Climate Disasters in Bangladesh: Impacts Assessment and Adaptation Measures

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Focusing on the climate disasters in Bangladesh, we attempt to answer the following two questions based on a questionnaire survey with respect to residents in both inland and coastal regions: 1) what are the impacts of climate disasters?, 2) how people adapted in the past and would adapt in the future to the occurrence of disasters?. The survey items include people's experiences and understanding of climate disasters, before-disasters adaptive behaviors, during-disasters response behaviors, and after-disasters recovery behaviors, barriers and important factors for the above behaviors, and future adaptation behavior under different disaster scenarios, household and individual attributes and so on. We implemented the survey in January to February, 2013 and successfully collected about 1,000 questionnaire sheets. Impacts assessment and adaptation measures in Bangladesh are reported based on the survey. Especially, the obtained findings are useful to identify the barriers of adaptation measures, the roles of different stakeholders in implementing adaptation measures, and the directions of adaptation measures in future.

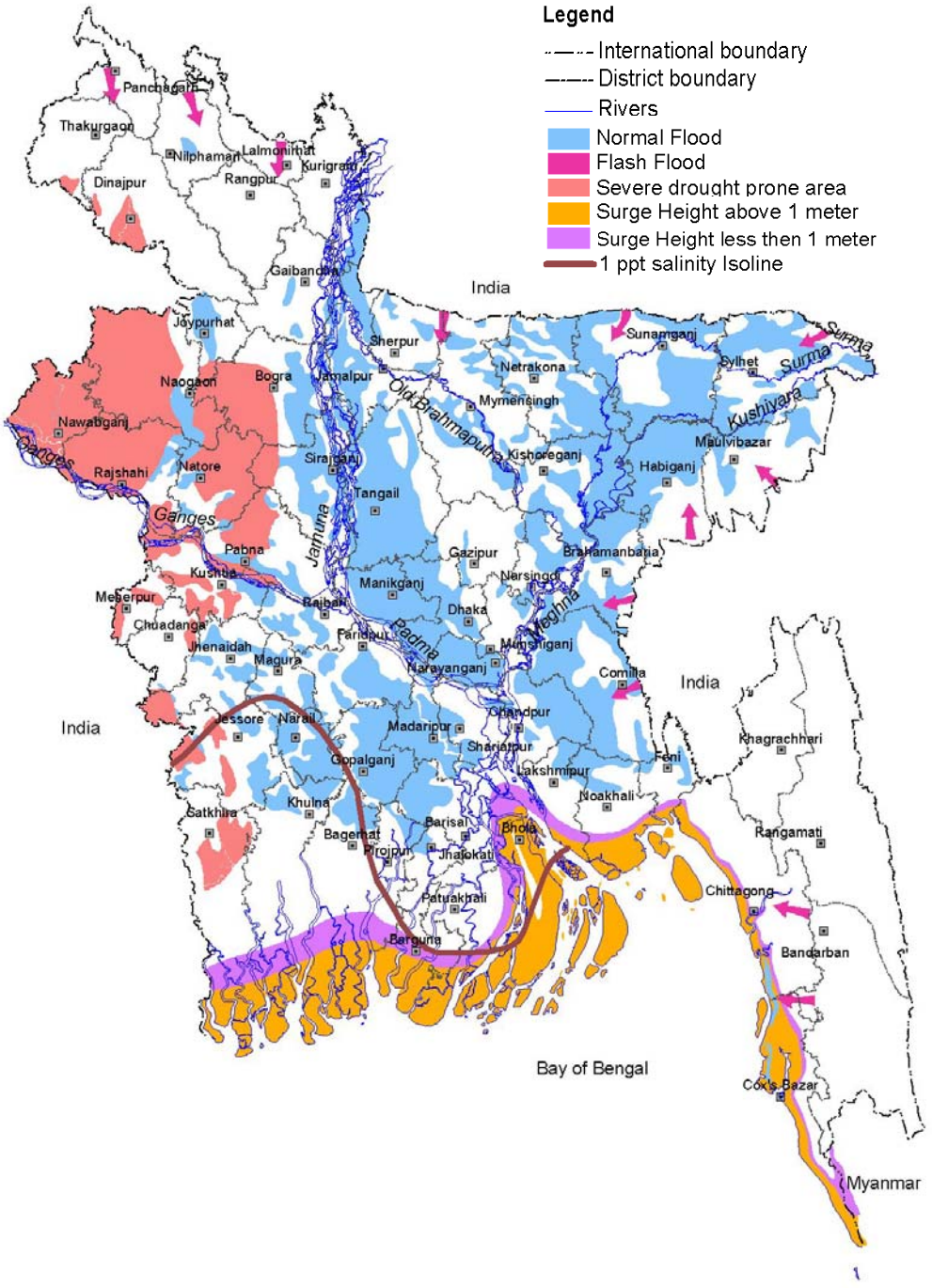
Key Words : *climate disasters, Bangladesh, adaptation behavior, impact assessment*

1. INTRODUCTION

Bangladesh is one of the most climate vulnerable countries in the world and the sixth most vulnerable country to flood based on deaths per 100,000 people exposed to cyclone/flood (UNDP, 2004). Floods, tropical cyclones, storm surges and droughts are likely to become more frequent and severe in the coming years. Bangladesh's high vulnerability to climate change is due to a number of hydro-geological and socio-economic factors that include: (a) its geographical location in South Asia; (b) its flat deltaic topography with very low elevation; (c) its extreme climate variability that is governed by monsoon and which results in acute water distribution over space and time; (d) its high population density and poverty incidence; and (e) its majority of population being dependent on crop agriculture which is highly influenced by climate variability and change (Ahsan,2006). Most parts of Bangladesh are located in the delta of three of the largest rivers in the world, and two-thirds of the country is less than 5 meters above sea level and is susceptible to river and rainwater flooding and, in lower lying coastal areas, to tidal flooding during storms. Vulnerability to different climate related hazards in Bangladesh is illustrated in Figure 1.

The most common water-related and climate change induced natural disasters in a deltaic floodplain such as Bangladesh is flood. Flooding in Bangladesh is the result of a complex series of factors. These include a huge inflow of water from upstream catchment areas coinciding with heavy monsoon rainfall in the country, a low floodplain gradient, and congested drainage channels, the

major rivers converging inside Bangladesh, tides and storm surges in coastal areas, and polders that increase the intensity of floodwater outside protected areas. Different combinations of these various factors give rise to different types of flooding. The most recent exceptional flood in 2007 inundated 62,300 sq km of land (42% of the total) and caused severe damage to lives and property, and the most serious mega flood occurred in 1998, causing nearly 70% of land inundated (World Bank, 2010). The impacts of sea level rise (SLR) are also serious.

