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Full Length Research Paper

Agricultural adjustment in flood-prone areas in Comilla of Bangladesh: A geographical study

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This paper focuses on agricultural adjustment inclination in flood-prone areas in Comilla, Bangladesh. The study's area is located in a tropical and rivers' oriented developing country in Southeast Asia. It has a huge potential of agricultural activities, such as fertile soils of deltaic plains, vast rainfall of monsoon climate, and available labors. On the other hand, natural hazards, for examples, floods, cyclones, droughts and arsenic contaminations make a common hazardous phenomenon at this distinctive geographical location of the Bengal Basin. The study was done based on a primary survey from June 2008 to May 2009 at household levels. Moreover, an empirical field observation was carried out to decipher the trend of floods, such as river flood, flash flood, and flood due to rainfall in the study area. Also, an interview questionnaire survey was done by the experts and farmers to collect information about indigenous knowledge, traditional beliefs, and perception of agriculture and climatic trend to decrease the damages of crops from floods. In addition, farmers grow vegetables and fruits at medium and high lands (bhiti*), *Transferee Aman and Aus at medium and lowland, and Aman at very lowlands. Furthermore, farmers devise some strategies, such as cultivating crops for a short length growing period (LGP), and sowing hybrid seed to harvest them within an expected time. Besides these, farmers take some previous initiatives; for instance, make social networks, conduct special training for collection of crops in a short time, and arrange preservation preparation on the availability of supporting resources, types of floods, and characteristics of rainfall. However, farmers of this study area are excluded from modern technologies and information systems. Finally, the application of indigenous techniques, such as observation of flood trends, and variation of monsoon winds of farmers to adjust agricultural activities in flood prone areas, bears an enormous significance for this study.

Key words: Adjustment process, crop diversification, land levels, perception.

INTRODUCTION

Bangladesh enjoys a unique geographical position as having the largest deltaic plain in the world. The fertile soil of floodplain is very important for agriculture (Hossain, 1998). It mainly contributes to the economic strengths of the country and puts in more than 20.6% to the Gross Domestic Product (GDP) in the country. Moreover, about 48.4% of the people depend on agriculture (Economic Survey Report, 2009). On the other hand, geographic settings of Bangladesh make it vulnerable to natural disasters (Panaullah, 2006). Due to the geographical location of Bangladesh, tropical hazards (for examples, cyclones, tornados, droughts and floods) occur here all year round.

Among natural disasters in the study area, the flood is more extensive and devastating. It destroys crops, houses, properties and lives of men and animals. Barsha (the flood season) has stimulated the agricultural settlement in the country over a long period of time, but Bonna (the abnormal flood) is considered as the actual hazard in the context of Bangladesh as it destroys crops, properties and infrastructure. However, the normal flood helps the agricultural activities, such as fisheries, to supply water in soils and fertilize lands for proper growing of crops.

Study area: Comilla

The study area is Comilla, a flood-prone and the most intensive agricultural area in Bangladesh (Figure 1).

