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Combating Flash Flood in *Haor* Areas: Strategic Adaptation towards Sustainable Crop Production

Smita Dash Baishakhy[1*], Mohammad Ashraful Islam[1], Md. Ruhul Amin[1] and Fahmida Husain Choudhury[1]

[1]Department of Agricultural Extension Education, Sylhet Agricultural University, Sylhet, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Author SDB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAI and MRA managed the analyses of the study. Author FHC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

In *Haor* areas of Bangladesh agricultural activities are limited to four - five months of a year due to water logged condition and *boro* rice is the prominent crop grown within this short time span in dry season. But farmers often had to face almost total crop failure due to recurrent flash flood events. This paper attempts to evaluate *Haor* farmers' adaptation through adopting strategies in securing *boro* rice from flash flood damage at pre-mature and mature stages. To reach this objective, a pre-tested structured questionnaire was used to collect data from randomly selected 115 *Haor* farmers from February to May, 2020 while Focus Group Discussion (FGDs) and Key Informant Interviews (KIIs) were also done as necessary during the research work. Results revealed that cultivation of short duration *boro* rice variety ranked top followed by practicing varietal diversification and early harvesting of rice (at 80% maturity) as the most significant adaptive strategies in securing *boro* rice. Obtained results also highlighted the possibilities of attaining desirable resilience through change in the adaptation behavior of *Haor* farmers' if the identified farming practices are widely promoted and adopted. Hence, any development plans for *Haor* area should integrate local knowledge with modern strategies thus resulting a location specific sustainable flash flood adaptation policy.

**Corresponding author: Email: smita.aext@sau.ac.bd;*

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1. INTRODUCTION

Bangladesh is an agro-based country where about 80% of rural people rely mainly on agriculture for their survival [1]; and this sector plays a pivotal role in poverty alleviation and sustainable economic development of the country [2]. Here, the north-eastern wetlands of the country locally known as *Haor* covers about 1.99 million ha of land area playing a big part on agriculture production system. About 0.71 million ha of net cultivable land is available in these *Haor* areas producing more than 5.25 million tons of rice each year [3]. Almost 80% of this is covered by *boro* rice, while only about 10% area is covered by T. aman production [4]. Though floods are not new for Bangladesh and are parts of farmers' life [5,6]; *Haor* areas are the worst sufferer of climate change resultant flash flood unlike other parts of the country due to its unique physical setting and hydrology [3]. These recurring flash flood events damages the standing crops, lives and properties every year. Now a days, intensity and severity of these flash flood events has been increasing under changed climatic condition over the last decades. As in the past, flashflood generally occurred in April or May during the early monsoon period but now comes much earlier. Additionally, risk of crop damage in agricultural sector is increasing significantly as available days for farming are reduced on an average by 10–15 days compared to 30 years back [7]. Since *boro* rice cultivation mainly depends on nature [8]; occurrence of flash flood has created adverse impacts on *boro* cultivation. For instance, in 2017 flash flood came earlier on 27 March destroying over one lakh hectare of land and nearly-ready-for-harvesting *boro* rice in about 183,795 ha areas in the *Haor* districts [9,10].

However majority of the rural farmers still rely on subsistence agriculture system characterized by low productivity [11], while these extensive and regular flash flood events are threatening the *Haor* agriculture system and resulting to food insecurity. Therefore, farmers' adjustment mechanism and their cropping decision behavior are important determinants for coping with flash flood. To cope with this flash flood risk, farmers are adopting different farming strategies under different context to secure their *boro* rice production although the relative success is less. As adaptation of technologies may locally be inappropriate in the context they are used or mal-adapted, that, finally lead to ineffectiveness of these practices thus creating new damages or hazards [6,12]. Some studies have been conducted on overall impact of climate change on agriculture [13,14,15,16,17], yet no significant work is done specifically on *Haor* crop production adaptation system. So it is necessary to access the impact and suitability of different adaptation strategies under varied dimensions. Despite the increasing trend of flash flood resultant crop loss; this study aimed to identify the strategies that best suited in *Haor* areas along with relevant assessment of these identified strategies to develop a sustainable flash flood management strategy. This will greatly define a risk proof measure to secure the *Haor* agriculture system in the long run and, at the same time, to build community resilience against flash flood damage.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted Sunamganj district, containing 95 *Haor*s and is one of the severely flash flood affected districts [3]. Then following the multi-stage sampling technique, two most severely flash flood affected upazilas under Sunamganj distruct namely Tahirpur and Biswamvorpur were selected purposively and from each upazila, two villages namely Dakhin Sreepur and Solemanpur from Tahirpur upazila and Raipur and Bahadarpur from Bishwambarpur upazila were finally selected as these villages had faced severe flash flood damage in the last years [9].