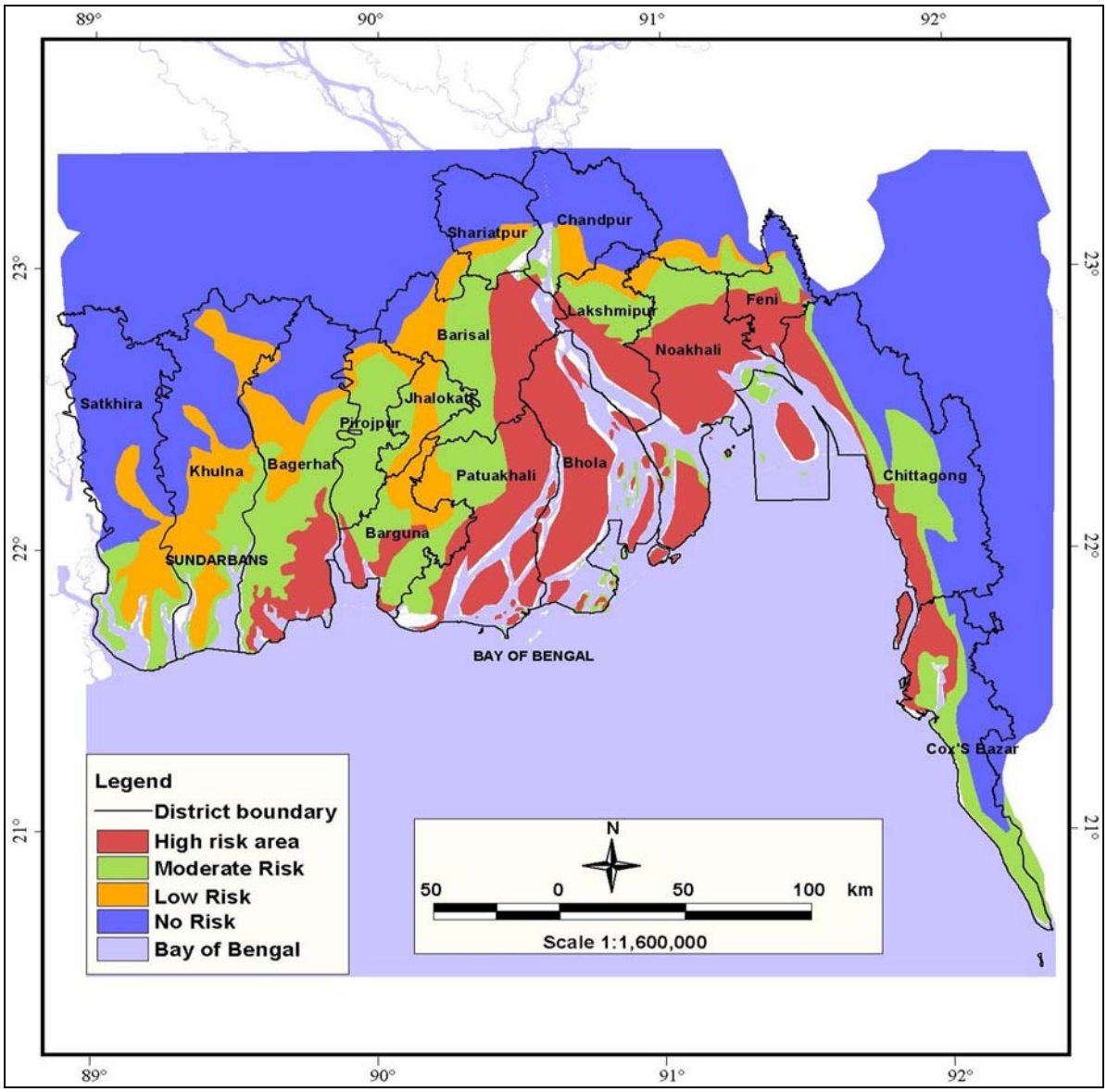


(Source: CEGIS (http://www.cegisbd.com/))

Figure 1. Vulnerability to different climate disasters in Bangladesh

There are about 31 million persons living along the coastal area and CEGIS[1] estimated that about half of the population are living within the risk area (see Figure 2).

[1] http://www.cegisbd.com/

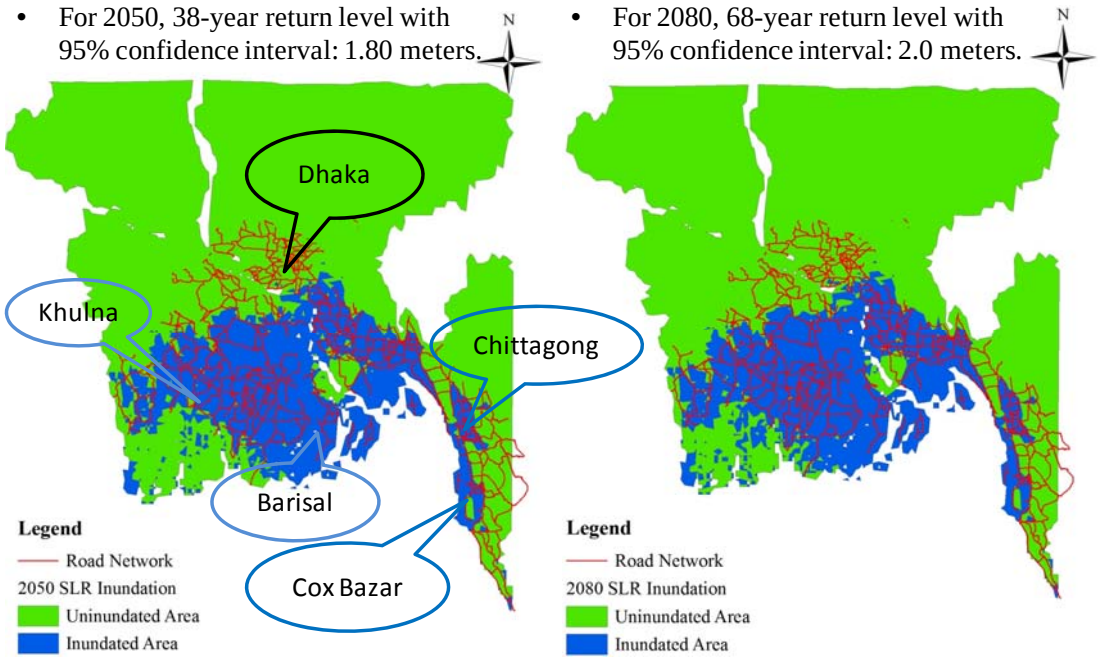


(Source: CEGIS (http://www.cegisbd.com/))

Figure 2. Population under disaster risks along the coastal area in Bangladesh

As shown in Figure 3, it is predicted[2] that the average sea level rise in Bangladesh in the future will be 1.8 m in 2050 and 2.0 m in 2080. Note that both global warming and storm surge were incorporated in the prediction. Based on the predicted sea levels, we further predicted that 60.61% and 62.86% of roads along the coastal area will be affected in 2050 and 2080, respectively, and the corresponding percentages for the whole country will be 23.48% and 24.35%, respectively.

[2] This study is a part of joint research led by the first author under the Global Environmental Leaders Education Program for Designing a Low-Carbon World, Hiroshima University, financially supported by MEXT Special Coordination Funds for Promotion of Science and Technology (2008.10-2013.03). The joint research is still on-going and its team consists of four groups: Environmental Impacts Assessment Group (deals with impacts assessment of SLR and cyclone), Urban System Design Group (deals with adaptation measures from the perspectives of citizen's lives and tourism), Ecosystem Group (deals with adaptation measures from the perspective of agriculture), and Policy and Institutional Design Group (deals with economic analysis of disasters induced damages and adaptation measures. This prediction was conducted by the Environmental Impacts Assessment Group, using the observed sea level records during the period between 1977.04.01 and 2009.03.31 (32 years): 1 hour interval between 1977.04.01 and 1988.03.31 and 30 minutes interval between 1988.04.01 and 2009.03.31.



SLR impacts on road infrastructure of the costal areas

Scenarios	Affected Road Segments	Total Length (Km)	Total Study Area Road Length (Km)	Percentage (%)
1.8 m (2050)	1935	4745.02	7828.47	60.61
2.0 m (2080)	2007	4920.97	7828.47	62.86

SLR impacts on road infrastructure of the whole country

Scenarios	Affected Road Segments	Total Length (Km)	Total National Road Length (Km)	Percentage (%)
1.8 m (2050)	1935	4745.02	20205.96	23.48
2.0 m (2080)	2007	4920.97	20205.96	24.35

(Source: The authors)

Figure 3. Predicted Sea Level Rise (=Global Warming + Storm Surge) in Future in Bangladesh

Due to climate disasters in Bangladesh, traffic on transportation networks has been frequently cut off here and there, bringing in various barriers to smoothly perform various economic activities and imposing huge impacts on citizens' daily life, and ecosystems (e.g., wetlands, forests and coastal areas) could be also seriously influenced by climate disasters.

From the long-term perspective, mitigation measures in both Bangladesh and other countries across the world are definitely required, but it seems not that easy. Accordingly, adaptation measures should be given a higher priority from the medium- and short-term perspective.

This study is a part of joint research led by the first author under the Global Environmental Leaders Education Program for Designing a Low-Carbon World, Hiroshima University, financially supported by MEXT Special Coordination Funds for Promotion of Science and Technology (2008.10-2013.04). The research questions raised for the joint research project are,

1) *What are the potential impacts of climate disasters in Bangladesh and how serious?*
Climate disasters could result in not only direct damages to various economic activities (esp., agriculture and industrial activities), but also indirect damages due to the cutoff and delay of traffic, which further worsen citizens' daily life because of extremely lower accessibility to various daily facilities. Ecosystems (e.g., wetlands, forests and coastal areas) could be also seriously influenced by climate disasters. On the other hand, climate disasters sometimes bring benefits. For example, land might become more nutritious after the flood. Such positive impacts should be also identified and made full use of adaptation measures. In the joint research project, impacts on transportation systems, economic activities and citizens' life as well as ecosystem

are targeted. Especially, it is necessary to clarify how serious of each type of impacts. Such information will be helpful to identity the policy priorities under the serious budget constraints in Bangladesh.