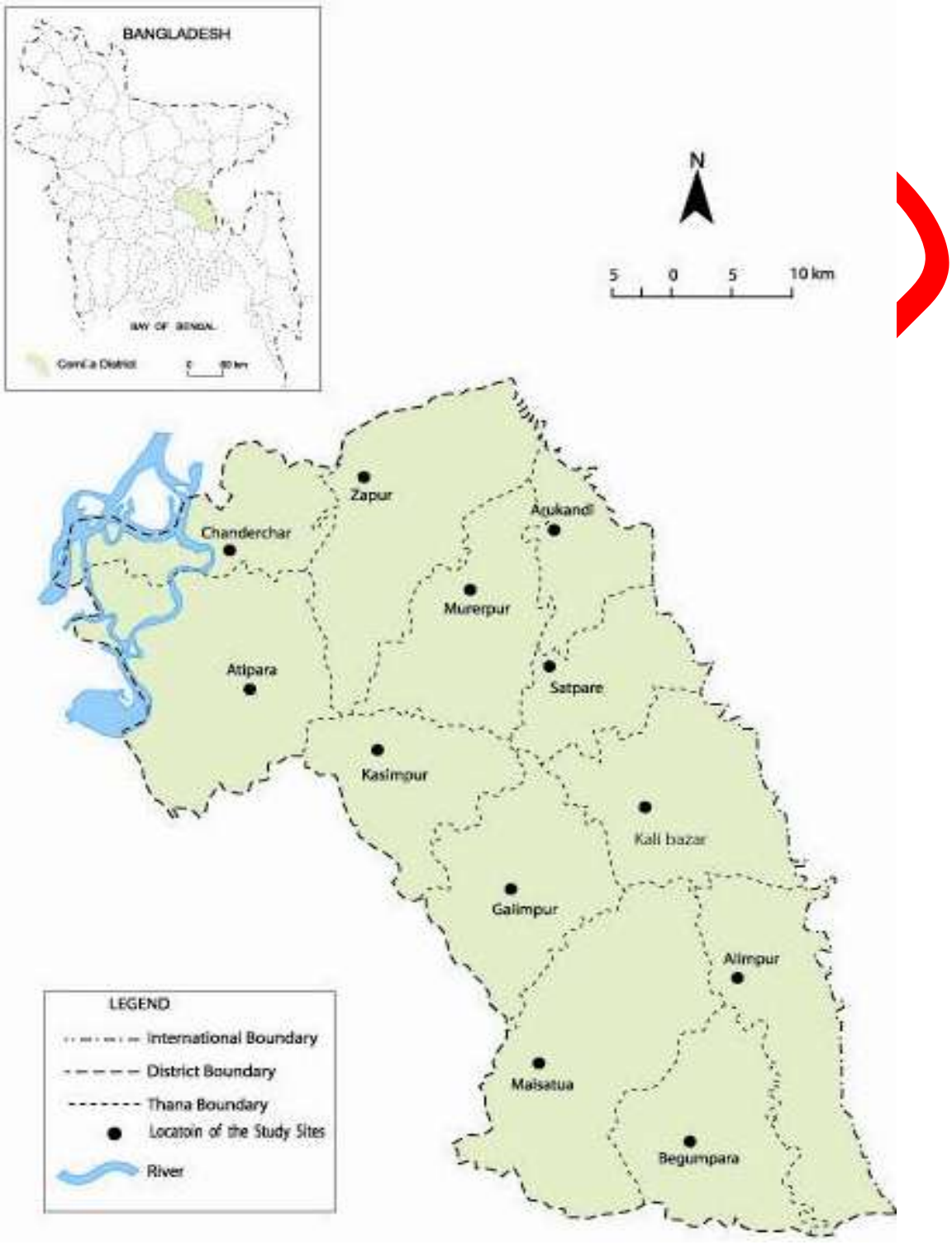


Figure 1. Study area.

It is one of the potential agricultural areas of the country. Moreover, floods are very common in this area (Figure 2). This area occupies an area of about 3,085.17 sq km and a total population of about 48,381 (BBS, 2008).

