. The number of Muslim fishermen was very few, most of the fishermen was Hindu. The physical status of this village was poor. All houses had an earthen floor and the wall was made by jute stick or tin. It was not very far from Baiday bazaar union. Fishermen

caught fish and sold them in Baiday bazaar early in the morning. There was no school near the village. Most of the fishermen were illiterate but they had tendency to educate their children. Maximum fishers were only dependent on fishing, only a few numbers of fishermen were involved n non-fisheries activities like rickshaw pulling, fish trading or working as a day labor.

Most of the fishermen drank tube well water. Only two or three number of fishermen had their own tube well where maximum fishermen have to depend on tube-well which was given from government. Drinking pure water was not a problem for them. This village was mostly affected by water pollution and land erosion. Most of the fishermen objected that they had to replace their house around three or four times because of land erosion. There was an embankment near the village but not every area of the village is protected by this embankment so it was still a big problem for them.

2.2.1.2 Shatviya para

It was a small village located between the Baiday para and Baiday bazaar. Mostly Hindu fishermen lived in that village. Fishermen had been living here for more than 80 years. They were mainly dependent on fishing, some fish traders were found also. They said that they had no any other quality to do any other job. There were no major floods in last few years and land erosion due the construction of embankment. They faced higher temperature problem now for climate change. According to their opinion they are mainly affected by water pollution and dredging activity. Most fishermen hardly reached the literacy level. Physical structure of the village was similar to Baiday para village but some fishermen had better condition than others. They had access to health, education and electricity.

2.2.2 Gojaria upazila

Gojaria Upazila was situated at 23.5417°N 90.6083°E, covering a region of 130.92 km². Gojaria had a population of 128,368 (Bangladesh census 1991). Gojaria had a literacy rate of 32.7% (counting people over the age of 7), compared to national figures of 32.4% (*BBS 2006*). Bangladesh Population Census 2001, it had no municipality, 8 unions, 114 mouza, 133 villages, population density was 1055 per sq. km., literacy rate in urban and rural area was 66.4% and 53.2% and the total population size was 138108. According to Cultural survey report of Gojaria Upazila 2007, all the unions of the upazila were under rural electrification net-work, 27.85% of the dwelling households have access to electricity. The sources of drinking water were tube-well (87.67%), tap (0.41%), pond

(1.54%) and others (10.38%). 38.35% (rural 36.17% and urban 82.34%) of dwelling households of the upazila used sanitary latrines and 54.86% (rural 56.94% and urban 12.90%) of dwelling households use non-sanitary latrines; 6.79% of households did not have latrine facilities(Bangladesh Population Census 2001). Average literacy rate was 53.08%, among them male 57.04% and female 50.1%.

2.2.2.1 Loshkordi

Physical structure of Loshkordi was better than any other study village. Around 100 villagers lived in that village but most of them were related to other non-fisheries job. Only one "Jele para" were found with 25 numbers of households. Half of the roads were made of bricks and rests of them were made by mud. All of the houses have access to electricity. They had well facility of tube-well water.

Some fishermen were also involved with some non-fisheries activities too. They had a greater tendency to educate their children and make them to do another jobs rather than fishing.

2.2.2.2 Vobanipur

In Vobanipur only 20 households were fishery dependent. Their physical condition was also improved than the villages of Sonargaon upazila. Most of the houses were semi-pacca in this village. All of the households had access to electricity. Most fishers were Hindu.

2.2.2.3 Ismanichar

This village was located very close to the bank of the river Meghna. There was a primary school near the village. There were 35 fishers families were found in this village. At rainy season water easily entered the village and flooded the area. Most of the fishers reported that they were more vulnerable to the water pollution, land erosion and flood than any other vulnerability. There houses were made on a different style than other villages of the study areas. The pillars of the houses were made by cement and the height of the pillars was more than 3 feet. They said that they followed that style to protect the houses from flood water.

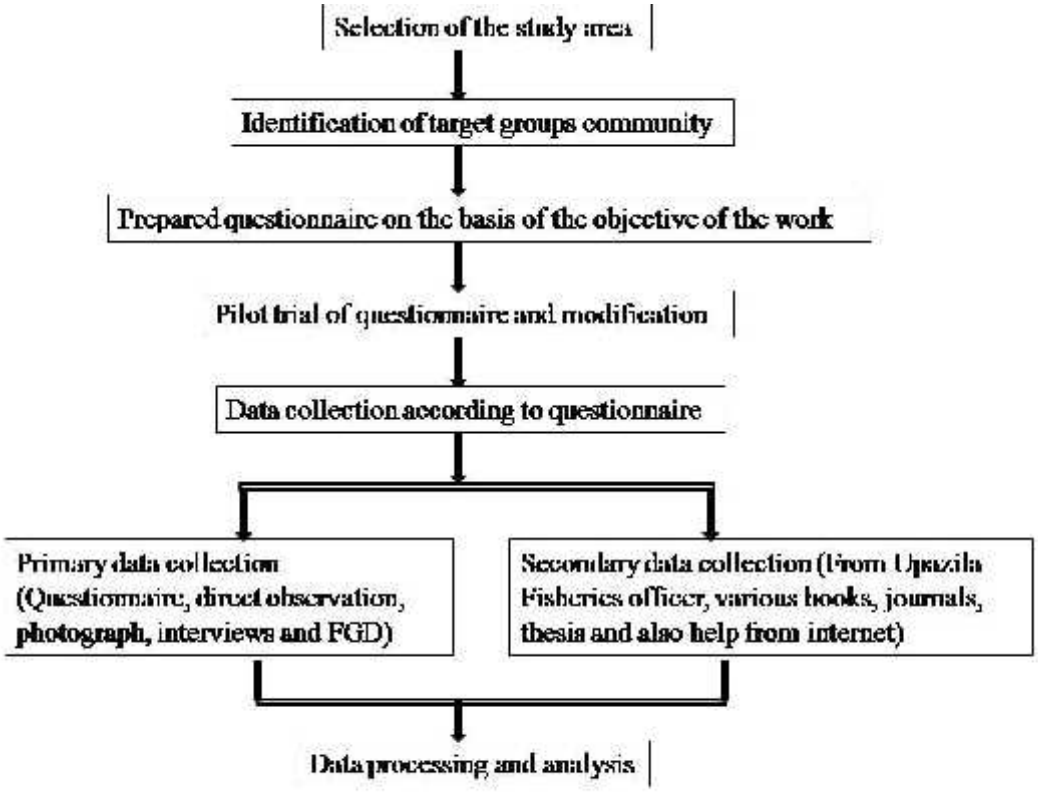

Figure 7 Methodology of the study.

2.3 Design and formulation of questionnaire

A questionnaire were developed in logical sequence and included various questions related to identify the sources of vulnerability of the Meghna fisheries, the impact of changing water quality due to the presence and types of pollutants on the river, the economic condition of the fishermen, factors affecting the livelihood of fisheries community. The questionnaire was developed in a way that both qualitative and quantitative data can be found.

After developing the first draft of the questionnaire, a pilot study was done to verify the appropriateness of the questionnaire. Necessary modification was done and finalized the questions of the questionnaire.

2.4 Determination of sample size

Sample size was determined according to Yamane formula (1973) as below-

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

Here,

N= Size of population

e= Deviation of sampling

n= Size of sampling

Therefore, sample size, $n = \frac{124}{1+124\ (.05)2} = 94.66$ (or 95).

Here,

Size of total population, N=124

Error, e = 5%

The final sample size (n) for household interview was 95.

2.5 Sampling technique

The purposive sampling technique was used in this study. It is a type of non-probability sampling that is most effective when one needs to study a certain cultural domain with knowledgeable experts within (Tongco, M.D.C., 2007). He also suggested to use this techniques to h both qualitative and quantitative research techniques

2.6 Scoping study

A scoping study was conducted to each community to review the current vulnerabilities and adaptation strategies adapted by the fishers of the study sites. Two RRAs was conducted with the local people in each community to understand the overall situation of the problems they face due to anthropogenic causes and climate changes. Appropriation and suitability of the research title and objectives was formulated through the scoping study to make the study robust. The findings of this thesis will therefore help them to adapt themselves with these vulnerabilities.

2.7 Data collection

During collection of relevant data, both primaryand secondary sources were used. Both quantitative and qualitative data were collected. Qualitative data were collected by semi-structured interview whereas qualitative data were collected by FGDs (Focus Group Discussion). Data were collected only from fishery-dependent households from the communities. They all were full-time fishermen. To get rid from biased information various types of methods were applied which has been reduced biasness and increased accuracy in findings (Stocking et al., 2001). Digital recorder, digital camera and field note book were used to capture data.

2.7.1 Primary data collection

Primary data were collected by structured household survey and focus group discussion (FGDs). Purposive sampling was applied to collect data directly from the fishermen. The study was undertaken between March and December 2016. Several visits were made to

the study area to collect data related to objectives of the study. After each visit collected data were checked for accuracy and clarity.

2.7.1.1 Household interviews

Household interviews were conducted to collect data about their livelihood activities, the sources and type of their vulnerabilities, impact of vulnerabilities on fishes and their lives. The adaptation strategies they were following to escape the problems or to cope up with them were also found out. The adaptation procedure they should follow to overcome the vulnerabilities will be found out.

2.7.1.2 Focus group discussion

FGDs involve a "Small group of people discussing a topic or issues (research problem) defined by a researcher" (Cameron, 2005).

FGDs were conducted in two stages. At the time of coping study, FGDs were to develop the the research objectives to get a overall idea about the study area and people. After data collection, the FGDs were conducted to collect the information about their adaptation strategies. A list of topics and possible questions were developed before conducting a FGD. 1.5 to 2 hours were needed for each FGD and a group of 7 to 8 peoples from each household were selected.

2.7.2 Secondary data collection

Secondary data about water pollution and climate change occurred in this area in previous and recent years, their impacts on fish and fishers were collected from relevant books, journals,thesis, and organizations to realize the situation.

2.8 Ethical consideration

The main consideration of the ethical issue is the confidentiality and consent gaining of the participants. Every participant was given necessary information about the purposes of the research. They were assured that information would be used only for research purposes.

2.9 Data analysis

2.9.1 Quantitative data analysis

The questions were post coded when needed, entered on the computer and analyzed using statistical software SPSS version 20.0, using descriptive statistics and compared means. Data were presented in the form of graphs and tables to give graphical representation by MS Excel and SPSS.

2.9.2 Qualitative data analysis

The qualitative data which were found by FGDs were prepared and organized for analysis. The data were reduced into themes through a process of coding and condensing the codes and finally the data were represented in tables or part of discussion.

Chapter 3
Findings of the survey and Discussion

3.1 Human capital

Human capital refers to the stock of knowledge, habit, social and personality attributes, including creativity, embodied in the ability to perform labor so as to produce economic value (Gary Becker, 1993). Fishermen of Sonargaon and Gojaria upazila were found to have low level of education, mostly were Hindu in religion.

3.1.1 Education

Literacy rate of the fishermen across the study areas showed wide variations (36 to 80%; Table 2). Among fishermen surveyed 41% were illiterate. Only 34% could write their name. Only 8% had primary and secondary education. None of the fishermen had received higher secondary education. The fishermen's literacy rate was lower than national level 61.5 % (UNESCO, 2015).

Between villages, while most (36%) had the primary education in Shatviya para, Loshkordi had 25% followed by Vabanipur (20%), Baiday para (19%) and Ismanichar (8%). Only 8% had secondary education found in Ismanichar followed by Baiday para (4%).

Literacy rate was higher among the fishers of Gojaria upazila (65%; Figure 8) than Sonargaon (60%). Some 42% of the fishermen of Gojaria upazila could only write their name which was lower in Sonargaon upazila (32.5%). The level of primary education was higher in Sonargaon upazila (25%) than that of Gojaria (16%). The fishermen of Gojaria upazila had received maximum secondary education (6%) than did Sonargaon upazila (3%). Rahman et al. (2012) found that among the fishers community of Nijhum Dwip under Hatiya upazila of Noakhali district 67% were illiterate, 17% received primary education and 17% could sign only.

Table 2 Distribution (%) of the fishermen by villages and levels of education of Sonargaon, Narayanganj and Gojaria upazila, Munshiganj district.

Villages	Levels of education					Total
	Illiterate	Can sign only	Primary	Secondary	Higher secondary	
Baiday para	26.93	50	19.23	3.85	0	100
Shatviya para	64.26	0	35.72	0	0	100
Loshkordi	20	50	25	5	0	100
Vabanipur	50	30	20	0	0	100
Ismanichar	44	40	8	8	0	100
Mean	41.04	34	21.6	3.37	0	100

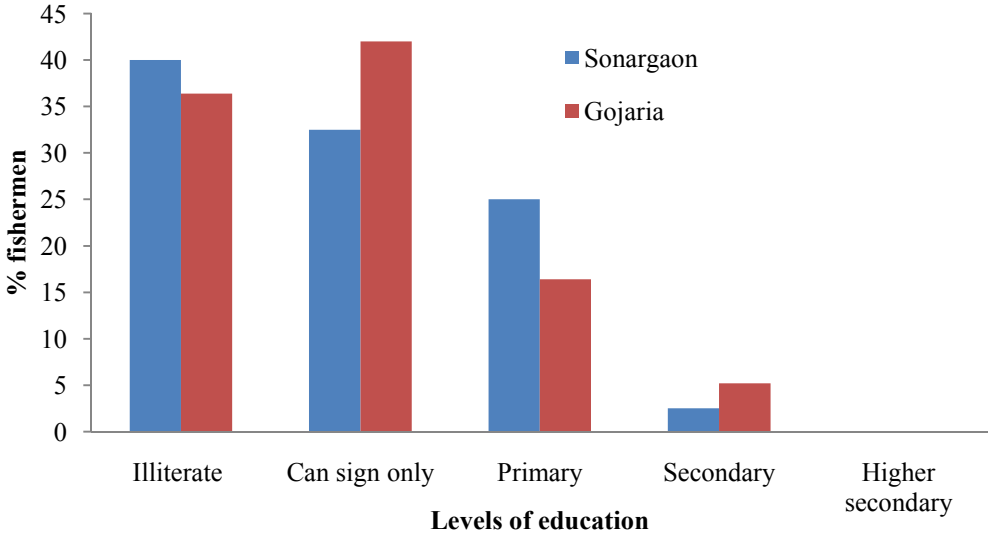

Figure 8 Distribution (%) of the fishermen of two upazila by levels of education.

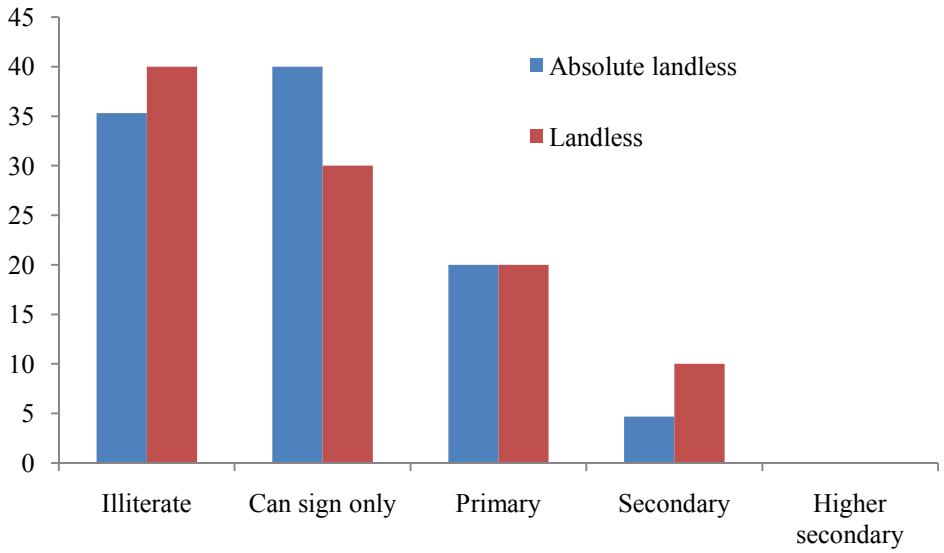

Figure 9 Overall distributions (%) of the fishermen of two upazila by levels of education and land class.

All fishers surveyed were of absolute landless and landless. Absolute landless had higher literacy rate (65%) than those of landless fishermen (60%; Figure 9). Fishers could had the ability to write were higher (40%) in absolute landless than had the landless (30%). Fishers who had primary education were equal between two classes (20%). On the other hand, the percentage of fishermen who received secondary education was higher among landless (10%) than absolute landless (7%) group. Literacy rate of landless fishermen was higher in Sonargaon upazila (40%) than absolute landless fishermen (67%; Table 3). But it was totally opposite in Gojaria upazila. In Gojaria, absolute landless fishermen (37%) were more illiterate than landless (33%). Fishers can sign only their name was higher among the absolute landless fishermen of both upazila (36 & 42 %). The absolute landless fishermen (27%) of Sonargaon upazila received more primary education than the landless fishermen (20%). The percentage of landless fishermen (33%) of Gojaria upazila had received more primary education than their absolute landless fishermen (16%). Sonargaon and Gojaria upazila both had a higher rate of absolute landless fishermen receiving secondary education.

Literacy rate was not satisfactory in those fishing communities. For this low level of education, they had little opportunity for non-fisheries related activities. It hinders their occupational mobility and limits other employment opportunities. They are less capable to improve their livelihood condition by reducing the negative impacts of their vulnerability. It was revealed from the study that most of the fishermen wanted to

educate their children so that they could live a better life than them. But sometimes they had to pull off their children from school and force to help them in fishing.

Table 3 Distribution (%) of fishermen based on land class and levels of education in two study areas.