2) *How to evaluate the potential impacts of climate disasters in Bangladesh?*
Better assessments of impacts need data with better quality and sufficient information, and better methodologies. In case of Bangladesh, available data sources are always problematic. To respond to such shortcoming of data availability, less data-intensive methods without seriously worsening proper representation of actual phenomenon are required. In the joint research project, evaluation methods are examined from both the macro-level and micro-level, where the macro-level requires the use of secondary data at various spatial scales, and the micro-level requires the first-hand data collected from the people and industries at risk. Evaluation methods at the macro- and micro-level should be properly combined. The problems are how to combine these methods in a logical and operational way.

3) *What kinds of effective adaptation measures should be taken, especially considering very limited budget constraints?*
Adaptation measures could be proposed from various angles, such as flood management, coastal polders, cyclone and flood shelters, management of agricultural land use and logistics, and the rising of roads and highways above flood level. Since transportation systems, economic activities and citizens' life as well as ecosystem are targeted in the joint research project, effective adaptation measures will be proposed from these four aspects. Due to the constraint of limited budgets in Bangladesh, various adaptation measures should be traded off and given different priorities in policy decisions.

4) *How to implement adaptation measures?*
Since climate disasters generate various damages to various sectors simultaneously, joint efforts from the various sectors are required. In this sense, it is necessary to clarify what kinds of cross-sector approaches are more effective from both the long-term and medium-, short-term perspectives.

In this specific study, we attempt to only answer the following two questions based on a questionnaire survey with respect to residents in both inland and coastal regions: 1) what are the impacts of climate disasters?, 2) how people adapted in the past and would adapt in the future to the occurrence of disasters?. For this purpose, we implemented a relatively large-scale questionnaire survey in January to February, 2013. The survey items include people's experiences and understanding of climate disasters, before-disasters adaptive behaviors, during-disasters response behaviors, and after-disasters recovery behaviors, barriers and important factors for the above behaviors, and future adaptation behavior under different disaster scenarios, household and individual attributes and so on. We successfully collected valid questionnaire sheets from 998 respondents.

2. LITERATURE REVIEW

The **impacts of disasters** as a result of climate change on Bangladesh are huge. Mahmud and Prowse (2012) investigated the impacts of cyclone Aila in 2009 in Kulna, Bangladesh and summarized that 99& of the households suffered losses. Nelson (2003) assessed the environmental health impact of flood, sea level rise, storm surge, and cyclone as a result of global climate change using the disability-adjusted life year method in Bangladesh, and found that particularly children and young people are very vulnerable to health impacts from climate change. In order to understand future sea level rise impacts in western Bangladesh, Karim and Mimura (2008) created eight flooding scenarios and identified the high risk areas and additional shelters needed to accommodate people affected.

Because of the differences in individual characteristics such as knowledge, education, income, and so on, and government policies, people's **adaptation choices** towards disasters resulted from

global climate change are also different. Patt and Schoter (2008) found that people rarely choose evacuation and resettlement to adapt to floods because of their different perceptions of climate change. Artur and Hilhorst (2012) analyzed the adaptation measures adopted by people in the flood-prone areas in Mozambique and pointed that people's adaptive strategies ranging from flood-proofing houses to everyday life behavior such as investment strategies are much more diverse than those mentioned by Osbahr et al. (2008). Sahin and Mohamed (2013) consulted three different stakeholders, the residence prefer building design improvement and protective structures, the politicians like building design improvement and retreat, and the experts think building design and public awareness improvement are the best choice. In Bangladesh, the government has constructed a large number of refugee shelters and embankments in coastal areas, while the early warning system needs to be further improved and more shelters are required for people at risks (Karim and Mimura, 2008). Mahmud and Prowse (2012) investigated the adaptation measures before and after cyclone Aila in 2009 in Bangladesh, and concluded that the pre-disaster intervention such as early warning system and disaster-preparedness training is better than the post-disaster relief.

Various factors affect individual's adaptation choices to climate change disasters. Adger (2003) stated that the adaptation to climate change is a function of individual's access to resources, and what's more, access to information plays an important role in choosing resources (Phillips, 2003). The stronger perception of the climate change risks the stronger response to adapt to climate change (Barnett and Adger 2003, and Hess et al. 2008). People's adaptations are also affected by their psychological factors such as ambiguity aversion (fear) and ambiguity seeking (hope) (Viscusi and Chesson, 1999). Grothman and Patt (2005) focused on psychological factors of people's risk perception and perceived adaptive capacity as the main sectors influencing individual's adaptation choice, and showed the importance of socio-cognitive factors in adaptation behaviors. Other factors such as personal experience, values, morals, culture, and so on also play important roles in adaptation choice including experts and decision makers (Sundblad et al. 2007). Adaptation responses also need people's behavioral change to better cope with the impacts of climate change disasters (Mozumder et al. 2011). Jin and Francisco (2013) found that people as well as local government along Zhejiang, China coastal area have little knowledge about sea level rise and adaptation strategies, and their knowledge and attitude towards adaptation are increased significantly when information brochures are provided to them.

3. SURVEY

Here, climate change disasters refer to flood, cyclone, storm surge, sea level rise, tornado, and drought etc. To achieve the purposes of this study, a questionnaire survey was first designed and consists of the following items.

1) Experience and understanding of climate disasters
2) Adaptive Behaviors to Damages
   (1) Before-disasters adaptive behavior
      - Concern about damages of future risks of disaster on family, house, properties, etc.
      - Measures prepared for responding to the potential risks of disasters ((1) no preparation, (2) elevate the house, (3) strengthen the house, (4) protect the house using wall, dike, and so on, (5) move to cyclone/flood shelter, (6) move family, livestock, and properties to safe place, and come back after flood/cyclone, (7) considering to move to other safe places permanently, (8) consult with experienced persons, and/or (9) others)
      - Confidence about the preparation
      - Cost for the preparation
   (2) During-disasters adaptive behavior (with respect to the most serious disasters)
      - Additional measures compared with the above measures in the above item category (1) (multiple choice)
      - places of moving in case of (6) or (7) in the above the above item category (1) (place

of relatives, place of friends/colleagues, roadside, place provided by the government, or other places)
- how to get the disaster information (newspaper, cell phone, radio, TV, Internet, and/or others)
- information providers (government, community, neighborhood, own experience, and/or others)
- the timing of information acquisition
- evacuation means (by walk, cart, use cattle, bicycle, rickshaws, and/or motorized vehicles)
- helps provided by government, community, and neighborhood (rescue, food, tent and quilt, clean water, money, shelter, no help received, and/or others)
- helps offered to neighborhood (rescue, food, tent and quilt, clean water, money, shelter, no help received, and/or others)
- cost of during-disaster responses

(3) After-disasters recovery behaviors (with respect to the most serious disasters)
- Capability of self-recovery (self-help)
- the most important things during the recovery (house repair, food, clothes, clean water, medicine, money, tent and quilt, grocery, and/or others)
- helps provided by government, community, and neighborhood (house repair, food, clothes, clean water, medicine, money, tent and quilt, grocery, shelter, no help received, and/or others)
- helps offered to neighborhood (house repair, food, clothes, clean water, medicine, money, tent and quilt, grocery, shelter, no help received, and/or others)
- the length of time and cost for the complete recovery

