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Exploring adaptation gaps among the stakeholders to flood shocks in *haor* agriculture of Bangladesh

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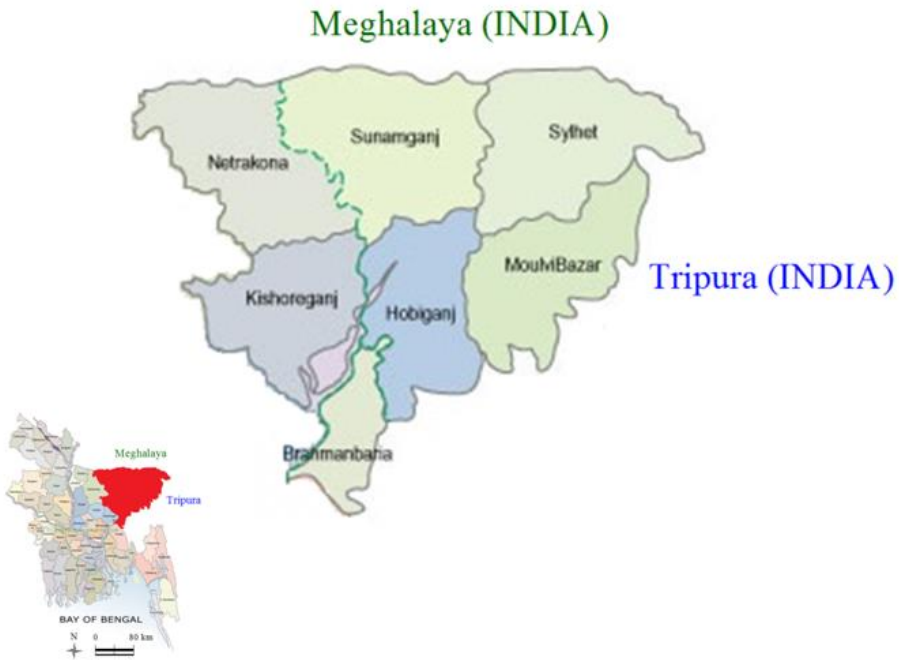
ABSTRACT

Haor areas at northeast Bangladesh face early flash flood during pre-monsoon season every year that destroy the staple mono crop Boro paddy with enormous loss of live and livelihoods in the areas. Despite many studies conducted regarding the matter but no study is associated to explore the adaptation gaps among the stakeholders on crop loss in *haor* areas. Therefore, the study was carried out to find out the farmer's perception and adaptation gaps in rice production affected by the flood shocks in *haor* areas. Both secondary and primary sources of information were collected. Secondary data were collected through the review analysis from books, booklets, published and unpublished reports, and grey literatures. Primary data were collected through interviewing with the various kinds of stakeholders like farmers, researchers, policy makers and extension agencies associated with *haor* agriculture. The main crop of *haor* areas is the *Boro* paddy cultivated from January to May. Thus an early flash flood of two weeks duration could destroy the entire production of standing paddy where the affected farmers do not find any other alternative to support livelihoods. The early flash flood that usually hits during early April which often continues to the monsoon flood till the month of September or even October. The *haor* farmers are advised by the policy makers, researchers and extension workers to cultivate the BRRI Dhan28 variety (grain yield 5.5-6.0 t/ha) in the early flash flood prone areas but to get higher yield they often practice the cultivation with the BRRI Dhan29 variety (yield 7.5 t/ha) whose life duration (160 days) is 20 days longer than the previous one. Therefore, the *Boro* paddy cultivated with BRRI Dhan29 is affected by the early flash flood. The loss of *Boro* paddy would be avoided through advancing the transplantation of this crop by 3 to 4 weeks. However, cool injury to the rice plants is the main barrier to do this. The development of cool tolerant *Boro* variety with short-duration characteristics is underway as expressed by the chief scientists working in the Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA). Until that some promising cool-tolerant rice genotypes can be imported from Asian regions like Nepal, Bhutan, India, Japan and Korea under the 'seeds without borders' initiative. The loss of *Boro* paddy can be compensated in favour of farmers through adopting crop insurance policy with providing some public subsidy as premium. Varietal purity should be maintained to achieve higher yield of paddy. The harvest of *Boro* paddy should be facilitated with mechanical harvesters for quick harvest in ahead of an early shock of flash flood. Cultivation of *Aman* paddy is scattered in the areas especially in the periphery of *haors* which is also affected by the long monsoon flood. Submergence resistant *Aman* rice cultivars like BRRI Dhan51, BRRI Dhan52, BINA Dhan 11, BINA Dhan12 and like others which could tolerate about 2 to 3 weeks of submergences can be practiced there with some successes.

Keywords: *Aman* and *Boro* paddy, climate change, early flash flood, farmer's perception, *haor* areas, monsoon flood, northeast Bangladesh, stakeholders

1. INTRODUCTION

The *haor* basin is located in north-eastern part of Bangladesh that bordered on three sides by the mountain ranges of India, with Meghalaya to the north, Assam to the east and Tripura to the south-east (Map1). The basin extends north to the foot of the Garo, Khasi and Jaintia Hills, and east along the upper Surma Valley to the Indian border (Bennett et al., 1995). The region is considered to be highly vulnerable to climate change especially flood shocks due to its hydro-physical settings.



Map 1 *Haor* areas of Bangladesh.

The *haors* are mosaic of wetland habitats with large back swamp or bowl-shaped depressions between the natural levees of rivers subject to monsoon flooding every year (Irfanuallh et al., 2011; Miah, 2013). There are altogether 373 *haors* situated in seven districts: Sylhet, Moulavibazar, Habiganj, and Sunamganj in the north-east, Netrokona and Kishoreganj in the north-central and Brahmanbaria in the central eastern region of Bangladesh (Ahmed, 2012). In terms of ecosystem, crop production practices, and economic activities and over all livelihoods of the farmers, *haor* areas are quite different from those of the other parts of the country. Despite cultivating a single crop with *Boro* paddy and the recurrence of flash floods, the *haor* region produces about 20 percent of country's total staple food (rice), covers almost one fifth of its total land area and provides livelihood for twenty million people (Rabby et al., 2011).

