Journal of Agricultural and Crop Research
Vol. 8(9), pp. 176-186, September 2020
doi: 10.33495/jacr_v8i9.20.159
ISSN: 2384-731X
Research Paper

Exploring the determinants and constraints of smallholder vegetable farmers' adaptation capacity to climate change: A case of Bogura District, Bangladesh

Muhammad Humayun Kabir[1]* • Md. Javed Azad[2] • Md. Nasirul Islam[3]

[1]Department of Agricultural Extension and Information System, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.
[2]School of Geosciences, The University of Sydney, Australia.
[3]National University, Bangladesh.

*Corresponding author. E-mail: mhumayunsau@gmail.com.

Accepted 22nd July, 2020.

Abstract. Climate change adaptation strategies are one of the best alternatives to reduce the impacts of climate change on vegetable production. This paper examined the adaptation capacity level of the vegetable growers, determinants of their adaptation decision and constraints they are facing. Data were captured through a Questionnaire survey and Focus Group Discussion (FGD) conducted with the farmers of Bogura district, Bangladesh. Frequency counts, mean, percentage, range and linear regression model, were used to analyze the data. The survey revealed that 52% of farmers had moderate adaptation capacity followed by 28 and 20% had low and high adaptation capacity respectively. There were nine strategies in the study area, some of which common are homestead vegetable gardening, alternative irrigation, use of integrated pest management (IPM), changing the sowing time, and vegetable beds are raised. Multiple regression analysis showed that farmers adaptation capacity is characterized by their annual family income, contact with media, and distance of home to the market. Barriers to expanding adaptation strategies identified by farmers include: lack of information on climate change, shortage of land, lack of credit access, flood effect, absence of flood tolerant variety, poor soil fertility and shortage of labor. This paper recommends that the Department of Agricultural Extension (DAE) should provide more information focus to adaptation strategies to the farmers live close to the market, having less income and owner of small farm size.

Keywords: Climate change, adaptation strategies, vegetable farming, constraints, Bangladesh.

INTRODUCTION

Vegetable refers to the fresh, edible part of a plant that can be consumed raw or cooked (Ward, 2016). This can be classified as fruit vegetables such as tomato, cucumber, okra; root and tuber/root vegetables such as potato, sweet potato, radish; green leafy vegetables such as amaranthus, celery, cabbage and bulb vegetables such as onion, garlic and shallot (Abewoy, 2018). Vegetable are important for nutrition in terms of bioactive nutrient molecules such as dietary fiber, vitamins, and minerals (Keatinge *et al.*, 2011; Kumar *et al.*, 2011). They are best resources for overcoming micronutrient deficiencies and provide smallholder farmers with much higher income and more jobs (Abewoy, 2018). Vegetable are produced all over the world but in a varied extent. Asia is the largest vegetable producer. China and India is the two largest vegetable producer of Asia cover 62% of world's total production with an individual contribution of 554 and 127 million metric tons respectively (Shahbandeh, 2020). Bangladesh has also gained remarkable improvement in vegetable production in the last few years (Zaman, 2019). In 2017-18 fiscal year, the country produced 15.95 million metric tons of vegetables which is higher than that of Viet Nam (15.73 mmt) who ranked 7th position in global vegetable production (Shahbandeh, 2020; DAE, 2019). Smallholder farmers' who are 57% of total farmer, role is very important for this achievement (Bangladesh Bureau of Statistics, BBS, 2019). However, on the way of achieving higher yield, they face various challenges such as climate change impacts (Kabir, 2015).

Climate change affects agriculture especially crop and vegetable sub sector in many ways such as increasing temperatures, changing rainfall patterns, rising sea levels, etc. (Dang *et al*., 2014; Obayelu *et al*., 2014; Hasan *et al.*, 2013). Vegetable crops are very much sensitive to these variations. Fluctuations in daily mean maximum and minimum temperature is the primary effect of climate change that adversely affects vegetable production, as many plant physiological, bio-chemical and metabolic activities are temperature dependent (Abewoy, 2018). Flood which mostly occurs due to heavy rainfall is another important abiotic stress and cause serious problems for the growth and yield of vegetable crops (Parent *et al*., 2008). The sea level rise is too much responsible for the salinity of the soil. Soil salinity reduces vegetable production in many ways such as initial water deficit, increasing soil concentration in the soil, reduction in germination percentage etc. (Abewoy, 2018; Jamil and Rha, 2014). Adaptation practices are good alternative to minimize these harmful effects in vegetable cultivation (Bryan *et al*., 2013).