3) Satisfaction with the measures taken in case of before-flood/inundation, in-flood/inundation, after-flood/inundation, before cyclone, during cyclone, after cyclone, sea level rise, salinity intrusion, drought, tornado, and others (in case of no experience, respondents do not need to answer)
4) Relative importance of pre-disaster preparations, during disaster responses, and post-disaster recovery
5) What are the most difficulties in adapting to the impacts of disasters (lack of money, lack of knowledge, lack of government policy, lack of help from government, lack of help from community, lack of help from neighborhood, and/or others)
6) Relative importance of the roles of government, community, neighborhood, and self-help in the whole process of fighting against disasters
7) Priority levels of the following measures for different stakeholders (government, community, and neighborhood): before-disaster (build dikes/seawalls, build elevated roads, build shelters, elevate the houses, early warning system), during-disaster (reinforce houses, evacuation assistance, move to safe places, quilt and other grocery, medical care, money), and after-disaster (house repair, find vacant land for relocation, offering jobs in the city, offering jobs abroad)
8) Future plan to adapt to natural disasters
   (1) possible choices of adaptation behavior ((1) no preparation, (2) elevate the house, (3) strengthen the house, (4) protect the house using wall, dike, and so on, (5) move to cyclone/flood shelter, (6) move family, livestock, and properties to safe place, and come back after flood/cyclone, (7) considering to move to other safe places permanently, (8) consult with experienced persons, and/or (9) others)
   (2) consideration level of impacts of disasters when constructing or retrofitting houses
   (3) consideration level of the potential impacts of disasters when choosing a new job
   (4) important factors affecting the choice of different adaptation measures (cost, effectiveness, easy implementation, level of risk, previous experience, and/or others)
   (5) willingness to accept the compensation from the government in case that the government

could not properly protect the respondent's house, land, and/or work from the disasters

9) Stated adaptation behavior under different flooding and/or sea level rise scenarios and cyclone scenarios: the former scenarios are defined by frequency level (three levels: every year, once every 2 years or once every 3 years), intensity level (three levels: reaches knees, reaches waist, or reaches chest or above), permanent/frequent inundation (two levels: yes or no), permanent salinity intrusion (two levels: yes or no), residential area is isolated by water (two levels: yes or no), and roads to other cities destroyed permanently (two levels: yes or no), and the latter scenarios are defined by frequency level (three levels: twice a year, once a year, or once every 2 years), intensity level (three levels: some structural damage to houses, some complete house structure failure, or complete failure on many houses), frequent inundation (two levels: yes or no), permanent salinity intrusion (two levels: yes or no), residential area is isolated by water (two levels: yes or no), and roads to other cities destroyed permanently (two levels: yes or no). Adaptation behaviors include two parts: life choice (a. same job, same location, and not reinforce the house, b. same job, same location, but reinforce the house, c. switch job, same location, and not reinforce the house, d. switch job, same location, but reinforce the house, e. same job, but shift house location, or f. switch job and shift house location) and inter-city travel behavior (a. still travel as usual, b. cancelled the trip, c. change trips (multiple choice) (c1. change travel modes/routes, c2. change to another destination, c3. change the visit duration and/or timing). As for stated inter-city travel behavior, the current behavior is reported with respect to three main destinations (destination name, trip purpose, visit frequency, main travel mode, travel cost, and travel time).

We carried out the survey with respect to residents living along the coastal regions and inland regions in January and February, 2013. As a result, 998 respondents provided valid answers.

4. PRELIMINARY ANALYSIS RESULTS

We start with the analysis of people's understanding and experience of natural disasters, and then explore how people prepared for and adapted to the natural disasters in the past. After that, we examine how people would like to adapt to the natural disasters under different scenarios of natural disasters in future. As a preliminary analysis, here, we only show some aggregate analysis results. In this preliminary analysis, we aim to identify the barriers of adaptation measures in Bangladesh, the roles of different stakeholders in implementing adaptation measures, and the directions of adaptation measures in future.

Profiles of respondents and their households

Profiles of respondents and their households are shown in Figure 4. As for respondents' age, 27% are 20s, 32% are 30s, and 22% are 40s. The largest group of respondents are those with only degrees of secondary school or below (34%), and 16% had no chances to study. Respondents with high school degrees are the second largest group of respondents (24%). Those who received education in colleges and universities or above are just 22%. Concerning the occupation, farmers and fishers account for 17%, respectively; 12% are labors, 15% are merchants and business men, 4% are rickshaw drivers and only 5% of respondents work in governmental offices. Among the respondents, 37% live in bamboo-made houses (the largest group), followed by 25% of respondents living in brick-structure houses and 16% in earthen houses. Only 4% of respondents live in reinforced concrete houses. Focusing on land areas owned by respondents, 28% have just a piece of land with no more than 50 m^2, respondents with land areas between 50 and 100 m^2 are the largest group, and 22% of respondents own land with more than 400 m^2.

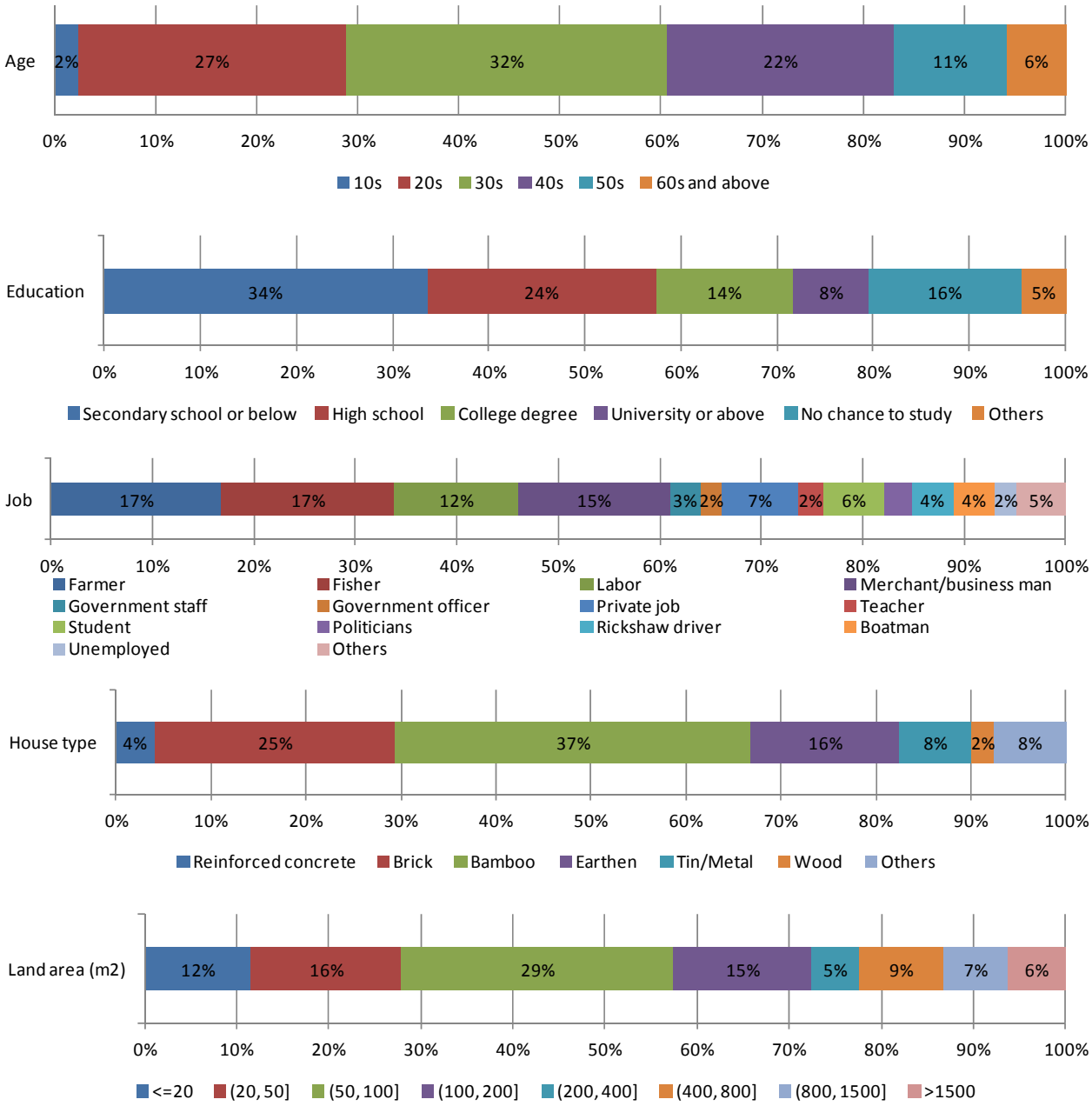


Figure 4. Profiles of Respondents and Their Households

Experiences and understanding of climate change disasters

Numbers of injured people caused by flood, cyclone, and tornado in the past are shown in Figure 5. Flood and tornado caused similar numbers of injured people: 8% of respondents had one injured member, 4% with two injured members, and 1% with three or more injured members.