Cultivation of *Boro* rice in *haor* areas is seriously hampered by early flash flood during pre-monsoon season. Rice security is synonymous to food security in many rice growing countries like Bangladesh (Brolley, 2015), which is an important issue for determining social and political stability (Nath, 2015). The matter is more applicable in *haor* areas of Bangladesh as the region is dominated mostly by mono-cropped *Boro* paddy. The *haor* areas lost around 800,000 metric tons of *Boro* paddy and 263,808,000 person day labour due to an early flash flood hit in March-April of 2017 (NIRAPAD, 2017; Siddique, 2017). Some other abiotic stresses reduce rice yield greatly (Vij and Tyagi, 2007) which challenge the future food security (Kumari et al., 2009). Early planted *Boro* rice in the *haor* areas has to face cold stress at the reproductive stages. Spikelet sterility is observed in the early planted *Boro* rice, if mean temperature in middle of February to middle of March prevails below 20°C for more than 5-6 days (Biswas et al., 2011). The farmers of the *haor* areas consider their *Boro* paddy as a chance harvest as the crop might have to encounter the flash flood every few years at mature or semi-mature stage (Biswas et al., 2008). Minimizing yield loss is a major concern to cope with the increasing food demands of over increasing population (Mahajan and Tuteja, 2005).

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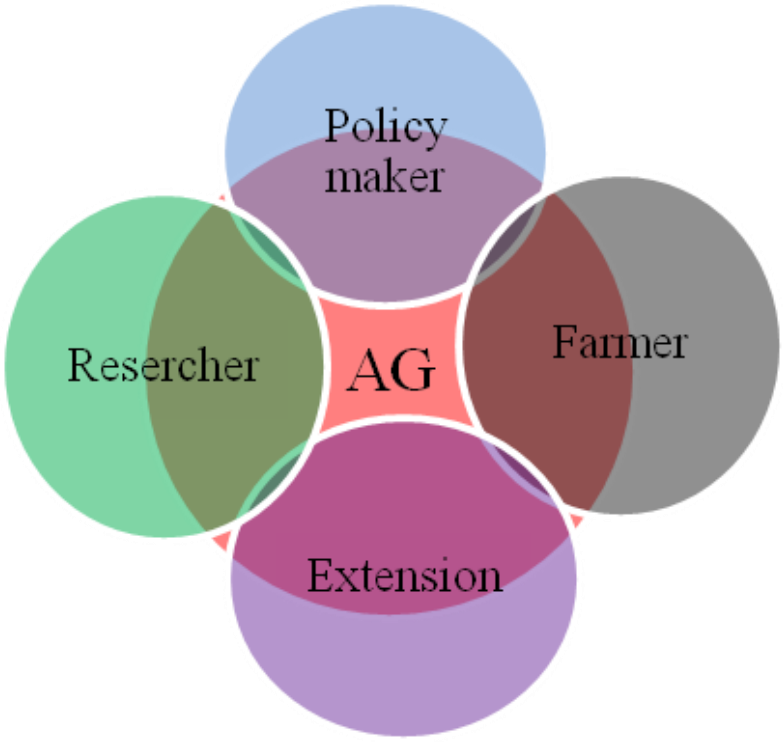
Cost of agricultural adaptation to early flash flood in *haor* areas is accounted so high. Bangladesh annually spends $1 billion, 6-7 percent of its annual budget, on climate change adaptation works (UNEP, 2014), however the achievements are still poor. So, best adaptation practices to climate shocks are of paramount importance in agriculture especially in *haor* areas.

In spite of huge cost on adaptive researches many farmers don't utilize innovations or technologies released from authority i.e., technologies are either not so befitted or those were not properly disseminated by the extension agencies to farmers. Another aspect is that researchers could not select suitable research items from farmers; hence sustainability of technologies may be poor. As a whole some adaptation gaps are common between policy makers, research institutes, extension workers and rural communities (Schematic diagram 1), and therefore the ultimate target couldn't reach to a satisfactory level. That means there are technologies at researcher or policy level but low adoption of those at grassroots level (Rahman and Islam, 2013; Thomas et al., 2013; Sutradhar et al., 2015) drains a lot of money and efforts from national budget. Although the issue is very crucial but not investigated so far (Asia Foundation, 2013; Huq and Rabbani, 2015). Therefore, there is an urgent need to conduct a study to find out adaptation gaps between various levels of stakeholders such as researchers, policy makers, farmers and extension for minimizing the production loss of crops to flood shocks in *haor* areas of Bangladesh.



Schematic diagram 1 Adaptation gap (AG) between the four categories of stakeholders in *haor* agriculture.

2. MATERIALS AND METHODS

The study was carried out in the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh 2202 during the time from July 2018 to June 2021. Climate change related books, booklets, journals, articles, leaflets, folders, published and unpublished reports and newspaper articles etc., on agricultural production for *haor* regions of Bangladesh were collected through purchase, institutional visits, personal communication and consulting with internet browsing on web. A list with most common examples of adaptation options (innovations) or technologies developed and recommended by the research institutes and those promoted by the extension agencies for better agricultural productivity in early flash flood affected *haor* areas were listed through analyzing those literature and consultation with relevant personnel or stakeholders working in the research institutes, Department of Agricultural Extension (DAE), Development Projects (DP), Non-government Organization (NGOs) etc.

Field level data were collected through survey with pretested open ended and semi-structured interview schedule or questionnaire from farmers from flood affected *haor* districts. In total, 2054 farmers from *haor* areas were personally interviewed by

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well-trained field enumerators. Data from filled questionnaires were inputted in computer programmes by well-trained data entry operators. The technologies those are used by the farmers (hereafter we referred as end users or service users of technology) were cross checked or matched with the technologies for those areas offered by the service providers like DAE as already collected through review of literatures and stakeholder consultation. Descriptive statistics were used to visualize the quantitative data of questionnaire.

Collective community or social responses were accumulated with a qualitative tool like Focus Group Discussion (FGD) meeting with farmers. The affected villagers or farmers were asked about the reasons for adaptation gaps, how can they adapted with recommended technologies and whether any other new technology is to be needed to face the adverse impacts of climate change. Stakeholder consultation with the personnel working at research institutes and Department of Agricultural Extension (DAE) was carried out to know their innovations and extension of those to the *haor* areas.

3. RESULTS AND DISCUSSION

Cropping patterns practiced in the *haor* region

The hydro-morphological features of *haors* allow agricultural activities especially crop production only for four to five months in a year. The major cropping patterns practiced in *haor* areas are:

(a) Boro-Fallow-Fallow: Cropping pattern of near about 70 percent farmers in *haor* areas is mono-cropped *Boro* so called *Boro*-Fallow-Fallow (Fig. 1). The land is submerged by water either for early flash flood or long term monsoon inundation from May to November (NCVAB, 2018). That's why the farmers cannot utilize the land to cultivate the crops other than *Boro* rice during the season extended from December to April or May. It is the main reason for lower cropping intensity in *haor* region. Nevertheless, fishermen and local people use these lands using vast water bodies for catching fishes when no crop is exist.

