



A Review on Adaptation Practices of Affected People with Riverine Floods in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Bangladesh is a riverine country. Every year flood devastated Bangladesh. Therefore, response and adaptation strategies of flood affected people are important for planning future mitigation action. Present study focuses to review on adaptation practices of affected people with riverine floods in Bangladesh to reduce vulnerability of awaited flood. Consequently, they adopt several adaptation techniques by their life long experience. The major adaptation practiced of the people are raise homesteads using 'dig-elevate-dwell' principle of settlement, cultivate flood tolerant paddy (e.g. bona aman), cultivate vegetables in floating bed, tube well have been placed on an elevated base or raised with an additional pipe, and cementing the base of tube well. People also use their indigenous knowledge to cure diseases during flood. Hence, holy basil, and basak (*Adhatoda Vasica*) are used to treat colds and fevers. On the contrary, durba grass, gando badal (*Gaultheria Fragrantissima*), garden mint, and Indian pennywort are used for diarrhea and dysentery. Basically, people's indigenous adaptation techniques have helped them to reduce damages of property and lives as well. Therefore, various types of adaptation should incorporate at the local level plan and implement by the concerned authority.

Keywords: Bangladesh; people; adaptation; dig-elevate-dwell; floating bed.

1. INTRODUCTION

Bangladesh is a tropical country in the world which lies between 20°34" and 26°38" north, and between 88° 01" and 92° 41" east. There are four distinct seasons in Bangladesh followed by pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November), and winter (December-February). The country is under sub-tropical climate. Besides, country's climate is more or less influenced by Indian monsoon. Consequently, country sees large amount of rainfall every year. Annual average precipitation is about 2300 mm, varying from 1200 mm in the northwest to 5000 mm in the northeast. Notably, about 80% rainfall occurs in the monsoon period [1,2,3].

It is one of the biggest active deltas in the world covering an area of about 1,47,570 square kilometers. It is downstream of more than 200 rivers including the Ganges, the Brahmaputra, and the Meghna which are popularly known as GBM river system. Again, Bangladesh is situated at the lower part of these river basins and nearly half of the area of the country is within 10m above mean sea level. As a result, according to physiography 80% of the country is flood plain. Moreover, Bangladesh has also 230 rivers including 57 trans-boundary rivers. Since the country is situated at the downstream area, drain out water 12 times larger than the country's area, receives huge amount of monsoon rainfall (i.e. 80% of the total rainfall), and water passes over country within a short period so it creates a pool with a depth of about 9m. Therefore, country experienced flood every year [1,4].

Monsoon flood inundated about (20-25) % area of the country is assumed beneficial for the crops, ecology, and environment as well. However, once every 10 years, one-third of the country is severely affected by floods including floods of 1988, 1998, 2004, 2007, and 2017 caused inundation of more than 60% of the country's area. These types of floods are causing direct and indirect damages to the crops, ecology, environment, and people [3,5]. As flood is a crucial part of our life. Therefore, lots of flood prevention, control, and mitigation efforts have been taken by the Bangladesh since 1950s [6]. Moreover, every flood affected people have taken indigenous adaptation strategies. However, adaptation techniques of people vary

over time depending on the nature and magnitude of flood [7].

There are several original studies about adaptation techniques of flood affected people in Bangladesh. Hossain and Rahman [8] studied about the adaptation techniques of char dwellers in the five district of Bangladesh including Rangpur, Kurigram, Gaibandha, Dinajpur, and Lalmonirhat. However, Roy et al. [9] discussed about the adaptation techniques of farming communities in char lands of Sirajganj in central Bangladesh. Another study had found the adaptation techniques including water supply, sanitation, and health of flood affected [10]. Adaptation techniques of two villagers from their previous experiences in central Bangladesh was narrated. This study also compares the adaptation measures of two villagers [11]. Besides, an empirical study about adaptation strategies with flood in the northern and north eastern part of the country was explained by Sultana and Rayhan [12].