Focusing on the damages of properties caused by climate disasters, 1) 47%, 62%, and 15% of households suffered from livestock damages caused by flood, cyclone, and tornado, respectively; 2) 53%, 73%, and 22% of households suffered from house damages caused by flood, cyclone, and tornado, respectively; 3) 44%, 57%, and 13% of households suffered from farm land and crops damages caused by flood, cyclone, and tornado, respectively.

Frequencies that houses and land are affected by flood and cyclone are shown in Figure 6. It is found that only 2%~3% of respondents have not been affected frequently by flood and cyclone, 47% affected by flood and 41% by cyclone every year or more. Even though cyclone does not occur every year, there are still a large number of respondents reported damages. This surely reveals the seriousness of water disasters, but at the same time it also means that there are some

misunderstandings about cyclone.

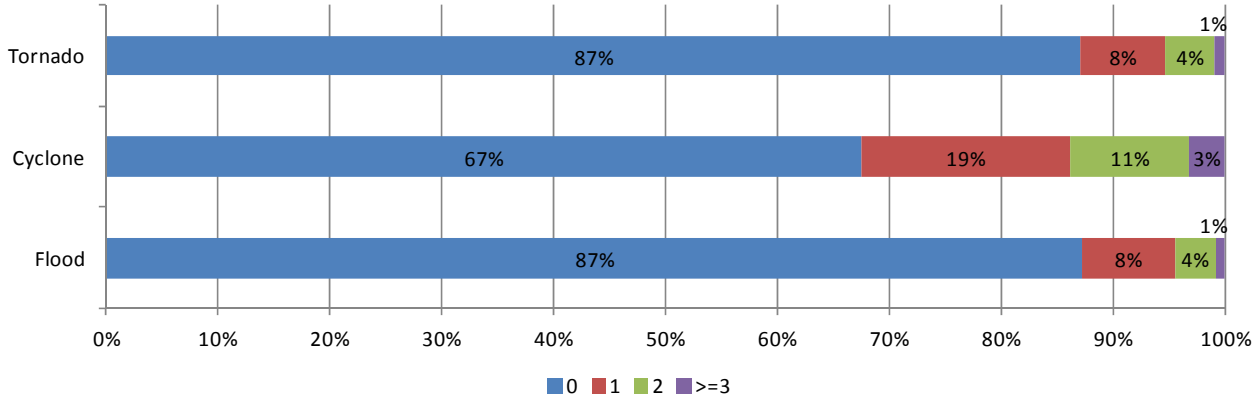


Figure 5. Numbers of Injured People Caused by Flood, Cyclone, and Tornado in the Past

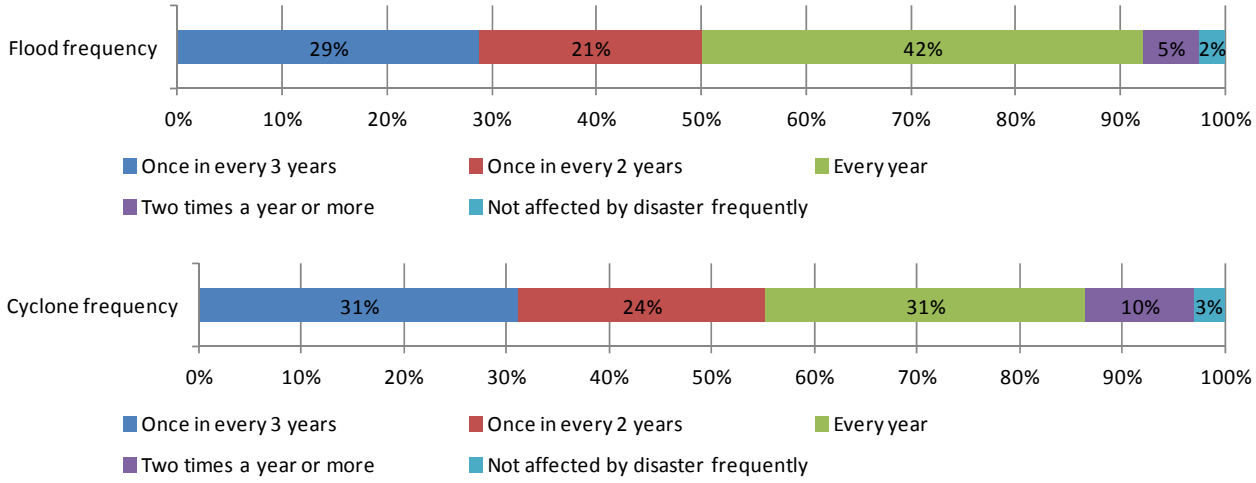


Figure 6. Frequencies that Houses and Land are Affected by Flood and Cyclone

Adaptation measures

Adaptation measures taken before disasters are shown in Figure 7. It is found that more than 30% of respondents did not prepare for anything against the occurrence of climate disasters. For those prepared measures, 26.7% strengthened their houses and 12.8% moved their families, livestock, and properties to safe places and came back after disasters, 8.8% elevated their houses and 7.9% protected their houses using walls, dikes and so on.

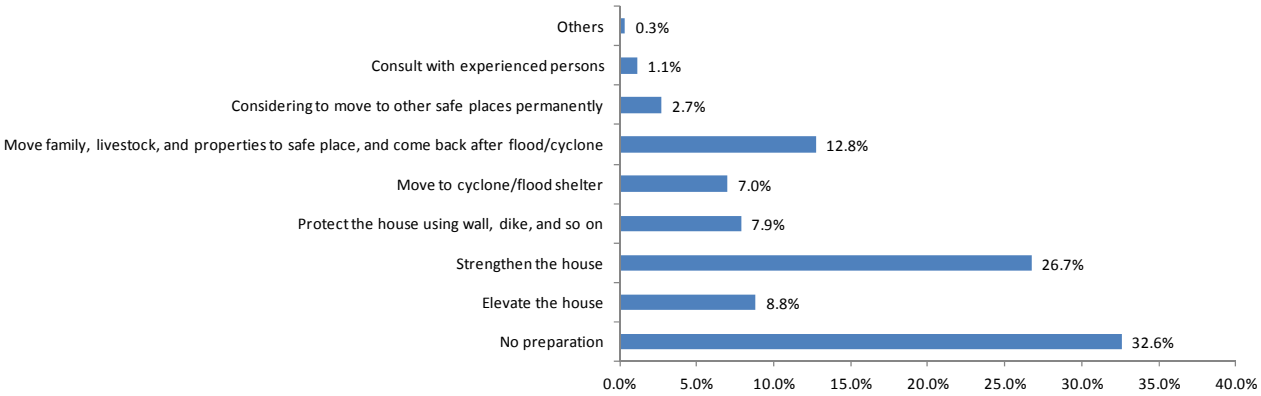


Figure 7. Adaptation Measures Prepared Before Disasters

Different from the measures taken before disasters, 3.6% of respondents, which accounts for the largest share, moved their families, livestock, and properties to safe places and came back after disasters, 15.1% moved to cyclone/flood shelters, and 27.9% still stayed in their houses by strengthening their houses (14.2%), protecting their houses using walls, dikes and so on (8.8%), and elevating their houses (4.9%). These percentage values are shown in Figure 8. As for the means of evacuation during disasters (see Figure 9), 64.5% of respondents just evacuated by walk, only 7.6% used motorized vehicles, and others used very slow travel modes including carts (4.2%), cattle (4.2%), bicycles (5.3%), and rickshaws (14.3%). Figure 10 shows the help received and offered during disasters. It is observed that 21.0% of respondents did not receive any help from government, 35.1% from community and 70.9% from neighborhood. It is also revealed that 79.0% did not provide any help to their neighbors. Nearly 40% of respondents received food, and in contrast, communities only provided food to 22.4% of respondents. As for clean water, about 23% of respondents received clean water from government and communities, respectively. Mutual help within neighborhood was not popular in the sense that only very lower percentages of respondents received help from and provided help to their neighbors. Communities provided shelters to 9.5% of respondents, but governments provided only to 5.8%.