Alam et al. (2010) said that more than 80% of the total cropped areas are covered by *Boro*-Fallow-Fallow cropping pattern in the major *haor* districts like Sunamgonj and Kishoregonj. It is a cropping pattern where crops are grown only in *Rabi* season (November-April) and land remains uncultivated during *Aus* (April-July) and *Aman* (July-November) seasons. That is only winter crops can be practiced in this cropping pattern. *Aus* rice (summer rice sown in March or April and harvested during the summer) is not grown in the *haor* areas of Sunamgonj, Kishoregonj, Sylhet and Habigonj (DAE, 2007).

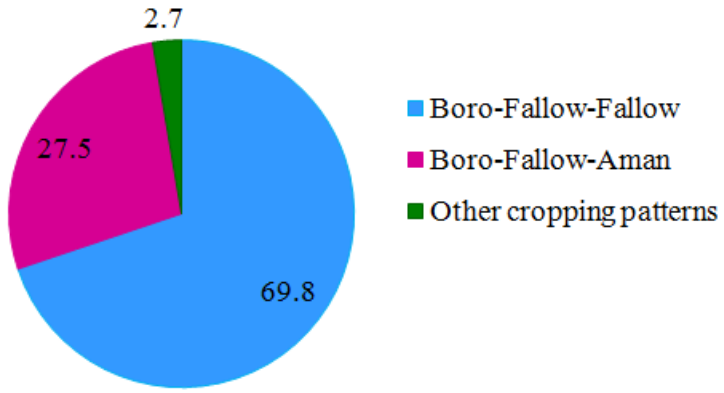

Figure 1 Cropping patterns practiced by the *haor* farmers (%).

(b) *Boro*-Fallow-*Aman*: A few double-rice based cropping patterns are also practiced in scattered else in the *haor* region. About one-fourth number of the total *haor* farmers cultivates second rice like broadcast or transplanted *Aman* mainly in relatively high land and the periphery of *haors* (*Kanda*) where inundation by monsoon flooding is not so severely occurred (Fig. 1) (Alam et al., 2010). In *Aman* season, rice is not grown profusely in the *haor* areas of Sunamgonj, Kishoregonj and Brahmanbaria (BRRI, 2004). In the *haor* basin, there is land (10-40% of the *haor* area varies from *haor* to *haor*) which is comparatively higher locally known as *Kanda*. Usually, recession of water from raised *kanda* lands gets faster and the lands become ready for agricultural activity 30 to 45 days ahead compared to the rice fields in low-lying areas. Again, raised *Kanda* lands are inundated lately by flash flood. These raised *Kanda* land is used for *Aman* cultivation.

(c) Other cropping patterns: Mustard-*Boro*-Fallow, Mustard-*Boro*-*Aman*, *Boro*-Jute-*Aman*, *Boro*-Vegetable-*Aman* etc are sporadically practiced in *haor* areas.

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Some other cropping patterns like Wheat-Fallow-Fallow, Groundnut-Fallow-Fallow, Mustard-Fallow-Fallow, Sweet gourd-Fallow-Fallow, Onion-Fallow-Fallow, Garlic-Fallow-Fallow, Radish-Fallow-Fallow, Cucurbits-Fallow-Fallow, Okra-Fallow-Fallow, Country bean-Fallow-Fallow etc are practiced and year-round vegetable like brinjal, chili etc also grown in the flood free areas of the *haor* region.

Huda (2004), Alam et al. (2010), Ali et al. (2018) support the said cropping patterns.

Extension activities at farmer's doorstep

It is revealed from the analysis of questionnaire survey that near about 70 percent of crop farmers are duly communicated through local agriculture and extension office of Department of Agricultural Extension (DAE) especially through the Sub-Assistant Agriculture Officer (SAAO) (Fig. 2). The farmers try to follow the crop production techniques with crop cultivars those recommended by the Upazila Agriculture and Extension Office. The SAAOs directly visit the farmer's field with a package of agricultural technologies those they were informed from their authorities. The respective officials are trying to disseminate the latest technologies from the top-down system to the local crop growers. The SAAOs are also highly concerned to utilize the local resources for the well being of farmers for optimizing their farm production.

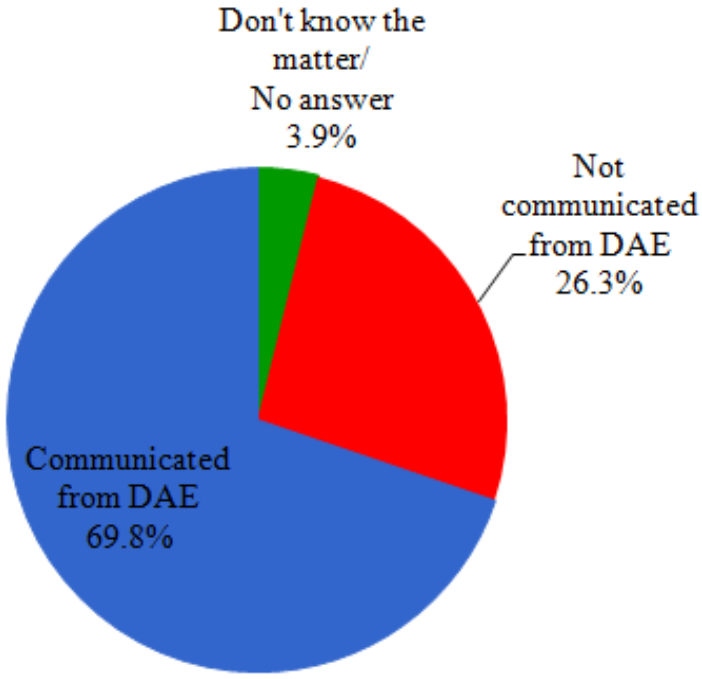

Figure 2 Communication from Upazila Agriculture/Extension Office to the crop farmers.