It is very clear that different studies on adaptation techniques with flood has already been conducted. These studies have been conducted on different places and on different people. However, no comprehensive review study was conducted on flood adaptation techniques. Therefore, present study tries to find out various types of flood adaptation techniques together which is practiced by the flood affected people. Since, this study covers various types of flood adaptation strategies together. Consequently, present study will be useful for the both environmental managers, and policy maker. Moreover, this study would help in finding out future path on integration of best adaptation practices in present and future climate change. On the other hand, learning the adaptation techniques from flood affected people would help to develop effective adaptation tools and strategies. Alongside, the identification of community adaptation strategies can improve efforts in flood risk reduction. Knowledge of local people can also assist in the development of coping mechanisms for the residents of other flood prone areas.

2. ADAPTATION PRACTICES IN INFRASTRUCTURE

Structural adaptation practices can reduce risk and poverty from riverine flood. For example,

about 135 families of three districts including Bogura, Gaibandha, and Sirajganj have built cluster villages above high flood level. Consequently, these houses lessen physical exposure of the families to flood and open the opportunity for doing economic activities [13]. To adapt with flood, people raise the platform of the houses and make barriers around the house with brick, water hyacinth, or put sandbags around the house to stand against the current, avoid construction of housing materials susceptible to flood (i.e. mud wall), rather they like to use bamboo, wavy iron sheet, thatch and wood (Fig. 1), build embankment, and flood shelter also [11,14].

There is a common practice to cultivate water resistant plants followed by banana, hogla (southern cattail), and kolmi (water spinach) around the house to retain the house from erosion. Surprisingly, people try to use materials that can easily detach part by part in order to transfer easily at the time of flood. People try to elevate their bed by using bricks or tie the bed to a wooden pillar. At the time of flood people also use *muchan*¹ and *pataton*² to save their lives and belongings [11]. Very often they try to build their house in the high ground or high patches of land. When such high ground is not available, they dig land and use the soil to elevate the land and establish houses there on. This is often called 'dig-elevate-dwell' principle of settlement [15]. The dig land also uses as a water retention pond (Fig. 2).

3. ADAPTATION PRACTICES IN AGRICULTURE

People select proper crop varieties which are suitable during flood. Besides, people developed new varieties of paddy i.e. bona aman by the natural process. This variety of rice can grow about 20 feet tall or even higher to withhold deep flooding. These paddy stalks just float on water and can grow up to a foot in a day to keep momentum with the fast rising level of flood water [15]. Moreover, there are another varieties

¹ *Muchan* is an indigenous structure made by bamboo or wood and use as a platform. This platform can raise using additional bamboo or wooden pillars when floodwater rises. People live on a *muchan* with all of their belongings at the time of flood [11].

² *Pataton* is known as ceiling. It is made by bamboo or wooden in the upper part of the house. During flood people store food, fuel, water, and other things on it [11].

of paddy followed by BRRI³ dhan-51 and 52 are developed in Bangladesh which are very flood tolerant and have submergence capacity at least 2 weeks under water. Consequently, these varieties of rice are very familiar in flood vulnerable region of Bangladesh such as Sirajganj, Rangpur, Kurigram, Gaibandha, and Lalmonirhat districts. On the other hand, people harvest vegetables in floating bed that is potentials to mitigate coping problem of Bangladesh [17].

Floating bed is very common practice in Gopalganj, Madaripur, Barishal, Pirojpur and Jhalokhathi districts where land remain submerged most of the time in a year. These beds are able to float on the surface of the water, thus creating areas of land suitable for agriculture within waterlogged regions. Farmers raise seedlings then produce vegetables like lady's finger, pumpkin, cucumber, water gourd, bitter gourd, tomato, turmeric, potato, spices and many more by using floating bed (Fig. 3). It is found that farmers produce more than 32 crops in the floating bed [18,19,20]. To keep pace with flood water, villagers of Sirajganj like to cultivate sugarcane and jute during flood [11].