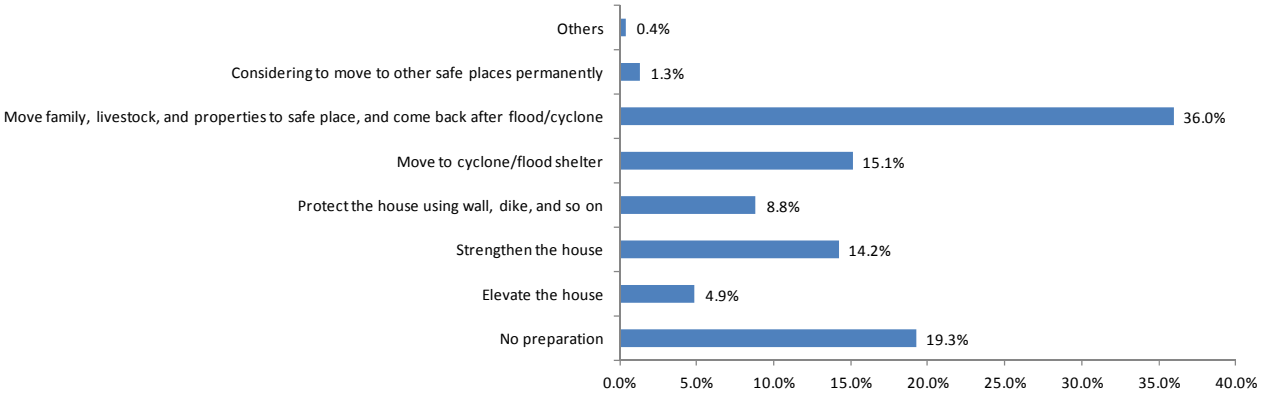


Figure 8. Adaptation Measures Taken During Disasters

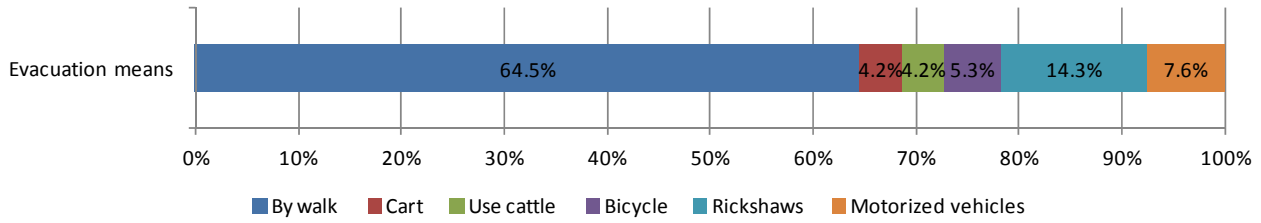


Figure 9. Evacuation Means During Disasters

Figure 11 shows the evaluation of self-recovery ability after disasters. It is found that only 18% of respondents are capable to deal with the recovery after disasters. Respondents reported that the most important things for the recovery are house repair (27.2%), food (25.9%), money (14.6%), medicine (14.2%), and clean water (14.0%) (see Figure 12). As time passes after disasters, more people could receive help from government and communities (those who could not receive any help decreased to 13.9% and 24.9, respectively, compared to the period during disasters), but not from neighborhoods (increased to 77.8%, compared to the period during disasters) (see Figure 13).

As for the future adaptation plans (Figure 14), it is found that 26.0% of respondents want to strengthen their houses, 16.8% want to move their families, livestock, and properties to safe places and come back after disasters, but 24.6% will have no preparation.

Comparisons between before-disasters, during-disasters, and future adaptation measures are shown in Figure 15, where the item “consult with experienced persons” before disasters is deleted and the percentages of other items are re-calculated. It is found that past experiences encourage

more people to protect their houses using walls, dikes and so on (the percentage increases from 8.0% and 8.8% to 13.6%) and consider to move to other safe places permanently (the percentage increases from 2.7% and 1.3% to 4.8%), but discourage more people to move to cyclone/flood shelters (the percentage decreases from 7.1% and 15.1% to 5.6%). Respondents show moderate adaptation plans between before-disasters and during-disasters with respect to other measures.

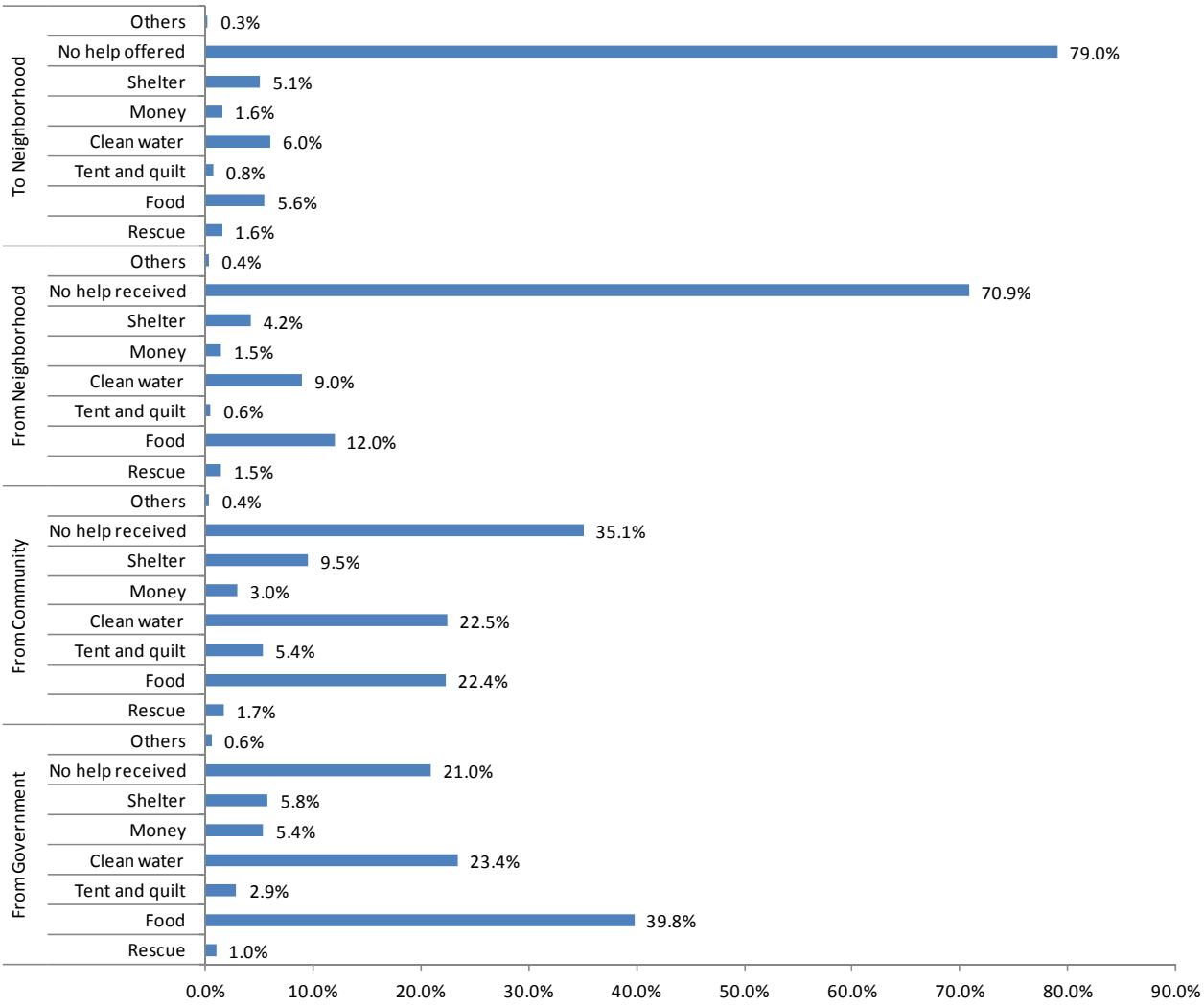


Figure 10. Help Received/Offered During Disasters

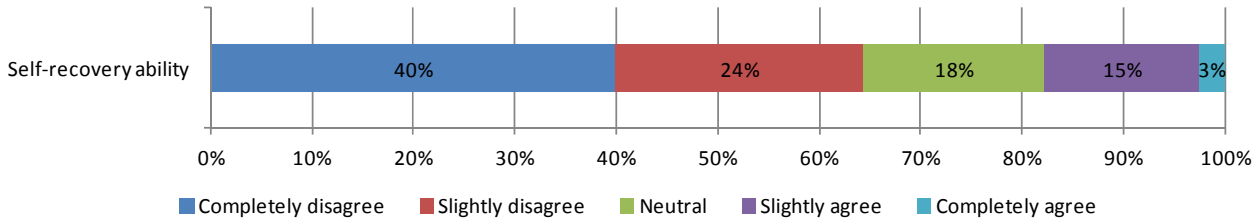


Figure 11. Evaluation of Self-recovery Ability

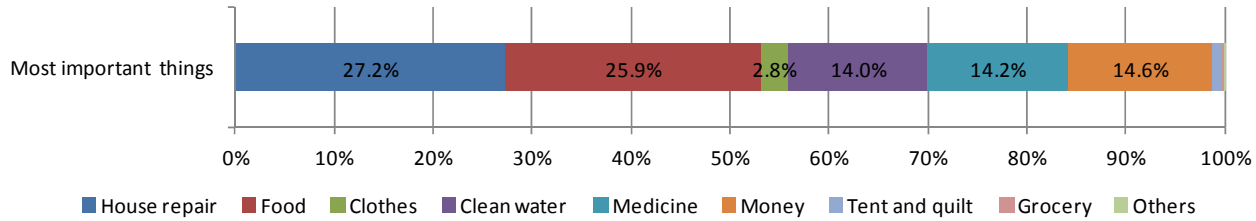


Figure 12. The Most Important Things During the Recovery: Evaluated by Respondents