Upazila	Land class	Levels of education					
		Illiterate	Can sign only	Primary	Secondary	Higher secondary	Total
Sonargaon	Absolute landless	33.33	36.36	27.27	3.03	0.00	100
	Landless	60.00	20.00	20.00	0.00	0.00	100
Gojaria	Absolute landless	36.54	42.31	15.38	5.77	0.00	100
	Landless	33.33	33.33	33.33	0.00	0.00	100

3.1.2 Religious status

In the present survey, it was found that maximum fishermen of both upazila were Hindu. There were only 31% Muslim fishermen in Baiday para village where Hindu fishermen were 70 % (Figure 10). On the other hand, there were no Muslim fishermen in Shatviya village. The number of Muslim fishermen of Loshkordi and Vabanipur villages was 15 % and rest of the fishermen was Hindu. Like other village the number of Muslim fishermen (36%) was also less in Ismanichar village than Hindu fishermen (64%).

In case of two upazila, the presence of Muslim fishermen was equal for Sonargaon and Gojaria upazila (20%; Figure 11). And the rest 80% fishermen of both upazila were Hindu. There were no fishermen of any other religion on those two study areas. Mia et al. (2015) found out that among the fisher's community of Meghna river of Ashuganj upazila had 90% Hindus and 10% Muslim.

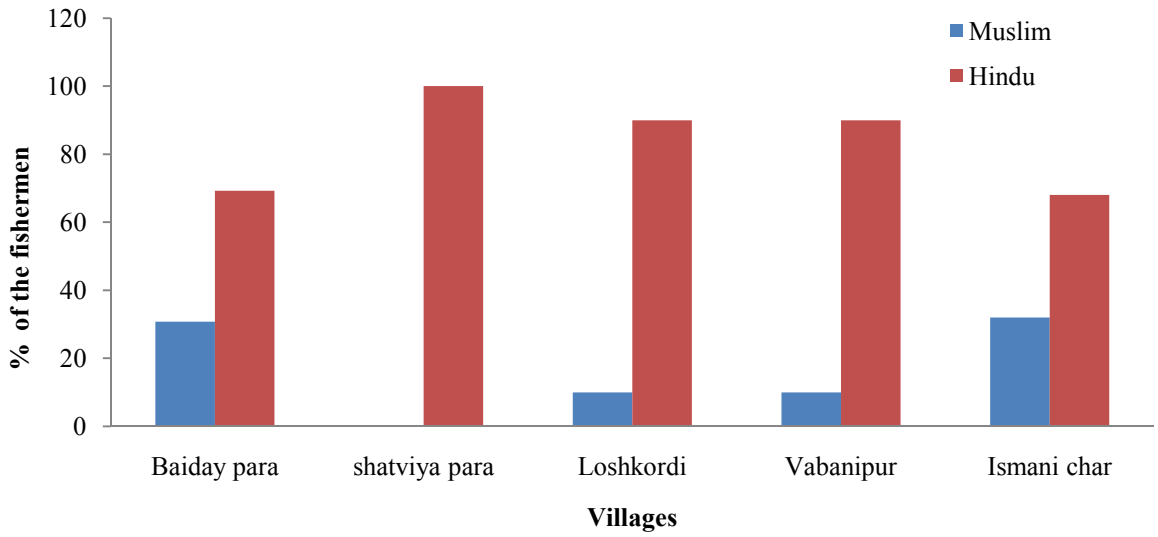

Figure 10 Religious statuses of the fishermen of the five villages of Sonargaon and Gojaria upazila.

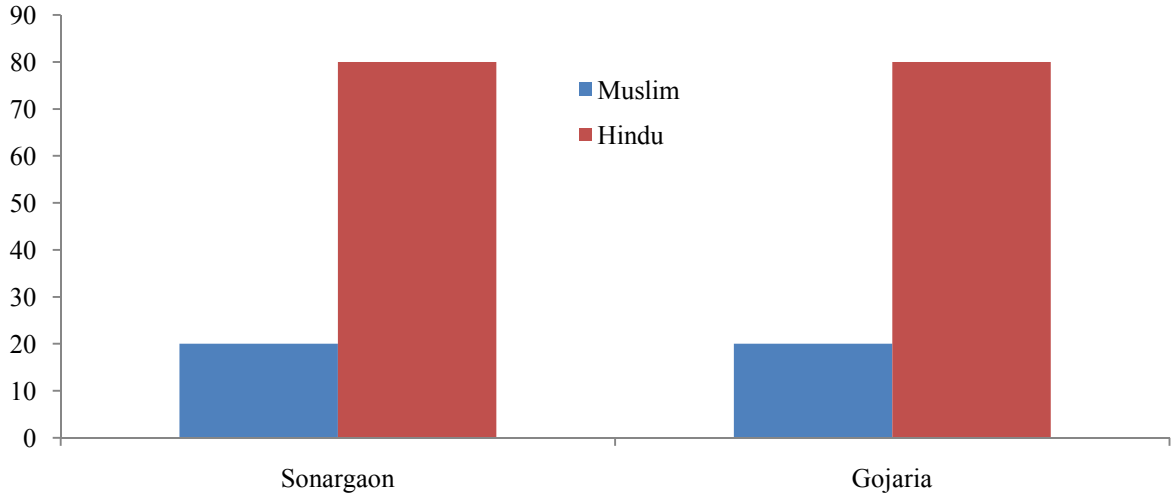

Figure 11 Overall distribution (%) of religious status of the fishermen of two upazila of Narayanganj and Munshiganj district.

3.1.3 Age structure

The age of the fishermen surveyed ranged from 21 years to above 60. Maximum fishermen interviewed (31%; Table 4) were on age class between 31 and 40 followed by age class 41-50 (22%), 21-30 (19%), 51-60 (15%). However, only 13 % were above 60.

Table 4 Distribution (%) of the fishermen by five villages and age class.

Village	Age class (year)					Total
	21-30	31-40	41-50	51-60	>60	
Baiday para	19.2	23.1	23.1	27	7.6	100
Shatviya para	28.6	7.2	21.4	21.4	21.4	100
Loshkordi	20	40	20	10	10	100
Vabanipur	10	50	20	10	10	100
Ismanichar	16	36	24	8	16	100
Mean	18.6	31.3	21.7	15.28	13	100

Between Sonargaon and Munshiganj upazila, the percentage of fishermen belonging to age class 21-30 was higher in Sonargaon upazila (24%; Figure 12) than Munshiganj upazila (16%). Around 40% fishermen of Munshiganj upazila were on the age class 31-40, which is 18% for Sonargaon upazila. The number of fishermen belonging to 41-50 and above 60 age class was nearly equal (10% & 13% respectively) for both upazila. Only 9% fishermen of Munshiganj upazila were under 51-60 age class where as 25 % of the fishermen of Sonargaon upazila belonged to this age class.

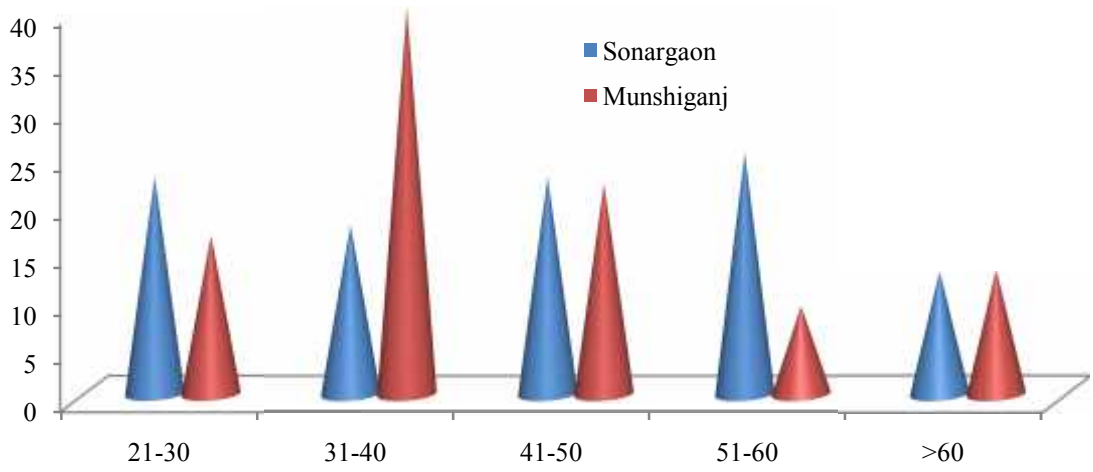

Figure 12 Distribution (%) of fishermen of two upazila by their age class.

3.1.4 HH size

HH size ranged from 2 to 7. The highest percentage of family consisted of 4 to 7 members (Figure 13). In Baiday para & Shatviya para village, most of the household

consisted of 6 members (35% & 43%, respectively). Only in Ismanichar, 4% HH had two family members. Most HH (40%) of Loshkordi village were found to have four members. In Vabanipur upazila 60% HH had five members. Ismanichar had 28% HH consisted of 3 to 5 members.

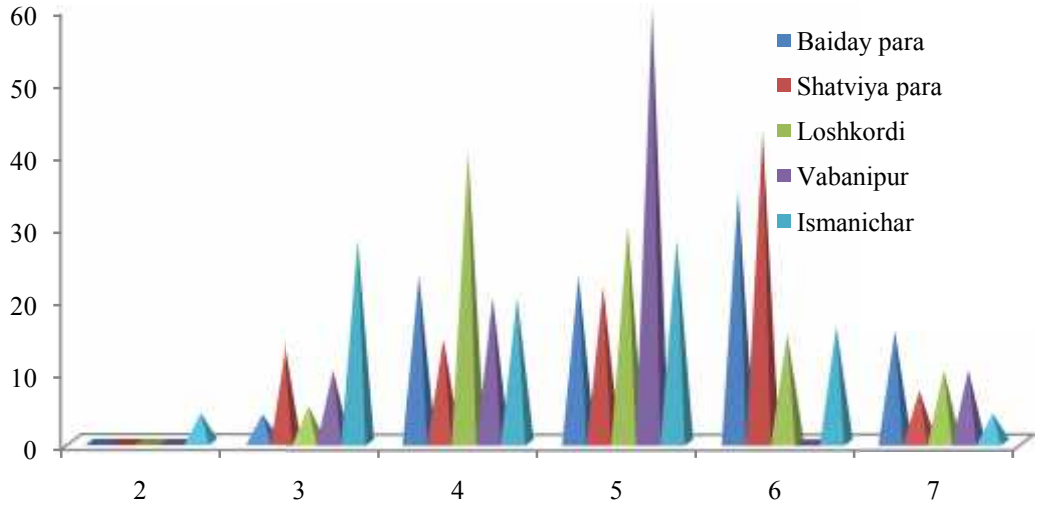

Figure 13 Distribution (%) of HH size of the fishermen of five villages of Sonargaon and Gojaria upazila.

3.1.5 Health status

Overall, most indicated suffered from fever (57%; Table 5) and cold (42%). Some also complained of Diarrhea (30.5%) and pain (27%). Some 21% were also got injury by various types of skin diseases (21%) which could be attributed to polluted water. Use of polluted water for cooking, washing clothes and taking bath were responsible for the outbreak of diarrhea and skin lesions.

Table 5 Distribution (%) of the fishermen by type of diseases they faced.

Diseases	% fishermen
Fever	56.8
Diabetics	12
Diarrhea	30.5
Cold	42.1
Pain	27.4
Kidney failure	15.8
Liver disease	6.3
Skin lesions	21.1
Others	11.6

Most absolute landless (91%) fishers were found suffering from various types of illness than landless group (Table 6). Fever (54%) and cold (46%) were found dominant among absolute landless whereas fever (50%) and pain (40%) were predominant in landless fishermen. Small asset holdings and low-income profiles might be responsible for these illnesses. The fishers might not have any surplus income that could be spent for treatment. Small asset holdings could also not make any further income to the HH.

Table 6 Distribution (%) of the HH by type of diseases they face and land class of the fishermen of the study areas.

Disease	Land class	
	Absolute landless	Landless
Fever	54	50
Diabetics	10.6	9
Diarrhea	30.6	30
Cold	46	30
Pain	42.4	40
Kidney failure	14.1	30
Liver disease	5.9	10
Skin lesions	33	10
Others	90.91	9.09

3.2 Natural capital

3.2.1 Land holding class

Sampled HH were belonged to two types of land classes: absolute landless and landless. Of the sampled HH, most were absolute landless (91%; Figure 14) in both upazila and only 9% were landless.

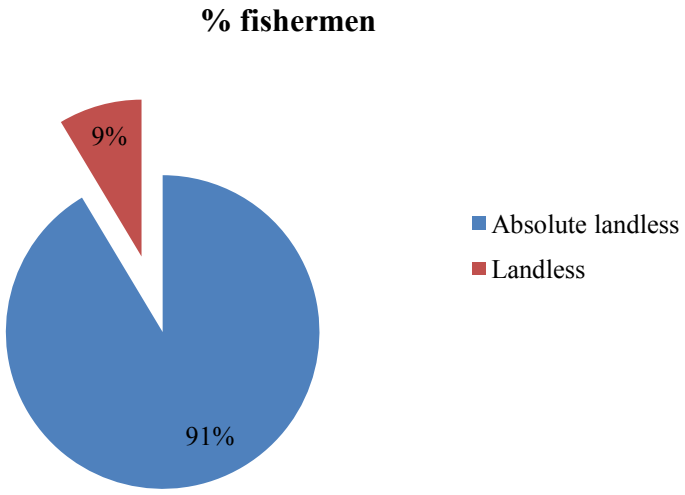

Figure 14 Distribution (%) of the fishermen by land class.

In Sonargaon upazila, nearly 96% HH in Baiday para and 66 % in Shatviya para were absolute landless (Table 7). In Gojaria upazila, nearly 100 % HH of Loshkordi and Vabanipur were absolute landless. In Ismanichar village, 88% were absolute landless and 12% landless.

Table 7 Distribution (%) of HH by villages and land class of the fishermen of five villages under two upazila.

Villages	% HH		Total
	Absolute landless	Landless	
Baiday para	96.2	3.8	100
Shatviya para	66.7	33.3	100
Loshkordi	100	0	100
Vabanipur	100	0	100
Ismanichar	88	12	100

Ownership of land

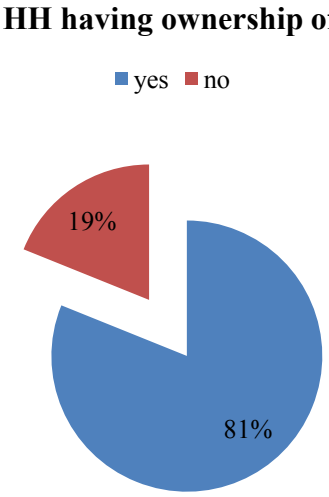

Figure 15 Overall distributions (%) of the ownership of land in two study area.

Among all fishermen of five villages, 19% HH had no land (Figure 15). They had to pay the owner of the land to build their own house on yearly basis.

Table 8 Mean value (TK) of natural assets of the HH by levels of education.

Type of natural capital	Level of education			
	Illiterate	Can sign only	Primary	Secondary
Land	639285.71	840000.00	925000.00	1075000.00
Livestock (cattle/buffalo)	00	210000	105000	00
Livestock (poultry /duck/pigeon)	00	500	150	00
Livestock (others)	00	30000	00	00
Mango tree	20666.67	41250.00	35000.00	7500.00
Jackfruit tree	60000.00	37500.00	30000.00	00
Coconut tree	9333.33	6000.00	3333.33	2500.00
Tree (others)	30000.00	12000.00	00	00
Total	759285.71	1177250	1095150	1085000

Literate fishermen had more natural asset (1100000 TK; Table 8) than illiterate ones (759285 TK) while compared the mean values of natural asset with level of education,

Mean value of natural assets was highest in Ismanichar village (1390952 TK; Table 9) followed by Loshkordi (986737 TK), Shatviya para (748633 TK), Baiday para (603595 TK) and Vabanipur (240333 TK).

Table 9 Mean value (TK) of natural asset of the HH by villages.

Types of natural asset	Name of villages				
	Baiday para	Shatviya para	Loshkordi	Vabanipur	Ismanichar
Land	510000	733333.33	894736.84	233333.33	1180952.38
Livestock (cattle/buffalo)	70000	0	0	0	210000
Livestock (poultry /duck/pigeon)	166.67	300	0	0	0
Livestock (others)	10000	0	0	0	0
Mango tree	30000	15000	30000	4000	0
Jackfruit tree	30000	0	45000	0	0
Coconut tree	6428.57	0	5000	3000	0
Tree (others)	10000	0	12000	0	0
Total	603595.24	748633.33	986736.84	240333.33	1390952.38

3.3 Physical capital

3.3.1 Home appliances

Productive physical asset

In ownership of productive physical asset, 11% HH of Baiday para had fishing trap (Table 10). Fishing trap was found not to be used in any other villages. While 53% HH in Vabanipur owned boats but Baiday para had the lowest (47 %). Half of the HH of Shatviya para and Loshkordi had their own net.

Table 10 Distribution (%) of HH having productive physical asset.

Village	Item		
	Fishing trap	Boat	Net
Baiday para	11.1	46.7	42.2
Shatviya para	0	50	50
Loshkordi	0	50	50
Vabanipur	0	53.3	46.7
Ismanichar	0	52.5	47.5

Table 11 Mean value (TK) of productive physical asset of five villages.

Type of productive physical asset	Name of the village				
	Baiday para	Shatviya para	loshkordi	Vabanipur	Ismanichar
Fishing boat	65500	70000	123529	62125	73333
Net	75000	59901.9	88235.29	50000	56842.11
Chair	33335	0	0	0	0
Total	173835	129901.9	211764.29	112125	130175.11

Mean value of productive asset was highest in Loshkordi village (211764 TK; Table 11) and lowest in Vabanipur (nearly 112000 TK).