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), "adaptation is the process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities". There might be seen three types of adaptation among the global farmers such as physiological adjustment (e.g. saline tolerant variety), routine adjustment (e.g. modification or changing of sowing time), and tactical adjustment (e.g. insurance subscription) (Smith, 2012; Zakaria and Matsui, 2020). Physiological and routine adjustment seems to be interested by the farmers of Bangladesh (Peal *et al*., 2020). The adaptation strategies can also be divided as general adaptation strategy (e.g. modification of sowing time, alternative irrigation) and climate smart adaptation strategy (e.g. alternate wet and drying, solar powered irrigation, biogas production) (IPCC, 2007). The differences between general adaptations versus climate smart is that the overall practices includes only general adaptation as ready technology but climate smart addresses both the difference and mitigation practices. In the develop countries like Bangladesh, the smallholder farmers use general adaptation strategies more than the climate smart strategies (FAO, 2009). The probable reason may be the use of climate smart adaptation practices requires more technical knowledge.

Bangladesh is an agro-based country. Rice is the staple food of the country covering around 70% of the total cultivated land (BBS, 2019). With regard to the area coverage and production, vegetable is the second most important crop next to rice (Kabir, 2015). They are regularly consumed by the people. Moreover, in recent years, consumers began to change their eating patterns by adding more vegetables to their diets for staying healthy (Ülger *et al.*, 2018). As a result, vegetable production area is expanding day by day (BBS, 2019). Eggplant is the most important vegetable crop in Bangladesh cover 16.89% of total vegetable cultivation area (Siddique and Azad, 2010). Tomato, cucurbits, bean, okra, cabbage and cauliflower are also grown plenty in Bangladesh. Vegetable production is the main source to provide nutrition and uplift the socio-economic benefit of smallholder farmers of Bogura district (Department of Agricultural Extension, DAE, 2017). Some studies focused on farmers perception towards effect of climate change in agriculture whereas others focused on climate change impact on food security (Akanda and Howlader, 2015; Kabir *et al*., 2016; Hasan and Kumar, 2020). But how the smallholder vegetable farmers of Bogura district adjust with adverse condition to climate change for maintaining their livelihood is not studied. Reasonably some questions such as what extent the farmers follow adaptation strategies? What are the factors influence their adaptation decision? What are the constraints of accepting adaptation? etc. may arise. Knowing these questions is necessary to increase the adaptation capacity of the farmers and thus the present study has been undertaken. The objectives of the study are: a) to assess the extent of using adaptation strategies by the vegetable growers; b) to identify determinants of adaptation decision; and c) to identify constraints faced by the farmers in accepting adaptation strategies.

MATERIALS AND METHODS

Study sites

The study has been conducted in Bogura district of Bangladesh (Figure 1). It is one of the three important districts of the country regarding vegetable production (Kabir, 2015). There are 12 upazilas (sub-districts) of Bogura district among which the data were collected from Dhunat upazila. The district is situated in the northern part of Bangladesh, located in between 24°32' and 25°07' north latitudes and in between 88°58' and 89°45' east longitudes (Banglapedia, 2015). The northern parts of the country especially the study area covers the agro-ecologies IV, V, XXVII which are characterized by low to