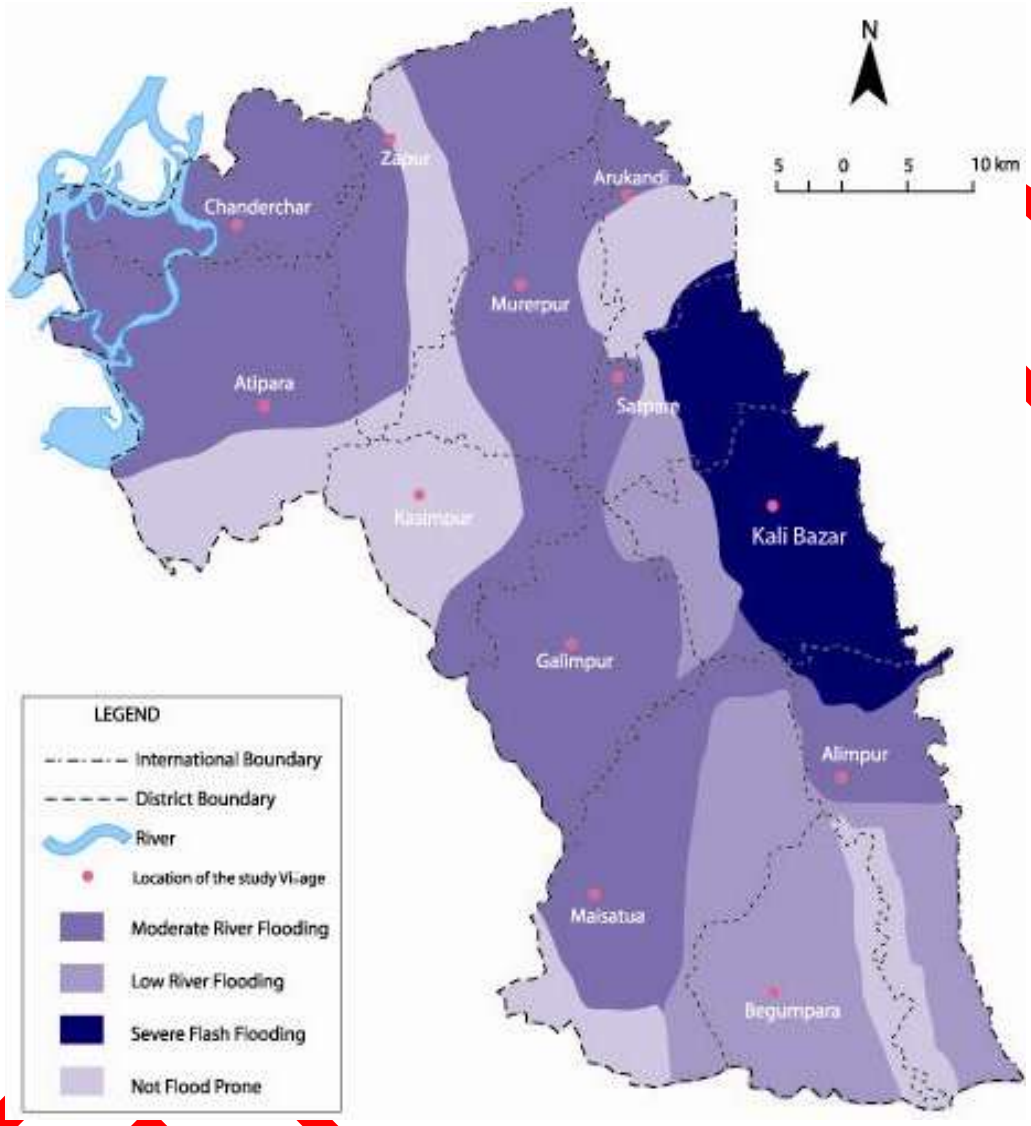


Figure 2. Flood pattern in the study area. Source: BARC (2006), SRDI and Field survey (2009).

Furthermore, more than 85% of the people in this area are farmers and the total cultivable land is 10,750 sq km. Meghna, Gumti and Dakatia are the main rivers of this area and Comilla is at the basin of the Gumti River.

Objectives of this study

The aims of the present study are to decipher the farmer's perceptions and adjustment processes at all stages of floods, for instance, pre-flood period, during flood period, and post flood period.

Also, this study aimed at identifying the cropping process of farmers to adjust with floods, and to suggest some initiatives to agricultural adjustment with flood, and make less crops' damages in the study area.

METHODOLOGY

Data were primarily collected through a questionnaire survey given to the farmers in the study areas. The data were collected from June 2008 to May 2009. Moreover, some secondary data were used to understand the problems and evaluate the trend of adjustment of agriculture. The study emphasized on analyzing the current level of crops' adjustments and the perceptions of farmers to decrease damages of crops from floods in the study area. In this connection, 200 agricultural households were chosen randomly in the study area. Besides, some appropriate statistical analyses, such as one-way frequency table, percentages, ratios, and figure of comparison of crops cultivation were prepared to find out the goals of this study. In addition, several cartographic techniques and

spatial analysis techniques were used to reveal the spatio-temporal variation of physiographical tables.

RESULTS AND DISCUSSION

This study shows that in flood vulnerable areas, farmers cultivate various crops by using their indigenous knowledge, traditional practices, and own perception in the study area. In this connection, farmers took some strategies and measures before floods, during floods and after floods. The study reveals that the farmers took two types of initiatives to adjust agriculture in the flood prone area.