Recommended and disseminated technologies for rice production in *haor* areas and observed adaptation gap

Department of Agricultural Extension (DAE) is being playing a pivotal role to disseminate the recommended technologies to the doorstep of the farmers. No particular rice variety has yet been developed by the research institutes of Bangladesh that can fit exactly to the particular condition exist in the *haor* areas. However, the main rice variety recommended for *Boro* season in *haor* areas is BRRI Dhan28 (grain yield 5.5-6.0 t/ha). It is a popular mega variety of rice for *Boro* crop. The BRRI Dhan29 (grain yield 7.5 t/ha) rice variety is also recommended for highland especially in the periphery (i.e. *Kanda*) of *haor* areas where early flash flood is not occurred. Since their release in 1994, these two BRRI varieties, which stretch from November to April, won farmers heart not only in *haor* areas but all over Bangladesh for their high yield potentials during *Boro* season. Because of the gap between research and extension, the varieties took 15-16 years from their release to reach full adoption, said Dr. Humnath Bhandari, the representative of the International Rice Research Institute (IRRI) for Bangladesh (Daily Star, 2018).

The main adaptation gap in *Boro* season is observed for selecting the rice variety by the farmers in *haor* areas. To obtain higher grain yield of paddy, the most of the *haor* farmers cultivate BRRI Dhan29 variety with neglecting the advice given by the DAE personnel (Fig. 3). The life span of this variety is about 20 days longer than the BRRI Dhan28 variety (140 days). As a result, matured and semi-matured rice paddy of BRRI Dhan29 is often affected by the early flash flood.

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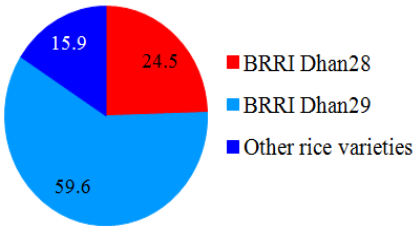

Figure 3 Rice varieties cultivated by the percentages of farmers in *haor* areas.

Source of dissemination of rice cultivars

Near about 40 percent farmers cultivate the said rice varieties (i.e. BRRI Dhan 28 and BRRI Dhan 29) due to the influence of the activities of Upazila Agriculture or Extension Office (Fig. 4). Near to a thirty percent rice growers acknowledged surrounding influence as all farmers in the area cultivate the same varieties of rice since many years while twenty percent rice growers replied that they cultivate the aforesaid varieties due to the positive influence of neibour farmers. Ten percent farmers used the variety as used these varieties by their parents. So, it is clear that with passing time the said varieties are fully adopted in the *haor* areas which is suppose to be continued until and unless an other one is identified as best.

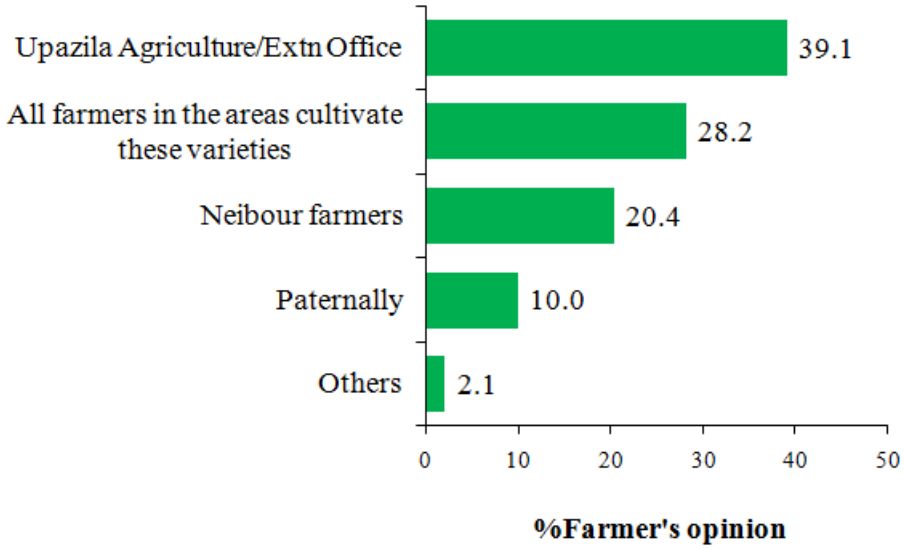

Figure 4 Sources of dissemination of used rice varieties in the *haor* areas.

Source of seed for rice cultivation in *haor* areas

More than 70 percent of the *haor* farmers use seed which is bought from local market (Fig. 5). Only a few percentage of the farmers utilize the personal seed from their own harvest as they realized that the varietal purity of the cultivated rice varieties like BRRI Dhan28 and BRRI Dhan29 become losen (mentioned later). About one-tenth of the total farmers collect rice seed from Bangladesh Agricultural Development Corporation (BADC) and another one-tenth use seed from government seed dealer and Upazila Agriculture/Extension Office. To boost rice porduction in *haor* areas, the these later two sectors of seed source can be strengthened or promoted under the leadership of BADC.

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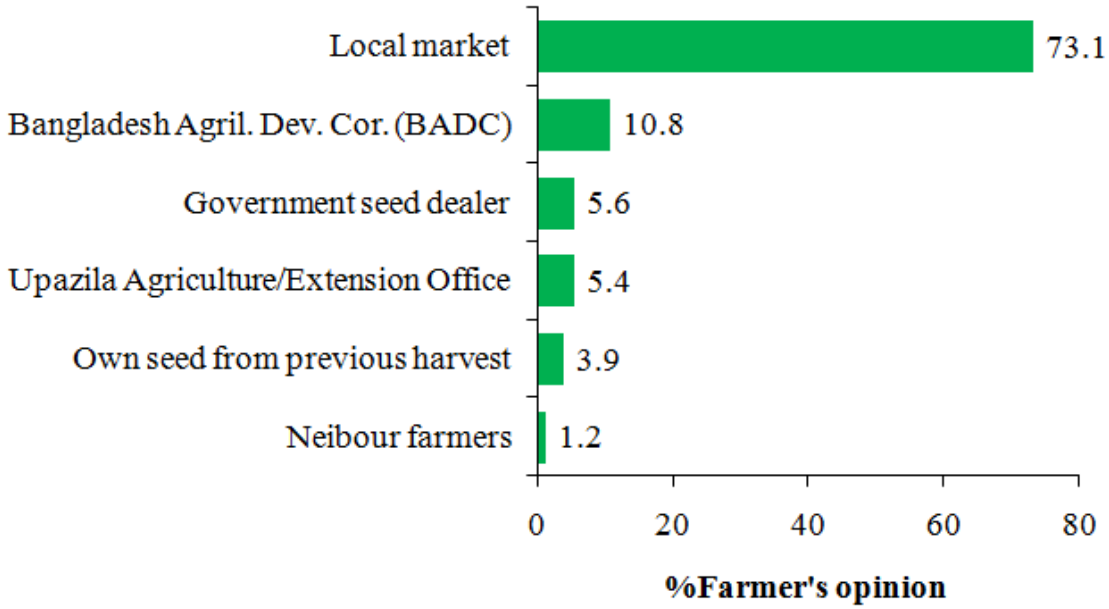

Figure 5 Sources of seed for rice cultivation in *haor* areas.

