social sciences

MDPI

Article

Climatic Impacts and Responses of Migratory and Non-Migratory Fishers of the Padma River, Bangladesh

Makidul Islam Khan [1,2,*], Goutam Kumar Kundu [1,3], Mosammat Salma Akter [1,4], Bishawjit Mallick [5] and Md. Monirul Islam [1,6]

1 Department of Fisheries, University of Dhaka, Dhaka 1000, Bangladesh; goutam.kundu@du.ac.bd (G.K.K.); sakter@univdhaka.edu (M.S.A.); monirulislam153@yahoo.com (M.M.I.)
2 World Fisheries University Pilot Programme, Pukyong National University, 45 Yongso-ro, Nam-gu, Busan 48513, Korea
3 School of Earth Sciences and Environmental Engineering, Gwangju Institute of Science and Technology, 123 Cheomdangwagi-ro, Buk-gu, Gwangju 61005, Korea
4 The Scripps Research Institute, Jupiter, FL 33458, USA
5 Faculty of Environmental Sciences, Technische Universität Dresden/DRESDEN concept, 01062 Dresden, Germany; bishawjit.mallick@tu-dresden.de
6 Interdisciplinary Centre for Conservation Science, Department of Zoology, University of Oxford, South Parks Road, Oxford OX13PS, UK
* Correspondence: makidul07@gmail.com

Received: 31 August 2018; Accepted: 27 November 2018; Published: 3 December 2018

Abstract: This study empirically assesses the impacts of climatic events on the inland fishers (i.e., migratory and non-migratory) in Bangladesh and explores their responses to those events. Here, the migratory refers to the fishers who change their fishing location seasonally and voluntarily, whereas the non-migratory fishers fish in the same area. It is assumed that there exist differences in both the impacts of an event and the responses to the event between migratory and non-migratory fishers and therefore, a 'difference triangle' conceptual framework is developed and tested empirically under this research. Employing mix-method (qualitative and quantitative), a field study was conducted during July–October 2015 from the Padma River depended fishers. Identified climatic events under this study are: storms, changes in rainfall and temperature and riverbank erosion. The migratory and non-migratory fishers were affected quite similarly by storms and changes in rainfall and temperature. However, riverbank erosion affected only non-migratory fishers. Both the migratory and non-migratory fishers adopted different strategies to cope with different climatic events, like, they took shelter in safe places, sold productive assets, reduced food consumption, took credit from informal sources and employed their school-going children. As adaptation strategies, they modernized their fishing boats, intensified fishing, built embankments and diversified livelihoods. Unlike the impacts, considerable differences were found in their coping and adaptation strategies. Comparing to non-migratory fishers, a smaller number of migratory fishers sold their assets, took informal credit and intensified fishing and diversified their livelihoods. The result of this study indicates the significance of differences in the impacts of climatic events for the migratory and non-migratory fishers and therefore, this research has policy implication for the betterment of fishers' community in general.

Keywords: climate change; impact; adaptation; migration; fisher; hazard

1. Introduction

In quest of better livelihood, human mobility is primitive but nowadays a lot of new challenges induced by environmental degradations lay emphasis on migration. Scientific evidences claim that the magnitude/frequency of environmental hazards and disasters has been increasing as a result of climate change (IPCC 2014) and therefore, people are facing new challenges in their livelihoods (e.g., changes in local social structure, income, assets distribution, etc.) (Black et al. 2011; Mallick and Vogt 2012). These new challenges differ greatly in the ways they perceive and adapt with the risks (Sjöberg 2000; Grothmann and Patt 2005; Patt and Schröter 2008). Literature shows that migration is considered as one of the best adaptation strategies to climate risks (Black et al. 2011; Foresight 2011; Mallick and Vogt 2012; Warner et al. 2008) and migration has different types and forms, such as temporary or permanent, forced or voluntary, seasonal, local, regional or international. Sometimes migration has been considered as a consequence of failure of adaptation strategies, and in some cases, it is the last chance of adaptation when other strategies fail to cope with the changes (McLeman and Smit 2006; Adger et al. 2009). There exists a distinct difference between the livelihood challenges of migratory and non-migratory people. In most of the cases, migration takes place due to the economic pull driven by social, political or environmental push. The poor people all over the world temporally migrate to secure their livelihoods but sometimes if they do not have enough resources to adapt with the changing environment, then they cannot migrate (Adger et al. 2009) and this refers to the difference between aspirations and capability (Carling 2002). Amongst the poor people, fishermen are more migratory due to the nature of their profession, as they have to travel from cannels to cannels, rivers to rivers, or different parts of the sea. Due to climate change, the number of fishing grounds and amount of fishing yields are declining and therefore, the frequency of fishing at distant places by the fishermen in general has also been increasing (Allison et al. 2009; Badjeck et al. 2010).

Fishermen who are almost stationary and fish in their neighboring rivers and cannels (hereafter referred as 'non-migratory fishers'), are well-aware about the changes related to social, environmental and political conditions of fishing in those places. Thus, they can accomplish their livelihood challenges by their local knowledge (perceptions) on environment and societies. In contrast, the migratory fishers, who usually fish outside their regions or community may not always have such kind of local knowledge and consequently may have different perception on the climate change related problems and have different strategies to solve them. Again, the challenges put by the climatic events (rainfall, floods, cyclones, erosion, etc.) to the fishing environment (sources and number of fishes) may also be perceived differently both by the migratory and non-migratory fishers (Abobi and Alhassan 2015).

The extreme weather and climatic events impact heavily on fishing sectors (fish production, fish growth and fish catch) (Allison et al. 2009; Johnson 2012; Jain et al. 2013) and thus affect the fishers' livelihood negatively. Similarly, the impacts of natural hazards are more destructive and far-reaching as the disruptions of livelihoods and infrastructure can result in displacement (temporary or permanent) (Badjeck et al. 2010; Westlund et al. 2007; Warner et al. 2008). These climatic impacts may also increase the risk of malnutrition or under-nutrition for highly fishery dependent communities (Ogutu-Ohwayo et al. 1997). Some of the studies particularly focused on the impacts of climate change and migration as an adaptation strategy in Bangladesh (Islam et al. 2014b; Mallick and Etzold 2015; Etzold and Mallick 2016).

The migratory and non-migratory fishers usually do not involve in the same livelihood activities or they do not share the same resources. Especially there is no study on how migratory and non-migratory fishers who are exposed to similar climate related events are affected and respond in a context where they have the same livelihood activity, that is, fishing from the same river. Besides, it is evident that the tendency of distant fishing will be increased as the inland fishing sources are declining and the laboriousness between the migratory and non-migratory fishers will also be strapped (Allison et al. 2009; Badjeck et al. 2010) and this has a policy demand for the improvement of the fisheries sector in general. Taking this into consideration, this study particularly aims to contribute to this specific research gap by investigating the following objectives:

- To identify how the impacts of climatic hazards vary between migratory and non-migratory fishers.
- To explore the differences between the responses to different climatic hazards taken by both migratory and non-migratory fishers.
- To contribute to the adaptation policy planning for the inland fishers' communities in Bangladesh.

In doing so, a case study has been conducted in Bangladesh, as it is the world's 4th largest inland waters capture fisheries producing country (FAO 2014). The fisheries sector supports 17.8 million people's livelihoods directly and indirectly (DoF 2015), who are involved in fishing and ancillary activities such as processing, packaging, marketing and distribution, manufacturing of fish processing equipment, net and gear making, ice production and supply, boat construction and maintenance (FAO 2014). The fishers of Bangladesh are exposed to multiple climatic hazards and disasters such as cyclones, flooding and land erosion (Islam et al. 2014a, 2014b). The fishers and fish farmers not only fish around or close to their locality but also sometimes migrate to other areas to carry out their activities. These include temporary or permanent movement of fishers, fish processors and fish traders and fisheries workers from one defined location to another, as a result of shifts in natural resource availability (Abobi and Alhassan 2015). This migration is due to various reasons, such as favorable climate, profitable employment, availability of water for fishing, riverbank erosion, lack of job to do in particular season and so forth. Islam et al. (2014b) has compared the vulnerability and adaptation strategies of the migratory and non-migratory fishers of two coastal communities. But this study did not consider the climatic impacts on the inland fishery based migratory and non-migratory communities and their response strategies to overcome the impacts. In fulfilling this research gap, this study selected two inland fishers' communities along the Padma River in Bangladesh. Both the qualitative and quantitative methods were employed for data collection. The results provide detailed information on the differences in the impact and responses caused by the climatic hazards in the selected fishers communities.