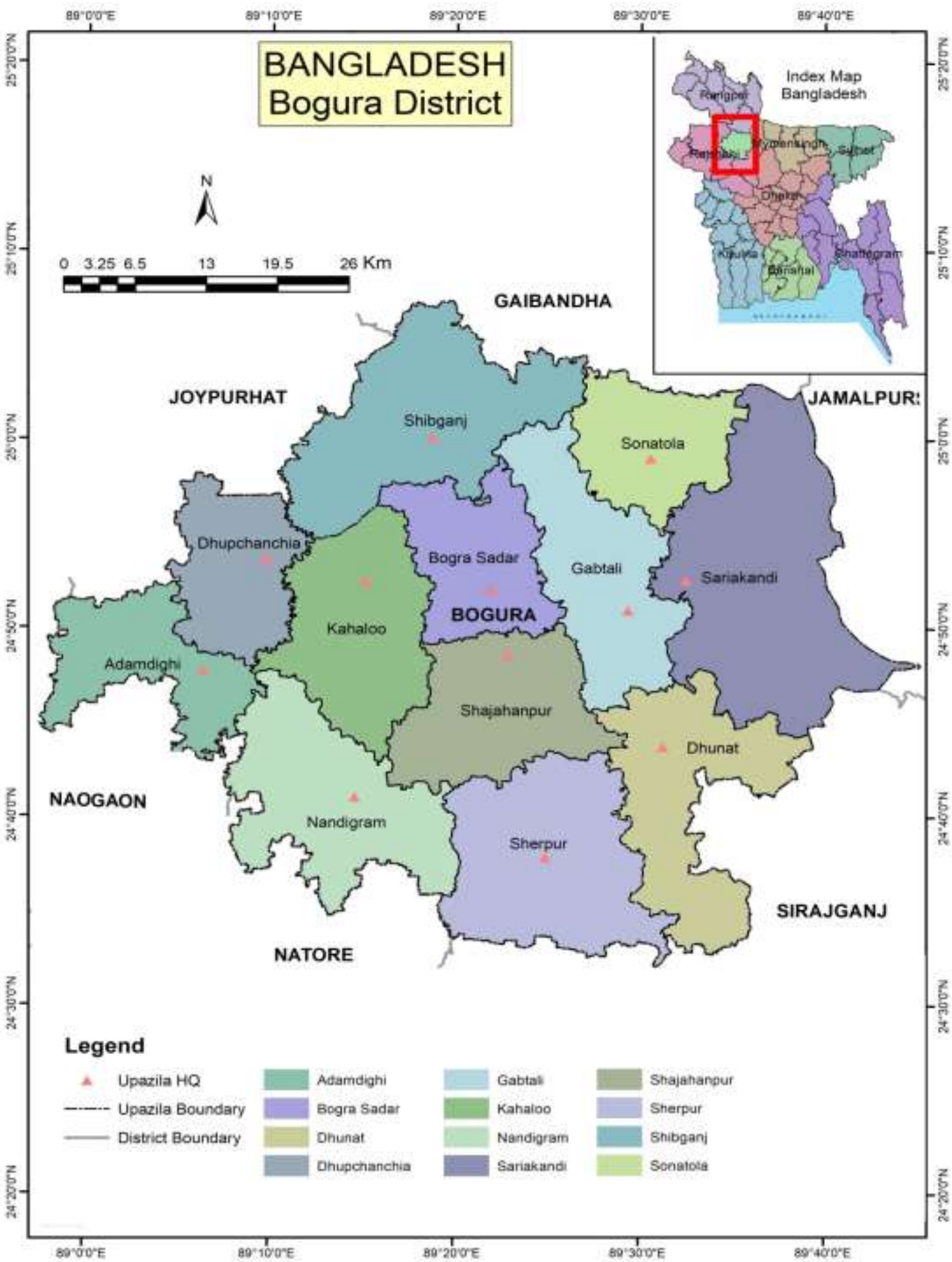

Figure 1. A map of Bogura district, Bangladesh where the study has been conducted.

medium level of organic matter in soil and medium fertility level (FAO, 1988). There are several cropping patterns in Dhunat upazila but vegetable is common to all patterns. The farmers cultivate vegetable in both Kharif (summer) season and Robi (winter) season. Eggplant, tomato, okra, cucurbits etc. are cultivate in Kharif season and bean, cabbage, cauliflower, radish etc. are cultivate in Robi season (DAE, 2017). The mean annual temperature ranges from 20 to 30°C and may exceptionally reach 30 to 35°C. The average annual rainfall of the district is 1762 mm and is characterized by extreme rainfall variability (Haq, 2012). The district stands on the bank of the river Jamuna. The inhabitants of the district often face flood for a short period of time in each year due to seasonal heavy

Table 1. Distribution of the vegetable farmers according to population and sample size.

District	Villages	Population (total farmers)	Sample
	Gosaibari	187	45
Bogura	Khoksabari	165	40
	Zorkhali	121	29
Total	3	473	114

Source: DAE (2017).

rainfall and the location (riverside). Vegetable farming was the farmers' main source of income which leads them to use adaptation strategies (BBS, 2019).

