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Assessment of flood vulnerability and adaptation: A study on smallholders in Gaibandha district, Bangladesh

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ABSTRACT

Disaster, vulnerability and adaptation have been the highly recognized studies in the contemporary globalized environment. The primary purpose of the study is to assess the flood vulnerabilities and adaptation strategies of smallholders in Gaibandha, a northern district of Bangladesh. The primary data of the study were collected from 110 respondents of five villages in Saghata Upazila who had been randomly selected by using survey questionnaire. Employing descriptive statistical tools, such as frequency test to explore the research objectives, the research data were collected from January 11 to May 20 in 2022. The study has discovered several determinants of flood vulnerability, such as less education, more frequencies of flood events, heavy rainfall, acute dependency to nature for cultivation, insufficient relief, faulty cropping system, lack of advanced infrastructure and lack of resilience. The study also found out various challenges to adaptation; i.e. resource scarcity, lack of alternative livelihood options, poor employment status, lack of early preparation and experiences, inadequate flood resistant cropping and lack of fund to tackle recurrent flood events in the study area. At final stage, several recommendations are suggested including both the government and international policies of disaster management for successful flood adaptations in the study region.

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Introduction

As a densely-populated and low-lying country, Bangladesh is located in South Asia, has a strong connection of rivers making largest sedimentary deposits around the globe (Akter et al., 2016; Alam, 1996). With a long coastline on the northern littoral of the Bay of Bengal, Bangladesh lies in the Ganges-Brahmaputra-Meghna (GBM) delta which increase the range of flood events (Brown et al., 2018; ESPA, 2018; Islam, 2016). For this, Bangladesh has identified climate change as rapidly emerging issue, though the developed world is primarily responsible for maximum carbon and greenhouse gas emissions, the Third World countries like Bangladesh are the core victims of the adverse effects of climate change and socio-economic and political spheres are also being influenced by it. In fact, during monsoon 30-35% of the total surface of Bangladesh is being flooded every

year (Milliman et al., 1989). Hence, the country is highly vulnerable to severe floods and ranked 6th most climate vulnerable in terms of flood and these events upset people's lives damaging resources like crops, livestock and other properties at a great extent (BCAS, 2001; Brammer, 1990; Islam et al., 2016; UNDP, 2004). Many studies (Azad et al., 2013; Faruque, 2021; Leya et al., 2020) observed that northern Bangladesh is affected by floods and much more vulnerabilities are being experienced by the people over the years while in Gaibandha disastrous floods create shortage of drinking water, and loss of lives and resources. Even, a greater number of people are compelled to migrate, to transform profession and depend on natural resource because of geographic location.

Again, climate induced disasters including floods cause large economic losses, reduce economic growth, especially in Bangladesh, the direct annual costs are estimated at 0.5-1% of gross domestic product (MoF, 2019). About disaster risk financing issues, Bangladesh will have to cost approximately $3.2 billion per year because of cyclones and floods (Ozaki, 2017). Again, since 1960s, Bangladesh has already been investing $10 billion for enhancing disaster preparation, coping mechanism and measures for losses reduction (Kabir & Hossain, 2013).

In 2004, flood events inundated more than 38% of land area and as a result the country experiences a damages of over $2 billion in various sectors including infrastructure, agriculture, and industry (MoEF, 2005). Especially in Saghata Upazila of Gaibandha district, the 2017 flood events damaged approximately worth about $140 million transplanted Aman crops. While seedbeds were washed away by the surging water and poor and marginal farmers faced more difficulties for preparing fresh seedbeds (The Daily Star, 2017). Whereas, integration of policies and its implementation from local to national level to combat climate variability is prioritized by international organization, in Bangladesh phases of policy implementation remains limited and only few empirical studies investigated the sustainability of climate adaptation strategies in the 21st century (ActionAid, 2012; UNDSEA, 2008). Again, adaptation to flood events in Bangladesh is urgent because of greatly impact on agriculture and socio-economic characteristics (Shrestha et al., 2018). Therefore, the objectives of the study were to assess the ranges of vulnerabilities of smallholders and to assess the adaptation strategies against flood events. Chamberlin (2007) defined smallholders as resources poor farmers who have limited land availability, shortages of capital, partitioned holdings and poor ownership to other inputs. The holding size of smallholders is directly linked with small farm sizes only 0.5 hectares or 1.23553 acres.