The remainder of this paper is organized as follows. The next section describes the conceptual framework of the study. Section 3 illustrates the methodology including the study sites, data collection and analysis. Section 4 presents the results, which are divided into two major sub-sections: impacts of climatic hazards and the response strategies taken by both the migratory and non-migratory fishers. Section 5 discusses the results to uncover the underlying mechanisms and potentials.

2. Conceptual Framework

In response to climatic events, the fishers usually take both short (coping) and long-term (adaptation) strategies. Responses to hazards/disasters are usually negotiated at the household level, resulting in an adaptive strategy that usually consists of a range of actions undertaken by the individuals within the household (Fujikura and Kawanishi 2012). For example, selling livestock or taking credit from formal or informal lending sources typically with higher interest rates and unfavorable terms and conditions are one of the common practices as short-term responses (Trærup and Mertz 2011). However, it is difficult to differentiate whether these responses (short term strategies) were adaptation strategies or one-off coping strategies for the adverse reduction of catch. However, sometimes a short term coping strategy may overlap with long term strategy and develop into an adaptation strategy (Agrawal 2010).

For example, diversification through several income generating activities are primary means through which many communities try to reduce their risk and cope with future uncertainty (Barrett et al. 2001). In fishing communities, switching the fishery sector to other non-fishery related activities is a common practice in response to climate change (Daw et al. 2009). In Lake Chad, fishers co-opt with farming (Sarch and Allison 2000), while in Africa people are encouraged to engage in more fishing activity when agriculture is affected by droughts (Conway et al. 2005). Chowdhury et al. (2011) reported that, due to worse overall socio-economic situation along the Naaf River, the children in fishing communities were co-opted in fishery related activities rather than engaging in education. Besides, the literature shows that local environmental knowledge plays a vital

role in adapting response strategies to the climatic events (Heimann and Mallick 2016; Adger et al. 2013; Price et al. 2014) and therefore, it is assumed under this study that there will be significant diversity in responses to the climatic events and hazards taken by the migratory and non-migratory fishers.

Accordingly, a conceptual 'difference triangle' and analytical model is proposed (Figure 1). Here, the triangle is the symbolic representation of household capitals, particularly, physical, human, natural, social and financial. This model describes that every single hazard differently impacts on the individual and therefore, ones responses differently to the impacts of the hazardous event. Here, the individual refers to the migratory and non-migratory fishers. Their responses are divided here into two broader categories of strategies: coping and adaptation. The gravity of the differences in impacts, coping and adaptation describe the foci of future adaptation policy planning. Impacts of different hazards are described according to their effects of different categories of household capital and the responses are categorized to the impacts of each capital aspect. This 'difference triangle model' is employed for achieving the study objectives in the context of internal migratory and non-migratory fishers in Bangladesh. Particularly, this study aims to investigate the impacts of climatic hazards on the Padma River fishery dependent migratory and non-migratory communities and their responses to those climatic hazards. It considers both migratory and non-migratory fishers and fishery related professionals involved with each group. The Padma River is selected because it is the 2nd longest river in Bangladesh and one of the trans-boundary (falls in Bangladesh and India) rivers that contributes significantly to the fisheries sector. The Padma River is also affected by the climatic hazards and disasters (Vineis et al. 2011; Mohsin et al. 2013) and therefore, this study on the Padma River fishery dependent migratory and non-migratory communities has an importance for national level policy implication.

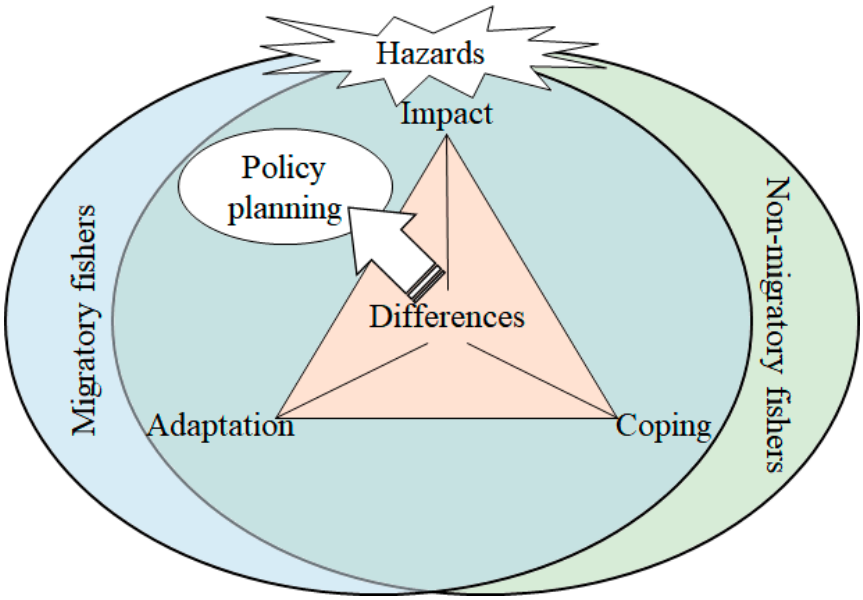

Figure 1. The conceptual model 'difference triangle' illustrating the development of policy planning based on the relationships between impacts, coping and adaptation of two types of fishers. Source: Authors' own illustration.

3. Methodology

3.1. Study Sites

Manikganj is one of the highly vulnerable districts in Bangladesh (Islam et al. 2013a). Two villages—Andharmanik and Dhulsura under Harirampur *upazila* (sub-district) of this district were selected as the study sites. These villages are located on the Padma riverbank (Figure 2) which is already affected by climate variability and changes (Islam 2004; Bhuiyan et al. 2008; Vineis et al. 2011).

Therefore, the impacts of climate variability and changes on the Padma River consequently affected the lives and livelihoods of fishers' dependent on it. The study sites are located about 70 km far from Dhaka city and it takes about 4 h to reach the study sites from Dhaka by bus. Every year a number of storms (winds speed 48 knots to 63 knots) hit the area. The nor'westers (*Kalbaisakhi*) usually hit the study area in May–April. The most devastating tornadoes in 1989 hit the Manikganj district, killing 800 people (Paul and Bhuiyan 2004). The study sites were severely affected by the floods in 1988 (Islam and Sado 2000) and 2004 (Shoji 2010) that caused a great physical and financial loss to the households.

River bank erosion is also a regular phenomenon in the Padma River. In 2007 and 2008, Bangladesh Water Development Board (BWDB) built an 1800 m long embankment in Andharmanik to protect the *upazila* town from the Padma riverbank erosion. But recently it is affected by the Padma riverbank erosion which is threatening the *upazila* complex compound, *upazila* health complex, police station, rest house and the 200 years old Andharmanik bazar. The detailed information of the studied communities are presented in Table 1 and described below.