4. ADAPTATION PRACTICES IN FISHERIES, POULTRY AND LIVE STOCKS

During the flood fishes of a pond move away. Therefore, some fishermen try to cultivate mono-sex tilapia fish (*Oreochromis niloticus*) in a cage system along the Meghna river in Chandpur, Lakshmipur, Patuakhali, Rajshahi, Dinajpur, Panchagarh, Nilphamari, Thakurgaon, and Rangpur district to cope with flood [22,23]. Poultry and live stocks are very important assets for low income group. Therefore, at the initial stage of flood, people try to keep their poultry and live stocks on the higher ground of their houses. If it is no possible, then they move poultry and live stocks to safer places including higher roadsides, relatives' house. When this becomes impossible, they sell their productive assets to another people [11].

5. ADAPTATION PRACTICES IN FOOD AND FUEL

During flood people have been suffering from shortage of food and fuel. People use *motki*

³ Bangladesh Rice Research Institute

(earthen pot) and polythene bags to store dry food and seed. Hence, people of flood affected area try to keep dry foods like chira, muri (puffed rice), gur (molasses), rice, pulse, oil, and salt as a preparation for flood. On the other hand, some households could not afford to keep dry food before flood due to their economic insolvency. These households try to follow different adaptation measures to face food crisis. They start to consume their productive assets followed by poultry hens, and ducks. Those who have no productive assets they try to sell their unproductive assets including furniture, borrow money from friends, relatives, neighbors, bank, and NGOs and sell their land [10,11].

Again, people who have no income during flood and fail to get enough money to buy same amount of food, try to adapt with flood by modification of their food habit and reduction of meals frequency. Often, try to buy inexpensive foods and women try to reduce food consumption to manage food for other members. It is also seen that people also take meals twice in a day. When people fail to manage any dry food or could not buy any food for cooking then female member (s) of the family try to collect food including leafy vegetables and roots from neighborhood thereafter boil them to eat. Sometimes, they depend on relief. If there is no alternative to manage food, then people have to starve [10].



Fig. 1. Flood resistant housing in Bangladesh [16]



Fig. 2. Dig-elevate-dwell principle of settlement [16]



Fig. 3. Floating agricultural practice in Bangladesh [21]

Since aluminium, earthen pot, and plastics are easier to carry and typically float as a result people use these to transfer their fuels. However, when flood water increase, people use *muchan* and *pataton* to store food, and fuel. Besides, people also keep portable cooker during flood. During flood fire wood and kerosene became expensive as a result flood victims cooked two meals once a day. However, it is a matter of regret that sometimes they have food but do not have any fuel to cook. Therefore, they try to collect fuel from far away and cook on the bed or on the boat [10,11].

6. ADAPTATION PRACTICES IN WATER AND SANITATION

Pure water is very necessary for life. However, pure water is very scarce during the flood. Realizing the fact from previous experience, flood vulnerable people have taken some measures considering water and source of water during flood. Newly tube wells have been set up on high ground that do not sink during flood. Further, height of tube wells, those sunk at the time of previous flood, have been increased using a pipe. Cementing the base of tube well so that polluted water cannot enter into the tube well (Fig. 4). For example, people of Bogura district are practicing flood proof raised tube wells [13]. People store drinking water in a container. People try to harvest rain water and store them in tank to ensure safe water. They disinfect water. Water purifying tablet is used to keep in the tube well water. Flood water is boiled before use.

Again, people use potassium alum and water purifying tablets with flood water before use [10].

Along with safe drinking water proper sanitation is also required to lead healthy life. However, it is difficult to manage proper sanitation during the flood. Since, most of the toilets became unusable at the time of flood, people have started to take few strategies to lessen the sanitation problem. Few measures are taken by the flood affected people to avoid submerging toilets during flood. Newly toilet have been set up on high ground that flood water does not enter into the toilet during flood. However, previously set up toilet have been replaced on an upward location. People try to increase the base height of the toilet using more than one sanitary ring, that raise the height of the toilet approximately 1.5 feet. Few villagers of Bogura district are practicing flood proof sanitary latrines [10,13].