Vulnerability and adaptation

Vulnerability and adaptation can be defined in multifarious aspects depending on the depth of research outline and relevancy of the concepts needed for analysis. For instance, Menoni and Pergalani (1996) identified that vulnerability can be understood as damage goods, people, buildings, infrastructures and activities in hazardous condition.

In this study, the conceptual framework of Turner et al. (2003) is utilized to understand the flood vulnerability of the smallholders, where vulnerability is illustrated as a function of exposure, sensitivity and adaptive capacity (figure 1). Exposure is the state and change in external stresses that a system is exposed to (Lawrence et al., 2011). Susceptibility is the probability of negative consequences of floods to the environment and society (Samuels et al., 2009) . Further, sensitivity can be understood as the degree to which a system is affected, adversely or beneficially, by a given exposure (IPCC, 2007a).

Resilience is the capacity of a community to adapt to changes in a hazardous area by modifying itself to achieve an acceptable structural and functional level (Galderisi et al., 2005).

In operational conception for this study, vulnerability is identified as inability of community people to cope an adverse flood event. Flood adaptation is defined as the capability of adjustment in facing flood events, which has destructive consequences to people's livelihood.

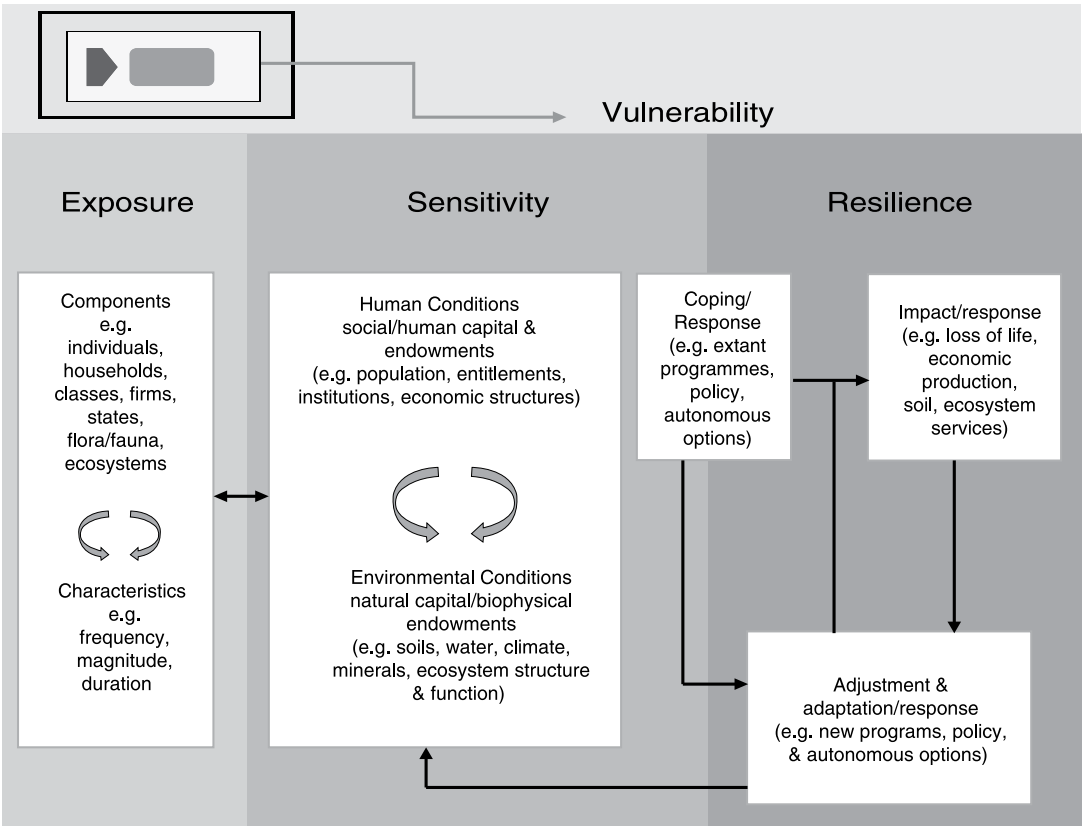

Figure 1: The conceptual framework of vulnerability

Source: Turner et al. (2003)