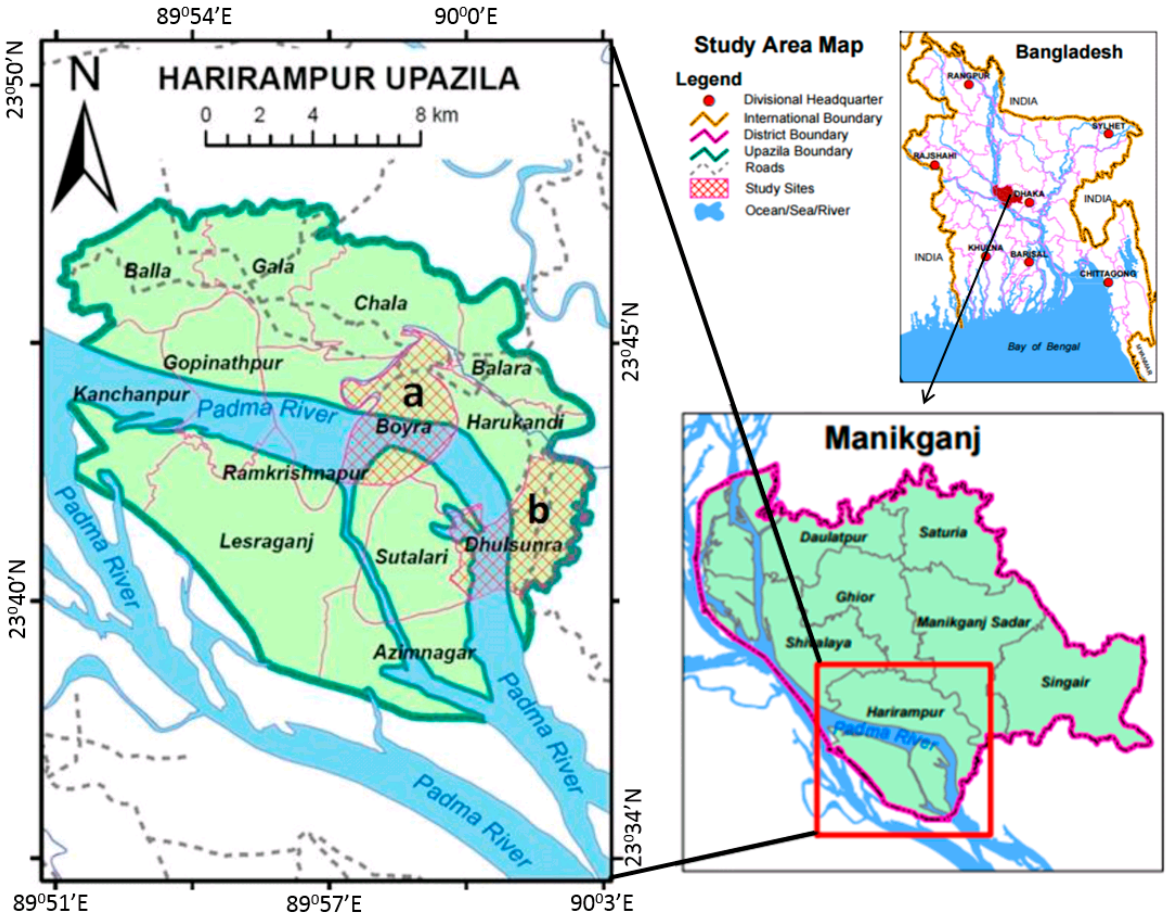

Figure 2. Map of the study sites under Harirampur *upazila*: (**a**) Andharmanik within Boyra union and (**b**) Dhulsura within Dhulsura union.

Table 1. Profile of the study sites.

Attributes	Andharmanik	Dhulsura
Total population	4161	992
Total household	982	254
Literacy (%)	68.8	57.9
Education institutions	2 primary schools, 1 high school and 1 madrasha	2 non-government primary schools
Health care facilities	1 public and 1 private hospital	No facility
Distance to nearby market place	The Andharmanik bazar is within the village	1.3 km, Ghoshayl bazar
Sources of drinking water	Filtered river water	Tube well water
Access to electricity (%)	53.3	30.2

Source: *Upazila* Statistics Division, Harirampur *upazila*.

The studied village-1, Andharmanik, has 4161 people in 982 households whereas studied village-2, Dhulsura, has 992 people in 254 households. In Andhamanik, the literacy rate was 68.6% (BBS 2011), whereas in Dhulsura the literacy rate was 57.9% (BBS 2011). There are two non-government primary schools which are the only formal educational institutions in Dhulsura. There are no government office, public or private hospital in Dhulsura. People with medical needs visit the nearby town Bandura which is about 25 km away from Dhulsura. Some common medicines are available in local pharmacies in Ghoshayl bazar which is about 1.30 km away from Dhulsura. Only one small bazar with three tea stalls, five groceries, two tailors, one electronic, one mosque and one temple is there. In Dulsura, people have no access to piped water supply. People (92.1%) used tube-well water for drinking (BBS 2011) that contains harmful arsenic (As) (from reconnaissance study). Tube well water also contains high concentrations of iron (Fe). So, people use locally filtered river water of uncertain quality for household works. In Dhulsura 30.2% of households have electricity access (BBS 2011).

In both study villages, the villagers are involved in fishing, agriculture, driving vehicles, fish trading, boat making, agricultural labor, household working, firewood selling, shop keeping, livestock rearing, aquaculture and in informal credit (loan) systems. Dhulsura has a smaller number of fishers than Andharmanik. The fishers who are directly dependent on the Padma River for their livelihoods, live nearby the river bank. The fishers live in clusters and the place is known as "*Majhi Para*" or "*Jele Para*" or "*Halder Para*" or "*Rajbongshi Para*." All the fishers' primary occupation is fishing in the Padma River. Some fishers have alternative livelihood options alongside fishing, such as fish trading, agriculture, daily labor, auto driving and firewood selling.

The usual fishing duration is 6 to 12 h per day which is extended when more fish are available in catch. There are two main fishing seasons: rainy (May to September) and winter (November to February). In these seasons, the fishers' fish about 10 to 16 h per day, although there are a few days (during rough weather, physical weakness etc.) when fishing does not take place. During the other three months of the year (March, April and October), the fishers either stop fishing or reduce fishing duration per day due to the occurrence of the local severe storms. The frequency of devastating nor'westers (*Kalbaishakhi*) is usually at a maximum in April. During that time of the year, the local fishers repair their fishing boats, nets and traps and migratory fishers go back their home.

Both study sites have "*Arat*" (fish auction center) at the bank of the Padma River. Fishers bring their catches to the nearby *arat* to sell. However, the fishers who have taken "*Dadon*" (advance money) from "*Aratdars*" (commission agents) or "*Mohajons*" (money lenders) through an informal loan system, are bound to bring/sell their catches to the respective *aratdar/mohajon*. In the *arat* a small portion of fish (known as "*Khoraki*" fish) are taken by the *aratdar/mohajons* as commission which was 5% of total catch in both the study sites.

There were no significant programs or activities from different institutions, particularly from the government and NGOs, which considered specific arrangement for the development of migratory and non-migratory fishers. However, micro-credit programs have been implementing by the NGOs as regular activities but they do not have any specific considerations for the fishers.

3.2. Migratory and Non-Migratory Fishers in the Study Sites

In this study, migration means seasonal or periodic movement of the fishers from one region or climate to another in accordance with the movement of fisheries or for better fishing activities. Fishers' seasonal migration is often undertaken to improve the socio-economic status of the household or fulfillment of their occupation. So, fishers who migrate to other areas are known as migrants/migratory fishers and those who do not migrate, they are known as non-migratory/local fishers. There are migratory fishers who come from different districts of Bangladesh, mainly from Sirajganj, Pabna, Barisal and Jamalpur. They come to the Padma River for a season (or shorter in the absence of enough catch) leaving their family behind and often live inside boats. They use large mechanized boats (8.5 Horse power) and, seine and gill nets for fishing. In each boat, there is a leader and 8–12 crews who catch fish for 2–16 h daily. Each group of migratory fishers has a leader who is known as "*Mohajon*" and usually takes most of the decisions on the boat during fishing. A comparative description between migratory and non-migratory fishers is given in Table 2. The migratory fishers are fully involved in fishing activities over generations. Therefore, their fishing equipment's are of less variety but bigger and more efficient and also possesses mechanized boats in all cases. In contrast, non-migratory fishers' fishing gears are comprised by a small cast net and lift net along with seine or gill nets.

Table 2. Comparative characteristics of migratory and non-migratory fishers of the Padma River, Bangladesh.

Variables	Migratory	Non-Migratory
Family traditional occupation (%)	100	91
Full time fishers (%)	100	89
Age of the household head (mean±sd)	42.05 ± 6.70	47.35 ± 11.11
Family composition (mean±sd)	5.84 ± 2.91	5.02 ± 1.73
Years of involvement (31 to 50 years) in fishing (%)	95	57
Annual income including expenses (mean)	BDT 43,684	BDT 35,278
Boat type	Mechanized	Mechanized and non-mechanized
Fishing traps used	No	Yes
Fishing gear used	Seine and gill net	Cast, seine, gill and lift net

Source: Field survey, 2015.

The migratory fishers generally use large seine and gill net for fishing but no fishing traps, spears, lines and hooks. Depending on their fish catch, they usually stay at one area for one to two months or more before migrating to another area. Similarly, their fishing duration per day varies between 12 to 16 h depending on their catches. In Dhulsura, this study found about 8–9 migratory fishing boats who came from different districts. The migratory fishers usually set their nets in the river in early morning after selling their catches at the nearby *arat*. The money is equally distributed to all members but if one has more share to the ownership of the boat/nets, then he gets money in proportionate to his share. Generally, they stay on the boat throughout day-night.

Depending on the types of nets and gears used for fishing, the amount of catch varies. Fish selling price also varies depending on fish size, species and quality and therefore, fishers' annual income varies. From household interviews, this study found that seine and gill net (such as *ber jal*, current *jal*) users' annual income was higher than other groups. About 26% migratory fishers had annual income above Tk. 60,000, since they used large seine and gill nets for fishing. In contrast, the non-migratory fishers who used only cast net and lift net their annual income was lower than other fishers.