Population and sample design

The researchers with the assistance of Upazila (Sub-district) Agriculture Officer and Sub-Assistant Agricultural Officer (SAAO) of Dhunat Upazila collected a list of total vegetable farmers of the selected three villages. The total number of vegetable farmers in these villages was 473; where 187 farm family heads from Gosaibari village, 165 from Khoksabari village, and 121 from Zorkhali village which constituted the population of the study (DAE, 2017). Thus, a total of 473 vegetable farmers constituted the population of the study.

To determine sample size from the population, we used Yamane's (1967) formula (Kabir et al., 2018; Peal et al., 2020). The formula with 8% accuracy level, 50 percent degree of variability and estimation of Z = 1.96 at 95% confidence level is presented:

$$n = \frac{z^2 P(1-P)N}{z^2 P(1-P) + N(e)^2}$$

Where:
n = Sample size, N = Population size, e = The level of precision, z = The value of the standard normal variable at the chosen confidence level and P = The proportion or degree of variability.

The sample size was resolved as 114. It was then selected from three villages following proportionate random sampling (Table 1). The vegetable growers were interviewed during the survey using a formal questionnaire. The questionnaire had two parts where the first part includes the socio-economic characteristics of vegetable growers and the second part deals with the various adaptation strategies to cope with climate change.

Variables and their measurement

The study considered two types of variables such as the dependent variable and the independent variable. The dependent variable was the level of adaptation capacity of the farmers while the socio-economic characteristics were the independent variables. Farmers' adaptation level was measured based on score. The score was a ratio between the number of adaptation practices used by individuals and total practices available in the study area (Peal *et al*., 2020; Kabir and Rainis, 2015). It was observed by the researchers through pilot survey that there were nine adaptation practices in the study area which are- cultivate vegetables on raised beds, cultivate vegetables on floating beds, practice homestead vegetable cultivation, cultivate vegetable on the embankments surroundings of pond/road, use of integrated pest management (IPM), use of the high yielding variety, modification of sowing time/early sowing, alternative irrigation and zero tillage. A farmer received score 1 for use any one of these practices. Later the score (1) was multiplied with his number of used practices and divided by total (9) practices. Suppose, if a respondent followed or adapted 3 strategies then his adaptation score would be 0.33 (1 × 3/9).

We also collected data on farmers' socio-economic characteristics which were considered as independent variables in the study. Eight independent variables were selected through literature review and pilot survey. These are farmers' age, education, vegetable cultivation area, annual family income, farming experience, number of vegetable grown, distance of farmers' home to the market, and media contact. Measuring procedure of these variables is shown in Table 2.

Data collection

To collect viable and authentic data from the respondents, a questionnaire was outlined carefully keeping in mind the study objectives. Simple and direct questions and different scales were used to obtain information from the respondents. The questionnaire was checked by the university faculties who had experience to design questionnaire for social survey and respective upazila agriculture officers. Before the final version of the questionnaire survey, a pre-test through preliminary survey was conducted; after which modifications were done to the instrument. Twenty four (24) vegetable farmers (5% of population) of the selected three villages participated in the preliminary survey. Besides questionnaire

Table 2. Variable measurement techniques.

Variable name	Score / measuring technique
Age	1 for each complete year of age of the respondent
Educational background	1 for each year of formal schooling and 0 for illiterate
Land for vegetable cultivation	1 for each decimal (dl) of land
Annual household income	1 for each 1000 BDT (Bangladeshi currency) income in a year
Farming experience	1 for each year of farming experience
No of vegetable grown	1 for each vegetable grown per season
Media contact	4 for regular contact, 3 for frequent contact, 2 for occasional contact, 1 for rare contact, and 0 for not at all contact
Distance of home to market	1 for each kilometer

Source: Kabir (2017)

survey, two Focus Group Discussions (FGDs) were conducted to achieve third objective of the study (identify the problems faced by the farmers in using adaptation strategies). The FGDs were held with the farmers who lived in the selected villages and cultivated vegetable. The participants were selected by the assistance of local extension agent. The number of participants was 7 and 9 in the first and second FGD respectively. However, like the preliminary survey, they were also beyond the sample size. During discussion, the first author played the role of moderator while the second author played the role of rapporteur (Krueger and Casey, 2009). At the beginning, the moderator briefed the objectives of discussion. Then the farmers were asked to mention the problems of climate change adaptation. Finally, they were asked to rate the problems through giving a score from 1 to 7 according to the severity. Later a mean score for each problem was calculated, and a rank order of the problems was made based on the value. (Roy *et al*., 2013). The data collection period was from March – 2017 to April – 2017.