Varietal impurity – an important adaptation gap for lowering rice grain yield

The research team discussed to the flood affected *haor* farmers through Focus Group Discussion (FGD) meeting to collect their views on production related issues. They argued that yield potentiality of the rice genotypes they cultivate like BRRI Dhan28, BRRI Dhan29 and others is getting lost day by day due to the gradual increasing of incorporation to the seed lots of these varieties from the seeds of other varieties. An agronomist can explain otherwise this matter as the loss of varietal purity. That means seeds of other or foreign varieties of rice have gradually been mixed to the seed lot of aforesaid varieties. Thus the *haor* farmers can't also use their own-produced rice grain as seed for next cultivation. Seeds from local market are also not as pure as claimed by the farmers although near about three-fourth number of total farmers utilize the seed from local market. The BRRI Dhan28 and BRRI Dhan29 varieties are more than 25 years old and thereby the yield potential is declining and they have become more susceptible to diseases and insect pests (Daily Star, 2018). Although BRRI dhan28 is an old age variety but no other varieties could prove their worth better than this variety regarding secured harvesting. Hence, Bangladesh Agricultural Development Corporation (BADC) could support farmers by supplying the pure seeds every year by replicating pure seeds either through their own management or through the Upazila Agriculture/Extension Office.

Advancing the *Boro* season – a viable way to avoid early flash flood

Most of the *haor* farmers (about ninety five percent) would like to advance the cultivation of *Boro* paddy for escaping the crop from early flash flood (Fig. 6). It is a long term dream of *haor* farmers. For doing so, early seedling transplantation is required. Nevertheless, it is a big challenge as early transplantation of *Boro* seedling is not possible (Fig. 7). More than seventy percent farmers believed that early transplantation of seedling of *Boro* rice is not practically feasible due to some ecological reasons like cool sensitivity of plant plants, fog incidence etc.

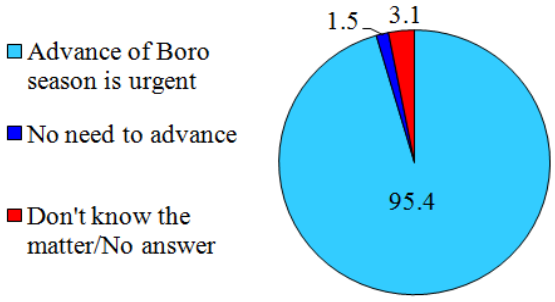

Figure 6 Percent farmer's opinion for the necessity to advance *Boro* cultivation

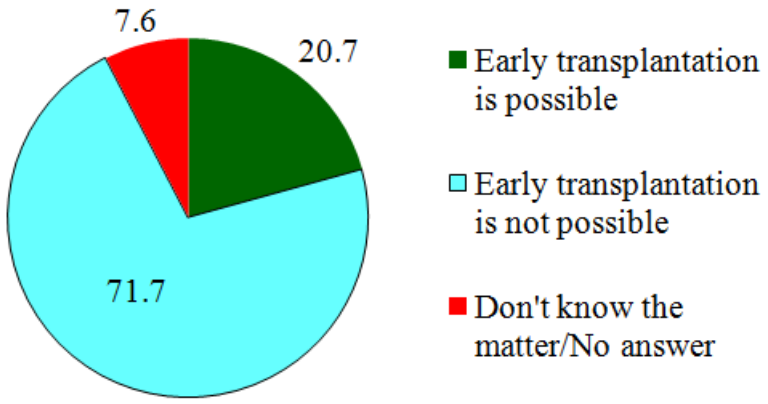

Figure 7 Percentage of farmers' opinion whether early transplantation of *Boro* seedling feasible in *haor* areas

Adaptation gap for advancing *Boro* cultivation in *haor* areas

Season advancement of *Boro* cultivation is urgently needed as early flash flood often destroy the matured or semi-matured rice paddy. However, cool injury is the main barrier to achieve this goal as expressed by the 64 percent of farmers in *haor* areas (Fig. 8). Planting of *Boro* rice at usual time do not cause cold injury at reproductive stage in *haor* areas, but crop has to encounter flash flood at maturity (Biswas et al., 2008). On the other hand, early transplanted *Boro* rice has every probability to face low temperature during February at reproductive phase that caused higher sterility of grain (Rashid and Yasmeen, 2017). As per opinion of the one-fourth of the total number of farmers in *haor* areas that their land for *Boro* cultivation remians submerged due to congested water or receding of previous stagnant water is delayed. About seven percentage of farmers, however, claimed that seedbed is a problem to start *Boro* cultivation at the earliest time. Therefore, development of cool-tolerant varieties of *Boro* paddy may bring a new avanue to escape the early flash flood in the *haor* areas that occur in the late march or in ealry April.

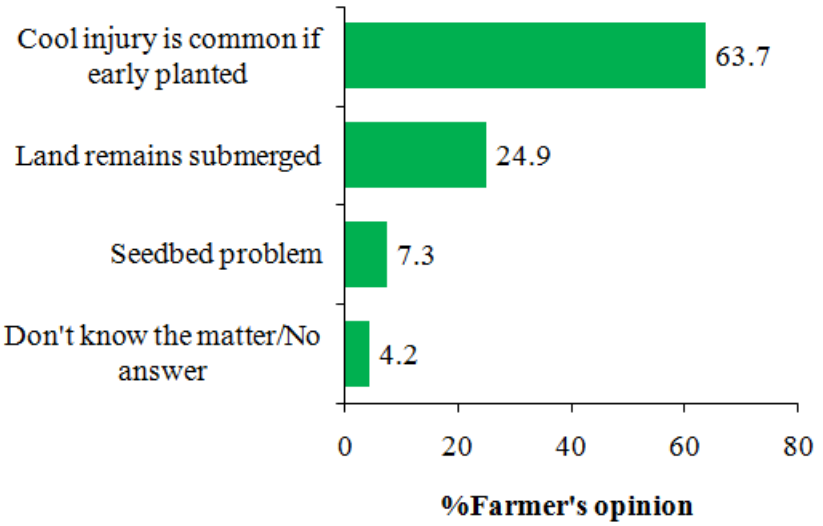

Figure 8 Barrier to advance *Boro* cultivation in *haor* areas

Development of cool-tolerant *Boro* paddy – scientific perception

The research team of the study discussed with the Director General (DG) of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh about the development of short duration and cool-tolerant *Boro* rice variety (Photograph 1). Mr. DG said that he and his team members are being continuously and whole heartedly working since a long time to develop a short duration and cool-tolerant *Boro* rice variety through applying nuclear radiation. He is also the Chief Scientist of the said progromme, assured that they are very close to found a cool-tolerant *Boro* rice variety with a life span of 135 days. They are trying to release this variety within the

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next four to five years. Once released the same, *Boro* cultivation can be advanced in *haor* areas that would escape early flash flood occurred in late March or in early April.