Non-productive physical asset

In ownership of non productive physical asset, 33.5% HH owned TV and Fan, 10% had watch and 13% had Radio (Table 12). Nearly 96% fishermen had their own house. Only few fishermen (8 %) owned jewelries.

Table 12 Distribution (%) of HH by non productive physical asset.

Items	% fishermen
Watch	10
Radio	12.9
TV	33.5
Fan	33.5
Jewelries	8.2
House	95.8
Others	1.8

Table 13 Distribution (%) of HH owned non-productive physical asset by two upazila.

Upazila	Items						
	Fan	jewelries	Radio	TV	Watch	House	Others
Sonargaon	29.9	8.25	14.43	30	15.5	97.5	2.1
Gojaria	38.4	8.2	11	38.4	2.7	94.5	2.4

Between upazila, nearly 30% HH of Sonargaon owned Fan whereas in Gojaria it was 38% (Table 13). While in Sonargaon upazila 97.5% HH had living house, in Gojaria 94.5% had the same. Some 30% HH had TV in Sonargaon upazila while 38% in Gojaria. The percentage of HH owned Jewelries and other non productive physical asset was same (8% and 2%, respectively) for both upazila.

Table 14 Mean value (TK) of non-productive physical asset of five villages.

Village	Non-productive physical asset							
	Fan	Jewelries	Radio	Watch	House	TV	Others	Total
Baiday para	1022	11250	429	127	155600	6650	9500	184578
Shatviya para	1200	1333	500	100	222857	7000	0	232990
Loshkordi	1000	17500	1000	67	195500	10000	10000	235067
Vabanipur	1290	1012	167	1000	114286	5500	0	123255
Ismanichar	990	17000	500	56	1096280	10000	0	1124826

In five villages, mean value of non-productive physical asset was highest in Ismanichar (1124826 TK; Table 14) followed by Loshkordi (235067 TK) and Vabanipur (123255 TK).

3.3.2 Residence

3.3.2.1 Ownership of the house

Most HH had own living house (96%; Figure 16) while rest had to pay monthly basis to the fishermen who let.

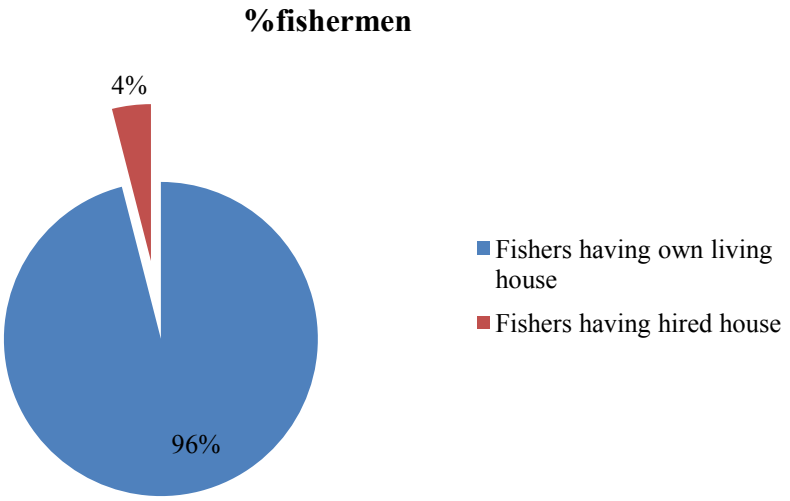

Figure 16 Overall distribution (%) of HH by ownership of the house.

3.3.2.2 Condition of house

While most of the houses was semi-pacca (58%; Figure 17), 40% was kaccha and the rest (2%) was pacca. The roof of the kaccha houses were made of jute sticks or tin mainly and the floor was made of mud. There were some pacca houses found in Loshkordi and Shatviya para villages which had pacca floor and tin made roof. In Ismanichar, in most of the houses floor was made by wood which was supported by cement pillar because that was regularly affected by flood. The nature of the house indicates the poor financial status of the studied people.

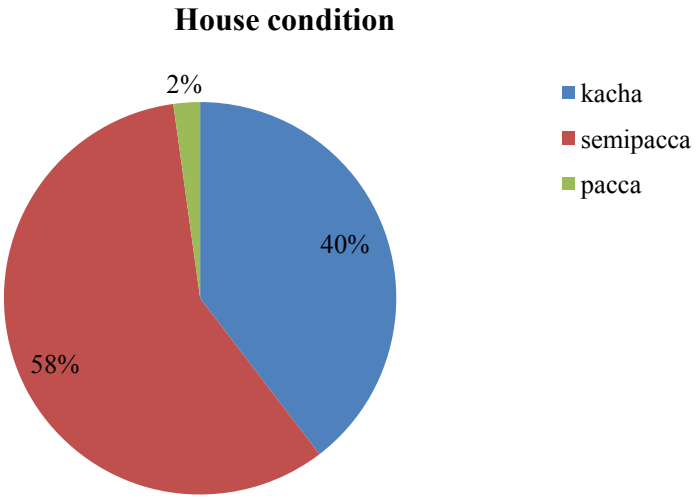

Figure 17 Distribution (%) of HH by housing condition of the study areas.

3.3.3 Sanitary condition

Survey revealed that nearly 55% HH had semi-pacca (Figure 18), 40% had kaccha sanitary condition and only 8% HH had pacca latrine. There were no HH without sanitary facilities. Mahmud et al. (2015) reported that 52% HH of the fishermen community along the Paira river had semi-pacca latrines, 26% used kacha latrines and only 3% used pacca latrines.

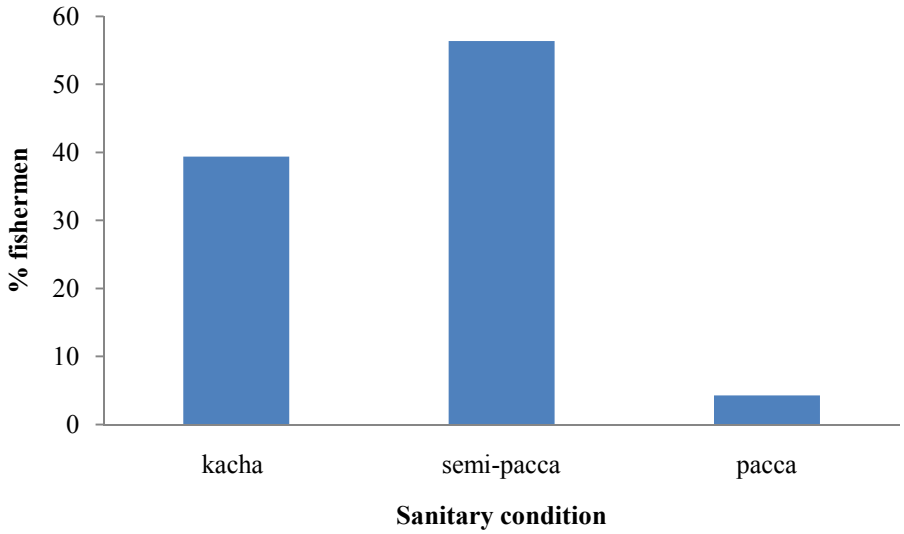

Figure 18 Distribution (%) of HH's sanitary condition of whole study arekas.

3.3.4 Drinking water facility

All (100%) fishermen had access to tube-well water. Therefore, drinking pure water was not a problem for them.

3.3.4.1 Ownership of the tube well

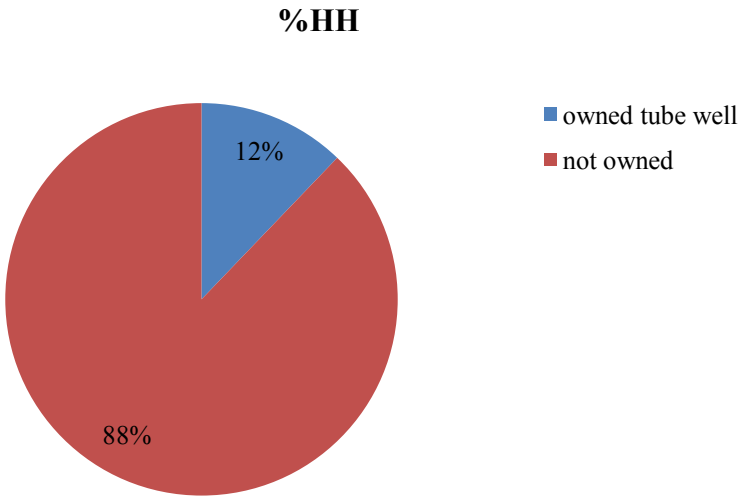

Figure 19 Distribution (%) of the HH having ownership of tube well.

Only 12% HH had their own tube-well in both upazila (Figure 19). Rest HH had to depend on other's tube-well or public tube well. Most of the owners of tube wells were Muslim.

3.4 Financial capital

3.4.1 Credit access

Various types of formal, informal and quasi-formal credit markets were the sources of financial capital for the poor fishermen. Formal credit market like Sonali bank, Krishi bank and some other private banks lent loans to poor farmer. Some quasi-formal credit markets, notably NGOs like BRAC, ASA, AMRA provide credit to the poor organized fishermen to purchase fishing gears and boats.

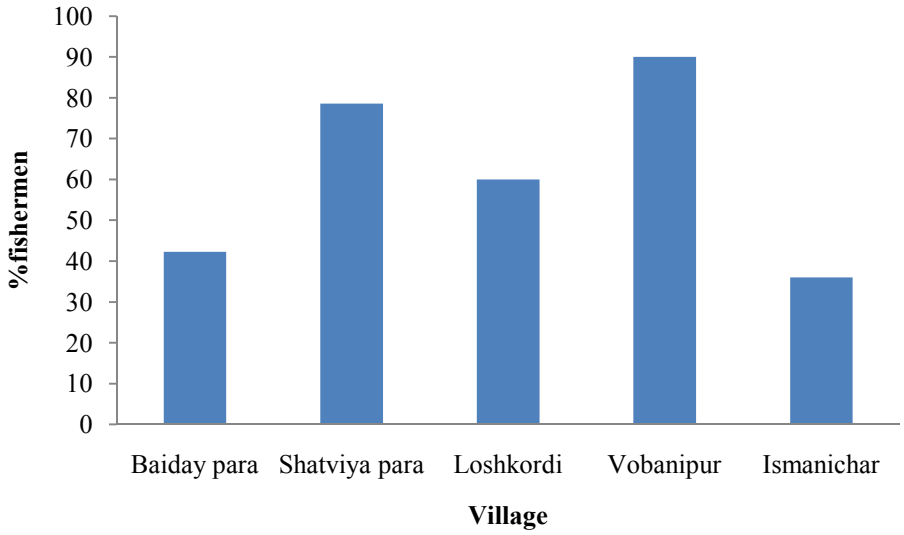

Figure 20 Distribution (%) of HH by took credit by villages of two study areas.

Most HH of Vabanipur (90%; Figure 20) were found in debt which was highest in Shatviya para (76%), Loshkordi (60%), Baiday para (41%) and lowest in Ismanichar (39%).

Table 15 Distribution (%) of the HH had access to credit by sources.

Sources of credit	%HH
Govt. bank	3.2
Private bank	2.1
NGO	51.6
Local money lender	18.9
Relatives or others	16.8

Most HH borrowed loan from NGOs (52%; Table 15) followed by local money lenders (19%) and relatives (27%). They also received loans from public (3%) and private banks (2%).

3.4.2 Savings

Normally people save money after meeting all their regular expenditures. As fishermen of the study areas were mostly under the poverty line, only 27% (Figure 21) HH were found to have a small amount of savings.

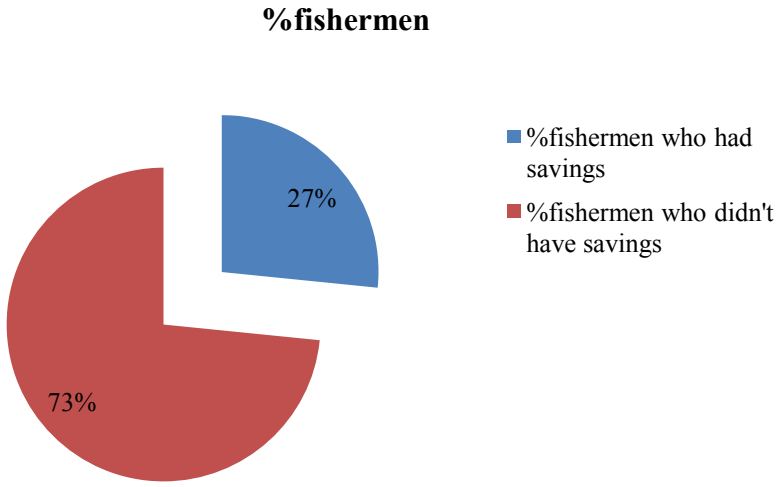

Figure 21 Distribution (%) of HH by savings.

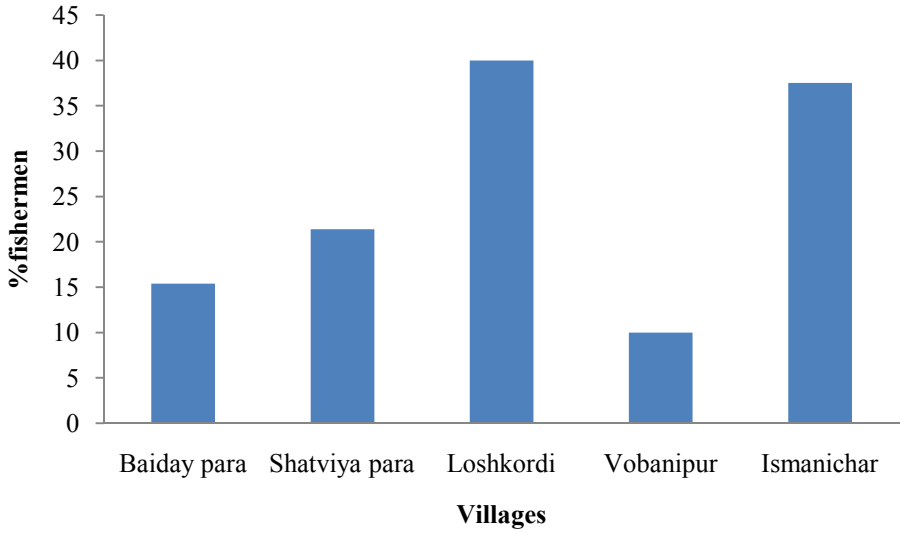

Figure 22 Distribution (%) of HH had savings by villages.

Nearly 40% HH of both Loshkordi and Ismanichar had savings (Figure 22). In Shatviya para 22% HH had savings which was 15% in Baiday para and 11% Vobanipur.

3.5 Mean value of all assets

Mean value of all assets was lowest among illiterate (734537.50 TK; Table 16) and highest among the fishermen who had received secondary education (1316025.00tk). Literacy rate had a great impact on the asset holding capacity of the HH.

Table 16 Mean value (TK) of all assets of HH by level of education.

Levels of literacy	Mean value of all assets
Illiterate	734537.50
Can sign only	941095.71
Primary	1004500.00
Secondary	1316025.00

Table 17 Mean value (TK) of all assets of HH by villages.

Village	Mean value of all assets
Baiday para	651130.77
Shatviya para	905264.29
Loshkordi	1166550.00
Vabanipur	202300.00
Ismani char	1159060.00

Estimated value of all assets indicated that the fishermen of Loshkordi was comparatively richer among all villages (1166550 TK; Table 17) was followed by Ismanichar (1159060 TK), Shatviya para (905264 TK), Baiday para (651131 TK) and Vabanipur (202300 TK).

3.6 Activities and income profiles

3.6.1 Livelihood strategies

Only 17 % HH were found to involve in non-fisheries activities. Some 33% HH had family's other member's contribution to their monthly income.

3.6.2 Income profiles

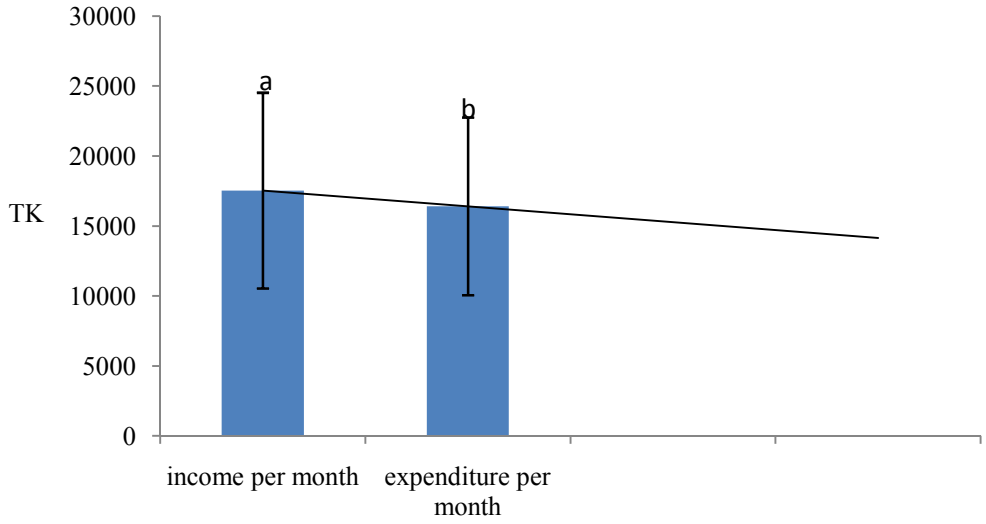

Figure 23 Monthly income and expenditure of HH.