The researchers have concentration on the importance of using technology in the crop fields, crop storages, training services from agriculture extension. The research findings reveal how smallholders face vulnerability induced by flood events recurrently and their challenging adaptation strategies. Moreover, the research outcome will also be useful for practitioners and further researchers about the adaptation approach, strengths and weakness following the needs of future generations. Lastly, the study recommends functional and sustainable adaptation strategies for the flood affected areas.

Literature review

In the recent decades, many researchers examined people's vulnerabilities exploring their adaptive capacities in the event of natural hazards, such as, flood across the world.

Azad et al. (2013) studied about flood vulnerabilities and relevant encountered problems especially for women in Sirajganj district, Bangladesh. They found that poor and disadvantaged women were more vulnerable than men. They also identified some other problems to their study as well; food, fuel, safe drinking water and unavailability of shelter. Floods also created social vulnerabilities among children, old aged and poor and destitute group.

In a paper of Food and Agriculture Organization explored that due to change of climatic factors agriculture in developing countries experience vulnerability and marginalization (FAO, 2002). Despite the contribution to the overall development ranging from 30-60%, employing maximum portion of people, getting foreign currency by exporting production with standard livelihoods, agriculture sector is threatened compared to other sectors. With the

advanced technology, productivity is taken into consideration experiencing multiple hazards for instance, natural and social hazards in the Asian countries including Bangladesh. In another study of FAO (2010), it is described that in developing countries climate change affected 11 % arable land, while 65 countries of the world lost 16 % agricultural GDP in cereal production.

In a study, among the other researchers, Peng et al. (2004) intimately investigated various data of rice production for six years regarding 227 farms categorizing six prime countries relating to rice production largely in Asian continent. They found that ranging from 10-20% of crops are seriously damaged by the increasing temperatures in that region.

In Asia-Pacific region, comparing with other sectors, agriculture is mostly vulnerable for various reasons. Because poor and rural farmers are severely affected by climatic disasters like extreme droughts, floods over the time, which directly influence their production level resulting the reluctance of sustainability of their strategy. Finally, the study is concluded by providing suggestions on disaster management from various level (Dev, 2011).

According to IPCC (2007a) for the duration of the next decades, billions of people, mostly in developing nations will face life-threatening freshwater. Basis on this, several studies predicated standing problem of complete water scarcity in over a third of the global population by 2025. Therefore, using sustainable water management, agricultural productivity and food security for global hungers can be improved (Rosengrant & Cai, 2002; Seckler et al., 1998).

In a report, World Bank stated that in 2008 destructive cyclone Nargis damaged more than US$4 billion while floods in 2015 caused a loss of US$1.51 billion in Myanmar. The floods of 2015 destroyed more than one fifth of cultivated crops (Myint et al., 2015). For this reason, Government of Myanmar Initiated Climate Change Strategy Plan (MCCSAP) which started in 2016 and to be continued till 2030 unlike the other countries like Bangladesh, focusing response, recovery and agricultural adaptation strategies (MoNREC, 2017) Adaptive strategies to climate change in Bangladesh were reviewed by Younus (2014) where he highlighted that the community-based adaptation measures were inadequate for experiencing and managing particular hazards and disasters including floods. The review noted that the poor farmers in the rural area faced miserable consequences to revive in the agricultural activities. The economic crises during the flooding periods left them helpless and vulnerable limit their further adaptive capacities to come back in the regular livelihood conditions.