2.2 Sampling and Data Collection

A total of 115 *Haor* farmers representing ~11% of the total population from these four villages were selected randomly thus constructing the study population. They were interviewed with the aid of a pre-tested structured questionnaire to collect primary data from February to May, 2020. Before conducting survey, Key Informant Interviews (KII) and Focus Group Discussion (FGD) were also conducted in each Upazila to gather qualitative information about different adaptive farming strategies from Upazila Agriculture Officer, Upazila Nirbahi Officer and model farmers of the respective Upazilas. In this way twelve strategies were selected as widely adopted by the *Haor* farmers. Necessary secondary data were also collected from different sources.

2.3 Empirical Approach

To quantify farmers' extent of adoption of selected farming strategies, a four-point Likert scale was modified ranging from 0 to 3 where, 0 means no adoption and 3 means highest adoption of an individual strategy [17,18]. Then they were asked to score individual strategy following this Likert scale against Adoption Index (AI) formula to access the impact and suitability of these adaptive strategies in the locality. Then strategies were finally categorized according to farmers mean adoption score following (Mean +/- Standard deviation) approach [19]. The Adoption Index (AI) formula was as follows:

$$AI = A_h \times 3 + A_m \times 2 + A_l \times 1 + A_n \times 0$$

Where,

AI = Adoption Index
A_h = Number of farmers fully adopted the strategy
A_m = Number of farmers moderately adopted the strategy
A_l = Number of farmers less adopted the strategy
A_n = Number of farmers did not adopt the strategy

2.4 Analytical Technique

The data collected were subjected to analysis using SPSS (Statistical Package for Social Science) software (Version 22). Mainly descriptive statistics were used to analyze the data.

3. RESULTS AND DISCUSSION

3.1 Identifying Adaptive *Boro* Rice Production Strategies

Adaptive practices are often mostly area-specific [20] thus indicating the necessity of identifying suitable strategy for *Haor* areas. Twelve strategies were identified during the research work through FGDs and KIIs as highly adopted by the farmers to secure their prominent crop *boro* rice from flash flood risk. These were: cultivating short duration *boro* rice varieties, change in transplanting time of rice seedling, practice of varietal diversification, transplanting older seedlings, shifting harvesting period of rice (at 80% maturity), growing *rabi* crops, use of raised seedbed during water logged condition, growing short duration vegetables, making necessary drainage system, fishing and selling them in the market, duck rearing and poultry farming. Then every respondent was asked to score each strategy according to their level of adoption and a summary of the findings is presented in Table 1 (Source: Field survey, 2020).

3.2 Categorization of Selected Twelve Adaptive Strategies

These adaptive strategies were categorized on the basis of farmers' adoption score and the result is shown in Table 2 (Source: Field survey, 2020). Results indicated that the most adopted practice was growing short duration *boro* varieties along with shifting harvesting maturity at 80% maturity and practicing varietal diversification. Contrary, the least adopted ones were poultry farming, duck rearing and using raised seedbed for seedling preparation.

3.3 Different Strategies Adopted by the *Haor* Farmers for Climate Change Adaptation

Here why farmers are adopting these practices to fight against flash flood hazard and their relevance with *Haor* crop production system is also explained.

3.3.1 Cultivation of short duration high yielding *boro* rice varieties

This is the most adopted technique to adapt with changed climatic and crop production scenario in the *Haor* areas. Cultivating *boro* rice highly depends on nature which makes it vulnerable to sudden flash flood damage [8]. Subsequently, the recent fluctuating and early flash flood occurrence under changed climatic condition only making the crop loss worse [7,10]. So, farmers now prefer such variety which has shorter life span and can be harvested well ahead of flash flood like BRRI dhan28, BRRI dhan29, BRRI dhan45 along with some traditional varieties like *Guchi*, *Lakhai* and *Tepi*. But they mostly grow BRRI dhan28 as it can be harvested up to 15 days earlier than BRRI dhan29 variety. In recent years farmers are also adopting some new varieties like BRRI dhan58 which can be harvested 7-10 days earlier than BRRI dhan28 along with Bina dhan14 in low scale. These finding are in line with some previous works [8,21] indicating its relevance to adapt with flash flood damage due to relatively shorter duration and higher yield.