Although monthly HH income (17532 TK; Figure 23) was found to be little higher than the HH expenditure (16405 TK), this information does not remain throughout the year. During fishing months, the fishers have higher income but during the remaining 5 months off season, they really don't have any income to the HH. During this off-season, mostly borrow loan from the NGO's and/or from the local money lenders.

3.7 Vulnerabilities

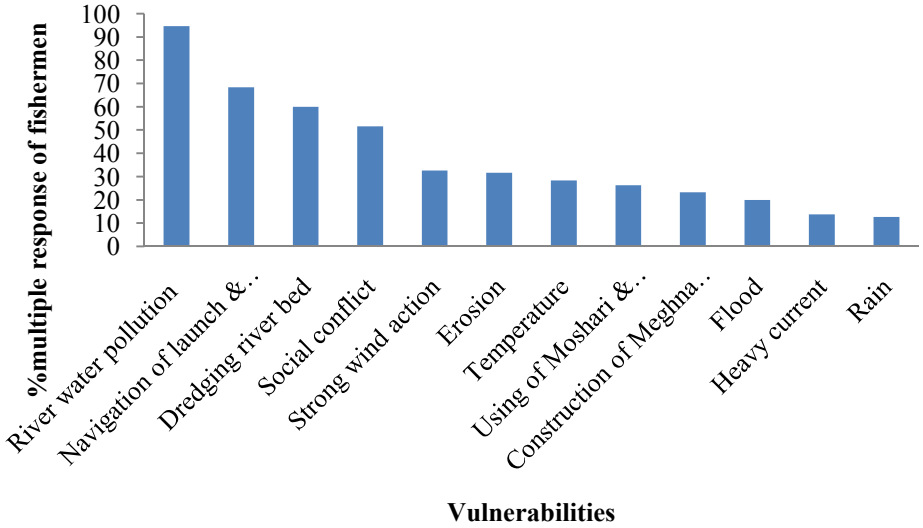

Figure 24 Problems faced by the fishers (%) of the study areas.

Nearly 95% fishermen claimed "River water pollution " as their main problem (Figure 24) followed by navigation of "vessels and ships" (65%), "Dredging river bed" (60%), "Social conflict"(52%), "Strong wind action" (33%), "Erosion"(32%), "Increasing

temperature"(28%), "Use of Current jal"(26%), "Construction of Meghna bridge"(23%), "Flood"(20%),"Heavy current"(14%), and "Rain"(13%). Therefore, it was clearly understood that the fishers' community of the river Meghna was primarily vulnerable to anthropogenic problems rather than natural calamities

Table 18 Distribution (%) of HH faced problems during fishing

Sources of vulnerabilities	Village				
	Baiday para	Shatviya para	Loshkordi	Vobanipur	Ismanichar
River water pollution	100	71.4	95	100	100
Navigation of large vessels	53.8	71.4	65	70	84
Dredging activity	84.6	78.6	25	70	48
Social conflict	50	78.6	45	40	48
Strong wind action	34.6	0	30	40	48
Erosion	42.3	14.3	0	30	56
Increased temperature	34.6	28.6	20	10	36
Current jal	38.5	0	25	40	24
Construction of Meghna bridge	19.2	0	20	40	36
Flood	11.5	0	15	30	40
Heavy current	7.7	0	15	10	28
Rain	7.7	0	10	10	28

All fishers of Baiday para, Vabanipur and Ismanichar responded 100% to water pollution as a source of their vulnerability (Table 18) that means they were the greater victim of water pollution than rest three villages. Fishers of Ismanichar (84%) were more vulnerable to the navigation of large vessel than any other village. Highest percentage of fishers (85%) of Baiday para reported against dredging activity. Land erosion, flood, heavy current and rain harmed most to the fishers of Ismanichar (56%, 40%, 28% and 28%, respectively).

3.7.1 River water pollution of Meghna

With the development of our country, the number of mills, factories is increasing at an alarming rate. The harmful disposal of these industries is affecting the aquatic ecosystem and the lives of the peoples who live around those areas badly. The river Meghna was thought to be pollution free before but for the last few years, the river water is also getting polluted for various anthropogenic causes and if this rate of pollution continues, the river Meghna will no longer be different than dangerously polluted Buriganga river.

Table 19 Chemical analysis of water sample collected from Meghna ghat, Meghna river (Source: MOFE 2015).

Date	Properties of river water									
	pH	EC	TDS	DO	BOD	Alkalinity	Chloride	TS	SS	Turbidity. NTU
May 2015	6.51	115.7	48.20	5.9	3	16	10.07	74.2	26	13.16
July 2015	6.51	115.7	48.2	4.8	2.0	20	10.07	95.2	47	-
September 2015	6.71	89.2	44.2	5.5	1.3	22	8.83	69.2	25	-
Oct0ber 2015	6.92	87.1	39.3	5.5	1.3	18	12	57	18	15
December 2015	6.62	102.6	49.9	5.8	1.3	56	7.99	63.9	14	4.10

pH ranged between 6.5 and 7 (Table 19). Electrical conductivity (EC), biological oxygen demand (BOD), total suspended solid (TDS) and turbidity had decreasing trend while levels of chloride, total alkalinity and total dissolve solids were increasing.

Table 20 Concentration of heavy metals in the Meghna river water (Hassan ekt al. 2015)

Heavy metals	Concentration (mg/L)
Fe	1.0224
Zn	0.0346
Cr	0.0088
Mn	0.003

The concentration of Fe in the river Meghna was found 1.0224 mg/L (Table 20) followed by Zn (0.0346 mg/L), Cr (0.0088 mg/L) and Mn (0.003 mg/L) which was within tolerance limit except the concentration of Fe.

3.7.1.1 Sources of pollution

From the FGDs and questionnaire survey revealed that the sources of water pollution of the Meghna river were the release of industrial effluents from cement industries, pulp and paper mills, jute and chemical industries. Although those industries should have Effluent Treatment Plant (ETP) but the owners do not operate to reduce energy cost. The owners aggregate the effluents over many months and suddenly discharge into the river systems which cause severe pollution to the river Meghna indicated by mass mortality of small to even large fishes and damage of the nets and other fishing gears. Paper mills factories were found to be mainly responsible for river water pollution (MOFE 2015). The river Meghna was used as a dumping ground for garbage. Ballast water from ship, steamer and launch also polluting the river water. As a result, the concentration of heavy metals and many other harmful chemicals were getting increased.

3.7.1.2 Effects of water pollution

Water pollution had a large impact on the river Meghna. After discharge of the effluents from the industries, water color turned into deep black and it remained for two to three days. Unpleasant odors released from the water. Fish of all sizes, from larvae to large died after the discharge. Fishermen could not catch any fish for nearly 15 days after one discharge and no income in those days. In winter season, the impacts of water pollution were found greater than rainy season. Water flow rate lowers in winter than in rainy season. Fishermen largely depend on the water for their various types of household purposes. After using polluted water, fishermen were easily attacked by various types of diseases, especially skin disease. Natural propagation has also been reduced as claimed by the fishermen. Fishermen of both upazila claimed that many species of fish are not found currently which were found before. Fish like Tekchanda , Soto pangus, Fewoa, Iar were not found (Source: FGD).

3.7.2 Navigation of vessels and ships

Fishermen of both upazila marked navigation of the large vessels as the second source of vulnerability (Figure 24%). The river Meghna has been using as the most important

waterway by many small to large vessels, motorized engine boats and cargos from Dhaka to many other parts of the country.

3.7.2.1 Effects of navigation of vessels and ships

Large vessels create large waves which affect fishermen's capability in staying over boat and maintaining stability during fishing along the river side.

The main adverse effect of the navigation was claimed by the fishermen is the damage of fishing nets costing more than 15000 TK which was needed just to mend a net. Many fishermen claimed that their boats were broken down each year for this reason.

Navigation of large vessels and ships also caused river erosion by creating large waves which caused river bank erosion. Fishermen also claimed that they noise the environment by their strong whistle which disturbed the aquatic system of the river. Deaths of many fishermen occurred during last few years for the uncontrolled navigation problem by those ships, cargo, boats and large vessels.

3.7.3 Dredging river bed

Many commercial companies were found to dredge the river bottom excessively for sand.

3.7.3.1 Effects of dredging

Many fishermen claimed that due to river dredging, the depth of the river has increased. Fish has moved to the deeper area. As a result, netting became more difficult and futile. After dredging, the banks of the river get covered by sand. Fishermen could not cultivate any agricultural product or could not rear any livestock; damaged nets, broken fishing traps etc. were common phenomenon in those areas. The most harmful effect of dredging was river bank erosion. Fishermen of Baiday para claimed that they lost around 2 to 3 houses every year for river bank erosion resulting from dredging. Erosion widens the width of the river more than 2 feet every year.

3.7.4 Social conflict

Conflicts among fishermen created mainly due to religion such as between Hindu and Muslim fishermen. Sometimes, conflicts were also made between poor fishermen and local or political leader, or between fishermen of two villages. Muslim fishermen were more dominant over Hindu fishermen. Hindu fishermen were not allowed to fish in every area of the river, though the river was open to fish for all. Sometimes Muslim fishermen attacked the Hindu fishermen for fishing in so called "no fishing zone" for the Hindus.

Fishermen from another region came every year at a certain time to catch fish on that area by bribing the local or political leaders. As a result, local fishers were not allowed to fish that time by those leaders.

3.7.4.1 Effects of social conflict

Some fishermen got seriously injured as fighting occurred often among them. As the Hindu fishermen were dominated by the Muslim, their economic condition getting worse over years. They theft boat or net each other as a revenge which amounts a lot of money in both sides.

3.7.5 Strong wind action

Fisher's community of the river Meghna was also found vulnerable to climate variability. Strong wind action was one of them. Fishermen had poor adaptive capacity against strong wind action. Strong wind creates strong waves. Wind speed may increase even up to 60 km per hour (Source: FGDs). This happened during (March to June) bangla Choitro to Joishto.

3.7.5.1 Effects of Strong wind action

Fishermen died by sudden attack of strong wind during fishing in the middle of the river. Strong wind created large strong waves. They left the boat and tried to reach the river bank. Some were failed to do that. Drowning of boat was another adverse effect of strong wind. For strong wind action boating became really hard. Fishermen lost their fishing net too. When the speed went really high, they had to stop fishing for those days. They had no income for those days. They had to rely on NGOs to borrow loan. Some fisherman of Baiday para said that it had a positive side too. During this period of strong wind they caught increased number of Hilsha fish.

3.7.6 Erosion

Erosion of the Meghna river bank happened for various anthropogenic and natural causes. Fishermen having large land area were mostly vulnerable due to land erosion (FGD).

3.7.6.1 Causes of river bank erosion

Dredging activity of the river is one of the main man-made reasons responsible for bank erosion. Continuous dredging in the river bank loosed the soil compact and river erosion happened. Navigation of ships and vessels created large and strong waves which were found also responsible for river bank erosion. Besides, seasonal variations of water level,

bank material consisting of loosely packed sand and silt and floods caused river bank erosion too.

3.7.6.2 Effects of river bank erosion

Homestead lands of fishermen were destroyed every year by bank erosion. One fisher lost his homestead land three to four times due to river bank erosion on average (FGDs). Hutton and Haque (2004) found that more than 40% of their study respondents had experienced displacement at least three to four times, 36% moved between 5 to 10 times and 14% at least 10 times. Fishermen had to fall into debt. They had no available land for agricultural or livestock rearing purposes in both upazila. Erosion in one area caused siltation of another area. Due to siltation, the water depth of that area reduced. Therefore, the fish habitat got changed. As the erosion mostly happened at night, respondents of Ismanichar claimed that they had to fall on a great danger without having any previous notice. They loosed their house and everything within seconds. Some fishermen of Baiday para and Ismanichar had to leave their paternal homestead for this erosion.

3.7.7 Temperature

Around 30% fishermen of two study upazila said that increasing temperature had an adverse impact on them. In bangla month Baishakh and Joishto, surface water temperature got increased. Bhuian et al. (2008) reported that as a consequence of climate change the water temperature has increased that caused reduction of water flow and a result spawning and nursing grounds of fishes have been drastically affected in recent years. In winter, reduced temperature had also an adverse effect on fish and fishers.

3.7.7.1 Effect of changing temperature

As the surface water temperature got increased, the number of surface feeder species got reduced. High temperature reduced the level of dissolved oxygen in water, some fishes move to deeper area for avoiding excess heat and limited oxygen. Catch per unit effort of the fishermen also reduced. They had to fish for more time than before to catch same quantity amount of fish. In summer season, fishing became tougher for the fishermen for sun heat. As a result, fishing duration got reduced. Some fishermen claimed that they easily got sick for fishing in high temperature. On the other side, Catch amount greatly reduced in winter. As a result of low temperature, metabolism and growth rate of the fish reduced in winter (Haler and Hardy, 2002). Breeding performance of the fishes also got reduced. Fishers also reported that they could not go to fish in winter season due to cold and dense fog. Fisher's daily income turned into zero in winter season. They had to take

loan from NGOs or relatives or other to maintain their family expenditure. Sometimes large ship or steamer could not see fish boat or net in morning due to dense fog, net or boat even fishermen got injured seriously for it.

3.7.8 Increased use of Current jal and Moshari jal

Fishermen of one area blamed another area's fishermen for using Current jal (gill net) and Moshari jal (Seine net). They also complained that fishermen from very distant area came and fished by using those net. Moshari jal (seine net) had potential negative impact which may consist of by-catch/discards (undersize specimens, no marketable specimens, non target species, etc.) and results from the use of a large net, with, frequently, too small meshes, in coastal waters (FAO 2017). Current jal means fishing net made of monofilament synthetic nylon fiber of different mesh sizes (The Protection and Conservation Fish Act. XVII, 1950).

3.7.8.1 Effects of increased use of Current jal and Moshari jal

As those net had a very small mesh size, all sizes of fish from fry to large were caught by this kind of net. The effect of using this net lasted for more than 2 to 3 months indicated by no catch over next few months.

3.7.9 Construction of the Meghna Bridge

Nearly 23% fishermen thought that construction of the Meghna Bridge had a negative impact on the Meghna fishers' community.

3.7.9.1 Effects of Construction of the Meghna Bridge

HH survey and FGD found that the effects of the construction of Meghna Bridge are increased amount of sack near the Meghna bridge reduced water depth from 90 feet to 25 feet. Thus fishes from the down do not pass to the upper. Fishermen of Sonargaon upazila mentioned that their catch has reduced than the fishermen who lived on the down the bridge. Because of the large pillar of the bridge, normal water flow of the river has been changed. Rivas et al. (2012) reported that Bridges do not allow water to flow normally. It created a great vortex into water which sometimes tears off fishing net and made netting difficult.

3.7.10 Flood

Though flood did not occur as much as before but during monsoon season some low land area of the study areas got flooded. Especially the fishermen of Ismanichar who lived very close to the river bank said that during heavy rain river water flooded their homestead land. Fishermen of Baiday para mentioned after 2008, there were no harmful

floods. According to Dai et al. (1997) some 30 to 50 % of the total land surface is flooded every year during wet monsoon.

3.7.10.1 Effects of flood

According to the findings of the FGD and questionnaire survey, effects of floods were Riverbank erosion, House and land property inundated, Fishermen had to stop fishing for days, some fishermen said that in some points flood was also a blessing for them. Increases amount water increased the availability of fish. During flooding fishermen were more vulnerable to water borne diseases like diarrhea, dysentery. According to the responses, around 30.5 % fishermen were affected by diarrhea and 21% by various types of skin diseases.

3.7.11 Heavy current

Around 13% of fishermen respond that heavy current was a problem for them. Strong wind creates strong current into the river.

3.7.11.1 Effects of heavy current

Netting became difficult for the fishermen. Heavy current sometimes tear off the fishing net which coasted a lot amount of money to the poor fishermen. Some fishermen mentioned that reduction of current velocity during winter also a problem. Siltation occurred; catch amount got reduced for four months at least.

3.7.12 Rainfall

3.7.12.1 Effects of changing rainfall pattern

Fishermen mentioned that the period and duration of raining had a great impact on fisheries.

Heavy rainfall increased the availability of fishes. On the other side, late rainfall caused a great problem to the fishers. It hampered the successful reproduction of many fish species, so fish catch amount decreased. Fishermen could not go for fishing during heavy rain. As they were not qualified for any other occupation, they had to remain jobless for those days which make them more vulnerable. Some rains are thundery. Fishermen of Baiday para said that they lost two fishermen last year for thunderstorm and one got seriously injured, got hearing disability and burned half pat of his body ; they also said that the number of thunder got increased than previous, as a result they were afraid of fishing during rainy season because of thunder.

3.7.13 Other vulnerabilities

3.7.13.1 Overfishing

The number fishermen of fishermen were increasing in both areas as they were not willing to go anywhere because they lacked the quality to do other works. Fishing pressure also increased.

3.7.13.2 Projects for supplying water to Dhaka from river Meghna

WASA is planning to make an entry point in Meghna ghat to supply water to Dhaka city, which will be more hazardous to the fishermen who dependent on Meghna.

Dhaka Water Supply and Sewerage Authority (DWSSA) planted a water intake point on river Meghna for supplying water to Dhaka. Meghna River will account for more than 40% of the raw water for this plant by 2021.

3.8 Links between Assets, Income and vulnerabilities due to water pollution among land classes

This radar diagram (Figure 25) is a descriptive rather than quantitative technique to examine the links between the four components of livelihoods. The figure is made from the total value of all tangible assets, total annual HH income, total HH income from fishing and vulnerabilities due to water pollution. The figure displayed an overall likelihood status of the fishers and the relative importance of asset, income and vulnerabilities due to water pollution.