Short term initiatives

Before the floods, farmers make high soil beds in the flood free areas to sow seeds of Aman *rice*, vegetables, and other transferred crops. Moreover, they cultivate hybrid seeds to grow crops, such as Boro, jute, and vegetables during the flood free periods. Furthermore, farmers took some measures to reduce damages of crops from floods.

Precaution before floods

Farmers make seedlings of broadcast Aman, vegetables, and other crops at flood-free highlands in the study area, while they cultivate short duration Boro, deepwater rice, and jute in lowlands of severe flood vulnerable areas. In this regard, farmers wipe out weeds, grasses, and use medicine to control pest. Sometimes, they cultivate sapling of long stem paddy and hard straw paddy like IRI-8, Chandina (BR1) and Biplab (BR3) in flash flood areas to resist the power of flood waters. However, the farmers harvest 80% of the ripen paddy (Aus or Boro) before they submerge flood and protect transplanted Aman field from flood water or floating weeds, debris, rats, and stem borers by making natural fence or enclosing the land with dainchya.

Action during floods

Farmers harvest 60 to 80% of mature crops before submerging floodwater. At this time, they prepare seedlings in flood-free highland and floating seedlings in raft or fence covered with soil in flood-free land. In September, the BR-22/BR-23/BINASHAO/ NAGIRSHAO/ Local Aman seed was seen before floodwater submerges. After recession of floodwater, farmers transplant sapling onto lands. Moreover, they prepare seedlings of cauliflower, cabbage, tomato, brinjal, chilli, gourd and other vegetables in the front of their houses, in wood-box, drum, old tin, poly-bag, plastic container and raft. After the recession of floodwater, they transplant them onto the land.

Initiatives after flood

Farmers prepare lands as soon as water drains away. Moreover, they plant transposable healthy bunch of sapling in the prepared lands. However, they refill the missing one and the drying plant right away. In December (mid Aswi), farmers transplant 7 to 8 saplings of 50 to 60 days old plants from each piece of land. Furthermore, farmers sow seeds, such as: molasses, lentils, coriander, maize, mustard, mashkalai and khesari without cultivating lands after the recession of floodwater. In addition to recovering plants, farmers make a systematic drainage system in lands to remove water that are still stagnant in the root of plants. In this regard, farmers take special care of medicinal plants and fruit trees. However, they pile fresh soil around roots of plants, and steady saplings and trees with bamboo sticks.

Long term initiatives

This study reveals that traditional crops' cultivation is very common in the study area. Farmers grow crops based on their indigenous knowledge and own experienced perceptions, as well as on the natural agro-ecological conditions of the area. Moreover, the farmers use the following strategies for long-term initiatives to adjust the agricultural activities.

Diversity of crops

Based on seasonal rainfall, three distinct partly overlapping crops seasons were recognized in the study area, such as Rabi season, kharif I, and kharif II (Figure 3). Rabi season is normally dry winter and it starts from October to early March. The occurrence of rainfall is about two inches. During kharif I, season (end of March to May) occurrence of rainfall is about fifteen inches before "bursting" of monsoon in June. Moreover, in Kharif II seasons (May to September), both broadcast Aman and transplanted varieties are cultivated in the study areas (Hossain, 1998).

This study shows usually, double and triple rice crops practice in medium to high land areas in the villages, for examples, Kasimpur, Satpura, Begumpara, Arukandi, and Mererpur. These places are not normally inundated under water by floods. Farmers grow Rabi vegetables, Boro T. Aus and Aman rice in these areas. Nowadays, three or four crop types are grown in Kasimpur village per year because the farmers opined that lands of this area are very fertile and water availability is sufficient.