3.3. Data Collection

Both primary and secondary data were collected through mixed method approaches. The total number of households of non-migratory fishers' was 111, according to the data collected from the Horirampur *upazila* Fisheries Office but there was no list for migratory fishers.' The total number of respondents was 73 (41 from Andharmanik and 32 from Dhulsura) including 19 migratory and 54

non-migratory fishers. A semi-structured questionnaire was designed following De Vaus (2002) and adapted to collect data from migratory and non-migratory fishers, who were selected by using simple random sampling method. The length of an interview was between 45 min to 1 h. The interviews were taken either at the respondents' home or boats.

Five focus group discussions (FGDs) (two with migratory and three with non-migratory fishers) and six key informant interviews were conducted to triangulate the findings of the semi-structured interviews. FGD was conducted with 6–9 fishers of different age groups and it lasted for about 2 h. As the key informants NGO personnel, sub-district government fisheries officer and local government representative, that is, chairman were selected and they were interviewed one-to-one basis to ensure the confidentiality of responses. The key informants' interview lasted between forty minutes to one and a half hours. All the respondents of this study were male as no female fisher was found. This study also collected 38 years of daily rainfall and temperature data from Bangladesh Meteorological Department (BMD), Dhaka to analysis the trend in rainfall and temperature in the studied area.

3.4. Data Analysis

The qualitative data were analyzed using the modified grounded theory approach (Strauss and Corbin 1990) and this consisted of three steps: (i) preparation and organization; (ii) reduction of the data into themes by coding; and (iii) representation in the form tables, graphs or as part of a discussion. Besides, literature review allowed potential predetermined groups of interviewed data before analyzing them. During the different phases of analysis, these groups were revised or modified based on the criteria that arose from the previously mentioned grounded theory approach. At the later stage of writing, selected quotes were translated into English. The Statistical Package for the Social Sciences (SPSS) was employed for statistical analysis.

4. Results

4.1. Socio-Demographic Statistics of the Respondents

Among the migratory and non-migratory fishers from both study sites, 93.15% were Hindu followed by 6.85% Muslims. This study agrees with the finding of Paul et al. (2013) in Turag river, Dhaka and Islam et al. (2013b) in Monirampur *upazila*, Jossore, but disagrees with the findings of Kabir et al. (2012) in the old Brahmaputra river and Khan et al. (2013) in the Tista river where most of the fishers were Muslim. Findings showed that most of the fishers of the Padma River in the both study sites belonged to the age group 31–40 years. During FGDs, it was revealed that young generation (age less than 30 years) of both migratory and non-migratory fishers in both study sites lost their interest towards fishing in the Padma River due to the decreasing catch and involved in other works to support their livelihood. Various negative impacts of climatic variability and changes also influenced it.

In this study, no female fisher was found in any of the study area. Faruque and Ahsan (2014) also found no involvement of females in the Padma River fishing in the Rajshahi district. Ahmed et al. (2009) reported that women have less freedom both socially and economically that restrict their activities. Women are mainly involved in making and repairing fishing gear and post-harvest activities such as processing and small-scale marketing (Ahmed et al. 2012). Sultana and Thompson (2008) also reported that women are often excluded from fishing.

From household interviews, this study found that 26.03% fishers in Dhulsura were migratory due to the low number of local fishers while there were no migratory fishers in Andharmanik. All migratory (100%) and most of the non-migratory fishers (88.89%) were full-time fishers but there were also part-time and occasional fishers among the non-migratory groups. Full-time fishers depend on fishing throughout the year for their livelihood and income (9–12 months per annum). Part-time fishers undertake fishing during part of the year (3–9 months per annum), mainly in the monsoon and post-monsoon seasons, supplementing their fishing income by working in farms as laborers and

driving vehicles. The occasional fishers are opportunistic and fish mainly for household consumption (less than 3 months per annum). They rely primarily on petty business, livestock rearing and agriculture for their livelihoods.

The migratory and non-migratory fishers of the study villages used different types of fishing nets in different seasons. The household survey found a total of ten (10) types of fishing nets used by the both migratory and non-migratory fishers. Length, width and mesh size of fishing nets varied depending on the fishers' choices and the capitals involved in fishing as well as the abundance of fish in the Padma River. In this study, 36.84% migratory and 29.63% non-migratory fishers shared their nets with other fishers who had no own fishing nets for fishing. As there exists difference in pattern, scope and collectiveness between migratory and non-migratory fishers it is expected that their responses to external threats also varies accordingly. The following section, describes the impacts of different climate hazards on the fishers' livelihood in the study villages.

4.2. Impacts of Climatic Hazards

The major climatic hazards were ranked based on their severity of impacts on the fishers' livelihoods and the rank was made based on the fishers' opinions during the interviews and was verified through FGDs. The higher to lower rank of the climatic hazards/disasters are as: storm > low rainfall > high temperature > low temperature > riverbank erosion (Figure 3). In two villages the type of climate related hazards/disasters are similar and impacts in a diverse ways as illustrated in Figure 4:

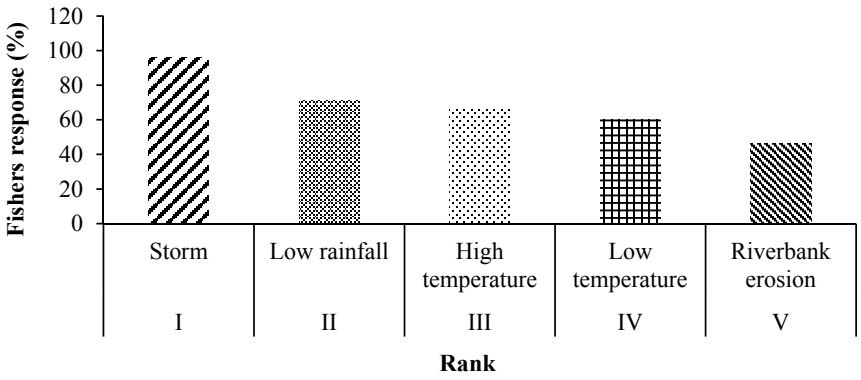

Figure 3. Rank of the climatic hazards and disasters based on their impacts on the livelihoods of migratory and non-migratory fishers of the Padma River, Bangladesh.

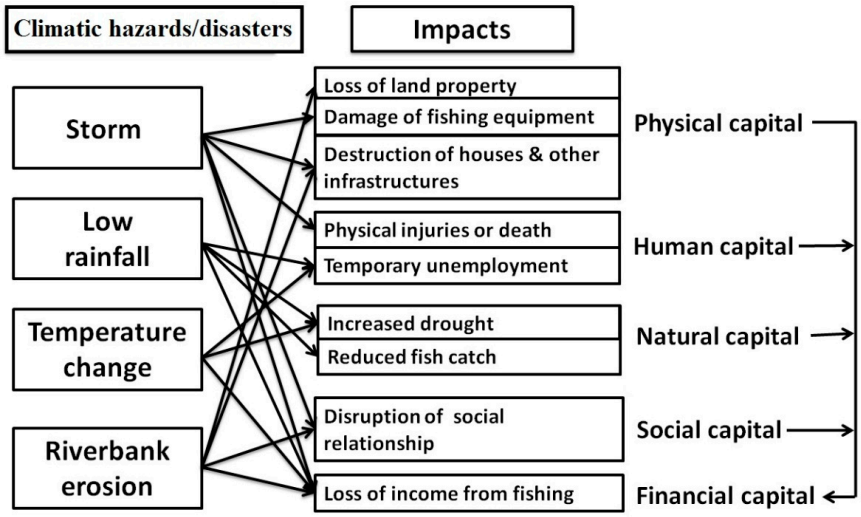

Figure 4. Impacts of climatic hazards/shocks on different livelihood capitals of fishers dependent on the Padma River fisheries, Bangladesh. Source: Author's own presentation.