Table 1. Salient features of different strategies adopted by the *Haor* farmers (n=115)

Sl no.	Adaptive strategy	Adoption category	Respondents		Total percent of farmers adopted	Mean of farmers adopted
			Frequency	Percent		
1.	Cultivating short duration *boro* rice varieties	Full	41	35.65	97.39	37.33
		Moderate	55	47.82		
		Low	16	13.91		
		No	3	2.61		
2.	Practicing varietal diversification	Full	27	23.48	78.26	30.0
		Moderate	33	28.69		
		Low	30	26.01		
		No	25	21.74		
3.	Harvesting rice at 80% maturity	Full	8	6.96	81.74	31.33
		Moderate	40	34.78		
		Low	46	40.0		
		No	21	18.26		
4.	Making necessary drainage system or channels for early removal of stagnant water	Full	0	0	18.26	7.0
		Moderate	0	0		
		Low	21	18.26		
		No	94	81.7		
5.	Use of raised seed bed for raising seedling	Full	0	0	13.91	5.33
		Moderate	0	0		
		Low	16	13.9		
		No	99	86.1		
6.	Transplanting Relatively older seedlings	Full	0	0	22.61	8.67
		Moderate	0	0		
		Low	26	22.6		
		No	89	77.4		
7.	Change in planting time of rice seedlings	Full	0	0	57.39	22.0
		Moderate	6	5.2		
		Low	60	52.2		
		No	49	42.6		
8.	Growing short duration vegetables	Full	0	0	19.13	7.33
		Moderate	3	2.6		
		Low	19	16.5		
		No	93	80.9		
9.	Poultry farming	Full	0	0	10.44	4.0
		Moderate	0	0		
		Low	12	10.4		
		No	103	89.6		
10.	Duck rearing	Full	0	0	13.04	5.0
		Moderate	3	0.9		
		Low	12	36.5		
		No	100	62.6		
11.	Fishing from the *beel*s in *Haor* areas and selling them in the market	Full	0	0	76.65	29.0
		Moderate	17	14.8		
		Low	70	60.9		
		No	28	24.3		
12.	Growing *rabi* crops to compensate yield loss by flash flood attack	Full	0	0	40.87	15.67
		Moderate	8	7.0		
		Low	39	33.9		
		No	68	59.1		

**Likert scale: 3-full adoption, 2-moderate adoption, 1-low adoption, 0-not at all*

Table 2. Categorization of strategies adopted by *Haor* farmers (n=115)

Sl. no.	Degree of adoption	Adaptive strategies under the category based on mean adoption score (in ascending order)
1	Less adopted	Poultry farming (mean score= 4.0)
2	Moderately adopted	Duck rearing (mean score=5.0) Using raised seedbed (mean score= 5.33) Proper drainage system (mean score= 7.0) Growing short duration vegetables (mean score= 7.33) Transplanting older seedlings (mean score= 8.67) Growing rabi crops (mean score= 15.67) Change in planting time (mean score= 22.0) Fishing (mean score= 29.0)
3	Highly adopted	Practicing varietal diversification (mean score= 30.0) Harvesting rice at 80% maturity (mean score= 31.33) Short duration *boro* variety (mean score= 37.33)

3.3.2 Practicing varietal diversification

It is another most promising strategy as the risk of crop loss is higher in case of longer duration rice varieties. Keeping this in view, farmers usually choose different varieties having varying crop durations and adjust them in such a way that leads to minimum crop loss with maximum yield [8,22]. So purposefully, they transplant both high yielding longer duration variety like BRRI dhan29 to get maximum yield with at least one shorter duration variety like BRRI dhan28 and/or traditional variety like *Tepi, Shail, Guchi* or *Lakhai* which are low yielding but can be harvested in mid-April just before the onset of flash flood [21]. Relatively newer varieties like BRRI dhan58, Bina dhan10, Bina dhan14 etc. were also growing recently in the *Haor* areas in a relatively lower scale.