This study reveals that traditional deepwater Aman rice

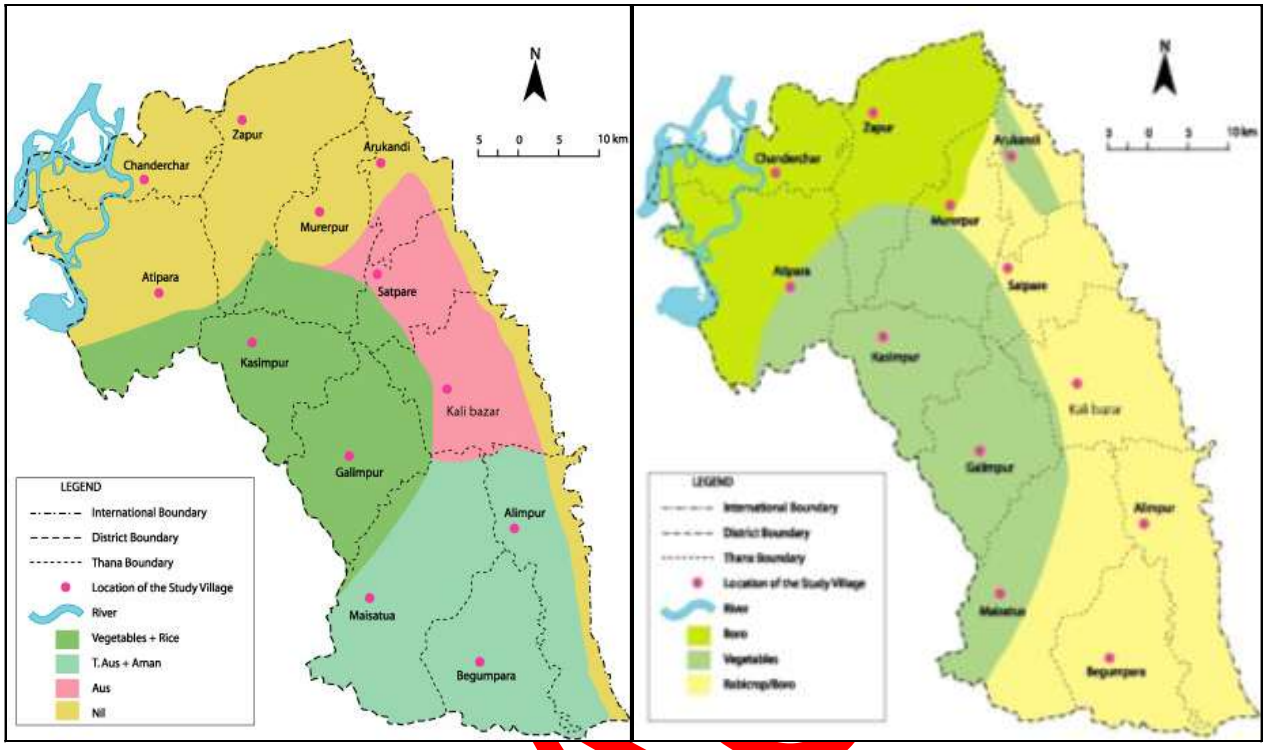


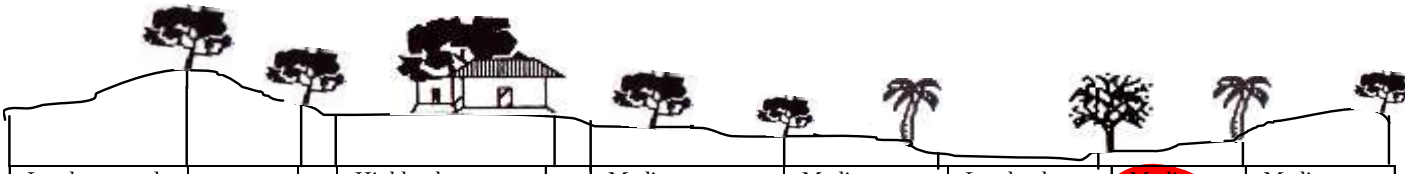
Figure 3. Crops diversity during Rabi and Kharif seasons in Comilla. Source: SRDI and Field Survey (2009).

Table 1. Changes of cropping system and yield rate.