The migratory and non-migratory fishers responded similarly on the rank of severity of impacts of various climatic and disasters, where storm was the most and river bank erosion was the least severe hazard. However, the two types of fishers differed in their perception on the impacts of different types of climatic hazards and disasters. Table 3 represents that the impacts of climate variability and change on livelihood has significantly differences for both the migratory and non-migratory fishers, whereas there is no significant difference for the impact of climate variability and the changes in fishing between them. The findings show that the storm hazards do not affect differently on both the fish catch and fishers' livelihood, whereas the impact of heavy rainfall as well as drought impact differently on both migratory and non-migratory fishers. However, storms has significant influence on the fishing equipment, other impacts were not different between the two fisher types. The impacts of storm on the fishing boats and gears were higher for non-migratory fishers (100%) than that of migratory fishers (94.7%) (t-test, $p < 0.05$). On the other hand, non-migratory fishers were more impacted by both high rainfall and drought than migratory fishers (t-test, $p < 0.05$). The migratory and non-migratory fishers also differed in their responses during storm when they were in the river. While the migratory fishers often take shelter in nearby canals or river bank, the non-migratory fishers leave the river in most cases. The two fisher groups also differed in terms of their livelihood options. Greater proportion of the non-migratory fishers had alternate occupation than migratory fishers.

Table 3. Impacts of different hazards on the migrant and non-migrants' fishing activities.

Variables That Impacts on Fishers		Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
		F	*p*	*t*	df	*p* (2-Tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Impacts of climate variability and change on livelihood	Equal variances assumed	12.949	0.001	4.120	71	0.000	0.729	0.177	0.376	1.082
	Equal variances not assumed			4.354	67.929	0.000	0.729	0.168	0.395	1.064
Impacts of climate variability and change on fishing techniques	Equal variances assumed	7.093	0.010	−1.263	71	0.211	−0.049	0.039	−0.126	0.028
	Equal variances not assumed			−1.432	40.000	0.160	−0.049	0.034	−0.118	0.020
Impacts of storm on fishing boats and gears	Equal variances assumed	18.772	0.000	1.914	71	0.060	0.279	0.146	−0.012	0.570
	Equal variances not assumed			2.076	59.293	0.042	0.279	0.134	0.010	0.548
Impacts of storm on fisherman life	Equal variances assumed	9.804	0.003	1.217	71	0.228	0.139	0.115	−0.089	0.368
	Equal variances not assumed			1.354	47.883	0.182	0.139	0.103	−0.068	0.347
Impacts of storm on fish catch	Equal variances assumed	3.274	0.075	0.882	71	0.381	0.024	0.028	−0.031	0.080
	Equal variances not assumed			1.000	40.000	0.323	0.024	0.024	−0.025	0.074
Impacts of high rainfall on fish catch	Equal variances assumed	13.580	0.000	−3.961	71	0.000	−0.764	0.193	−1.149	−0.380
	Equal variances not assumed			−4.119	70.646	0.000	−0.764	0.186	−1.135	−0.394
Impacts of drought on fish catch	Equal variances assumed	13.746	0.000	−2.299	71	0.024	−0.249	0.108	−0.465	−0.033
	Equal variances not assumed			−2.246	59.714	0.028	−0.249	0.111	−0.471	−0.027
Impacts of high temperature on fish catch	Equal variances assumed	12.712	0.001	1.649	71	0.103	0.181	0.110	−0.038	0.401
	Equal variances not assumed			1.800	56.563	0.077	0.181	0.101	−0.020	0.383

4.2.1. Storm

Storm was the main climatic event that had great adverse impacts on the fishers' fishing activities and their livelihoods (Figure 3). Fishers' interviews revealed that storms had damaged all (100%) non-migratory fishers fishing gear and crafts in contrast to 94.7% for migratory fishers (Table 2). Key informant interviewees reported that fishers lost their fishing nets (e.g., seine and gill net) because they did not get enough time to pull those before leaving the river to nearby safe places. The fishing traps, used by only non-migratory fishers, could be easily damaged or lost (in 77.8% cases) in the river water. Four non-migratory fishers also reported that they had lost their non-mechanized boats in the river. FGDs revealed that storms impact on the households' physical capital which not only to reduce fishing capacity but also to destroy or damage of physical infrastructures and services and thus in turns can deteriorate the fishers' financial condition.

Storms also affected the human capital, ranging from safety-at-river to livelihood activity. Data showed that 94.74% migratory and 90.74% non-migratory fishers became physically injured, for example, according to fishermen interviews, they faced mainly dizziness due to the high wave (the boat moved up and down with the waves), fever due to staying all time in direct contact of both sunny and rainy weather, diarrhea as a result of drinking river water when the boat was sinking and they swam hard to reach the river bank and red eye problem. For healing the injuries, usually they do not take any treatment. When they become injured, they stayed at home rather than going fishing. Sometimes they visit local village doctor or local healers (i.e., *Kabiraj*). As an extreme case, one non-migratory fisher stated, "In 2005 to 2007, three fishers died on a storm as a result of boat drown." Two migratory fishers added that one fisher died in 2010 for the same reason. All migratory and 98.15% of the non-migratory fishers reported that storms resulted reduced fish catch, which resulted in reduced income for fishers and affected their livelihoods negatively. Thus both migratory and non-migratory fishers were affected quite similarly by storm.

4.2.2. Rainfall and Temperature Change

Low rainfall in rainy season (decreasing mean rate 95.03 mm per year) and high temperature (increasing mean rate 0.0107 °C per year) in summer have been reduced the water depth in the Padma River over the past 3 decades (from BMD data). The reduced water level facilitated to create sandbars in the river with decreased productivity (i.e., reduced natural capital), overfishing and use of illegal gear (Figure 3). This resulted less availability of fish and less yield for 84% migratory and 93% non-migratory fishers. This situation made some fishers unemployed. During winter, cold waves and fogginess had adversely affected all migratory and 94% non-migratory fishers' catch. Thus, the impact of rainfall and temperature change on the migratory and non-migratory fishers does not differ significantly.

4.2.3. Riverbank Erosion

Data shows that 96.3% non-migratory fishers were victims of riverbank erosion, whereas none of the migratory fishers were affected by this. This erosion destroyed the land and as a consequence, it constrained the fishers from taking loans from the bank due to lack of collateral. Riverbank erosion also resulted in displacement that greatly disrupted fishers' livelihoods. The dislocation and relocation of households due to riverbank erosion will involve extra cost and sometimes may cut social support from their relatives and friends that create impacts on both financial and social capital. One non-migratory fisher from Dhulsura said "I and my family have experienced displacement as many as four times due to river erosion."

4.3. Response Strategies

4.3.1. Response to Storm

The list of adopted strategies taken by both migratory and non-migratory fishermen to adjust to the consequences of storm are presented in Figure 5 and these strategies are separated as coping and adaptation strategies based on the characteristics described in conceptual framework (see, Figure 1). However, Table 4 presents if these strategies have any significant differences between migratory and non-migratory fishers. Since the fishers' main income source is fishing they usually cannot skip fishing even in severe category of storms. The most important coping strategy during storm was taking shelter in the nearest safe places as reported by all migratory and 92.6% non-migratory fishers during interviews, for examples, tying up their boats in small canals or nearby riverbanks or a place where there were less wave and storm flow such as on sandbars (Table 3). When they found no safe place to take shelter, then they stayed in their boats and prayed to the God.

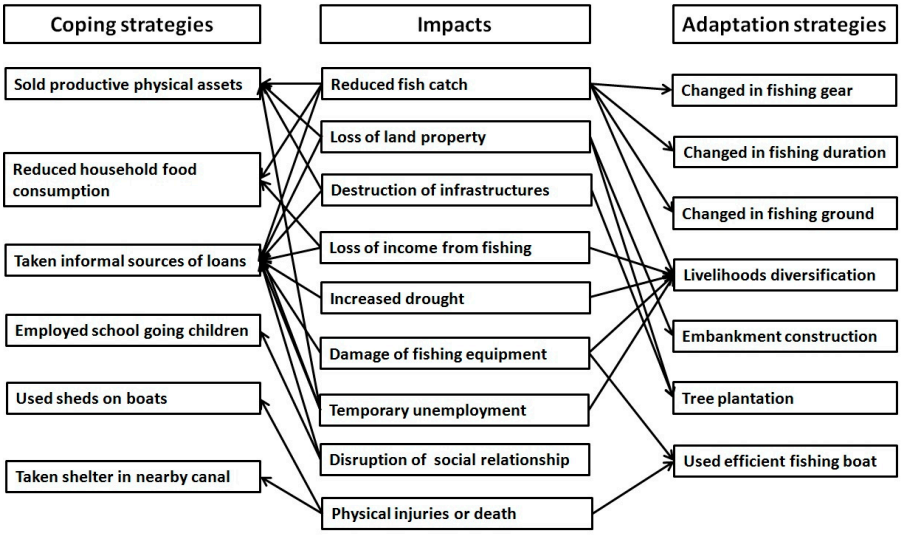

Figure 5. Response strategies (coping and adaptation) to the impacts caused by different hazards by the fishers' dependent on the Padma River fisheries, Bangladesh. Source: Authors own illustration.