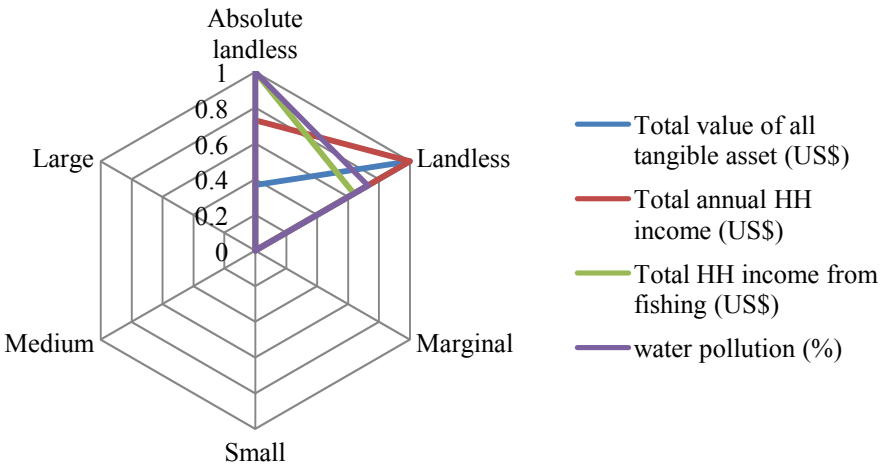

Figure 25 Descriptive links between assets, income and vulnerability due to water pollution of the fishers surveyed in villages of Bangladesh.

All surveyed fishers were only absolute landless and landless. Landless fishers had higher asset holdings than did the absolute landless group. Similarly, total HH income was also higher in landless fishers than in the landless group. However, total HH income

from fishing was higher in absolute landless group than that of landless group that could be due to their total dependency on fishing. Landless fishers had other sources of income than fishing. Since absolute landless fishers depend mostly on fishing that is why they claimed for maximum water pollution from neighboring industries.

3.9 Impact of vulnerability on fish

Fishermen of both district (100%) mentioned that within 10 years catch amount of fish got catastrophically changed and fishers blaimed many industry and factories for polluting river water.

3.9.1 Impact on fish catch

Amount of daily fish catch was found to reduce. Fishermen blamed pollution of the Meghna river water by industries was mainly responsible for this.

3.9.1.1. Comparison of fish catches over ten years duration

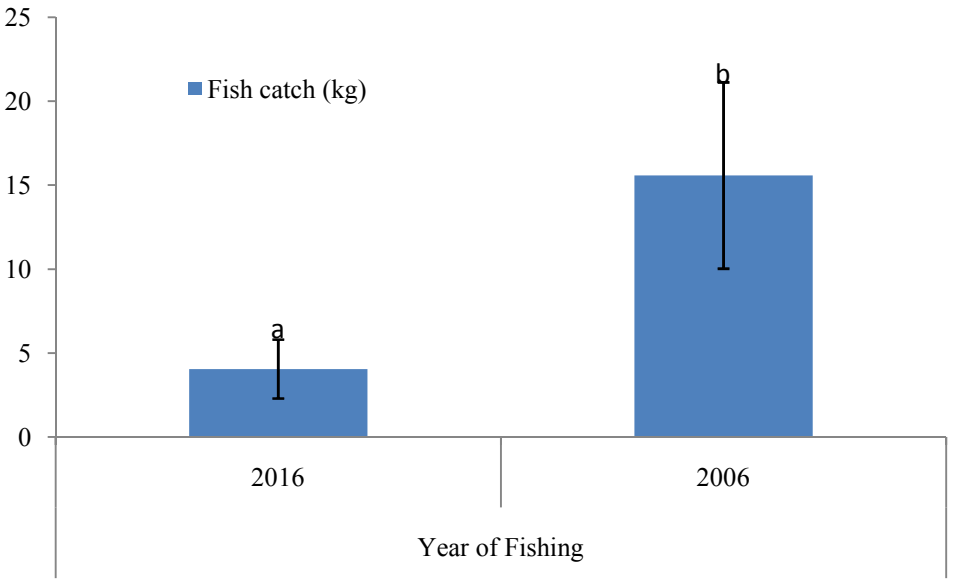

Figure 26 Hilsha catch (*Nenuacosa toil*) over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean daily catch of Hilsha (*Nenuacosa toil)* reduced by 15.58 kg to 4.05kg (Figure 26) over the one decade.

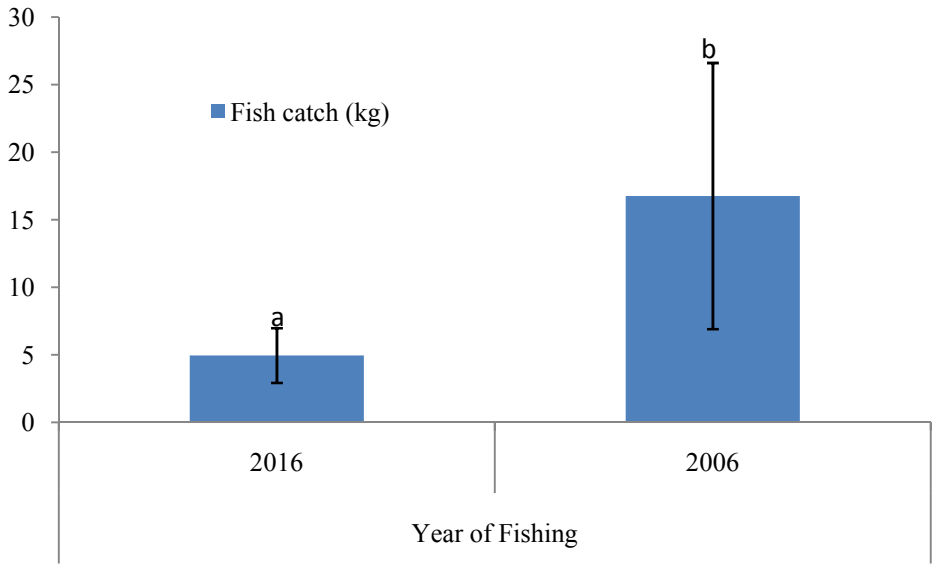

Figure 27 Chewa catch (*Pseudapocryptes elongatus)* over 10years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean daily catch of Chewa (*Pseudapocryptes elongatus*) reduced 16.39 kg to 4.78kg (Figure: 27) within last 10 years.

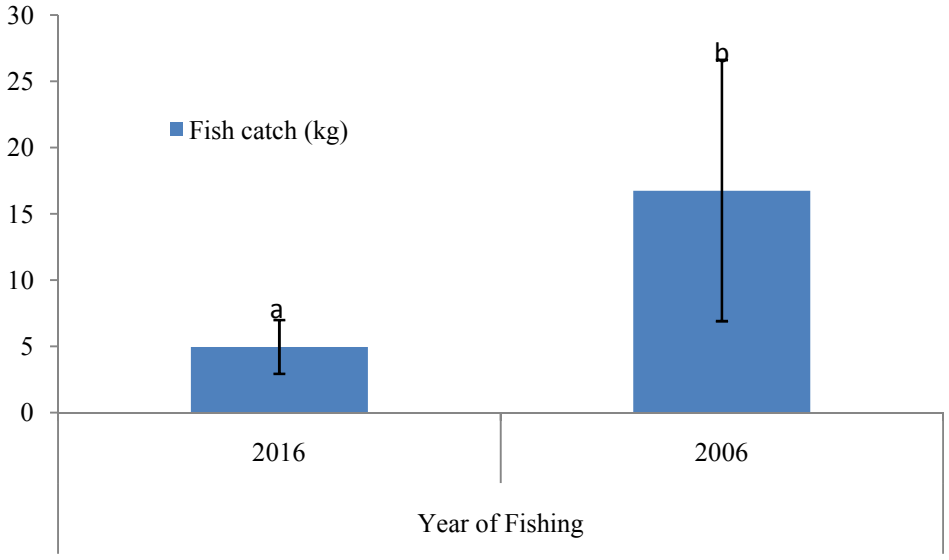

Figure 28 Kachki catch (*Corica soborna*) over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean daily catch of Kachki (*Corica soborna*) reduced 16.75 to 4.95 kg within last 10 years (Figure 28).

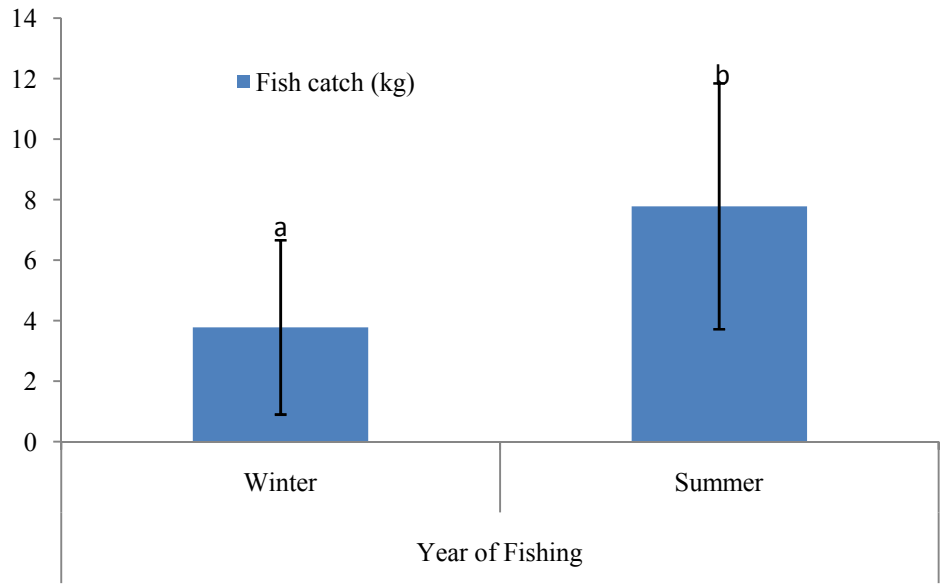

Figure 29 Chapila catch (*Gudusia chapra)* over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean daily catch of Chapila *(Gudusia chapra)* reduced 15.89kg to 3.90kg within last 10 years (Figure 29).

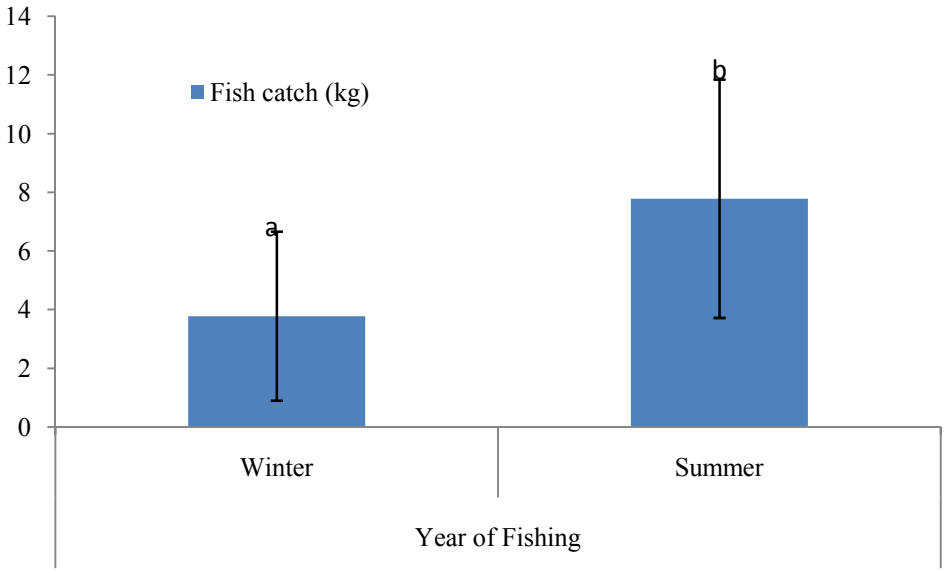

Figure 30 Gura echa catch (*Macrobrachium lamarrei*) over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean daily catch amount of Gura echa (*Macrobrachium lamarrei*) reduced 8.07kg to 2.14 kg within last 10 years (Figure 30).

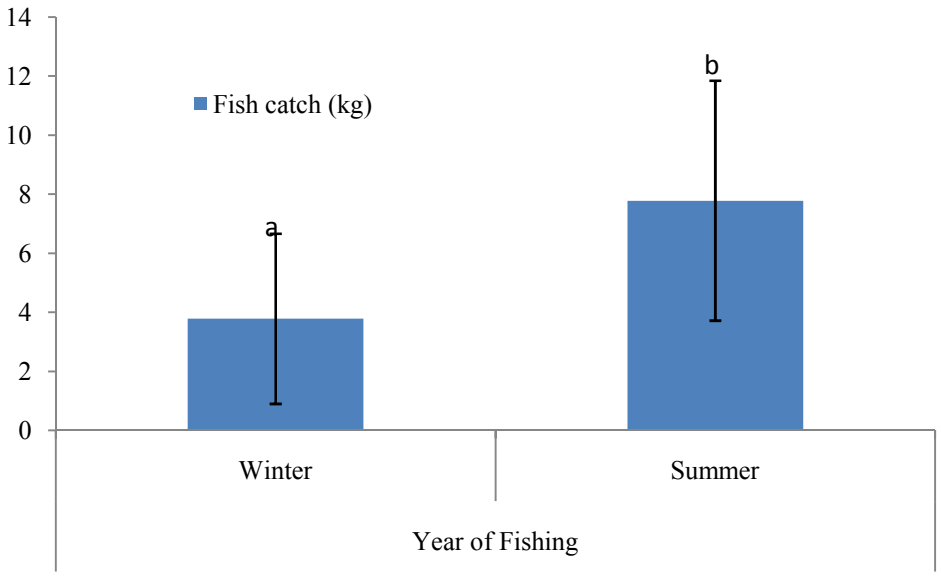

Figure 31 Bele catch (*Awaous grammepomus*) over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean daily catch amount of Bele (*Awaous grammepomus*) reduced by 9.21 kg to 1.29 kg within last one decade (Figure 31).

3.9.1.2 Seasonal comparison of fish catches

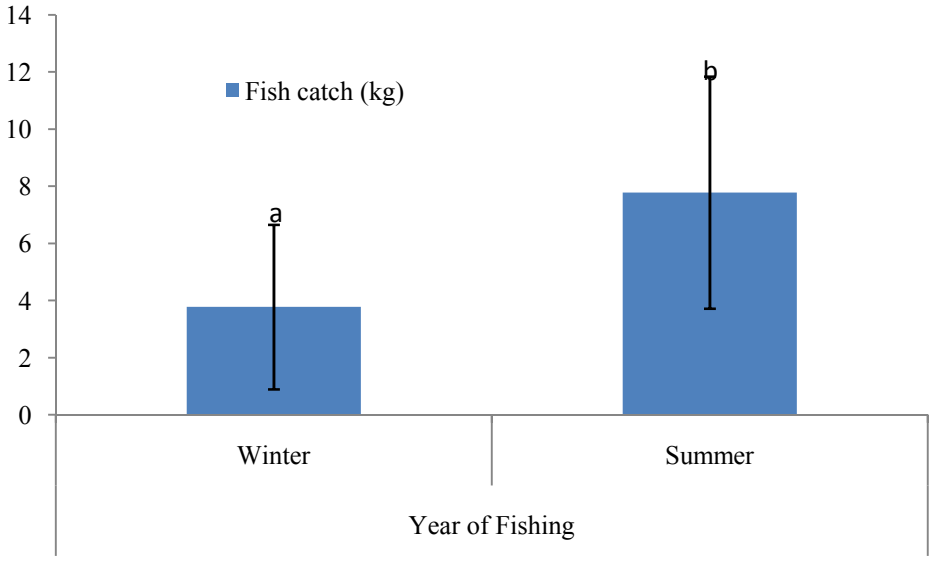

Figure 32 Summer catch over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean present daily catch amount was 7.66kg in summer where it was 21.69 kg before 10 years (Figure 32).

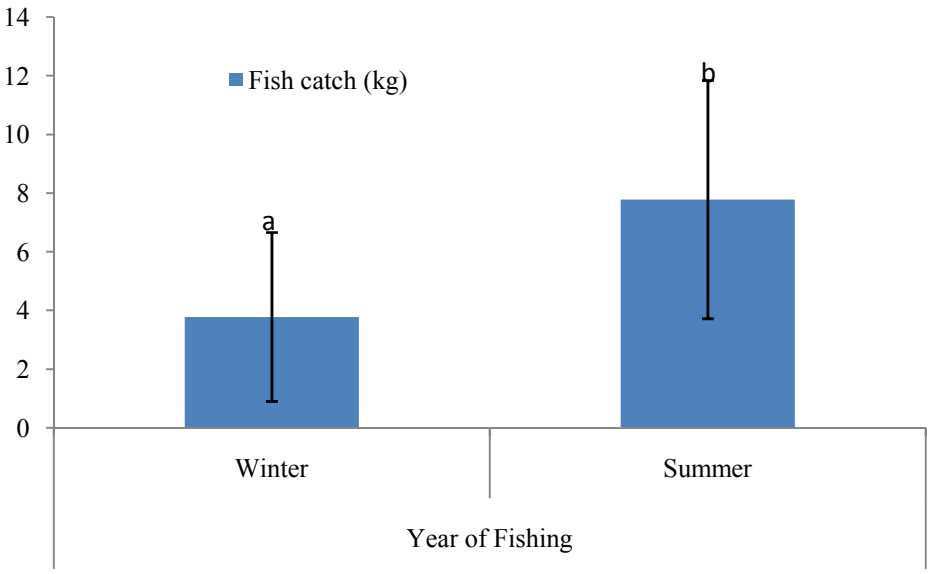

Figure 33 Winter catch over 10 years duration. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean present daily catch was 3.78 kg in summer while it was 9.62 kg before 10 years ago (Figure 33).