Data analysis

Descriptive statistics such as frequency, range, mean, percentage were used to analyze the socio-economic status of the farmers, their level of adaptation capacity, and the constraints faced by the farmers in adaptation. On the other hand, to identify the significant determinants responsible to farmer's decision to use strategies, multiple regression analysis was used. The formula for analysis is presented below:

$$Y = B_0 + B_1X_1 + B_2X_2 + ... + BnXn$$

Where Y = dependent variable (adaptation capacity to climate change), B_0 = intercept, B_1-n = coefficient of the explanatory variables, X_1-n = explanatory variables (farmers' age, education, amount of land under vegetable cultivation, annual family income, farming experience, number of vegetable grown, the distance of farmers' home to market, and media contact). The statistical package for social science (SPSS version 24) software was used to analyze the data.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

Fifty percent (50 %) of the farmers' is between 36 and 50 years old (Table 3). Majority (71%) of the farmers' age range was from 20 to 50 years which showing good labour availability in the study area. Regarding their educational level, about one-third had no formal education which is consistent with the current national average literacy rate of 68% (BBS, 2019). On the other hand, 65.1% of respondents had primary to secondary level of education. According to the Ministry of Agriculture, the farmers who have less than 1 hectare or 247 decimals land are considered as small farmers (DAE, 1999). Majority (87%) of the farmers utilized 20 to 80 decimals land for vegetable cultivation. The majority of the farmers had long experience in farming (14 to 28 years) with annual family income up to 140,000 BDT (Bangladeshi currency) equivalents to USD 1647 (1 USD = 85 BDT). In the context of media contact, a greater portion of the farmers had lower contact with various media. A poor extension agent and farmer ratio (1:900) may be responsible behind this (DAE, 1999). The farmers cultivated at least two to nine vegetables per season. Most of them cultivated four to five vegetables such as eggplant, tomato, bean, okra, cucurbits etc. of their land in a crop season. Though there was a variation between distances of farmers home to the nearest market (a place where farmers sell their products directly to the buyers or consumers), on average, farmers have market access within 2 km.

Farmers' use of adaptation strategies

According to the Department of Agricultural Extension

Table 3. Socio-economic characteristics of the farmers (n = 114).

Characteristics	Categories	Frequency (%)	Observed range	Mean
Age	17 to 35	24 (20.8)	17-64	45.61
	36 to 50	57 (50.0)		
	Above 50	33 (29.2)		
Level of education	No education	36 (32.1)	0-15	4.15
	Primary education	40 (34.9)		
	Secondary education	35 (30.2)		
	Higher secondary education	3 (2.8)		
Land for vegetable cultivation	20 to 80 decimal	99 (86.8)	20-230	60.82
	81-160	10 (8.4)		
	Above 160	5 (4.8)		
Length of farming experience	Up to 14 years	17 (15.1)	1-42	21.45
	>14-28	79 (68.9)		
	Above 28	18 (16)		
Annual family income	Up to 1647 USD	99 (86.8)	176-4941	1152.9
	>1647-3294 USD	13 (11.4)		
	Above 3294 USD	2 (1.8)		
Contact with media	Up to 3	77 (67.9)	0-9	2.41
	4 to 6	30 (26.5)		
	Above 6	7 (5.6)		
No of vegetable grown	Up to 3	30 (26.4)	2-9	4.5
	4 to 5	55 (48.1)		
	Above 5	29 (25.5)		
Distance from home to the nearest market	Up to 1 km	45 (39.6)	0.4-5	2.29
	2 to 3 km	47 (41.6)		
	Above 3 km	22 (18.8)		

Source: Field survey (2017).

Office, Dhunat Upazila of Bogura District, the farmers face climate change effects especially flooding, and seasonal variations of temperature and rainfall in cultivating vegetable. They also mentioned that the farmers use various strategies to adapt with climate change. There are nine adaptation strategies in the study area (Table 4) among which cultivate vegetables on raised beds, cultivate vegetables on the embankment of pond/road, and floating vegetable cultivation were developed to face flood effect. The rest strategies were used to adapt with seasonal variation of temperature and rainfall.