3.3.3 Shifting harvesting period of rice at 80% maturity

As in recent years flash flood attack the *Haor* areas just before the time of harvesting, farmers can do nothing but to witness the loss of their almost ripen crops. So they are now trying to harvest their crops as soon as it reaches the ripening maturity at 80% level [21,22]. This strategy aids in escaping harvest loss by early flash flood damage. But due to shortage of farm labor and complex harvesting tradition existing in *Haor* areas; most of the farmers could not reap their rice at 80% maturity level. In addition, if the situation gets worse due to floods; the contract of wage goes so up that farm owners have to leave their crops in the fields un-harvested. As the estimated post-harvest losses are 9.49%, 10.51% and 10.59% for *aman*, *boro* and *aus* rice respectively at the farm level; so labour crisis is the worst nightmare for *Haor* farmers [23,24]. The good news is that, Government of the People's Republic of Bangladesh are now providing up to 70% subsidy to buy mechanical harvesters for the *Haor* farmers which would greatly aid in the labour crisis problem [23].

3.3.4 Fishing from the *beel*s and selling them in the market

Hence *Haor*'s people's livelihoods and culture are largely dominated by *Haor* economy where *beel* fisheries play a significant role; this practice plays great role to compensate farmers crop loss by acting as their supporting income generating source. The *Haor* region has an estimated fish habitat area of around 967,000 ha which contributes nearly 20% of the total inland fish production [3]. So, thousands of poor households in *Haor*s subsist on fishing and fish trading for a significant part of the year as their main livelihood options. Sunamganj district is in surplus in overall fish production as according to DoF, around 55000 MT fish was harvested in 2009 [25]. Fish is captured round the year from rivers and *Haor*s/*beel*s in the district in addition to organized harvesting during winter. But, unfortunately, these *beel*s and water bodies are controlled by few local powerful people. They, through their muscle power manipulate the leasing process and obtain lease from the concerned authority. In some occasions, they allow common fishermen to fish in their water bodies through paying money; otherwise they restrict the entrance of common people. In addition to that, often the common people do not get fair price due to their lack of access to direct fish market, poor communication channel, and dominance of fish traders or middlemen. Thereby, effective marketing system and proper

communication channels should be established to support the poor fishermen and local *Haor* community.

3.3.5 Change in planting time of rice seedling

As in most cases *boro* rice is grown under rain-fed condition, this strategy gives farmers an option to save the crop from early flash flood damage. So, a smaller portion of farmers are practicing early transplanting of rice seedlings within the period of mid-December to late-December in *Haor* areas [21,22]. This method of direct wet seeding of germinated seeds shows a relative benefit to escape flash flood attack during harvesting period over traditional seedling transplanting methods. Because it can be harvested 10-12 days earlier than traditional seedlings transplanting methods. In addition to that, as soon as flood water recedes from the *Haor* areas and the land remain soft; direct seeding of *boro* rice in zero tillage field has advantages to establish the crop earlier and thus can escape early flash flood damage. But the main drawback of this technique is, early planting of seeds may cause cold injury to rice plants during winter resulting in anther deformation to the crop.

3.3.6 Cultivation of *rabi* crops

As in recent years the loss due to flash flood is huge and the uncertainty of secure harvesting of *boro* rice is high; many farmers are growing different *rabi* crops at the side of *Haor* areas (locally named "*kanda*") even in their main field as supplementary crop when it is not occupied by *boro* rice. Again, as most of the *Haor* areas are used only for single cropping i.e. *boro* rice, the land remains unproductive for a longer period of time throughout the year. So, the *Haor* areas have great potentiality to utilize this vast amount of fertile land by incorporating *rabi* crops in their year-round cropping cycle. Many studies also established significance of growing *rabi* crops like wheat, mustard, potato, chili, brinjal, onion, ground nut etc. at the side of *Haor* (locally named "*kanda*") areas and also on unoccupied main land as these have great economic value and market demand [8,21,26].