Addressing the issues related to climate adaptations, Asian Development Bank and *International Food Policy Research Institute* have recognized vulnerable nations to climate change in Asia-Pacific and described into three categories according to the agenda of adaptive capacity, exposure and sensitivity (Asian Development Bank, 2009).

A research survey is conducted on 380 households in Sirajganj and Tangail districts by Alam et al. (2017). They found that recurrent droughts, destructive cyclones and uneven floods increased more from earlier decades representing 91%, 81% and 83% respectively. The findings of the research revealed that their livelihoods were being vulnerable with the climate change because they faced crises in infrastructure, adequate heath privileges. Introducing new crop varieties, mapping time framework of planting crops with generated new policy and acceleration of high value crops are considered as adaptation options in that study.

Methods and materials

The 'Northern Bangladesh' comprising 16 districts of Rangpur and Rajshahi divisions. Since, the northern part of Bangladesh experience severe floods, and three districts like; Gaibandha, Kurigram and Lalmonirhat lie to devastating flood prone region. The data of the study were collected from January 11 to May 20 in 2022. Applying a range of sampling procedures, the study area and respondents were selected. At the outset, employing purposive sampling, the researchers selected Saghata Upazila of Gaibandha district.

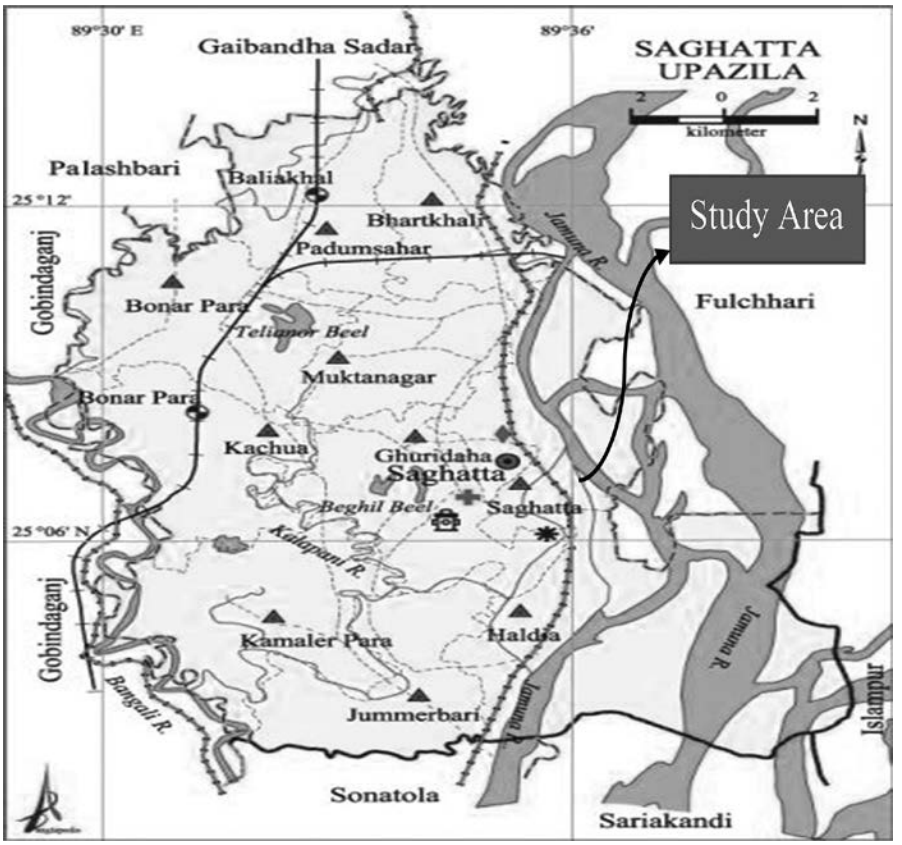

Figure 2*:* Location of the study area (Coordinates: 25°6.3´N 89°35.2´E)

Using simple random sampling, the study is covered on the five villages namely Chinirpatal, Haldia, Gobindi, Nalchity, Hasilkandi of Saghata Upazila under Gaibandha district which lies in 25˚6.3˚ North and 89˚35.2˚ East in northern Bangladesh. The Upazila has been chosen for couple of reasons, for instances, the area considered one of the most flood prone areas, and the Upazila is located to the adjacent of the corresponding researcher's living place. Thus, it was the convenient place for collecting data. Using survey, structured questionnaire, the researchers collected quantitative data.