All farmers used adaptation strategies but in a varied extent. They were classified into three categories such low adaptation capacity (up to 0.33), moderate adaptation capacity (> 0.33 to 0.67) and high adaptation capacity (> 0.67 to 1) based on mean ± Sd of the adaptation score (Peal *et al*., 2020; Nasrin *et al*., 2019; Kabir *et al*., 2018). Frequency, percentage, means etc. of these groups are presented in Table 5.

Majority (80%) of the farmers had low to moderate adaptation capacity and only 20% farmers had high adaptation capacity (Table 5). It is assume that the higher the use of adaptation strategies, the lower the loss of crop production. Yet about one-third of the farmers fall into low adaptation capacity which urges steps should be taken by responsible GOs and NGOs to increase farmers' adaptation capacity.

The farmers were not also varied in terms of using number of adaptation strategies but also selection of strategy (Table 4). All strategies are not similar regarding ease of use and importance. For an example, alternative irrigation is easier than changing the sowing time. In addition, changing the sowing time is important to

Table 4. Use rate and rank order of individual adaptation strategies.

Adaptation strategies	Frequency (%)	Rank order
Cultivate vegetables on raised beds	44 (39)	6
Cultivate vegetables on floating beds	14 (12)	7
Practice homestead vegetable gardening	76 (67)	1
Cultivate vegetable on the embankments of pond/road	9 (8)	8
Use of integrated pest management (IPM)	67 (59)	3
Use of a high yielding variety	55 (48)	5
Modification or changing the sowing time	64 (56)	4
Alternative irrigation	72 (63)	2
Zero tillage	5 (4)	9

Source: Field survey (2017).

Table 5. Distribution of the farmers according to their use of adaptation strategies.

Categories	Basis (score)	Frequency (%)	Range		Mean	SD
			Possible	Observed		
Low adaptation capacity	Up to 0.33	32 (28)				
Moderate adaptation capacity	> 0.33 to 0.67	59 (52)	0.12 - 0.89	0 - 1	0.50	0.17
High adaptation capacity	>0.67 to 1	23 (20)				

Source: Field survey (2017).

Table 6. Multiple regression analysis showing the contribution of socio-economic characteristics of the farmers (independent variables) on the use of climate change adaptation practices (dependent variable).

Dependent variable	Independent variables	β	P	R^2	Adj. R^2	F
Use of climate change adaptation practices in vegetable farming	Age	0.004	.968	0.290	0.277	3.487
	Education	-.152	.186			
	Vegetable land	-.005	.955			
	Farming experience	.152	.237			
	Annual income	.267	.016*			
	Contact with media	.221	.036*			
	Types of vegetable grown	-.035	.733			
	Distance from market	.387	.000**			

** Significant at $P < 0.01$; *Significant at $P < 0.05$.

minimize losses due to climatic hassle. Usually farmer prefers strategies those are easy and require less skill (Veisi, 2012; Rogers, 2003). Therefore, the extension agent should motivate them to focus more on important strategies rather than numbers.

Determinants of adaptation strategies

Multiple regression analysis shows that there is a significant relationship between respondents' annual income, contact with media and distance of home to the market, and their use of adaptation strategies (Table 6). Among these variables, distance of home from the market was significant at the one percent level of confidence and annual income and contact with media were significant at the five percent level of confidence. However, the rest variables do not show any significant contribution to the use of climate change adaptation practices (Table 6).

The value of R^2 is a measure of how the variability in the dependent variable is accounted for by independent variables such as farmers' annual income, media contact and distance of home to the market in the present study. The value of $R^2 = 0.290$ means that independent variables accounted for 29% of the variation in farmers' use of climate change adaptation practices. The F ratio is 3.487 which is significant at .01% level of probability.

The output of the analysis showed that distances of farmers' homes from the nearest market is the most important factor that influences farmers' use of climate change adaptation practices which is similar to the

Table 7. Problems faced by the farmers in adaptation and their rank order (n = 16).