Crops	Cultivated lands (%)		Yield in kg/ha		Percent change of crop land and yield (%)
	1987- 88	1999-2000	1987-88	1999-2000	
Rice	127.7	110.0	2,164	3,589	66
Aus TV	30.9	7.3	1,220	1,416	16
B. Aman TV	67.6	45.4	1,618	1,842	14
T. Aman	1.7	5.3	2,605	3,914	50
Boro	27.5	52.0	4,541	5,386	19
Other crops	45.9	32.5			
Jute	7.1	4.3	1,801	1,891	5
Wheat	6.4	4.8	1,734	2,121	22
Pulses	15.0	9.4	892	852	-4
Oilseeds	6.8	2.3	992	862	-13
Potato	4.3	2.9	10,578	26,741	153
Vegetables	0.9	2.6	6,352	11,621	83
Others	5.4	6.2	-	-	-
Cropping intensity	173.6	142.5	-	-	-

Source: SRDI (Thana Instruction Guide) (1999) and Field Survey (2009).

is a major crop in the flood-prone areas, for examples, Kasimpur, Atipara, Zapur, Arukandi, Murerpur, Satpara, Begumpara and Alimpur villages. In 1987 to 1988, total lands of this area consist of nearly two-third of the rice land, such as traditional Aus rice and deepwater Aman. The productivity of these crops is very low, for instance, 1.6 and 1.2 t/ha (Table 1). Moreover, Boro rice grows in the dry season with MVs yielding about 2.8 times that of B. Aman, but its cultivation is limited to areas with access to irrigation. Recently, a rapid expansion of irrigation



Land type and area coverage		Road Side	Highland (*bhita*) 10 %	Mud Road	Medium highland (danga) 20 %	Medium lowland 30 %	Lowland 40 %	Medium lowland	Medium highland
Enterprise	Metal road		Homesteads, roads		Crop fields 100 %	Crop fields 100 %	Crop fields 100 %		
Soil type			Sandy loam		Loam	Silty loam	Silty loam		
Crops / Cropping pattern and trees.			Kitchen garden, seedbed of *boro* Mango, guava, bamboo		*Boro*- Deep water *Aus* 100 %	*Boro* 100 %	*Boro* 100 %		
Livestock			Cattle, buffalo, goat, chicken, duck, pigeon						
Problems			Insufficiency of animal power at peak time of on-farm activities.		Need regular irrigation during winter season.	Flood water submerged the land during rainy season.	Flood water submerged the land during rainy season.		
Adjustment Process					*Boro cultivate* during *Rabi* season and Aus cultivate on highland.	Only cultivate *Boro* during *Rabi* season and left the land fallow during rainy season	Only cultivate *Boro* during *Rabi* season and left the land fallow during rainy season		

Figure 4. Land use pattern in Atipara Village of Daudkandi Upazila. Source: Field survey, 2009.

facilities, for example, power pumps, shallow machines and tube-wells help farmers to cultivate shifting rice like low-yielding mixed Aus, Aman, Rabi crops, and Boro rice.

The study shows that Boro rice cultivation is gradually increasing and it is almost 52% of the total cultivable land in 2000. The crops patterns intensity has almost disappeared in favor of single-cropped Boro rice, because of the reducing crops' intensity substantially. Farmers safely grow short-duration modern Boro and T. Aman varieties and keep lands unused during the periods of heavy flooding. The dry-season crops, particularly the pulses and oilseeds, are endangered substantially in the flood-prone villages, such as, Chanderchar and Atipara (Figure 4).

This study shows that farmers grow short duration HYV Boro rice in Rabi season, and keep the lands unused in Kharif season. In low flood affected areas, farmers grow double to triple rice crops in a year. In some cases, farmers reduced the risk of flood damage by choosing suitable varieties, for examples, cultivating early-maturing Boro varieties (HYV or local), quick-maturing Aus varieties (HYV or local), long seedlings of Boro, Aus or Aman, quick-maturing wheat varieties, and late-maturing Aman varieties.

Land levels

Most parts of the study area are uneven. Moreover, it normally consists of a succession of broad ridges and depressions varying in size and shape. The cultivation of crops on each of the various levels determines the frequency of floods, effectiveness of drainage, and the amount of silts deposited by floods. The farmers' choice of cropping practices influences the relationship of floods in the study areas.

Crops types in the study area

Farmers grow short duration crops with high yield varieties (HYV) to reduce the damage done to crops from floods. The length of the growing period is very important towards the adjustment of agriculture in flood-prone areas. However, some farmers grow deep water rice after harvesting the Boro rice.