7. ADAPTATION PRACTICES IN HEALTH

Outbreak of different types of diseases including skin ailments, cold, diarrhea, cholera, typhoid, malaria, and dengue is very common at the time of flood. Therefore, people try to cope with these diseases by following some measures. For example, flood victims are practicing long lasting insecticide treated nets and bed nets to prevent mosquito. Few people who are little bit conscious about health try to keep some simple medicine and first aid as well. Typically, they store medicine for fever and oral saline for diarrhea [10]. Surprisingly, local people use their own



Fig. 4. Tube well on high ground with cementing base [24]

knowledge of medicine. They have taken medicine from a local pharmacy with and without consultation with a doctor. Along with allopathy, people have also used indigenous herbal medicine including tulshi (Holy basil), basak (*Adhatoda Vasica*), thankuni (Indian Pennywort), gando vadal (*Gaultheria Fragrantissima*), durba grass (*Eragrostis Cynosuriodes*), and pudina (Garden mint). Of these, tulshi and basak are used to treat colds and fevers, on the contrary durba grass, gando badal, pudina, and thankuni are used for diarrhea and dysentery [11].

8. ADAPTATION PRACTICES IN NETWORK AND COMMUNICATION

During flood it is very difficult to communicate with each other. When floodplains are inundated households use boats to maintain regular communication. Each and every household in flood affected area have at least one boat [15]. It is also seen that people prepare *gathua*⁴ to resume their daily activities during flood [11].

⁴ *Gathua* is a float made by water hyacinth and thatch [11].

Besides, people also use mobile phone to continue their communication with other people. Flood affected people in Bangladesh also try to use rickshaw, van car, wheelbarrow, and bicycle as well for network and communication building with others during flood [8].

9. ADAPTATION PRACTICE IN RIVER BASIN MANAGEMENT

River basin management is another way of adaptation. Local people raised about 31.32 square kilometers of land around Beel Bhayna and Beel Dakatiya. Then river basin management help to increase river flow and depth thereafter to reduce incidence of water logging [25]. Moreover, local communities filled about 450 acres of land using sediment around Beel Jethua belonging to the Kabodak river basin. After filling the particular area then height raised to 1.5 meters [26]. It is found that river basin management is effective to raise land and make it cultivable, lessen the water logging crisis thereafter increase the navigability of rivers as well.

10. DISCUSSION

The different communities and stakeholders of Bangladesh are already using several types of adaptation practices with riverine flood based on their experience learned from previous riverine flood events. There are good number of adaptation practices in infrastructure, agriculture, fisheries, poultry and livestock, food and fuel, water and sanitation, health, network and communication, and river basin management sectors as well (Table 1). Implementation of such adaptation strategies can potentially reduce physical and economic losses. These practices have been found completely suitable in these climatic environments and have enormous potential to reduce the long term vulnerability of Bangladeshi people. However, people are used to relying on different types of indigenous adaptation strategies. Taking of specific strategy more or less depends on people's socioeconomic characteristics and the nature of the flood. However, these strategies are highly efficient only in a normal flood situation. When floodwaters cross danger level and rise, people have no alternative but to migrate to a safer place [11].

A similar study has been conducted in the capital of Indonesia i.e. Jakarta. The study has found several adaptation measures of flood affected community. Though, most of these adaptation

measures were taken at the household level. For example, raising of the level of house, and building of houses with additional floors. The increasing level of house is effective to prevent flood water from entering. However, it is effective when the inundation level is lower than the house level. When the inundation level is higher than the house level, then water enters at the house, inhabitants try to shift their furniture to the second floor to avoid loss and damages of the property. Moreover, shared adaptation measures were also taken between households with in the affected community, particularly by building small dikes to prevent water from entering settlements areas. More importantly, the types of adaptation measures taken by the local people are determined by socioeconomic conditions [27].

In India similar adaptation strategies are found within the affected community. They adopt several strategies based on their experience from previous flood events. They elevating their houses, using flood tolerant crops and what not. The most widely used adaptation strategy in Jiaganj, West Bengal is elevating the houses as elevating houses prevent flood water from entering into the houses [28]. The present study has some limitations. This paper did not follow comprehensive community survey which would have allowed researchers to get a more accurate and new types of adaptation strategies.