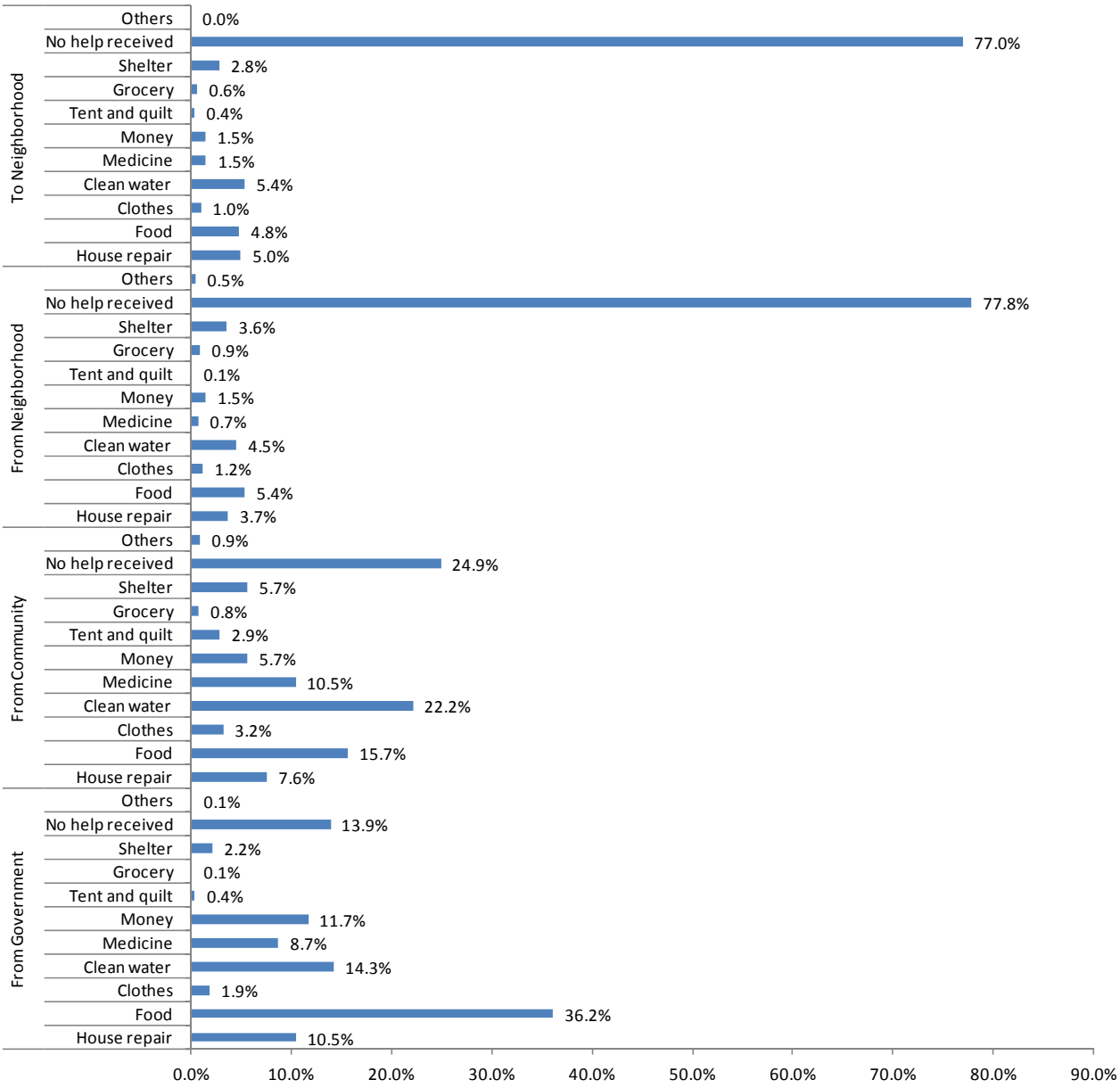


Figure 13. Help Received/Offered After-disasters Recovery

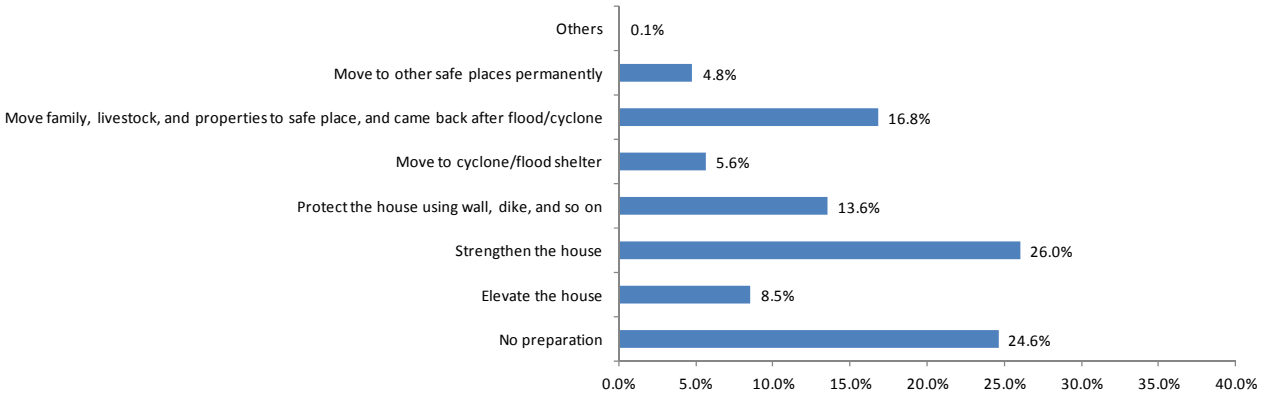


Figure 14. Future Adaptation Plans

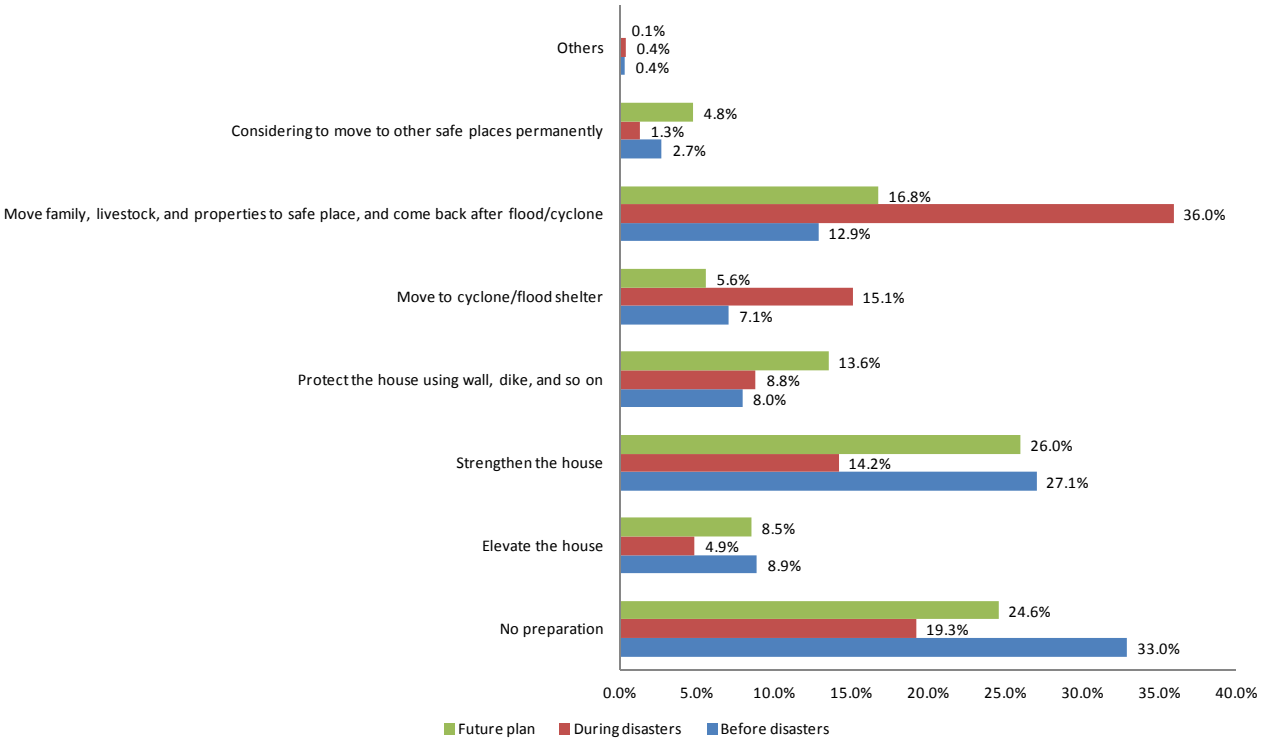


Figure 15. Comparisons between before-disasters, during-disasters, and future adaptation measures

Barriers and capability of adaptation measures

It is observed (see Figure 16) that the current major difficulties in adapting to the impacts of climate disasters include lack of money (32.9% of respondents reported), lack of government policy (21.8%), lack of help from government (21.1%), and lack of knowledge (18.3%). It is obvious that more than 40% of difficulties come from the government side.

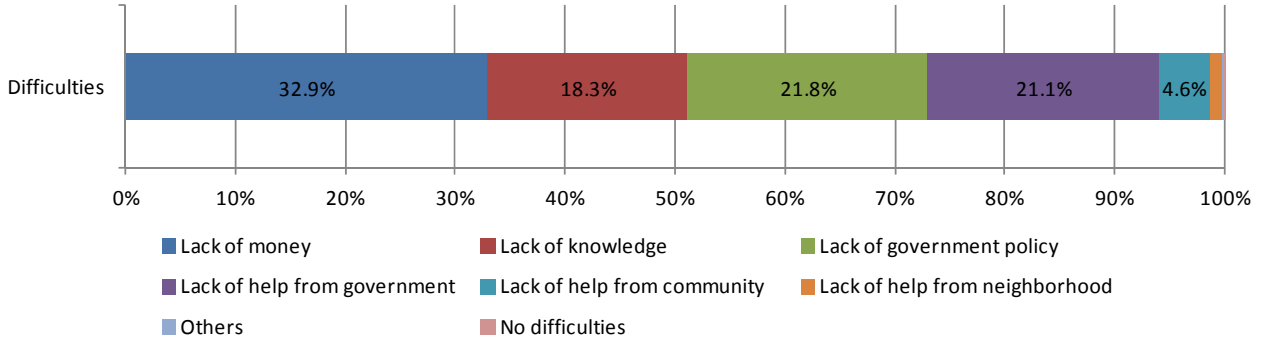


Figure 16. Current Major Difficulties in Adapting to the Impacts of Climate Disasters

Figure 17 shows how respondents are capable of dealing with adaptation measures in terms of finance, physical strength, family structure, help from neighbors, knowledge about countermeasures, and time. It is confirmed that 53.1% of respondents are not capable at all in terms of finance and it is not available of help from neighbors for 47.6% of respondents. In Figure 16, very few people reported the difficulties coming from lack of help from neighbors, probably caused by such unavailability of help from neighbors. In other words, this might mean that many people have only limited resources for themselves and therefore cannot provide any help to their neighbors. Looking at other capability indicators, about 10% ~ 20% of respondents surely have not enough capability and more people are not so confident about their capabilities in terms of family structure, compared with other indicators.

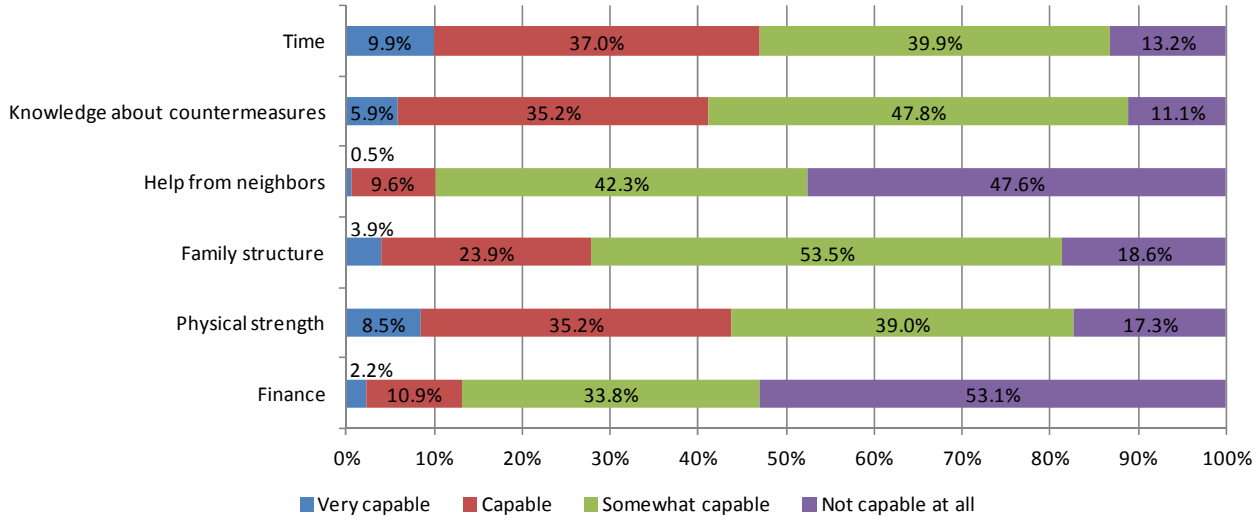


Figure 17. Capabilities in Dealing with Adaptation Measures

Stated adaptation preference

In this study, we also investigated respondents' stated adaptation preference under different flood and cyclone scenarios. Detailed results will be reported at the time of presentation.

5. CONCLUSIONS AND CHALLENGES