3.9.1.3 Comparison of current daily fish catch between summer and winter season

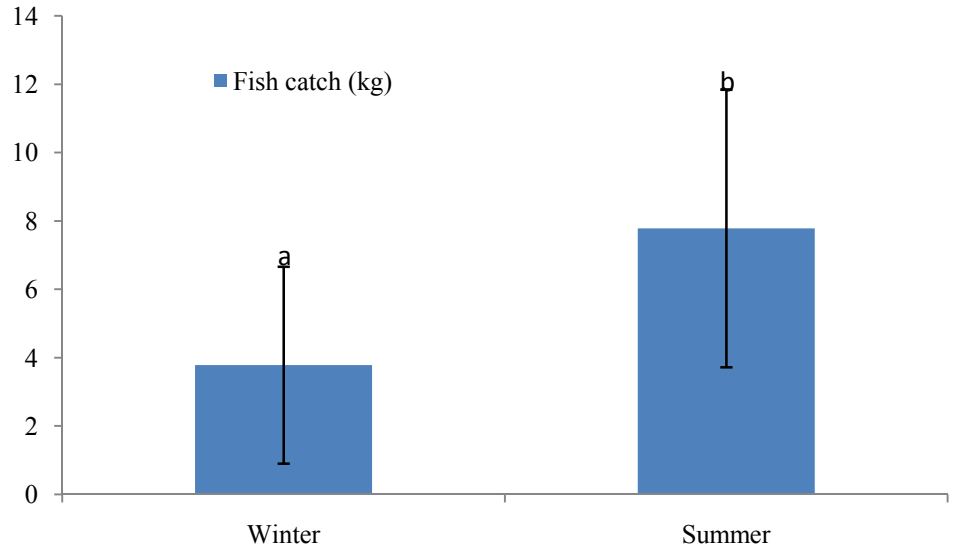

Figure 34 Current daily fish catch in summer and winter season. Bars (mean ± SD) with different superscript letters denote significant difference (t-test; p<0.05).

Mean current daily catch amount was 3.78 in winter and 7.78 in summer and standard deviation was 2.887 and 4.062 (Figure 34).

3.9.2 Impact on fish health

Most fishers (29%) told that fishes were mainly suffering from "fin and tail rot" problem (Figure 35). Chemically polluted water and presence of organic waste was could be

responsible for these types of disease outbreak. Some 25% respondents reported ulceration on fish body. Fishermen also claimed that sizes of the fishes were decreasing over duration (22%). Catch of big fishes were fewer. Some fishes had larger head size compared to their body (16%) that indicates imbalanced nutrition. Some fish were found to have damaged gill (5%) and liver (3%).

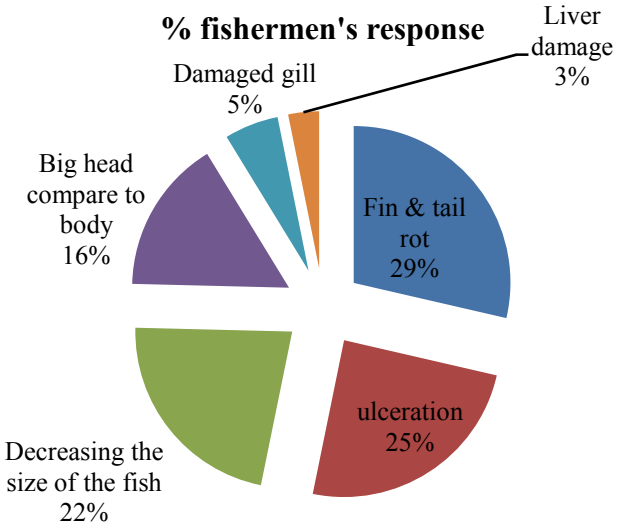

Figure 35 Percentage of fishermen responses about fish health problem on study areas.

Table 21 Fishers response (%) of fish health problem by villages.

Village	Fish health problem					
	Big head comparing to the body	Decreasing size	Ulceration	Fin & tail rot	Liver damage	Gill damage
Baiday para	7.4	9.5	10.5	11.6	0	0
Shatviya para	0	2.1	4.2	5.3	1.1	0
Loshkordi	2.1	5.3	3.2	4.2	0	2.1
Vabanipur	5.3	4.2	6.3	5.1	3.2	2.1
Ismani char	6.3	8.4	8.4	11.6	0	3.2

Most of the fishermen of Baiday para village (11.6% among all villagers; Table 21), Shatviya para village (5.3%) and Ismanichar (11.6%) reported that fishes were mostly found having fin and tail rot. On the other hand fishers of Loshkordi (5.3%) and

Vabanipur (6.3%) reported decreased size and ulceration on the fish body were main problem found in fish.

3.10 Adaptation strategies

3.10.1 Adaptation to water pollution

The fishers did not have any adaptation strategies to cope with water pollution. They had to stop fishing for more than one month after one discharge of industrial effluents. Only 16% fishermen had other sources of income (Source: survey), rest of the fishermen had to take loan or spent savings for supporting their family. Some told that they protested sometimes against those industries who were polluting the river but it was futile. They were threatened by the local or political leader for raising their voice. They mentioned that it's were out of their hand. They wanted to take government some necessary actions against the industry/miil/factory as soon as possible.

Department of Environment (DoE) under the Ministry of Environment and Forest (MoFE) is responsible to monitor and control water pollution of the river systems and enforce the Environment Conservation Act, 1995 (amended in 2010) if violation by industry and others sources. DoE does not have sufficient staff for regular monitoring, for example, suspension of factory operations or imposing fines besides this are highly politically sensitive, therefore they took limited or no actions against violators.

MoFE reported that paper and cement factories are mainly responsible for polluting the Meghna water although all factories had ETPs but they did not operate to save energy cost.

3.10.2 Adaptation to "change of rainfall pattern"

Delayed rainfall had some serious impact on fisher's livelihoods. Since the propagation of fishes reduced, fish catch also reduced due to low natural recruitment opined by the fishers. To compensate they increased fishing hours. Most fish from 4 pm to whole night. As the catch has reduced 16% fishers got involved with other occupations. Few worked as day laborer, some pulled rickshaw while some worked in factories. But most fishermen remained workless.

3.10.3 Adaptation to other vulnerabilities

Embankment construction

Although both upazila had embankment to reduce erosion, it was found non-functional due to faulty and unplanned construction. Many areas of both upazila are still under serious risk of erosion. Every year Meghna expands in width. In some areas such as

Ismanichar the embankment remains under water due to increased water level. In Baiday para and Shatviya para village, the area without embankment got eroded.

Livelihood diversification

Most of the fishermen (94%) of both upazila were only involved in fishing. The fishers could not fish for months due to water pollution including the banned period. While some were found to mend their net or repairing boat during idle time, few others involved in alternative opportunities like rickshaw pulling, land labor or working in the factory.

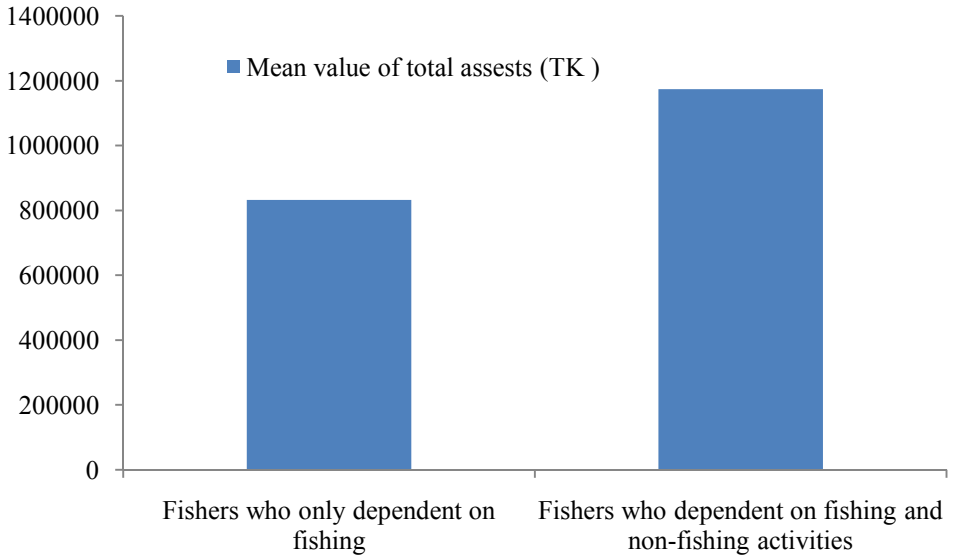

Figure 36 Mean value (TK) of total assets of the fishers involved in only fishing and fishing and non-fishing activities.

It was found from the investigation that the fishermen who were involved with non-fishing activities besides fishing had a better livelihood condition than others. The mean values of total assets of those fishermen were relatively higher (1200000 TK; Figure 36) than those who were only dependent on fishing (800000 TK). It was also found that fishermen dependent solely on fishing were more vulnerable than others. Diversification through occupational multiplicity is also a primary means by which many individuals reduce risk and cope with future uncertainty (Elis, 2000; Barrett et al., 2001; Wouterse and Taylor, 2008).

Migration

When the fishers could not catch sufficient fish to maintain their livelihoods due to increased pollution or other vulnerabilities, some 20-30 fishermen formed a group and migrated to Mawa or Chandpur for fishing. They usually took their boat and net with

them. To fish in an area other than their own, they had to pay to the local people or had to share a percentage of their profit.

Education

Education had a great impact on the livelihood status of the fishermen. Literate fishermen had a greater amount of total asset and savings than illiterate fishermen (Table 22).

Table 22 Mean value (TK) of total assets and savings of fishermen by levels of education.

Level of education	Total asset	Savings
Illiterate	734537.50	8211
Can sign only	941095.71	11824
Primary	1004500.00	9568
Secondary	1316025.00	15000

Mean value of total assets was lowest for the illiterate fishermen (734537.50 TK) and highest for the fishermen who had received secondary education (1316025.00 TK).

Similar results were found after calculating the total amount of savings of the fishermen. Illiterate fishermen had lowest mean savings (8211 TK) where it was much higher for the fishermen who could sign (11824 TK), fishermen who had received primary education (9568 TK) and highest for the fishermen who had received secondary education (15000 TK). It was because literate fishermen had more ability to cope themselves to difficult situations. They had more quality to switch their job when needed. Most of the literate fishermen had a tendency to save some money from their income for future needs.

Borrowing loans

Most of the fishermen of both districts received loan from NGOs, govt. bank, local money lender and sometimes from relatives. They informed that around 6 months in a year they had a higher amount of catch and the daily income of this period was also high but for the rest of 6 months the catch amount decreased radically. Especially at the winter season or after the release of effluents from factories, the catch amount turned into zero. To support their family in this period they usually took loan.

Using more efficient fishing tools

Due to heavy current and navigation of launch and steamer in the river, most of the fishermen faced the common problem of tearing apart their net. As the cost of a net is very high especially for a poor fisherman, they faced serious economic threat.

Fishermen of Baiday para informed that they used more strong thread for mending net to overcome this problem. Some fishermen used fishing trap and fishing hook besides net to add their income. Though it was only seen among Muslim fishermen. Hindu fishermen were only dependent on net.

Change in fishing techniques

Fishermen of Ismanichar village used a different fishing technique called "Jhop". They gathered water hyacinth in one place of the river and bounded them with bamboo stick and ropes. Fish of all sizes gathered there. Sometimes they fed to the fish, as a result the number of fishes increased within few days. After few months, they could easily caught the fish by surrounding the place with net and earned a higher amount of profit without any big expense.

Change in fishing time

Around 90% fishermen of both districts were found to change their fishing time as an adaptation strategy against these vulnerabilities. They normally went for fishing from 4 pm to whole night. They said that moon light night was better for catching fish. They also observed that they could catch more fish during dark night than day light. They mentioned that fishing at night also protected them from heat of sun.

Change in house construction methods and materials

In Ismanichar, all fishermen's houses were of different style. The floors of the houses were made of wood or cement and those were supported by cement pillar. Those pillars were 1 or two feet in height and 5 to 6 inch in diameter. They told that it was a protection against flood. During monsoon, the water flooded the village and the level of water increased more than 2 feet. To protect their house from flood they used that technique on making their house.

Women's participation

Besides doing household chores, women were also found to help their husband in fishing activities like net mending, making fishing trap etc. Women also reared livestock animals. Some women were found tailoring by hand machine. They did that to add some

extra income to improve their household condition, though the numbers of them were very few. Only six to seven women were found in Ismanichar with this quality.

Permanent migration

Some old fishermen complained that once the Meghna river was the best river for fishing than any other river in this country and they had very few natural hazardous problem compared to other areas. They used to earn a good amount of money for maintaining their family. But these days, the scenery changed. For various types of human activities, the condition of the Meghna river was worsen day by day. The catch reduced highly and they became totally dependent on loan. Some fishermen of Loshkordi village were found to be permanently migrated from this village to another area and in Ismanichar and Baiday bazaar village some fishermen were found planning to leave this village. They were trying to buy land in another area. Another reason of fishermen migration was land erosion too.

Covering yard with sack

The fishermen of Baiday para and Ismanichar were in big danger for land erosion. Some house yard was found covered with sack filled up with soil or sand. They informed that it was for saving the homestead land from soil erosion.

3.11 Potential adaptation strategies

To improve the livelihood status of fishermen, some necessary adaptation strategies should be followed.

3.11.1 Potential adaptation measures to water pollution

Government should establish a more collaborative, innovative, and enforceable system by involving all key stakeholders, including the industries themselves. Rewarding system to the polluters as a pollution control measure can be helpful to reduce water pollution; Ecologically Critical Area should be identified on the river Meghna to treat that place specially. Government should provide more support to DOE. Identifying major polluting industry, Promoting international cooperation to control water pollution will also be helpful.

Increasing water flow system (BWDB), under Ministry of water resources has already submitted a project titled "Augmentation of Buriganga flow by restoring links with Jamuna river", this type of management approach can be taken for the Meghna river. Besides that, controlling disposal of solid waste and using proper water treatment plants

in the factory should be ensured by industries. Govt. should take steps to moving tannery and other factories from river side.

3.11.2 Potential adaptation measures to other vulnerabilities

Increase the participation of women in non fishing activities

Women can perform other jobs beside household chores like making cloths, making traps for selling or other handicrafts.

Education

It is clear to all that education can change anyone's condition better than any other factor. Fishermen's awareness should be increased to educate themselves and their children. Educated fishermen have the ability to migrate their jobs other than fishing. It would be helpful decreasing their dependency on fishing. Educational institutes should be set up to these areas to improve their educational status.

Government support during banned period

During the ban period and off-season, fishermen had no other jobs to do. Government provides rice to the fishermen but they complained that all of them were not getting this facility and the amount of rice was lower than their demand. Besides, rice was not the only thing they need to maintain a family for that long time. Government should give loans to the fishers at a low interest rate and alternative job opportunities during off-period.

Extra involvement of fishers into non-fisheries activities

For fishermen with other qualities rather than fishing, give them the chance to involve with other business or work.

Making insurance

Increasing the practice of making insurance can help fishermen to survive on extreme hazardous moment.

NGO support

NGOs can support fishermen by supplying food aid, cash for work with less interest.

Commercializing livelihoods

Investment on poultry, livestock or others small business likes buying a shop with sharing.

Making local fishermen organization

With the equal effort from Hindu and Muslim fishermen making a friendly relationship with each other, they can avoid social conflict. By being united, they can stand against any hazard.

Public awareness

Public awareness should be increased through media or various publications to protect Meghna fishery.

Chapter 4

Conclusions and Recommendations

4.1 Conclusions

The present study was conducted to assess the sources of vulnerability and livelihood strategies of the fishers of the river Meghna of Sonargaon and Gojaria upazila to identify the adaptation processes they follow to avoid the impacts of vulnerabilities. Without adaptation, the effects of increased level of water pollution, climate change and other anthropogenic changes will result a great loss to the lives and assets to the fishers' community of Sonargaon and Narayanganj district. The major findings of the study are:

1. The fishers' community of Sonargaon upazila in Narayanganj district and Gojaria upazila in Munshiganj district were mostly affected by various anthropogenic causes rather than climate variability. Water pollution of the river Meghna, navigation of vessels and ships, illegal dredging, social conflicts, use of current jal, construction of the Meghna bridge were the main anthropogenic activities that jeopardizing fishers lives.
2. Water pollution of the river Meghna by the release of industrial effluents from cement industries, pulp and paper mills, jute and chemical industries was their main problem.
3. Species diversity and catches were decreasing year to year specially over last decade of the river Meghna.
4. Some fishes e.g. Soto Pangus, Fewa, Tek Chanda are totally extinct from those area.
5. The fishers' community was found as a highly disadvantaged group of the society and their livelihood standards were very low. They were the people of lower economic strata.
6. Fishers who are dependent on only fishing activities were found to more vulnerable to various anthropogenic and climate changes than fishers who were involved in both fishing and non-fishing activities.
7. The number and catches of fish vary between seasons which increase at pre-monsoon but reduced in winter.
8. Literacy rate among fishers were slightly lower than national literacy level. Educated fishermen had a better livelihood status than illiterate ones. It indicated that educated fishermen had more adaptive capability to face vulnerabilities.

9. The present survey found out livelihood diversification may be the best adaptation strategy against various types of vulnerabilities.
10. Permanent migration was another option for the fishers to avoid the impacts of those vulnerabilities.
11. Most fishers were absolute landless.
12. Government support during off-season may help to resolve their distress.

4.2 Recommendations

Based on the major findings and observations, the following recommendations are made:

1. Government should take necessary actions to control water pollution are being caused by many industries.
2. Government and NGO's should train the peoples to cope vulnerabilities.
3. Ecologically Critical Area should be identified on the river Meghna to treat those areas specially.