Photograph 1 Discussing with Director General of Bangladesh Institute of Nuclear Agriculture (BINA) on the development of short duration and cool-tolerant *Boro* rice variety suited for *haor* areas.

The research team also discussed with the Chief Scientist of Plant Breeding Programme at the Bangladesh Rice Research Institute (BRRI), Gazipur on the aforesaid issue. He confirmed us that his team is working to develop a cool-tolerant rice genotype that is suitable to adapt in *haor* areas. He said that cool-tolerance of rice is a polygenic character so it will take some time to reach the expectation through breeding programme. However, they assured us that they will get success and the time is not so far.

Saving *Boro* rice production

Cultivation of short duration rice varieties in *Boro* season is the crying need of the *haor* farmers. (Fig. 9). The minimum life span of the popular rice variety-BRRI Dhan28 is 140 days, therefore farmers could not harvest it by April. Nevertheless majority of the *haor* farmers cultivate more longer life spanned variety-BRRI Dhan29 (160 days) for the sake of yield adavantage. Farmers need the rice variety with more reduced life span. They also couldn't advance rice cultivation due to their (most other varieties too) sensitivity to cool temperature and fog incidence in *haor* areas. Thus, two adverse conditions, such as low temperature stress especially during early growth stages and flash flood at maturity affect the *Boro* rice in the *haor* areas of Bangladesh. Therefore, the *haor* farmers urge to authority for introducing a rice cultivar which could successfully tolerate the cool situation during *Boro* season (Fig. 9). If these hopes are fulfiled, the *haor* farmers could successfully harvest the *Boro* rice well before the hit of early flash flood in the areas.

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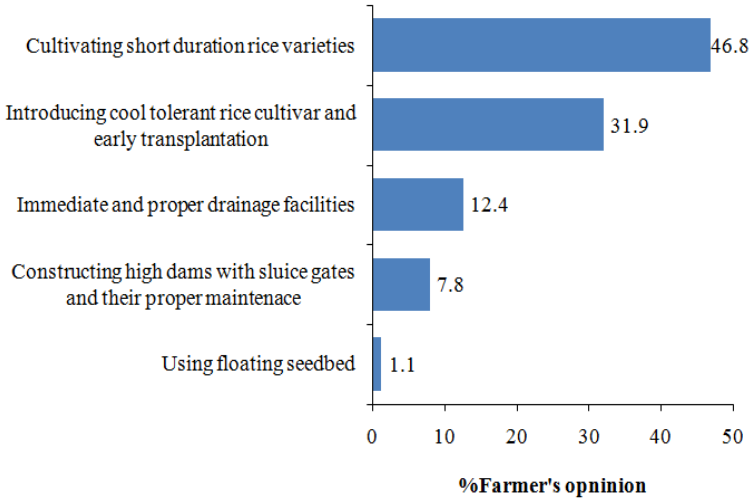

Figure 9 Farmer's expectation for saving *Boro* production in *haor* areas.

Low temperature induced rice yield loss is a big problem in the many areas of the world (Peyman and Hashem, 2010). It is a major constraint to rice production in mountainous regions of the tropics and in the temperate rice-growing regions of the world (Xie et al., 2012). Northern districts of Bangladesh including *haor* region are cold prone. *Boro* rice is greatly affected by cold during crop establishment and reproductive stage. Seedling mortality sometimes goes up to 90% especially in northern part of the country. In recent years, more than 2.0 million hectares of rice crop in northern and north-eastern parts (e.g. the *haor* basin) of Bangladesh have been affected by severe cold spell causing partial to total yield loss. We have to find out a way to cope with this situation. The most important thing to mitigate this issue is the cultivation of short duration cold-tolerant varieties in the *haor* areas. The scientists working in the Bangladesh Rice Research Institute (BRRI) are giving their efforts to develop a cold tolerant rice variety. A little success was also made with the development of a cold-tolerant variety named BRRI Dhan36, but its performance is not praiseworthy in the existing level of cold stress.

Rice varieties suited in *Boro* season with shorter growth duration (130 to 135 days), higher yield and tolerant to low temperature with some desirable traits to the farmer are earnestly needed in the *haor* areas of Bangladesh. Until and unless a suitable cold-tolerant *Boro* rice cultivar is developed by the scientists working in BRRI or BINA, we could collect and introduce some cold-tolerant genotypes which are available in different countries especially from Asian origin (BOX 1).

BOX 1 Some promising cold-tolerant rice varieties practiced in Asian region

Nepal: Jumli Marsi, Chhomrong, Machhapuchre-3, Palung-2, Chandannath-1 and Chandannath-3, Tainan-1, Chainan-2, Chainung-242, Taichung-176, Himali, Kanchan, Khumal-2, Khumal-3, Khumal-4, Khumal-5, Khumal-6, Khumal-7, Khumal-8, Khumal-9 and Manjushree 2, etc.

Bhutan: Jakar Rey Naab, Khangma Maap, Yusi Rey Kaap1, Yusi Rey Kaap2, Yusi Rey Maap1, Yusi Rey Maap2, Barkat, Kuchum, etc.

India: Akshaydhan, Taramati, Bhadrakali, RNR 18805, RNR 17813 and WGL 44, HPU1, Himali, Kanchan, Himdhan, Himalaya1, K332, Kalimpong1, Khonorullo, Meghalaya1, etc.

China: B55, Banjiemang, Lijiangheigu, Yunlu 29, etc.

Japan: Jyoudeki, are Ouu 415, Hitomebore, Ouu-PL 5, Iwate 100, Tohoku 207, Tohoku PL 3, etc.

Korea: Jinbubyeo, Junganbyeo, SR30084-F8-156, etc.