Statistical package for social science (SPSS) was used to analyze and interpret quantitative data. Again, based on written transcripts, coding categories and subcategories are generated while open and semi-structured questions are coded, cleaned and refreshed. For data presentation, the researchers used figures, charts, and tables.

Results and discussions

Determinants of flood vulnerability

In this section, several factors that determine flood vulnerability were identified in the five study villages of Saghata. These factors comprise the education level, frequency of floods, infrastructure, cropping system, loss of cultivation, rainfall, trainings, flood relief, employment status, warning system and flood insurance. On the basis of the depth of the respondents, these factors likely to contribute to the creation of flood vulnerability in the region.

Ranges of flood vulnerability

In order to measure and assess the ranges of vulnerability, the major four components (social, economic, environmental and physical) and three groups of indicators (exposure, susceptibility and

resilience) were utilized in the study area. Table 1 shows the necessary indicators, valuable components, identified factors of flood vulnerability, relationship with vulnerability connecting with components and factors and lastly description of the respondents. A total of 11 indicators were identified from household level for assessing vulnerabilities induced by flood events.

Compare to other factors, education level influenced more to their vulnerability because it has a great connection to sensitivity. While, a large portion of the respondents (45%) remained beyond literacy and only 37 % acquired primary education only, though few of them earned more than primary school degree. Besides, due to insufficient literacy, overall consciousness of farmers to their livelihoods, crops production, standardization of health, nutrition, and dealing with poverty also be vulnerable (Barman & Islam, 2020; MoF, 2019). Again, climate policy-oriented training can be useful to recover the devastating situation of any flood affected areas with a chance to the vulnerability reduction (WHO, 2002). Most of the respondents did not get any training (95%) regarding climate adaption which represents another limitation of education level. So, lack of trainings for the resilience and as social components flood vulnerability were determined.

Employment status is regarded another characteristic of social and economic components. The diversified status of employment has low risk of vulnerability because stronger socio-economic features reflect better resilience in a specific region (Cardona et al., 2012). Unfortunately, all of the participants in the study lead their livelihoods depending on agricultural production, farming as main source of survival. At the same time, smallholders are affected by various difficulties in order to cultivate crops and managing production system in the current ongoing climatic variation, which also added other dimensions of weakness to adaptability.

Studies conducted by IPCC (2007b), Islam et al. (2016) and Lawrence et al. (2011) demonstrated that vulnerabilities also being increased with the more recurrent flood occurrences in a specific region. Similarly in this study, the heavy rainfall and frequencies of flood events in the livelihoods of smallholders make vulnerable because of involvement to exposure and susceptibility factors respectively. It is also evident that 81.8% farmers face floods and most of the flooding events are riverine (72.2 %) meaning that either upstream water from other rivers join to the region or heavy rainfall and existing water of the rivers submerge the region. The findings revealed that the people of these five villages experience heavy rainfall and flood twice (56%) in a year. In some areas, even everyday (54%) people face heavy rainfall especially from June to September and in the monsoon periods. Nonetheless, on the basis of these findings, it is unwise to generalize flood vulnerability because each region is different from others (Munyai et al., 2019).

The cropping variations and more cultivation as economic components has positive roles to reduce vulnerability. But the fact is that as the exposure factors, almost half of the respondents (44%) claimed variations of crop production did not play role for the vulnerability because crops are being damaged, submerged by the flood events. In the matter of food production, majority (70%) of the respondents argued that their paddy fields are greatly submerged while farmers mostly depended on paddy fields as main crops production. In addition, damages of seedbeds, vegetables, diseases of crops, and pond fish migration also contribute to the level of vulnerability.