References

Ahmed, M.K., 2003. A checklist of the prawn and shrimp fauna of Bangladesh with some new records. Freshwater fisheries research station Chandpur, Bangladesh.

Alan, J.D., Flecker, A.S., 1993. Biodiversity conservation in running waters: Identify the major factor that threatens destruction of riverine species and ecosystems. Bioscience.43, 32-43.

Bangladesh climate change strategy and action plan, 2009. http://www.climatechangecell.org.bd/Documents/climate_change_strategy2009.pdf

Bangladesh Hydro Medit, 2014. Volos, Greece. 318-323.

Bangladesh population and housing census, 2011. Bangladesh Bureau of Statistics. Vol.4.

Bangladesh Population Census, 2001. Bangladesh Bureau of Statistics.

Bangladesh population census, 1991: national series. Volume 2: union statistics.

Bankoff, G., Frerks, G., Hilhorst, D., 2004. Mapping vulnerability: disasters, development, and people. Routledge.

Barkes, F., Jolly, D., 2002. Adapting to climate change: Social ecological resilience in a Canadian western Arctic community. Conserve. Ecol. 5, 18.

Barrett, C. B., Reardon, T., Webb, P., 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. Food policy. 26, 315-331.

Bhuyan, M.S., Akhtar, A., Saim, K.M., Islam, M.S., 2016. Present status of socio-economic condition of the fishing community of the Meghna river adjacent to Narshingdi district, Bangladesh. J. Ent. Zoo. Stu. 4, 611-616.

Bundell, K., Maybin, E., 1996. After the prawn rush: The human and environmental costs of commercial fish farming. Christian Aid report. London.

Chambers, Robert, and Gordon Conway, 1992. Sustainable rural livelihoods: practical concepts for the 21st century. Institute of Development Studies (UK).

Chapman, D.C., Conway, G.R., 1992. Sustainable rural livelihoods: Practical concepts for the 21st century. Institute of development studies discussion paper. 296.

Cultural survey report of Gazaria Upazila, 2007. Banglapedia. http://en.banglapedia.org/index.php?title=Sonargaon_Upazila.

Dai, A., Fung, I. Y., Genio, A. D.D.,1997. Surface observed global land precipitation variations during 1900–88. J. CLIMATE. 10, 2943-2962.

Department of Fisheries (DoF), 2005. Annual Report, 2005. Department of Fisheries, Government of People's Republic of Bangladesh, Dhaka, Bangladesh.

Department of Fisheries (DoF), 2007. Annual Report, 2007. Department of Fisheries, Government of People's Republic of Bangladesh, Dhaka, Bangladesh.

Department of Fisheries (DoF), 2015. Annual Report, 2015. Department of Fisheries, Government of People's Republic of Bangladesh, Dhaka, Bangladesh.

Dewey, J., 1929. The Quest for Certainty. In J. Boydston, ed. The later works: 1925-1953. Carbondale, USA, Southern Illinois University Press.

Ellis, F., 2000. Rural livelihoods and diversity in developing countries. Oxford university press.

FAO, 2014. The state of the world Fisheries and aquaculture 2014: Opportunities and challenges. Rome: Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations.

FAO, 2017. Fishing gear types. Fisheries and Aquaculture department, Food and Agriculture Organization of the United Nations.

Becker, G.S., 1993. Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education. Third ed. Chicago, University of Chicago Press.

Hassan, M., Rahman, M. A. T., Saha, B., Kamal, A. K. I., 2015. Status of heavy metals in water and sediment of the Meghna River, Bangladesh. Amer. J. Environ. Sci. 11, 427-439.

Hewitt, K., 1995. Exclusive perspectives in the social construction of disaster. Int. J. Mas. Eme. Dis. 13, 317-339.

Halver, J. E., Hardy, R. W., 2002. Fish nutrition. Academic press.

Hughes, R., Adnan, S., Dalal-Clayton, B., 1994. Floodplains or flood plans. International Institute for Environment and Development, and Research and Advisory Services, London.

Huq, S., 2001. Climate change and Bangladesh. Science. 294, 1617-1617.

IPCC, 2011. AR4 SYR Synthesis Report Annexes.

IPCC, 2007. Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental

Panel on Climate Change, In: Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linden, P.J. and Hanson, C. E. (eds.). Cambridge, Cambridge University Press, UK.

IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Fifth assessment report.

Islam, S.,2003. Banglapedia: national encyclopedia of Bangladesh/chief editor, Sirajul Islam; managing editor, Sajahan Miah. Asiatic society of Bangladesh.

Jana B.B., 1994. Deposition of pollutants and their impacts on fisheries. Environmental Monitoring, Vol-2.

Kabir, K.M.R., Adhikary, R.K., Hossain, M.B., Minar, M.H., 2012. Livelihood status of fishermen of the old Brahmaputra river, Bangladesh. IDOSI publications. World appl. Sci J. 6: 869-873.

Mahmud, S., Ali, M. L., Ali, M. M., 2015. Present scenario on livelihood status of the fishermen in the paira river, southern Bangladesh: constraints and recommendation. Int. J. Fis. Aquat. Stud. 2, 23-30.

Martin, E.A., Ruse, M., Holmes, E., 1996. Oxford dictionary of biology. Oxford: Oxford university Press.

Mia, M. S., Yeasmin, F., Moniruzzaman, S. M., Kafi, M. F. H., Miah, M. I., Haq, M. S., 2015. Socio-economic condition of the fisher's community of Meghna river of Ashuganj Upazila in Brahmanbaria District, Bangladesh. J. Nat. Soc. Sci. 2, 42-47.

Mondal, M., Asadujjaman, M. D., Amin, M. D., 2013. Analyses of Catch Composition and Fish Marketing of the Meghna river at Ramgati Upazilla under Lakshmipur District in Bangladesh. Middle-East J. Sci. Res. 16, 1452-1461.

Osbahr, H., Twyman, C., Adger, W., & Thomas, D. (2010). Evaluating successful livelihood adaptation to climate variability and change in southern Africa. Ecol. Soc., 15(2).

Population Census Wing, BBS. http://en.wikipedia.org/mop/ndb/arpc9_ v1/tables04.htm .Retrieved November 10, 2006.

Rahman, M., Rahman, M. M., Hasan, M. M., & Islam, M. R., 2012. Livelihood status and the potential of alternative income generating activities of fisher's community of Nijhumdwip under Hatiya upazila of Noakhali district in Bangladesh. J. Bangladesh. Res. Pub. 6, 370-379.

Rahman, S.M.S. Golden Bangladesh –log in. goldenbangladesh.com.

Rashid, H., 2015. Geography of Bangladesh (second revised edition), university press limited.Dhaka.Bangladesh,1991. 529.

SCL Newsletter, 2000. Sustainable Coastal Livelihood Newsletter, Volume 1, No. 1. IMMLtd., University of Exeter. UK.

Stocking, M.A., Murnaghan, N., 2001. A handbook for the field assesment of land degradation. London, Earthscan Publications Limited.

The Protection and Conservation Fish Act, XVII ,1950.

Tongco, M.D.C., 2007. Purposive sampling as a tool for informant selection. Ethnobotany Research & Applications. 5,147-158.

UNESCO Education Sector, "The Plurality of Literacy and its implications for Policies and Programmes: Position Paper". Paris: United National Educational, Scientific and Cultural Organisation, 2004, p. 13, citing an international expert meeting, 2003, UNESCO.

UNESCO Institute for Statistics, 2015. Literacy Statistics Metadata Information Table.

Vogel, C., 2005. Seven fat years and seven lean years, climate change and agriculture in Africa.IDS Bulletin. 36, 30-35.

Williams, M., 2002. Climate change information kit. The united nations environment programme and the climate change secretariat (UNFCC) and sponsored by UNEP, the UN development programme, the UN department of economic and social affairs, the institute for training and research, the world meteorological organization, the world health organization, and the UNFCC. Geneva, Switzerland.

WMO, 2002. Scientific Assessment of Ozone Depletion: Global Ozone Research and Monitoring Project–Report No. 47, World Meteorological Organization, Geneva, Switzerland.

Wouterse, F., Taylor, J. E., 2008. Migration and income diversification: Evidence from burkina faso. WORLD DEV.36, 625-640.

Yamane, T., 1973. Statistics: an introductory analysis. New York.

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).

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).

Diversification - Diversification is the process by which a household increases the diversity (i.e. number) of its income generating activities (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 capital- 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.

Appendix B

QUESTIONNAIRE SURVEY

SECTION A. Address of the contact person for this questionnaire:

1. Name of the village:
2. PO:
3. Upazilla:
4. District:
5. Is this village is the birthplace of the head family member? : Yes(1)/ no (0)
6. How long has she/he been living in this area? :
7. Name of the head family member:
8. Name of the interviewee :
9. The relationship of the interviewee with the head member:
10. Religion : Islam(1)/Hindu(2) /other …….(3)
11. Age :
12. Date:

SECTION B: Typology of HH

Household size (total HH member):

Household information:

Name of the HH member	Relation	Sex	Age	Marital status	Education	Occupation

SECTION C. Asset holding of the household

1. Do your HH has ownership to land Y/N if Y

Area **Value (tk)**

Total land owned (decimal)

2. Livestock **number** **value(tk)**

- Cattle/buffalo
- Poultry/duck/pigeon
- Others (Specify)

3. Trees(2 years plus)
    - Mango
    - Jackfruit
    - Coconut
    - Others
4. Home appliance

Type	Number	Value
Watch		
Radio		
TV		
Fan		
Jewelries		
Shop		
Others		

5. If they have any fish related physical wealth like net/boat/fish drying yard/Arot/track/others? yes (1)/no(0).

If yes,

Fishing related physical wealth	Number of them

Fishing boat	
Net	
Total	

6. Have you your own house? Yes (1) / no(0)
7. If yes , then observation of the house condition not to ask

House condition	Number of them	Value(tk)
Kacha house(1)		
Semi pacca(2)		
Pacca(3)		

8. What is the condition of your sanitary facilities? Kacha(1) / semi pucca(2) / pucca(3)
9. Have you any vehicle for transportation? Yes(1) / no(2)

SECTION D.**Health**

- Do you drink tube-well water? Y/N , if Y, Own/Not
- Do you suffer from any disease? Y/N If Y,

Diseases	Yes/ no	Total amount of taka you spent for this disease?
Fever		
Diabetics		
Diarrhea		
Cold		
Physical pain		
Dysentery		
Kidney failure		
Liver diseases like hepatitis, jaundice		
Skin lesions		
Skin allergy and inflammation		

If others, please mention…		

SECTION E. What are the problems you face on fishing in the Meghna river?

I. If one of the problem is 'pollution of the river water'

Why you think it is a problem?

1. massive death of fish
2.
3.
4.
5.

Solution :

1.
2.
3.

II. If one of the problem is 'dredging activity' on the riverbed

Effect

1. Netting is difficult due to the increase of the depth: yes(1)/no(0)
2. Fish's presence on the deeper water: yes(1) /no(0)
3. Destruction of the house
4. Others

Solution:

1.
2.
3.

III. if one of the problem is 'the movement of steamer and launch'

Effect

1. Death of people
2. Drowning of the boat
3.
4.

Solution

1.
2.
3.

IV. if one of the problem is 'social conflict'

Effect

1. Hindu fishers have to give a percentage of the earning to the Muslim fishers
2. Attack when fishing
3.

Solution

1.
2.
3.

V. If one of the problem is 'strong wind action',

1. What is the frequency per year? .....
2. What are the effects?

Effects of storm	Yes(1)/ no(0)	Number of them on a year	Losses (tk)per year
1. Death of people			
2. Drowning of the boat			
3. Destruction of the house			
4. Others			

Solution:

1.
2.
3.

VI. Do you notice any change after the construction of Meghna bridge? Yes(1) / no(0)

If yes, what are the changes?

1. Hinders the movement of fish
2. Reducing water current
3. Others ……

Solution:

1.

2.

3.

VII. fishers coming from another area and using ‘mosharijal’ and ‘current jal’

Effects:

1.catch all sizes fish

2.

3.

Solution:

1.

2.

3.

VIII. Do you feel any change on temperature of this area for last few years? Yes(1)/no(0)

If yes, what is the impact of this increasing temperature?

Impacts	yes/no
1. Fishing gone difficult on day time	
2. Reduction on the amount of water	
3. Reduction on the abundance of water	
4. Others	

Solution:

1.

2.

3.

IX. Is erosion of the rivers bank occurs? Yes/no

If yes, what is the effect of erosion?

Impacts	yes/no
1. Decreasing the living area	

2. Decreasing the area for agricultural use
3. Others

Solution:

1.
2.
3.

X. Others

Effects:

1.
2.
3.

Solution:

1.
2.
3.

Problems	Yes(1) / no(0)	Rank
1. Pollution of the river		
2. Dredging activity		
3. Using Moshari& current jal		
4. Strong wind action		
5. Construction of the Meghna bridge		
6. Flood		
7. Rain		
8. Launch & steamer movement		

9. Temperature increase		
10. Social conflict		
11. erosion		
12. heavy current		
13. drought		
14. salt water intrusion		
15. others		

SECTION F. Do you notice any change on the biodiversity of the river?

a) What type of net you use for fishing?.....

b) Reduction of the species number of fish? Yes /No; If yes,

Present(1) or absent(0) now	Amount per catch at present	Amount per catch at past

c) TOTAL AMOUNT PER CATCH (DAILY):

Season	Catch amount(present)	Catch amount (past)

SECTION G. Do you observe any disease in fish? Yes/no

I f yes,

Disease	Yes/no	Percentage of diseased fish per catch
Big head comparing to the body		
Decreasing the size of the fish		
Ulceration		
Fin and tail rots		
Liver damage		
Damage in gill and epithelia		
If others,		

SECTION H. Household income

1. Annual income from the other source of the head member himself

Type of occupation	income

Note: use code of occupation

2. Household income from family members

Family members who contribute	Income source	Given time(month/ year)	Income/month	Observation

3. How much money do you income per month?.....tk.
4. How much money do you expense for family or for other maintenance?.....tk.

SECTION I. fishing activities

1. How many months do you catch fish in a year?.....months.
2. How much fish do you captured in a day? ……
3. How much do you earn in a day? ……..tk.
4. How much money you expense for catching fish in a day?.....tk.

SECTIONJ. Cash as asset

i. Do you have cash money as assets? Y/N if Y how much? …….(tk)
ii. Did you lent out money? Y/N if Y how much? ……(tk)

SECTION K. Access to assets

1. Sources of credit: Can you get credit from? Y/N if Y

Name of organization Amount (tk) Installment for repayment (tk)
Govt. Bank Private bank
NGO
Cooperative
Local moneylender
Other

2. What services do you have access to- health(1)/ education(2)/electricity(3)/training(4)

SECTION L. Indebtedness of the HH

1. Total outstanding loans till date (tk) and why?

SECTION M. Savings

APS/DPS	Insurance
Bank savings	
Small scale business	
Cash in hands	
NGO savings	

SELECTED FOR FGD: YES / NO.

THANKS FOR CO-OPERATION !!!!!!

Appendix C

Checklists for focus group discussion (FGD)

Selecting criteria: most senior fishermen of that study area, middle aged, group were consisting with 5to 6 members.

Copies of informed consent and confidentiality forms were provided to each participant and read aloud for the benefit of those who could not read. Participants were provided an opportunity to ask any questions. Verbal agreement were taped. Suggested probes were included. All group members in the conversation were encouraged for participation.

1. What do you think about the topic that has brought us here today (sources of vulnerabilty and adaptation strategies)?
2. Do you feel any changes on your livelihood for last few years?
    - ✓ Change on your income per month?
    - ✓ Change on your yield production per month?
    - ✓ Changes on your monthly production cost?
3. Do you change your fishing style for last few years?
    - ✓ Change on your fishing time?
    - ✓ Change on your fishing frequency per day?
    - ✓ Change on your fishing area on the river?
    - ✓ Change on fishing gear?
4. According to you, what are the reasons for this changes?
5. What do you know about water pollution?
6. Do you have any idea about climate change and variability?
7. Do you think, water pollution of the Meghna river as one of the main cause behind this?

   If anyone agree with it,
    - ✓ How?(please explain)
8. What types of water pollution occurs in this river ?
    - ➢ Waste and sewage from industry
    - ➢ Hot waste water from the power plant and the industry
    - ➢ Pesticides and insecticides from the agricultural run-off
    - ➢ Oil pollution
    - ➢ Waste water carried out by the canal from other densely polluted river
    - ➢ Ballast water
    - ➢ Others
9. What are the effects of water pollution?
    - ➢ Mass death of fish?
    - ➢ Decrease primary production?
    - ➢ Change the color of water?
    - ➢ Others?
10. What types of climate variability occur in this area?
    - ➢ Increase the number of flood?

- Increase the number of cyclone?
- Increase the number of storm frequency?
- Drought?
- Rain?
- Others?

11. What are the effects of climate change on biodiversity of the river?
    - ✓ Change in fish distribution?
    - ✓ Change in availability of brood stocks?
    - ✓ Change in availability of fish seeds?
    - ✓ Change in the presence of other aquatic organisms?
12. What do you do to cope up with this changes?

Appendix D

Distribution (%) of the fishermen by villages and levels of education of Sonargaon, Narayanganj and Gojaria upazila, Munshiganj district.