Table 1. Adaptation practices of affected people with riverine floods

Vulnerability from flood	Adaptation with flood
Flood water enter into the house	Raise homestead
Shortage of pure drinking water because tube well inundate by flood water	Tied additional pipe with tube well to get pure drinking water
Academic activities are hampered due to inundation	Raise land of academic institutions and set up well communication system
Split embankments and roads	Repair embankments and roads
People suffering from stagnant water	Prepare floats and boats for moving from one place to another
Flood water enter into the market places	Raise land of markets
Submerge crops and vegetables	Cultivate advance crops, cultivate vegetables in floating beds, and establish floating seedbeds
Float fishes from the ponds by the flood water	Raise side of the ponds, use net around the side of the pond, fish culture in improved technology e.g. cage fish culture
Flood water enters into the cattle house and sell cattle at lower price due to deficiency of food	Make high ground for the cattle and preserve food
Increase abduction and robbery	Arrange to guard at night
Outbreak of water borne diseases	Arrange treatment and drink pure water
People have died for snake bite	Keep carbolic acid in the house

Source: [9]

This research also did not focus on the comparison of different methods using clear photographs only because of shortage of available photographs in the literature. Though these limitations, researchers tried to find out maximum numbers of flood adaptation strategies.

11. CONCLUSION

Since every year floods occur in Bangladesh. Therefore, people have taken several measures to cope with flood. People raise the platform of the houses using 'dig-elevate-dwell' principle of settlement and make barriers around the house with banana, southern cattail, and water spinach trees, put water hyacinth, or sandbags around the house to stand against the current and retain the houses from erosion. They also developed flood tolerant varieties of paddy i.e. bona aman, BRR1 dhan-51 and 52. Moreover, farmers raise seedlings or use floating bed to produce vegetables, for example, lady's finger, pumpkin, cucumber, water gourd, bitter gourd, tomato, turmeric, potato, and spices as well. About 32 varieties of vegetables are produced in the floating bed. People store different types dry foods including chira, puffed rice, molasses, rice, pulse, oil, and salt to cope with flood. Some flood victims try to buy inexpensive foods and try to reduce food consumption, mainly by women, to manage food for other members. It is also seen that people also take meals twice in a day. When there is no alternative to manage food, then people have to starve.

During flood pure drinking water is very rare. Therefore, newly tube wells have been set up on high ground and cementing the base of tube well so that polluted water cannot enter into the tube well. Further, previously set up toilet have been replaced on an upward location. People also try to increase the base height of the toilet about 1.5 feet for practicing flood proof sanitary latrines. People also use their indigenous knowledge to cure from different diseases during flood. Hence, holy basil, and basak (*Adhatoda Vasica*) are used to treat colds and fevers, on the contrary durva grass, gando badal (*Gaultheria Fragrantissima*), garden mint, and Indian Pennywort are used for diarrhea and dysentery. River basin management is another way of adaptation. Local people raised about 31.32 square kilometers of land around Beel Bhayna and Beel Dakatiya. Then river basin management help to increase river flow and

depth thereafter to reduce incidence of water logging and make it cultivable, lessen the water logging crisis thereafter increase the navigability of rivers as well. Basically, they try to save lives and reduce damages of property. Besides, these adaptation practices could be fitted to the future changing environment (i.e. climate change) of Bangladesh. Yet, few earmarked programs should be launched for infrastructure, agriculture, fisheries, poultry and livestock, food and fuel, water and sanitation, health, network and communication, and river basin management sectors. Proper training should also be arranged on adaptive tools and technology. Moreover, awareness of flood affected people should be increased by establishing community volunteers. The volunteers will provide message regarding forecasting and preparedness activities. Various organ and departments of the government including NGOs should come forward for rising awareness. Since, adaptation is a continuous process so it should incorporate at the local level plan and implement it by the different organizations, institutes, and departments as well. The lesson learned from the study could be reproduced with modifications to be found from advanced and original research and applications in real field life.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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