Source: Karki et al. (2010); Jiang et al. (2011); Gautam and Shrestha (2012); Ghimiray et al. (2013); Nakagomi (2013); Wang et al. (2013); Basuchaudhuri (2014); Neelima et al. (2015); Endo et al. (2016)

Use of submergence tolerant rice cultivars against monsoon flood hit

Cultivation of submergence tolerant rice is very important in *Aman* season where recurrent monsoon floods often strike the *haor* areas. More than one-third of the total number of farmers expressed that they didn't know the submergence tolerant rice prevously (Fig. 10). Near to one-third number of total farmers agreed that submergence tolerant rice could potentially cope the flood incidence while twenty eight percent farmers opposed it.

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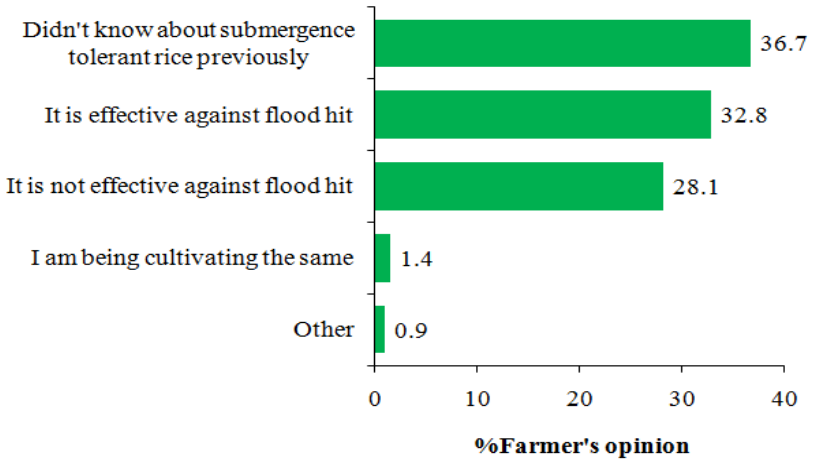

Figure 10 Farmer's opinion on the role of submergence tolerant rice genotypes against the incidence of monsoon flood in *haor* areas.

Saving *Aman* and *Aus* rice production

The cultivation of *Aman* rice is little and *Aus* rice is much scattered in *haor* areas. After providing the necessary ideas and utilities of the sumbergence rice, the *haor* farmers would like to cultivate submergence tolerance cultivars of *Aman* and *Aus* rice. Near to a two-third number of the total farmers in *haor* areas demand these (Fig. 11). Rice of lowland ecosystem is typically cultivated in 5-25 cm of standing water, which are highly vulnerable to monsoon flash floods of 50 cm or more. Like the *haors* and some other lowland areas of Bangladesh, submergence is a recurring problem in the south and south-east Asia where paddy is extensively cultivated. Developing and promoting submergence tolerance rice cultivars with a number of agronomic and quality traits are needed to address the problem (Septiningsih et al., 2009)

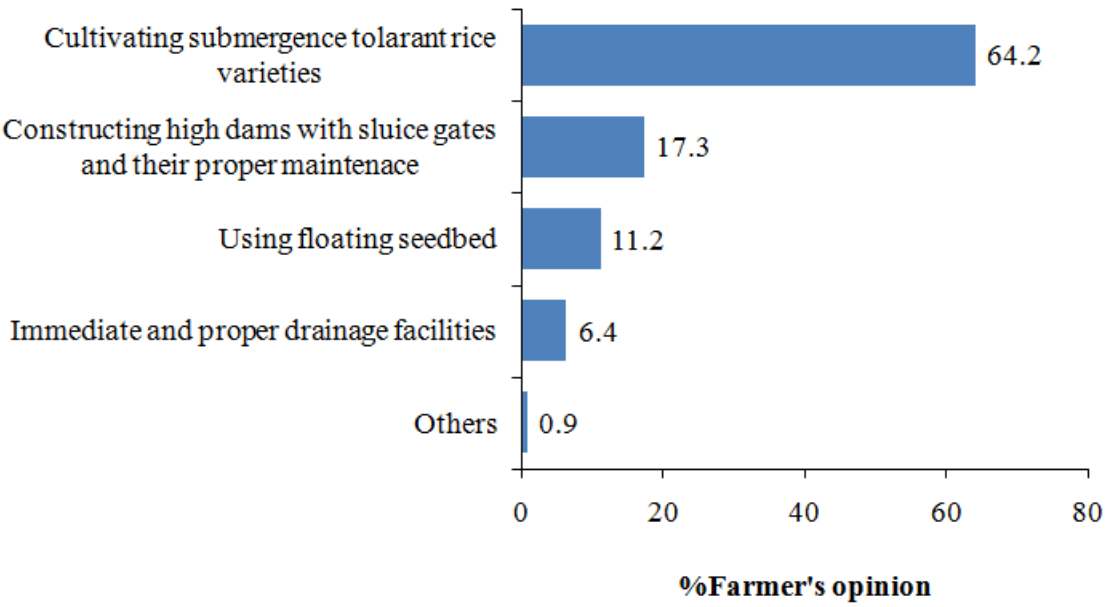

Figure 11 Farmer's expectation for saving *Aman* and *Aus* production in *haor* areas.

Bangaldesh Rice Research Institute (BRRI) released two importance submergence tolerance rice cultivars like BRRI Dhan51 and BRRI Dhan52 which tolerate about two weeks of submergence. Thereafter Bangaldesh Institute of Nuclear Agriculture (BINA) relased some other submergence tolerant cultivars like BINA Dhan11 and BINA Dhan12 that tolerate more longer submergence as like as three weeks or even more (Odishabytes, 2021). The prime responsible character of the submergence tolerance paddy is that the plant posseses *Sub1* gene (Bailey-Serres et al., 2010).

The Bina Dhan11, developed by the BINA, fits the submergence requirements well with a yield potential of 5.5 ton/ha. It is a submergence tolerant version of the Indonesian mega variety Ciherang. The cultivar produces medium slender grain with good

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taste and has the yield advantage of 1-3 t/ha as compared to the other varieties of similar duration of submergence character (Odishabytes, 2021). This variety is introduced jointly in India, Bangladesh and Nepal under the 'seeds without borders' initiative. The variety is also fuel efficient as the parboiled rice cuts 10-15 minutes to cook as compared to the other varieties (Odishabytes, 2021).

Although some progress is occurred on submergence tolerance for *Aman* rice, but there is no such cultivar for *Aus* rice. So research work should endeavour to develop a submergence tolerant variety for *Aus* rice.

Adoption of insurance policy in *haor* agriculture

Most farmers about eighty four percent of the totals have demanded to operate the crop insurance programme to compensate production risks against flood hit especially for *Boro* rice in the *haor* areas (Fig. 12). It is also evident that around ten percent of the farmers in the *haor* region didn't know about the crop insurance policy.