Problems	Mean	Rank order
Lack of information or knowledge on climate change	5.67	1
Shortage of land	5.13	2
Lack of credit facilities	4.98	3
Flood effect	4.78	4
Absence of flood-tolerant variety	4.13	5
Poor soil fertility	3.27	6
Shortage of labour	2.56	7

Source: Field survey (2017).

studies of Idrisa *et al*. (2012), Kabir (2015) and Holloway *et al*. (2002). The direction between these two events was positive which indicate the higher the distance between farmers home to nearest market the higher the use of climate change adaptation practices by the farmers. The probable explanation of getting positive signs is that farmers who stayed close to the market might have more distractions from vegetable farming as they might be spending more time in non-agricultural activities (Kabir *et al*., 2017). Moreover, these farmers might think that whatever the amount produced they were able to quickly sell them without having spent much on transportation. This implies the necessity to arrange meetings or informal discussions for farmers staying close to the market to make them more aware of the significance of using climate change adaptation strategies.

From the analysis, it is also observed that farmers' contact with media was positive and significantly contributed to their use of climate change adaptation practices. It means that the more the extension media contact of the farmers the more is their use of strategies. This may be due to the fact that media contact increases the knowledge about adaptation strategies which supports farmers to motivate using climate change adaptation strategies (Popoola *et al*., 2020). Some earlier studies of Sharmin (2005), Sayeed (2003) and Kabir (2002) mentioned that media contact motivate farmers to use more sustainable practices.

Based on the above findings, it can be concluded that the annual family income of vegetable growers had significant contribution to the decision of using climate change adaptation strategies. This means that the annual family income of the vegetable growers and their use of adaptation strategies were not independent of each other. More clearly it can be said that adaptation strategies users were found more among those vegetable growers who had more annual family income than the others with less annual family income. Economic resources is an important relevant for smallholder farmers' adaptive capacity mentioned by Razak and Kruse (2017) in their study on smallholder farmers adaptive capacity in Ghana.

Constraints faced by the farmers in using adaptation strategies

Two FGDs were held to identify problems faced by the farmers. From the discussion, it was observed that farmers faced various problems in using climate change adaptation practices. These are flood effect, shortage of land, lack of credit facilities, shortage of labour, lack of information/knowledge on climate change, poor soil fertility, and absence of flood-tolerant variety. The rank order of these problems was made based on mean value. The mean value was calculated considering the total score of each problem (from two FGDs) and number of participants in both FGDs. The rank order of the problems based on their severity is presented in Table 7.

Lack of information or knowledge on climate change was the most severe barrier to use climate change adaptation strategies. Lower level of education might negatively effect to gain knowledge about innovation (Quayum and Ali, 2012; Adeogun *et al*., 2008). The average education of the farmers in the study area was primary level (Table 3) which probably acted as a hinder for the farmers to gain knowledge or information regarding climate change effects in vegetable cultivation. Therefore, meeting, demonstration programs, awareness campaigns on climate change effects from the agriculture offices should be increased.

The shortage of land was the second most important barrier in using climate change adaptation practices. A study conducted by Uddin *et al.* (2014) also found that a shortage of land is a problem to use adaptation practices. The farmers were owner of small farm size. Moreover, some of them were under the marginal farm category. As these farmers (both small and marginal farmers) had a fewer amount of land, thus they were less aware of regarding use of sound practices to recover the loss of vegetable production. Thus, they were reluctant to use climate change adaptation practices.

There was lack of credit facilities for the farmers in the study area. To use some adaptation practices such as supplementary irrigation, changing planting time, raised bed, or Sarjan method of cultivation, there is a need for capital. On one hand, government organizations do not want to grant loans to them for their low income. On the other hand, the NGOs desired higher interest rate for providing loans. So, getting credit was a problem for them. According to Nhemachena and Hassan (2008), access to affordable credit increases the financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take. The result implies an important role of increased institutional support in promoting the use of adaptation options.

According to Adelekan *et al*. (2014), flooding has constituted a major problem to agriculture-related activities, resulting in major financial and infrastructural losses to the farmers. The finding is consistent with the present study where flood effect acted as barrier to the farmers to cultivate vegetable with adaptation strategy. Though flood tolerant variety for some crops have already been developed in Bangladesh, yet it is absent for vegetables (Rahaman *et al*., 2019). To minimize the flood effect problem, farmers followed some strategies like cultivate vegetable in raise bed and floating vegetables, but their numbers are few (Table 4). Therefore, the extension agent should strengthen their support to use these strategies. At the same time, Bangladesh Agricultural Research Institute (BARI) should develop flood tolerant vegetable variety or such innovation where farmers can cultivate vegetable in parallel to flood or water.