Climate change and its effects are increasingly becoming pressing issues. Increased risk of bridge failure during extreme weathers, periodic or permanent inundation of coastal infrastructures, increased maintenance and protection costs in respect to vulnerable infrastructures are several examples of the many potential impacts of sea level rising on transportation systems and other fundamental lifeline infrastructures. In this study, we made an initial attempt to examine adaptation measures under the ever-increasing risks of climate disasters in the context of Bangladesh at the disaggregate level. We collected a data set including 998 valid questionnaire sheets, which further contain various items related to adaptation measures in both coastal and inland areas of Bangladesh. This study is supported by an interdisciplinary joint research scheme, where experts from the fields of environmental impacts assessment, ecosystems, and environmental economics as well as urban and transportation planning are involved. In this study, even though we only provided results of preliminary analysis, the obtained findings are useful to identify the barriers of adaptation measures in Bangladesh, the roles of different stakeholders in implementing adaptation measures, and the directions of adaptation measures in future.

Future studies will be done by incorporating all the information collected in the survey. Impacts of climate disasters will be quantified in more details from both behavioral analysis and system analysis from the interdisciplinary perspective. Adaptation behavior will be further analyzed from the perspectives of behavioral understanding and modeling as well as responses to different adaptation measures. Feasible adaptation measures will be proposed and examined by integrating insights from both interdisciplinary and cross-sectoral studies.

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(http://home.hiroshima-u.ac.jp/hitel/citi_qol.html). Special thanks go to Dr. Assis. Prof. Hansoo Lee, Graduate School for International Development and Cooperation, Hiroshima University, who provided us the prediction results of sea level rises in future and valuable advices on how to set future flood and cyclone scenarios, as well as other members of the joint research under the above MEXT program.

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