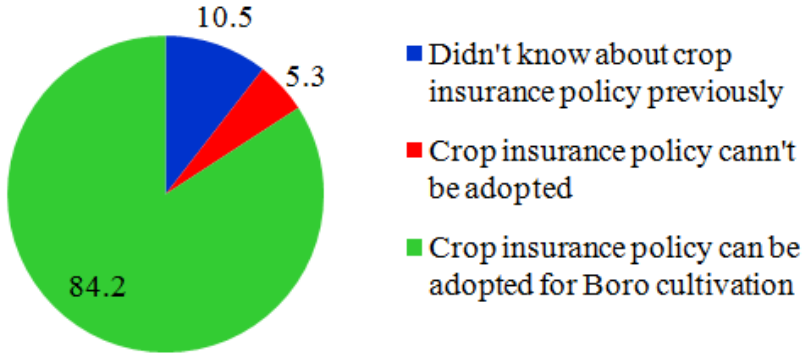

Figure 12 Percent farmer's opinion on adoption of crop insurance programme in the *haor* areas

One-fourth of the total number of *haor* farmers would like to agree to pay premium of the insurance policy while more than sixty percnt farmers don't like to pay any premium of the crop insurance policy (Fig. 13). If government pay the partial premium or provide any kind of subsidy on their farming against flood risk, in that case, more than three-fourth number of the total farmers agreed to pay the remaining part of the premium. In an alternative option, they would like to pay the value of insurance premium with providing rice after their harvest as they urged during FGD discussion. Very recently, the state-owned Sadharan Bima Corporation (SBC) has launched and started to pilot for the first time, flood index-based crop insurance for *haor* areas. Previous initiative on crop insurance policy in Bangladesh agriculture which was found more generalized, not successful or simply failed. But with applying adequate terms, conditions and cautions like use of specific cultivars, planting time etc, the crop insurance initiative could be implemented.

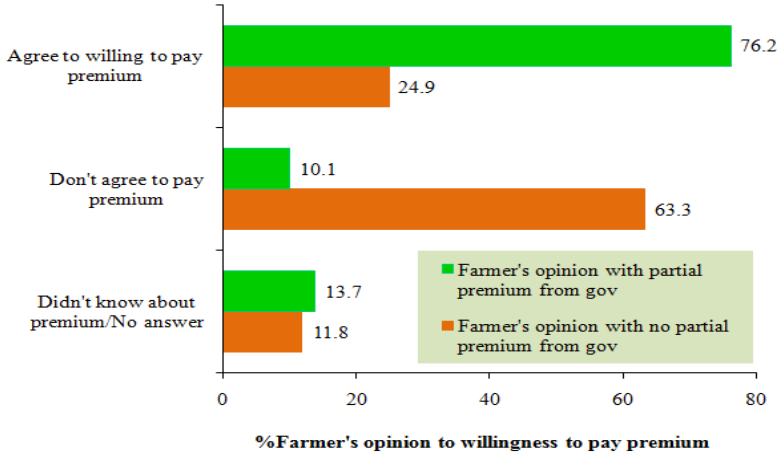

Figure 13 Farmer's opinion on willingnes to pay premium of crop insurance programme if governmnt provide any subsidy in the *haor* areas.

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Miscellaneous issues

The *haor* farmers strongly urged to facilitate machinery farming which could mitigate labour shortage problem especially during harvesting time that may avoid the risk of quickly spreading flash flood to some extent. Most of the farmers claimed that they are not getting the proper price of rice as compared to production cost. Therefore, they are highly reluctant for rice cultivation although there is no practical option other than rice cultivation in the region. As a result many famers keep their land uncultivated. They would like to sale their rice at the end of season with logical price through rice collection programme of the public procurement system. The participated farmers in the FGD meeting have requested to set up rice milling, drying and processing plant and proper marketing facilities of rice in the *haor* areas. Although the *haor* region is a purely rice producing area since time immemorial but such facilities are yet to developed there.

4. CONCLUSION

All the qualitative and quantitative data were analyzed by using proper scientific methods or techniques. Many adaptation gaps are noticed which considered to be the main constraints for crop production in *haor* areas. Some important adaptations gaps with proper remedies are stated below

1. Most of the farmers are advised to cultivate rice with BRRI Dhan28 variety in the *Boro* season but to get higher yield many farmers use BRRI Dhan29 variety whose life span (160 days) is 20 days longer than the BRRI Dhan28 (140 days). As a result *Boro* crop grown with BRRI Dhan29 variety is often subjected to early flash flood in *haor* areas.
2. Advancing *Boro* season is only the viable solution for avoiding early flash flood in *haor* region that ensure safe harvest but cool sensitivity or cool injury of rice plant is one of the main hindrances to do that. Development of short duration and cool-tolerant rice cultivars suited for *Boro* season is underway as committed by the Chief Scientists of pertinent research organizations of Bangladesh. Until the development of that type of rice variety by the scientists, some suitable rice genotypes with aforesaid traits can be imported and introduced under the 'seeds without borders' initiative from abroad especially Asian regions like Nepal, Bhutan, Nepal, Bhutan, China, Japan and Korea.
3. The *haor* farmers are advised to cultivate BRRI Dhan51, BRRI Dhan52, BINA Dhan11, BINA Dhan12 etc in *Aman* season as these varieties can tolerate up to a period of 2-3 weeks of submergence which is very important to mitigate the flood hit in the *haor* areas. However, no *Aus* rice with aforesaid traits is so far developed. So research work should endeavour to develop a submergence tolerant *Aus* variety that would widen the rice cultivation in that season.
4. Most of the farmers use the rice seed collected from local market, the said seeds which varietal purity is already questionable as these seeds are being multilied over the years through non-scientific cultivation practices. Varietal purity is highly important for getting optimum yield from a crop and BADC could play a significant role to this issue.
5. A majority of the farmers would like to get the crop insurance policy in the *haor* region for getting compensation of yield loss especially for *Boro* paddy from early flash flood. However, the farmers are not willing to pay the premium of the insurance policy if the government will not pay the partial value of that or provide any kind of subsidy in crop prduction. The farmers, alternatively, would like to pay the premium of insurance policy through providing rice directly from their field during the time of harvest.
6. Harvest of *Boro* paddy in *haor* areas can be facilitate with mechanical harvester which could mitigate labour shortage problem for avoiding the risk of early flash flood to some extent.

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Ethical approval

Not applicable.

Funding

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Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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