Table 4. Percentage of Padma River migratory and non-migratory fishers adopt response strategies to climatic hazards and disasters.

Response Strategies	Migratory Fishers (%)	Non-Migratory Fisher (%)
Coping Strategies		
Sold productive liquid assets	63	94
Reduced household food consumption	32	83
Taken informal sources of credits	68	100
Employed school going children	53	52
Taken shelter on boats	100	57
Taken shelter in nearby canal or river	100	93
Adaptation Strategies		
Used mechanized boats	100	56
Changed in fishing duration	47	100
Changed in fishing gear	100	57
Changed in fishing ground	100	No change
Livelihood diversification	59	100
Embankment construction	Was done by government	Not applicable

Source: Field survey, 2015.

After the storm, selling of assets such as gold or livestock (e.g., cows, goats, etc.) serves as a coping strategy to finance the buying or repairing the fishing boats, equipment and gear. 63% of migratory and 94% non-migratory fishers reported to sell their assets for such purposes. For the same purpose, 68% of migratory and all non-migratory fishers took credit from informal sources like local money lenders (called *Dadondars*). These types of credit are typically with high interest rates and with unfavorable terms and conditions. The *Dadondar* used to give credit on the condition that the fishers will be obliged to sell their fish to the money-lenders at a lower price until repayment is completed.

To adjust to the storm and increase fishing efficiency, the fishers have modernized their fishing crafts and gear. About 10 years ago most of them had used non-mechanized boats for fishing. However, currently all migratory and 56% non-migratory fishers use mechanized boats for fishing.

4.3.2. Response to Rainfall and Temperature Change

The rainfall has reduced and temperature has increased and therefore they were forced to change their traditional ways of coping with such changed situation. Due to reduced rainfall fish-catch has decreased which forced fishers to sale their resources to cope with the adverse livelihood conditions. The other most common coping strategies were selling fishers' productive assets followed by reduced household consumption and taking loans from friends, relatives or others (Table 3). Another strategy against decreasing fish catch was to extend the duration of fishing hours and use of more efficient fishing gears (Figure 5). About half of the migratory (47%) and all non-migratory fishers had increased the average fishing duration per day by 3 h and 4.18 h respectively. 50% non-migratory fishers upgraded their fishing gear (i.e., replaced their cast/lift nets and fishing traps with seine and gill nets). In contrast, this rate of upgradation was 100% for the migratory fishers. To adapt to this condition 50% non-migratory fishers also used more traps for fishing, whereas none of migratory fishers used them. Thus, migratory fishers used more efficient gear whereas non-migratory fishers used more diverse fishing gear.

4.3.3. Response to Riverbank Erosion

As stated earlier, only non-migratory fishers were affected by river-bank erosion and it resulted in physical and financial losses to them. In response to such losses, they had to sell their productive assets, reduce food consumption and take informal loans and so forth. (Figure 5). Embankment construction was an initiative taken from the government and it has influenced the livelihood options for non-migratory fishers. The main purpose of embankment construction was to control riverbank erosion. During household interviews, 61% non-migratory fishers from Andharmanik reported that embankment construction in Harirampur *upazila* is a maladaptive strategy as it disconnected the Padma River from the nearby "*Diyarbeel*" (*beel* is a natural depression) and associated floodplains. As a result, small size fish, eggs, larvae, fingerling, juveniles and so forth, cannot go to the *beel* or floodplains. FGD participant's reported that fish production reduced by 20% due to embankment construction.

In response to the reduced yield and other climate related events mentioned above, the non-migratory fishers intensified fishing more than their migratory counterparts, whereas the migratory fishers diversified their livelihoods more than the non-migratory fishers (Figure 6). Intensified fishing such as—increased fishing duration and number of fishing gears (Table 4)—surpassed the diversification of income sources (e.g., farming agriculture, agricultural labor, driving vehicles, etc.). The fishers only accept those response options with least economic cost. From this judgment, as increasing fishing hours does not bear any financial cost but only requires more labor. But if fishers found other alternatives where the opportunity cost of labor is high, then they would not invest more input on this scale. However, as mentioned previously that the income from fishing is decreasing as a result of climate variability and changes, fishers extend their fishing duration and trying to exploit the shrinking resources more since they have no other choices. Fishers who have money and more human capital they invest in more gears but who are not capable to do that they switch fishing and involve in non-fishery related activities. This study found that 50% of the

both fishing communities had stopped their children from going to school and involved them in fishery related activities to intensify the fishing or in non-fisheries related activities. This strategy can therefore be treated as maladaptive. FGD participants reported that fishers co-opted with other non-fishing activities to support their livelihoods due to reduction of yields from fishing. Additionally, the migratory fishers who had diversified livelihood strategies were less vulnerable compared to non-migratory fishers.

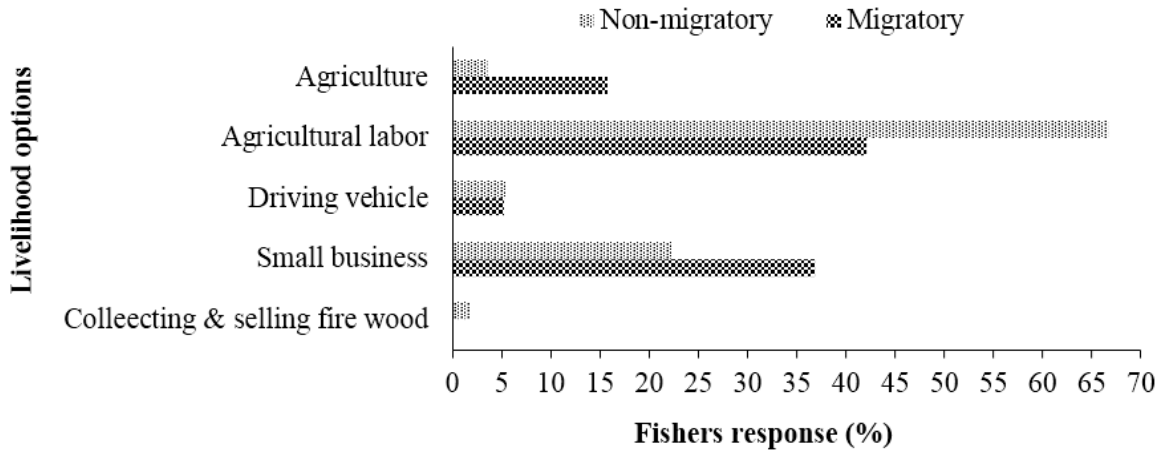

Figure 6. Livelihood diversification of the migratory and non-migratory fishers' dependent on the Padma River fisheries, Bangladesh.

5. Discussion

Results shows that both groups of fishers were similarly affected by the storm in terms of loss of human, physical, financial capitals. However, the impacts vary between the groups according the nature and type climatic events. These findings contradict with the outcomes of Islam et al. (2014b) who stated cyclone *Gorki* destroyed or severely damaged almost all non-migrants' houses while only a half of the migrants had experienced similar impacts in the coastal region of Bangladesh. This contradiction may be because of the fact that for this study the migratory fishers are seasonal and voluntary, whereas it was permanent and forced in case of Islam et al. (2014b). The results related with physical injuries and death due to storm surges support the findings of IPCC (2007) that the fishing community people usually share the largest fatalities caused by storm-surges. For example, the 1970 cyclone killed 300,000 people in coastal Bangladesh many of whom were from fishing communities. Result shows and reflects the study of Badjeck et al. (2010) that after storm there were reduced fish catch and it is also observed that other hazardous events have also significantly differences in impacts on the migratory and non-migratory fishers. In addition, the respondents reported the decreasing trend in water depth of the Padma River as one of the main reasons of decreasing fish catch. Like this study, Vineis et al. (2011) reported that the Padma River water depth has reduced as a result of low rainfall and changes in landscape dynamics of river discharge from upstream flow (Auerbach et al. 2015; Met Office 2011). This study also supports the findings of O'Reilly et al. (2003) who mentioned that fish production has declined in Lake Tanganyika in the recent past largely due to increasing temperature. Displacement of households in the studied fishing communities supports the findings of Islam et al. (2014a), where they claimed that most of the people living in erosion prone areas are susceptible to displace after an erosion event taken place (Mallick and Etzold 2015). Findings show that both the migratory and non-migratory fishers have taken loans and sold their livestock as short-term strategies, which supports the findings of Trærup and Mertz (2011).