Crops diversification

Farmers of the study areas cultivate various types of crops based on the climatic conditions and trends of flood; for instance, they cultivate them on high land, after harvesting ginger, onion, garlic and tomato, and cucumber plants as mixed crops. Short duration vegetables are incorporated into the gap between HYV T. Aman harvest and Boro planting on the medium high land.

Crops strategies and process

The adjustment processes of farmers in different disasters are more innovative than the government or non-governmental agencies. Their patterns of choice of adjustments are very effective and dynamic in nature. Farmers developed these adjustments for successful adaptation by themselves (Hafiza, 2004). They participate in sharing their own activities to ensure the protection of the crops damaged by flood.

Farmers harvest their mature crops with the help of neighbors and relatives during early flash flood or extreme flood situation. With the help of neighboring farmers, they protect the B. Aman field from flood wave or floating weeds, debris, rats and stem borers.

Farmers face shortage of seeds after flood, especially the small and marginal farmers. Big farmers hold adequate reserve stocks of seed to re-sow or replant their own land. Farmers sometime borrow seeds from neighbors or often travel together long distances to obtain seed or seedlings' re-sowing or replanting in an emergency. When farmers lose their cattle due to extreme flood, they borrow cattle from neighbors to plough lands.

The flood effect on occupation is severe on small or marginal farmers than on big farmers. Small farmers or marginal farmers are occasionally wage laborers. During the period of flood, they do not have any agricultural work; as such, they engage themselves as boatmen (10%), rickshaw puller (35%), day laborer (10%), etc. However, the effect of flood on big farmers is very significant on their livelihood.

The economic status of flood-affected farmers is incomparable to flood-free farmers. Flood has a bad effect on the economy of small and marginal farmers. To recover their loss due to the flood damage (20%) and also to buy agricultural inputs (60%), grow rehabilitation crops (30%) or purchase cattle (10%), farmers take loan from NGOs, Samitti or mohajons (money lender) with high interest. They try to increase production of their normal Kharif or Rabi crops in the following season. However, floods may destroy their crops, and they fail to return money after selling their small piece of lands or other assets. Consequently, they become wage laborers or engage with any other job that comes their way.

RECOMMENDATIONS

This study is concluded with some recommendations. After disastrous losses of Aus, jute, deep water Aman or T. Aman occurrence, farmers need additional amounts of seed or planting material of Rabi crops (especially HYV seed of wheat and vegetables). For overcoming the loss of crop, farmers need training for suitable cultivation. Suitable crop rotation helps farmers to increase production by using additional amounts of seed (including HYV seed, where appropriate), fertilizer and other inputs. There is need to supply the additional amount of credits (or rehabilitation grants) so that flood affected farmers can grow rehabilitation crops, purchase cattle or in some cases, fodder, or increase production of their normal kharif or Rabi crops in the following season. Also, the agricultural loans of flood-affected farmers need to be rescheduled. Provision of long-range forecasting of the seasonal flooding is essential before the beginning of the season, and the information should be accessible to farmers. It is essential that the Ministry of Agriculture and its component (Directorates, Boards and Institutes) should be prepared at all times to deal with an emergency caused by flood affecting agricultural production.

Conclusion

The present study focused on the perception of farmers like cropping pattern, land level and land use, change of cropping pattern, length of the growing period, cultivating flood-prone crops, growing Rabi crops, crop diversification, etc., in flood-prone areas liable to flooding. Comilla is one of the most intensive cropped areas in the

country. Agriculture is the main occupation of the people. However, flood damages crops every year. Flood is more vulnerable in lowland areas. Farmers cultivate their crops using their perception and indigenous knowledge about the environment, especially the duration and magnitude of flood. Flood affected farmers grow single or double crops in a year and leave the land fallow for 5 to 6 months during the rainy season. The flood-free farmers grow triple to four crops in a year, but sudden heavy rain may damage their crops. The study focuses on the perception of farmers inhabiting the flood vulnerable areas concerning both the barsha and bonna. This study also focused on how the farmers at the field-level, adapted to and affected by flood, may suggest new and less costly ways of flood damage reduction.

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