Name f the village	illiterate	literate	primary	secondary	higher secondary
Baiday para	7	13	5	1	0
%	19.44	36.11	26.32	25.00	0.00
shatviya para	9	0	5	0	0
%	25.00	0.00	26.32	0.00	0.00
Loshkordi	4	10	5	1	0
%	11.11	27.78	26.32	25.00	0.00
Vabanipur	5	3	2	0	0
%	13.89	8.33	10.53	0.00	0.00
Ismani char	11	10	2	2	0
%	30.56	27.78	10.53	50.00	0.00
Total	36	36	19	4	0

		Count	
Problem_criteria	Is one of the problems in the meghna river, Dredging activity?	57	60
	Is one of the problems in the meghna river, using moshari & current jal?	25	26.31579
	Is one of the problems in the meghna river, Strong wind action?	31	32.63158
	Is one of the problems in the meghna river, Construction of the Meghna bridge?	22	23.15789
	Is one of the problems in the meghna river, Flood?	19	20
	Is one of the problems in the meghna river, Rain?	12	12.63158
	Is one of the problems in the Meghna river, Launch & steamer movement?	65	68.42105
	Is one of the problems in the Meghna river, Temperature increase?	27	28.42105
	Is one of the problems in the meghna river, Social conflict?	49	51.57895
	Is one of the problems in the meghna river, Erosion?	30	31.57895
	Is one of the problems in the meghna river, heavy current?	13	13.68421
	Is one of the problem in the meghna river, drought?	6	6.315789
	Is one of the problem in the meghna river, others?	0	0

	Is one of the problems in the meghna river, pollution of the river water?	90	94.73684
		95	

		Count	
$disease_fish	if yes, is it big head comparing to the body?	20	21.05263
	if yes, is it decreasing size?	28	29.47368
	if yes, is it ulceration?	31	32.63158
	if yes, is it fin tail root?	36	37.89474
	if yes, is it liver damage?	4	4.210526
	if yes, is it damage gill?	7	7.368421
	if yes, is it other disease?	0	0

		$disease_fish						
		if yes, is it big head comparing to the body?	if yes, is it decreasing size?	if yes, is it ulceration?	if yes, is it fin tail root?	if yes, is it liver damage?	if yes, is it damage gill?	if yes, is it other disease?
		Count	Count	Count	Count	Count	Count	Count
Name of the village	Baiday para	7	9	10	11	0	0	0
	shatviya para	0	2	4	5	1	0	0
	Loshkordi	2	5	3	4	0	2	0
	Vabanipur	5	4	6	5	3	2	0
	Ismani char	6	8	8	11	0	3	0

		Is this village is the birthplace of the head family members?					
Name of the District	Name of the Village	Yes	% of Yes	No	% of No	Total	% of the Total
Narayanganj	Baiday para	22	84.6	4	15.4	26	100.0
	shatviya para	14	100.0	0	0.0	14	100.0
Munshiganj	Loshkordi	18	90.0	2	10.0	20	100.0
	Vabanipur	10	100.0	0	0.0	10	100.0
	Ismani char	0	0.0	0	0.0	0	0.0

		Religion							
Name of the District	Name of the Village	Muslim	% of Muslim	Hindu	% of Hindu	Others	% of Others	Total	% of Total
Narayanganj	Baiday para	8	30.77	18	69.23	0	0	26	100.0
	shatviya para	0	0.00	14	100.0	0	0	14	100.0
Munshiganj	Loshkordi	2	10.00	18	90.00	0	0	20	100.0
	Vabanipur	1	10.00	9	90.00	0	0	10	100.0
	Ismani char	8	32.00	17	68.00	0	0	25	100.0

Age Interval	Name of the district											
	Narayanganj				Munshiganj							
	Name of the village				Name of the village							
	Baiday para	%	shatviya para	%	Loshkordi	%	Vabanipur	%	Ismani char	%	Total	% of the Total
21-30	6	33.33	4	22.22	4	22.22	0	0.00	4	22.22	18	100.00

31-40	7	22.58	1	3.23	8	25.81	6	19.35	9	29.03	31	100.00
41-50	6	28.57	3	14.29	4	19.05	2	9.52	6	28.57	21	100.00
51-60	7	46.67	3	20.00	2	13.33	1	6.67	2	13.33	15	100.00
61-70	0	0.00	1	14.29	2	28.57	0	0.00	4	57.14	7	100.00
71-80	0	0.00	2	66.67	0	0.00	1	33.33	0	0.00	3	100.00

Household Size	Name of the district					
	Narayanganj		Munshiganj			
	Name of the village		Name of the village			Total
	Baiday para	shatviya para	Loshkordi	Vabanipur	Ismani char	
2	0	0	0	0	1	1
3	1	2	1	1	7	12
4	6	2	8	2	5	23
5	6	3	6	6	7	28
6	9	6	3	0	4	22
7	4	1	2	1	1	9
Total	26	14	20	10	25	95

Distribution (%) of the fishermen of two upazila by levels of education.

Education	Name of the district										
	Narayanganj				Munshiganj						
	Name of the village				Name of the village						
	Baiday para	% Of Baiday	shatviya Para	%	Loshkordi	%	Vabanipur	%	Ismani char	%	Total
illiterate	7	19.44	9	25.00	4	11.11	5	13.89	11	30.56	36
literate	13	36.11	0	0.00	10	27.78	3	8.33	10	27.78	36
primary	5	26.32	5	26.32	5	26.32	2	10.53	2	10.53	19
secondary	1	25.00	0	0.00	1	25.00	0	0.00	2	50.00	4
higher secondary	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
Total	26	27.37	14	14.74	20	21.05	10	10.53	25	26.32	95

Overall distributions (%) of the fishermen of two upazila by levels of education and land class.

Land Class	illiterate	literate	primary	secondary	higher secondary
absolute landless (no cultivable land)	30	34	17	4	0
%	88.24	94.44	89.47	100.00	0.00
Landless	4	2	2	0	0
%	11.76	5.56	10.53	0.00	0.00
Marginal	0	0	0	0	0
%	0	0	0	0	0
Small	0	0	0	0	0
%	0	0	0	0	0
Medium	0	0	0	0	0
%	0	0	0	0	0
Large	0	0	0	0	0
%	0	0	0	0	0
Total	34	36	19	4	0

Distribution (%) of fishermen based on land class and levels of education in two study areas.

	Land class	illiterate	literate	primary	secondary	higher secondary	Total
Narayanganj	Absolute LandLess	11	12	9	1	0	33
	%	33.33	36.36	27.27	3.03	0.00	100
	Landless	3	1	1	0	0	5
	%	60.00	20.00	20.00	0.00	0.00	100
Munshiganj	Absolute LandLess	19	22	8	3	0	52
	%	36.54	42.31	15.38	5.77	0.00	100
	Landless	1	1	1	0	0	3
	%	33.33	33.33	33.33	0.00	0.00	100
	Total	34	36	19	4	0	

Religious status of the fishermen of the five villages of sonargaon and gojaria upazila

Religion									
Upazila	Village	Muslim	% Muslim	Hindu	% Hindu	Others	% others	total	%total

Sonargaon	Baiday para	8	30.77	18	69.23	0	0	26	100
	Shatviya para	0	0	14	100	0	0	14	100
Gojaria	Loshkordi	2	10	18	90	0	0	20	100
	Vabanipur	1	10	9	90	0	0	10	100
	Ismanichar	8	32	17	68	0	0	25	100

Age class

Age Interval	Name of the district											
	Narayanganj				Munshiganj							
	Name of the village				Name of the village							
	Baiday para	%	shatviya para	%	Loshkordi	%	Vabanipur	%	Ismani char	%	Total	% of the Total
21-30	6	33.33	4	22.22	4	22.22	0	0.00	4	22.22	18	100.00
31-40	7	22.58	1	3.23	8	25.81	6	19.35	9	29.03	31	100.00
41-50	6	28.57	3	14.29	4	19.05	2	9.52	6	28.57	21	100.00
51-60	7	46.67	3	20.00	2	13.33	1	6.67	2	13.33	15	100.00

61-70	0	0.00	1	14.29	2	28.57	0	0.00	4	57.14	7	100.00
71-80	0	0.00	2	66.67	0	0.00	1	33.33	0	0.00	3	100.00

Distribution (%) of HH size of the fishermen of five villages of Sonargaon and Gojaria upazila.

Household Size	Name of the district					
	Narayanganj		Munshiganj			
	Name of the village		Name of the village			Total
	Baiday para	shatviya para	Loshkordi	Vabanipur	Ismani char	
2	0	0	0	0	1	1
3	1	2	1	1	7	12
4	6	2	8	2	5	23
5	6	3	6	6	7	28
6	9	6	3	0	4	22
7	4	1	2	1	1	9
Total	26	14	20	10	25	95

Distribution of the HH by type of diseases they face and land class of the fishermen of the study areas by using multiple response.

	absolute landless (no cultivable land)	landless	marginal	small	medium	large
If yes,is it fever?	49	5	0	0	0	0
If yes,is it diabetics?	9	3	0	0	0	0
If yes,is it diarrhea?	26	3	0	0	0	0
If yes,is it cold?	39	1	0	0	0	0
If yes,is it physical pain?	26	0	0	0	0	0
If yes,is it kidney failure?	12	3	0	0	0	0
If yes,is it liver disease?	5	1	0	0	0	0

If yes,is it skin lesions?	18	2	0	0	0	0
If yes,is it other?	10	1	0	0	0	0

Ownership of house

Have you your own house?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	91	95.8	95.8	95.8
	No	4	4.2	4.2	100.0
	Total	95	100.0	100.0	

Ownership of land

Frequency	Percent
77	81.1
18	18.9
95	100.0

Mean value of land by literacy level, villages and land class

Illiterate(Value) in mean	literate(Value) in mean	primary(Value) in mean	secondary(Value) in mean	higher secondary(Value) in mean
639285.71	840000.00	925000.00	1075000.00	
Baiday para	shatviya para	Loshkordi	Vabanipur	Ismani char
510000.00	733333.33	894736.84	233333.33	1180952.38
absolute landless (no cultivable land)	landless			
592857.14	2587500.00			

Mean value and number of livestock, tree and house by land class

	land_class					
	absolute landless (no cultivable	landless	marginal	small	medium	large

	land)					
	Mean	Mean	Mean	Mean	Mean	Mean
Number of Livestock(Cattle/buffalo)	1	3				
Number of Livestock(Pultry/duck/pigeon)	1					
Number of Livestock (Others)						
Value of the Livestock(Cattle/buffalo)	70000.00					
Values of the Livestock(Pultry/duck/pigeon)	200.00	210000.00				
VAlues of the Livestock (Others)	10000.00					
Number of mango tree(two year plus)	2					
Number of jackreuit tree(two year plus)	1					
Number of Coconat tree(two year plus)	1					
Number of Other tree(two	1					

year plus)						
value mango tree	27266.67					
value jackfruit tree	33000.00					
value coconut tree	5615.38					
value others	10500.00					
Number of house	1	1				
Total value(tk) of the house	162099	133750				

Mean number and value of livestock, tree and house by villages

	Name of the village				
	Baiday para	shatviya para	Loshkordi	Vabanipur	Ismani char
	Mean	Mean	Mean	Mean	Mean
Number of Livestock(Cattle/buffalo)	1				3
Number of Livestock(Pultry/duck/pigeon)	1	2			
Number of Livestock (Others)					

Value of the Livestock(Cattle/buffalo)	70000.00				210000.00
Values of the Livestock(Pultry/duck/pigeon)	166.67	300.00			
VAlues of the Livestock (Others)	10000.00				
Number of mango tree(two year plus)	2	1	2	2	
Number of jackreuit tree(two year plus)	1		2		
Number of Coconat tree(two year plus)	1		1	2	
Number of Other tree(two year plus)			2		
value mango tree	30000.00	15000.00	30000.00	4000.00	
value jackfruit tree	30000.00		45000.00		
value coconut tree	6428.57		5000.00	3000.00	
value others	10000.00		12000.00		
Number of house	1	2	1	2	1

	Education1				

	(class)				
	illiterate	literate	primary	secondary	higher secondary
	Mean	Mean	Mean	Mean	Mean
Number of Livestock(Cattle/buffalo)		3	2	0	
Number of Livestock(Pultry/duck/pigeon)		2	1	0	
Number of Livestock (Others)		1	0	0	
Value of the Livestock(Cattle/buffalo)		210000.00	105000.00	0.00	
Values of the Livestock(Pultry/duck/pigeon)		500.00	150.00	0.00	
VAlues of the		30000.00	0.00	0.00	

Livestock (Others)					
Number of mango tree(two year plus)	2	3	2	1	
Number of jackreuit tree(two year plus)	2	1	1	0	
Number of Coconat tree(two year plus)	2	1	1	1	
Number of Other tree(two year plus)	1	2	0	0	
value mango tree	20666.67	41250.00	35000.00	7500.00	
value jackfruit tree	60000.00	37500.00	30000.00	0.00	
value coconut tree	9333.33	6000.00	3333.33	2500.00	
value others	30000.00	12000.00	0.00	0.00	
Number of house	1	1	1	1	.
Total value(tk) of the house	174706	160857	129444	140000	.

Number of respondents used fishing trap by villages .

$net_boat_chair	Baiday para	shatviya para	Loshkordi	Vabanipur	Ismani char
chair_cat	5	0	0	0	0
fishing_boat_has	21	11	17	8	21
net_has	19	11	17	7	19
Total	21	11	17	9	22

% Non- productive physical asset among fishermen

	Number	Percent
Have any watch?	17	10.0%
Have any Radio?	22	12.9%
Have any tv?	57	33.5%
Have any fan?	57	33.5%
Have any jewelries?	14	8.2%
Have any others?	3	1.8%

Distribution (%) of HH owned non-productive physical asset by two upazila.

	$physical_asset						
Name of the upazila	Have any fan?	Have any jewelries?	Have any others?	Have any Radio?	Have any tv?	Have any watch?	Total
Sonargaon	29	8	2	14	29	15	97
%	29.90	8.25	2.06	14.43	29.90	15.46	100
Gojaria	28	6	1	8	28	2	73
%	38.36	8.22	1.37	10.96	38.36	2.74	100
Total	57	14	3	22	57	17	170

Distribution (%) of HH's sanitary condition of whole study areas.

		Frequency	Percent	Cumulative Percent
Valid	Kacha	38	39.4	39.4
	semi pacca	53	56.4	95.7
	pacca	4	4.3	100.0
	Total	94	100.0	

Distribution (%) of the HH having ownership of tube well.

		Frequency	Percent	Cumulative Percent
Valid	own	13	13.7	13.7
	not	82	86.3	98.9
	Total	95	100.0	

% respondents to savings

	Yes	%	No	%
Savings	69	73	26	27

Mean value of all asset by level of education

			total_asset
Education1 (class)	illiterate	Mean	734537.50
	literate	Mean	941095.71
	primary	Mean	1004500.00
	secondary	Mean	1316025.00
	higher secondary	Mean	

Number of fishermen responded to vulnerabilities (multiple response)

	Count
Is one of the problem in the meghna river,Dredging activity?	57
Is one of the problem in the meghna river, using moshari & current jal?	25
Is one of the problem in the meghna river, Strong wind action?	31
Is one of the problem in the meghna river, Construction of the Meghna bridge?	22
Is one of the problem in the meghna river, Flood?	19
Is one of the problem in the meghna river, Rain?	12
Is one of the problem in the meghna river, Launch & steamer movement?	65
Is one of the problem in the meghna river, Temperature increase?	27
Is one of the problem in the meghna river, Social conflict?	49
Is one of the problem in the meghna river, Erosion?	30
Is one of the problem in the meghna river, heavy current?	13
Is one of the problem in the meghna river, drought?	6
Is one of the problem in the meghna river, others?	0

Is one of the problem in the meghna river,pollution of the river water?	90
	446

% fishermen having physical asset by landclass

	$physical_asset						
Land Class	Have any watch?	Have any Radio?	Have any tv?	Have any fan?	Have any jewelries?	Have any others?	Total
%	9.93	12.58	33.77	33.77	7.95	1.99	100
Landless	1	3	5	5	2	0	16
%	6.25	18.75	31.25	31.25	12.50	0.00	100
Total	16	22	56	56	14	3	167

Descriptive links between assets, income and vulnerability due to water pollution of the fishers surveyed in villages of Bangladesh.

(Radar diagram)

	Absolute landless	Landless	Marginal	Small	Medium	Large	
Total value of all tangible asset (US$)	0.366508	1	0	0	0	0	

Total annual HH income (US$)	0.728771	1	0	0	0	0
Total HH income from fishing (US$)	1	0.638952	0	0	0	0
water pollution (%)	1	0.729167	0	0	0	0

Mean land allocation (decimal) by level of education, village and land class

Do your HH has ownership land?				
Frequency	Percent			
77	81.1			
18	18.9			
95	100.0			

illiterate	literate	primary	secondary	higher secondary
4.8000	6.4667	7.0000	6.5000	
Baiday para	shatviya para	Loshkordi	Vabanipur	Ismani char
4.85714	7.33333	4.26316	2.33333	8.68182

absolute landless (no cultivable land)	landless	marginal	small	medium
4.15	22.13			

Mean value of total assets, savings and debt of fishers by villages

		total_asset	total saving current	dedt_all
Baiday para	Mean	651130.77	4000	20461.54
shatviya para	Mean	905264.29	886	88214.29
Loshkordi	Mean	1166550.00	18000	48920.00
Vabanipur	Mean	202300.00	2000	41510.00
Ismani char	Mean	1159060.00	18625	20560.00

Mean value of total assets among fishers involve in only fishing and fishing and non-fishing activities

		total_asset
fisher & others	Mean	1173593.75
only fisher	Mean	832741.03

Plate 1

A. HH interview with the fishers of Ismanichar.

B. Industrialization along the river Meghna from the study sites.

C. Protection from erosion by sand sack.

D. HH interview with the fishers of Baiday para.

E. FAD made by the Muslim fishers.

E. Mancha house to avoid flood in Ismanichar.