Particularly, it was found that as response strategies, lesser number of migratory fishers sold their physical assets, took informal credit/loans and intensified fishing comparing than their non-migratory counterparts. But more of them used modernized boats and diversified their livelihoods. These have

the potential for the migratory fishers to become less vulnerable compare to their non-migratory counterparts, despite the fact that both groups are adopting some maladaptive strategies such as embankment construction as described in Section 4.3.3 and involving children in non-fishing related activities which are harming aquatic biodiversity and children education respectively.

Adopting motorized boat instead of traditional one is an example of changing in the adaptation practices. In order to increase the number of fishing gears (i.e., increasing number of fishing traps), unlike extending fishing duration, the fishers have to bear a financial cost. Fishers in this study practiced above strategies (changed in fishing duration and gears and increased number of fishing gears) about 5 years or more to increase their income from fishing and therefore these strategies can be regarded as adaptive strategies. Similarly, involving children (around 52% in both migratory and non-migratory fishers' communities) in non-fishing activities to support their livelihoods due to reduction of yields from fishing has been reported in this study that supports the findings of Daw et al. (2009). This study agrees with the findings of Chowdhury et al. (2011) who reported that worse socio-economic condition led the children in fishing community to involve in fishing sector rather than taking education at schools. This study further contributes to the literature that unlike the impacts considerable differences were found between the migratory and non-migratory fishers in their coping and adaptation strategies and their local environmental plays the vital role in their response strategies. This signifies the conceptual framework of 'difference tri-angle' describes in Section 2.

Thus, future adaptive tools and strategies to combat with extreme events should be designed in a way that considers the differences in impacts as well as responses taken by different occupation groups. Short-term strategies must consider the immediate and early recovery supports depending on their pattern of occupation and social characteristics and the long-term infrastructural as well as institutional supports should address the demands and acceptance of community itself. It is evident that community does not always accept the long-term supports that are designed without their consultations and participations in decision-making process (i.e., cyclone shelter and its management, see details in Mallick and Vogt 2012).

As the main aims of this study is to understand the impacts of climatic hazards on the fishers and how the fisher responses to those hazards, therefore, the economic, social and political dimensions of migration decisions were not considered in the analysis. However, this study signifies the differences between migratory and non-migratory fishers, which are somehow signifies the social attributes of understanding social dimensions and the results show the differences between them. In addition to this, there was a weakness to make statistical inferences (generalizations) of this study due to the sample size, however, it provides some new insights of the impacts of climate variability and change and their response strategies to overcome the impacts. The findings of such a study could also contribute to an understanding of these issues in other parts of the Bangladesh with similar environmental, socio-economic and livelihood conditions. Employment of the multi-staged sampling and mixed method approaches is helpful for robustness of the findings (Abbas et al. 2016). Cross nation comparative of this kind of studies may also help countries learn from each other.

Author Contributions: Conceptualization, M.I.K. and M.M.I.; Data curation, M.I.K.; Formal analysis, M.I.K., G.K.K. and B.M.; Funding acquisition, M.M.I.; Methodology, M.I.K., M.S.A. and M.M.I.; Supervision, G.K.K., M.S.A. and M.M.I.; Writing—original draft, M.I.K. and G.K.K; Writing—review & editing, M.I.K., G.K.K., B.M. and M.M.I.

Funding: This research was supported by the International Foundation for Science (IFS), Sweden (Grant number S/5556-1).

Acknowledgments: The authors are thankful to the participants in the field study. The authors are also thankful to the anonymous reviewers for their valuable suggestions and comments for revising the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

Abbas, Azhar, T. S. Amjath-Babu, Harald Kächele, and Klaus Müller. 2016. Participatory adaptation to climate extremes: An assessment of households' willingness to contribute labor for flood risk mitigation in Pakistan. *Journal of Water and Climate Change* 7: 621–36. [CrossRef]

Abobi, Seth Mensah, and Elliot Haruna Alhassan. 2015. A Review of Fisheries-Related Human Migration in the Gulf of Guinea. *Journal of Coastal Zone Management* 18: 395. [CrossRef]

Adger, W. Neil, Suraje Dessai, Marisa Goulden, Mike Hulme, Irene Lorenzoni, Donald R. Nelson, Lars Otto Naess, Johanna Wolf, and Anita Wreford. 2009. Are there social limits to adaptation to climate change? *Climatic Change* 93: 335–54. [CrossRef]

Adger, W. Neil, Jon Barnett, Katrina Brown, Nadine Marshall, and Karen O'Brien. 2013. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change* 3: 112–17. [CrossRef]

Agrawal, Arun. 2010. Local institutions and adaptation to climate change. In *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*. Edited by Robin Mearns and Andrew Norton. Washington, DC: World Bank.

Ahmed, Md Sagir, Md Shah Alam, and Hafeza Akther. 2009. Livelihood assessment of a Jatka fishing community at north Srirumthi village, Chandpur, Bangladesh. *South Pacific Studies* 29: 1–12.

Ahmed, Md Kawser, Sadeka Halim, and Shamima Sultana. 2012. Participation of women in aquaculture in three coastal districts of Bangladesh: Approaches toward sustainable livelihood. *World Journal of Agricultural Sciences* 8: 253–68.

Allison, Edward H., Malcom C. M. Beveridge, and Martin L. Van Brakel. 2009. Climate change, small-scale fisheries and smallholder aquaculture. In *Fisheries, Sustainability and Development*. Edited by Per Wramner, Mikael Cullberg and Hans Ackefors. Stockholm: Royal Swedish Academy of Agriculture and Forestry, pp. 109–22.

Auerbach, L. W., S. L. Goodbred, Jr., D. R. Mondal, C. A. Wilson, K. R. Ahmed, K. Roy, M. S. Steckler, C. Small, J. M. Gilligan, and B. A. Ackerly. 2015. Flood risk of natural and embanked landscapes on the Ganges–Brahmaputra tidal delta plain. *Nature Climate Change* 5: 153–57. [CrossRef]

Badjeck, Marie-Caroline, Edward H. Allison, Ashley S. Halls, and Nicholas K. Dulvy. 2010. Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy* 34: 375–83. [CrossRef]

Barrett, Christopher B., Thomas Reardon, and Patrick Webb. 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics and policy implications. *Food Policy* 26: 315–31. [CrossRef]

BBS. 2011. *Bangladesh Population Census 2011*; Dhaka: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, 466p.

Bhuiyan, Sharmin Siddique, M. A. R. Joadder, and Abdus Salam Bhuiyan. 2008. Occurrence of fishes and non-fin fishes of the River Padma near Rajshahi, Bangladesh. *University Journal of Zoology, Rajshahi University* 27: 99–100. [CrossRef]

Black, Richard, W. Neil Adger, Nigel W. Arnell, Stefan Dercon, Andrew Geddes, and David Thomas. 2011. The Effect of Environmental Change on Human Migration. *Global Environmental Change* 21: S3–11. [CrossRef]

Carling, J⊘rgen. 2002. Migration in the Age of Involuntary Immobility: Theoretical Reflections and Cape Verdean Experiences. *Journal of Ethnic and Migration Studies* 28: 5–42. [CrossRef]

Chowdhury, M. S., M. S. Hossain, N. G. Das, and P. Barua. 2011. Small-scale Fishermen along the Naaf River, Bangladesh in Crisis: A framework for management. *Mesopotamian Journal of Marine Science* 26: 146–69.

Conway, Declan, Edward Allison, Richard Felstead, and Marisa Goulden. 2005. Rainfall variability in East Africa: Implications for natural resources management and livelihoods. *Philosophical Transactions of the Royal Society of London A* 363: 49–54. [CrossRef] [PubMed]

Daw, Tim, W. Neil Adger, Katrina Brown, and Marie-Caroline Badjeck. 2009. Climate change and capture fisheries: Potential impacts, adaptation and mitigation. In *Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge*. Edited by Kevern Cochrane, Cassandra De Young, Doris Soto and Tarûb Bahri. FAO Fisheries and Aquaculture Technical Paper. No. 530. Rome: Food and Agriculture Organization of the United Nations.

De Vaus, David. 2002. *Surveys in Social Science Research*, 5th ed. London: Routledge.