Infrastructure is more crucial for the development of any country and acts as sensitive factors of vulnerability determinants. The more advanced infrastructure, the less opportunity to be vulnerable, but when the roads and bridges are damaged, submerged shelter centers, houses are washed away the ultimate results belongs to chances of vulnerability that happened mostly in the region.

There is a high social vulnerability compare to economic and environmental vulnerability in the study region. The smallholders are possessed by several factors for their vulnerability for instance;

Table 1: Flood vulnerability indicators, components, factors, relationship with vulnerability and description of respondents (N=110)

Indicators	Components	Factors	Relationship with vulnerability	Description	Responses %
Education/ literacy level	Social	Sensitivity/ susceptibility	Less education, high chances of vulnerability and low rate of consciousness	Illiterate Primary Secondary Higher secondary Graduation	45 37 13 3 2
Frequency of flood events	Environmental/ physical	Sensitivity/ susceptibility	Higher flood occurrence in a year, higher vulnerability	4 times 3 times 2 times 1 time	30 56 9 5
Infrastructure	Economic	Sensitivity/ susceptibility	Good quality of housing and infrastructure, low rate of vulnerability	Damage of road and bridges Flooded houses Damage of shelter center Electricity problem Transport and mobile network	23 47 18 7 5
Cropping/ cultivation	Economic	Exposure	Variations of cropping and more production, lower vulnerability	Aman rice Boro rice Jute Vegetables Corn Fish	38 32 10 7 5 8
Loss of crops/ cultivation	Economic	Exposure	More losses of crops/ cultivation, higher vulnerability	Crops damage Spread diseases Seedbeds Storage Migration of pond fish	44 31 10 8 7
Rainfall	Environmental /physical	Exposure	More and heavy rainfall, high chances of vulnerability	24 hours 72 hours Weekly Fortnightly Monthly	54 26 12 6 2
Employment status	Social/ economic	Resilience	More employment, less chance of vulnerability	Farmer Business Teacher No job	94 2 2 2
Warming system	Social	Resilience	Having warning, less vulnerability	Monsoon Event oriented Daily Weekly Monthly	8 17 68 5 2
Relief	Social/ economic	Resilience	More relief, less vulnerability	Dry food Money Animals Seeds No relief	62 15 8 6 9
Training on climate policy	Social	Resilience	Having training, less vulnerability	Yes No	5 95
Flood insurance	Social	Resilience	More insurance policies, less vulnerability	Yes No	7 93

Table 2: Flood adaptation strategies and description of respondents (N=110)

Adaptation options	Description	Respondents (%)
Alternative Livelihood/ employment	Driving rickshaw/auto rickshaw	32
	Shopkeepers	7
	Moving to safer place/migration	18
	Fish seller	3
	Day labor	25
	Working in garments	8
Loan/debt	Yes	78
	No	22
Flood resistant cropping	Very high	1
	High	1
	Medium	4
	Low	7
	Very low	87
Water purification	No boiling	7
	Boling	11
	Purifying by medicine	4
	No purification	78
Safety of shelter/house	Making hyacinth barrier	9
	Rising homestead	11
	Leaving house during flood	25
	Using rooftop	14
	No measure	41
Raising fund	Available fund	8
	Available distribution	9
	No active fund	72
	No measure	11
Dam/storage of carrying waterbody	Yes	7
	No	93

flood insurance, relief and warning system. For the resilience, relief is ranked on the top but the affected communities reported something silly. Because dry food items (62%) are distributed as flood relief though few of them reported money and cattle's, their numbers are not so high. Another important social component flood insurance (not registered 95%) is badly needed to the region, it can be very handy for the reconstruction of cottages and houses after disasters like floods. About weather warning, it is discovered that people unconsciously ignore warning forecast, though it broadcast daily (68%). We found several reasons regarding respondents' ignorance about weather warning such as; less social awareness, lack of trainings, inadequacy of access to information and traditional mentality of negligence. So, vulnerability remains in their shoulders directly or indirectly.