3.3.7 Duck rearing

Duck rearing has an effective potentiality in the *Haor* areas as a supplementary source of income. The water basins in the *Haor* areas has tremendous potentiality for successful duck farming [27]. Geographical advantages like natural feed resources, abundant water for swimming, tolerable temperatures etc. have made *Haor* regions especially suitable for duck farming [28]. Almost every family in the *Haor* region to own few ducks mainly for egg production and for meat purpose. Duck rearing is higher especially during the rainy and autumn season due to abounded water body and availability of natural feeds. These household ducks as well as the commercial duck farms are mainly operate with a scavenging system and additional feed is only supplied for a short period of the year. A Survey by the Borgachashi Unnayan Project (Tenant Farmers Development Project), of BRAC showed that approximately 1.5 million ducklings are produced annually in *Haor* areas [26]. But despite tremendous opportunities of profitable duck farming in *Haor* areas, they have remained unexplored so far. The main hindrances are lack of improved duck varieties, unavailability of capital, shortage of vaccines and health care supports, traditional feeding system, and lack of effective value chain from production to marketing.

3.3.8 Transplanting relatively older seedlings

Though the recommended age for BRRI dhan28 variety is 20-25 days and for BRRI dhan29 variety is 30 days; farmers sometimes transplant older seedlings that were aged up to 30-45 days to avoid flash flood attack. This practice is less used but not uncommon among the farmers [21]. But the limiting factor is that, rice yield is considerable less in case of using relatively older seedlings. If proper care is taken in choosing the seedling age, vulnerability to the flash flooding could be reduced to some extent by using older seedlings [29].

3.3.9 Growing short duration vegetables

Due to frequent crop loss by flash flood, *Haor* farmers are trying to accommodate other short duration vegetables before *boro* rice pre-flood and post flood period cropping pattern. Red amaranth, stem amaranth, spinach, radish, potato, etc. were now widely grown by the farmers before cultivation of *boro* rice in lands where flood water recedes fully at the end of October and first week of November.

Additionally, a considerable number of farmers are growing these short duration vegetables at the side areas of *Haor* (locally named "kanda") or in their homestead areas to ensure a little

amount of extra earning and to support the nutritional need of their families [30,31]. Thus risk of early flash flood damage and cold injury due to early planting of *boro* rice seedling may be avoided by developing appropriate duration of cropping patterns harvestable before the risk period of early flash flood.

3.3.10 Making necessary drainage system or cannels for easy removal of stagnant water

It was one of the least adopted strategy as only a few number of farmers can effectively use this practice. This is because making drainage cannels and maintaining them requires a great amount of money and more labour force. In addition, most farmers in *Haor* areas are small farmers inheriting fragmented lands that limit their chance to construct and maintain the drainage systems or cannels.

3.3.11 Use of raised seedbed for raising seedling during water logged condition

Only a smaller portion of farmers had practiced growing of rice seedlings in a raised seedbed during unavailability of suitable land due to water logged condition. Sometimes they also use raised seedbed to grow seedling separately in relatively earlier period when their main land is still occupied with other crops or rice to compensate the overlapping of crop growing periods. That aids in escaping late transplanting of rice seedlings. Though it is relatively least used; but has a considerable suitability under *Haor* farming condition to minimize the probable yield loss to a certain limit.

3.3.12 Poultry farming

It is very common to have at least one or two pair of poultry in almost every household in *Haor* areas to meet up their protein demand through providing eggs and meat supply. They somehow turns it a supplementary earning source by selling the eggs and poultry for meat purpose in the local market. But due to lack of habitat and natural feed supply during flooding or water logged condition, commercial poultry farming is difficult; as ensuring dry farming place and continuous food supply is costly and laborious job. But if proper support and technical guidance is given, it can be a potential economic source for the *Haor* farmers.

4. CONCLUSION

Haor wetlands have significant ecological importance and economic contribution to the country. But the recurring flash flood events have become a curse for local *Haor* community. Farmers have been fighting a never ending war against the flash flood damage to secure their *boro* rice production. Therefore, the Government and extension organizations should come forward to develop deliberate strategic policies that can address crop security needs of the farmers against climatic challenges. Extension agencies also should have to provide input supply and arrange training and demonstration programs on improved practices for the farmers to facilitate their technical adeptness. Moreover, policy makers and development agencies should take targeted actions in accordance with revised priorities for investment and policy creation to improve *Haor* farmers' livelihood and to develop necessary infrastructure and better market environment for them.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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