DoF. 2015. *National Fish Week, 2015. Compendium*. Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock. (In Bengali)

Etzold, Benjamin, and Bishawjit Mallick. 2016. Moving beyond the focus on environmental migration towards recognizing the normality of translocal lives—Insights from Bangladesh. In *Migration, Risk Management and Climate Change: Evidence and Policy Responses*. Edited by Andrea Milan, Benjamin Schraven, Koko Warner and Noemi Cascone. Global Migration Issues Series. Cham: Springer, vol. 6, pp. 105–28.

FAO. 2014. *The State of World Fisheries and Aquaculture 2014: Opportunities and Challenges*. Rome: FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations.

Faruque, Md. Hasan, and Dewan Ali Ahsan. 2014. Socio-economic status of the Hilsa (*Tenualosa ilisha*) fishermen of Padma River, Bangladesh. *World Applied Sciences Journal* 32: 857–64.

Foresight. 2011. *Migration and Global Environmental Change*. Final Project Report. London: The Government Office for Science.

Fujikura, Ryo, and Masato Kawanishi. 2012. *Climate Change Adaptation and International Development: Making Development Cooperation More Effective*. London: Routledge.

Grothmann, Torsten, and Anthony Patt. 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* 15: 199–213. [CrossRef]

Heimann, Thorsten, and Bishawjit Mallick. 2016. Understanding Climate Adaptation Cultures in Global Context: Proposal for an Explanatory Framework. *Climate* 4: 59. [CrossRef]

IPCC. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by Martin Parry, Martin L. Parry, Osvaldo Canziani, Jean Palutikof, Paul Van der Linden and Clair Hanson. Cambridge: Cambridge University Press.

IPCC. 2014. Summary for Policymakers. In *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova and et al. Cambridge: Cambridge University Press.

Islam, M. Nazrul. 2004. Eco-biology of freshwater Gobi, Glossogobius giuris (Hamilton) of the river Padma in relation to its fishery: A review. *Journal of Biological Sciences* 4: 780–93.

Islam, Md Monirul, and Kimiteru Sado. 2000. Development of flood hazard maps of Bangladesh using NOAA-AVHRR images with GIS. *Hydrological Sciences Journal* 45: 337–55. [CrossRef]

Islam, A. K. M. Nazrul, Uttam Kumar Deb, Muhammad Al-Amin, Nusrat Jahan, Ishita Ahmed, Shamma Tabassum, Mazbahul Golam Ahamad, Ashiqun Nabi, Naveen P. Singh, Byjesh Kattarkandi, and Cynthia Bantilan. 2013a. *Vulnerability to Climate Change: Adaptation Strategies and Layers of Resilience-Quantifying Vulnerability to Climate Change in Bangladesh*. Patancheru: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 36p.

Islam, Md Rezaul, Md Nazmul Hoque, Shams Muhammad Galib, and Md Anisur Rahman. 2013b. Livelihood of the fishermen in Monirampur Upazila of Jessore district. *Journal of Fisheries* 1: 37–41. [CrossRef]

Islam, Md Monirul, Susannah Sallu, Klaus Hubacek, and Jouni Paavola. 2014a. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: Insights from coastal Bangladesh. *Regional Environmental Change* 14: 281–94. [CrossRef]

Islam, Md Monirul, Susannah Sallu, Klaus Hubacek, and Jouni Paavola. 2014b. Migrating to tackle climate variability and change? Insights from coastal fishing communities in Bangladesh. *Climatic Change* 124: 733–46. [CrossRef]

Jain, Sunil, Gunwant Sharma, and Y. P. Mathur. 2013. Effects of temperature variations on fish in lakes. *International Journal of Engineering Research & Technology* 2: 2516–23.

Johnson, Terry. 2012. *Fisheries Adaptation to Climate Change*. Alaska Sea Grant Marine Advisory Program. Fairbanks: University of Alaska Fair Banks.

Kabir, K. M. Rejwan, Ripon Kumar Adhikary, M. Belal Hossain, and Maruf Hossain Minar. 2012. Livelihood Status of Fishermen of the Old Brahmaputra River, Banglades. *World Applied Sciences Journal* 16: 869–73.

Khan, M. A. Rahman, M. Idris Miah, M. Belal Hossain, Afroza Begum, M. H. Minar, and Rejaul Karim. 2013. Fish biodiversity and livelihood status of fishing community of Tista river, Bangladesh. *Global Veterinaria* 10: 417–23.

Mallick, Bishawjit, and Benjamin Etzold. 2015. *Environment, Migration and Adaptation—Evidence and Politics of Climate Change in Bangladesh*. Dhaka: ICCCAD and AHDPH Publishing House.

Mallick, Bishawjit, and Joachim Vogt. 2012. Cyclone, Coastal Livelihood and Migration—Empirical evidence from Bangladesh. *International Development and Planning Review* 34: 217–40. [CrossRef]

McLeman, Robert, and Barry Smit. 2006. Migration as an adaptation to climate change. *Climatic Change* 76: 31–53. [CrossRef]

Met Office. 2011. *Climate: Observations, Projections and Impacts—Bangladesh*. Exeter: Met Office Hadley Centre and Department of Energy and Climate Change of the United Kingdom.

Mohsin, A. B. M., Sk Md Mohaimenul Haque, Shams Muhammad Galib, Md Foyzul Hassan Fahad, Nipa Chaki, M. Nazrul Islam, and Md Mojibar Rahman. 2013. Seasonal abundance of fin fishes in the Padma River at Rajshahi district, Bangladesh. *World Journal of Fish and Marine Sciences* 5: 680–85. [CrossRef]

O'Reilly, Catherine M., Simone R. Alin, Pierre-Denis Plisnier, Andrew S. Cohen, and Brent A. McKee. 2003. Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa. *Nature* 424: 766–68. [CrossRef]

Ogutu-Ohwayo, Richard, Robert E. Hecky, Andrew S. Cohen, and Les Kaufman. 1997. Human impacts on the African great lakes. *Environmental Biology of Fishes* 50: 117–31. [CrossRef]

Patt, Anthony G., and Dagmar Schröter. 2008. Perceptions of climate risk in Mozambique: Implications for the success of adaptation strategies. *Global Environmental Change* 18: 458–67. [CrossRef]

Paul, Bimal Kanti, and Rujuan Hossain Bhuiyan. 2004. *The April 2004 Tornado in North-Central Bangladesh: A Case for Introducing Tornado Forecasting and Warning Systems*. Quick Response Research Report 169. Boulder: Natural Hazards Center.

Paul, Bijoya, Hasan Faruque, and Dewan Ali Ahsan. 2013. Livelihood status of the fishermen of the Turag river, Bangladesh. *Middle East Journal of Scientific Research* 18: 578–83.

Price, Jennifer C., Iain A. Walker, and Fabio Boschetti. 2014. Measuring cultural values and belief about environment to identify their role in climate change responses. *Journal of Environmental Psychology* 37: 8–20. [CrossRef]

Sarch, Marie-Therese, and Edward H. Allison. 2000. Fluctuating fisheries in Africa's inland waters: Well adapted livelihoods, maladapted management. Paper presented at the 10th International Conference of the Institute of Fisheries Economics and Trade, Corvallis, OR, USA, July 9–14.

Shoji, Masahiro. 2010. Does contingent repayment in microfinance help the poor during natural disasters? *The Journal of Development Studies* 46: 191–210. [CrossRef]

Sjöberg, Lennart. 2000. Factors in risk perception. *Risk Analysis* 20: 1–12. [CrossRef]

Strauss, Anselm, and Juliet M. Corbin. 1990. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Sage London: Publications Inc.

Sultana, Parvin, and Paul Thompson. 2008. Gender and local floodplain management institutions: A case study from Bangladesh. *Journal of International Development* 20: 53–68. [CrossRef]

Trærup, Sara L., and Ole Mertz. 2011. Rainfall variability and household coping strategies in northern Tanzania: A motivation for district-level strategies. *Regional Environmental Change* 11: 471–81. [CrossRef]

Vineis, Paolo, Queenie Chan, and Aneire Khan. 2011. Climate change impacts on water salinity and health. *Journal of Epidemiology and Global Health* 1: 5–10. [CrossRef]

Warner, Koko, Olivia V. Dun, and Marc Stal. 2008. Climate change and displacement: Field observations and empirical research. *Forced Migration Review* 38: 13–15.

Westlund, Lena, Florence Poulain, Hans Bage, and Raymon van Anrooy. 2007. *Disaster Response and Risk Management in the Fisheries Sector*. Rome: Food and Agriculture Organization of the United Nations.