Adaptation strategies of smallholders

Several strategies were adopted for livelihood, for instance; rickshaw pulling, migrating to other place, what Ngie (2012) called relocation as part of the adaptations.

Some of respondents engaged in selling labor power, starting small business and started working in the industry. Interestingly, smallholders chose auto-rickshaw driving (32%) and involvement to day labor (25%) as alternative options instead of farming.

Consequently, due to the dependency on nature for agriculture, farming as main profession, the poor employment ability and inadequate earning, the community goes to loan (78%) though the interest rate hesitates them. Again, lack of resources makes them helpless because establishment of dam and such infrastructures

need a great involvement, the responsibilities belong to the state and forcefully smallholders have nothing to do in this regard.

To the recovery and resilience of flood affected region specially the farmers, flood resistant cropping cultivation is urgent (ReliefWeb, 2017). The ways need to be implemented the flood resistant crops for the community, hasn't developed yet from the government and Bangladesh Agricultural Development Corporation (BADC) in the flood affected region. As a result, very low numbers of smallholders cultivate and practice flood resistant cropping system.

Hence, water is called life and when this water is contaminated by germs can be caused of dangerous disease. In the study region, maximum people drink water without any purification (78%) especially during the flood events. Even, boiling is impossible for some respondents, resulting various diseases and cost a lot to cure the diseases after the events. Saving the shelter is another option of adaptation, though few number attempt to make water hyacinth barriers, some people use rooftop, a greater number leaves house for survival and 41% takes no measure for the safety of housing what actually the real example of their economic and social conditions of the locality. In the developed nations, raising climate fund reduces the minimum losses of resources during and after flood events as recovery and rehabilitation stage (UNEP, 2010). Whereas in Bangladesh need more climate fund for the community level and its equal distribution to the root level so that victims can be beneficiary. The majority raised voice about active climate fund (72%) for the reconstruction of the smallholders to reduce the vulnerability.

Again, to correlate the current findings with other studies, we found similarities and dissimilarities relevant to flood adaptation strategies. For instance; Anik and Khan (2012) found that with the changes of climatic hazards, local people adopted a changing pattern to their current livelihood strategy. A study conducted by Ngie regarding coping strategies of flood affected people in Diepsloot, it is revealed that people adopted relocation and evacuation as coping mechanism (Ngie, 2012). In addition, Munyai et al. (2019) suggested various social and economic components, which contribute for determining respondent's capability and response power during flood events.

Conclusion and recommendations

From above discussion, it is concluded that smallholders of northern part of Bangladesh especially Saghata Upazila of Gaibandha district are vulnerable in facing flood events and adaptation strategies. Using conceptual framework of vulnerability Turner et al. (2019), 11 indicators are identified for measuring flood vulnerability utilizing four components of vulnerability. From the determinants of vulnerability, it is discovered that several indicators mostly influence to the vulnerability level of smallholder's livelihoods; poor literacy level, infrastructural rigidity, more frequencies of flood events, traditional cropping system and loss of crop production, insufficient relief, scarce resources, dependency on nature for agricultural production, no training and funds for rehabilitation. Again, socio-economic characteristics also responsible for their vulnerability with lack of resilience and sensitivity. However, smallholders adopted various strategies of adaptation, though there exist more challenges which should be undertaken as serious concern by the ministry of disaster management and relief for further safety of such flood affected communities around Bangladesh.

The following measures can be undertaken to build resilience against floods. Developing public awareness is vital for community resilience. Besides, efficient early warning systems can be reduced flood vulnerability. For this, effective campaigns about vulnerability and adaption strategies should be conducted by both the government departments and NGOs. Thus, local resilient funds can be raised for. Further, advanced response and recovery mechanisms for affected communities may be developed. The government should take effective initiatives for river engineering and settlements along the mighty rivers. Nonetheless, considering agrarian societal ecosystem in rural Bangladesh, agricultural research institutes and universities should invent more flood tolerant crop varieties for addressing national food security.

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