CONCLUSION

As climate change is an uncontrollable issue, it is better to use adaptation strategies to minimize losses of vegetable production. This paper examined smallholder vegetable farmers' adaptation capacity level, their adaptation decision factors and constraints they are facing. The survey revealed that with or without government support, the farmers followed some adaptation strategies such as cultivation of vegetables in their homestead area, alternative irrigation, use of IPM, and changing the sowing time etc. Majority of the farmers had moderate adaptation capacity which needs to be improved. To use adaptation strategies, the farmers were influenced by their annual family income, contact with media, and distance of the home to the market. With that, they have limitations to use the adaptation strategies due to lack of information/knowledge on climate change, shortage of land, lack of credit facilities etc. It is recommended that the DAE should strengthen information dissemination program like meeting, training, demonstration etc. focus to adaptation strategies for vegetable farming. In this context, the farmers stayed close to the market, having low income and lower contact with media should be emphasized as participants of the aforementioned program. Thus, the farmers' adaptive capacity to climate change as well as their livelihood will be improved.

ACKNOWLEDGEMENTS

We are grateful to Sher-e-Bangla Agricultural University Research System (SAURES) for providing financial support to make the study possible. We are also extended our thanks to the farmers and staff of the department of agricultural extension of Dhunat upazila (sub-district) under Bogura district for their cooperation during data collection.

REFERENCES

Abewoy D (2018). Review on Impacts of Climate Change on Vegetable Production and its Management Practices. Adv. Crop Sci. Tech 6:330. Doi:10.4172/2329-8863.1000330.

Adelekan I, Olajide-Taiwo L, Ayorinde A, Ajayi D, Babajide S (2014). Building urban resilience: Assessing urban and peri-urban agriculture in Ibadan, Nigeria. Padgham, J. Jabbour, J. (Eds.). Nairobi: United Nations Environment Programme (UNEP).

Adeogun OA, Ajana AM, Ayinla OA, Yarhere MT, Adeogun MO (2008). Application of logit model in adoption decision: A study of hybrid clarias in Lagos State, Nigeria. American-Eurasian J. Agric. Environ. Sci. 4:468-472.

Akanda MGR, Howlader MS (2015). Coastal Farmers' Perception of Climate Change Effects on Agriculture at Galachipa Upazila under Patuakhali District of Bangladesh. Global J. Sci. Frontier Res: D. 15(4):30-39.

Banglapedia (2015). Retrieved from http://en.banglapedia.org/index.php?title=Bogura_District.

BBS (2019). Preliminary report on Agri Census, Bangladesh Bureau of Statistics, Government of the People's Republic of Bangladesh.

Bryan E, Ringler C, Okoba B, Roncoli, C, Silvestri S, Herrero M (2013). Adapting agriculture to climate change in Kenya: Household practices and determinants. J. Environ. Manage. 114:26-35.

DAE (2019). Crop production wing, Department of Agricultural Extension, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka.

DAE (2017). Upazila Agriculture Office, Department of Agricultural Extension, Dhunot, Bogura, Bangladesh.

DAE (1999). Agricultural Extension Manual (January 1999 revision). Department of Agricultural Extension. Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka.

Dang HL, Li E, Nuberg I, Bruwer J (2014). Farmers perceived risks of climate change and influencing factors: A study in the Mekong Delta, Vietnam. Environ. Manage. 54:331-345.

FAO (2009). Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies. Retrieved from http://www.fao.org/docrep/012/i1318e/i1318e00.pdf.

FAO (1988). Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy. p. 570.

Haq MN (2012). "Bogura District". In Sirajul Islam and Ahmed A. Jamal (ed.). Banglapedia: National Encyclopedia of Bangladesh (Second ed.). Asiatic Society of Bangladesh.

Hasan M, Alamin M, Islam S, Hasan R (2013). Scenario of climate change on agriculture in South-East coastal belt of Bangladesh. **Int**. J. Eng. **Sci**. Technol. Res. 2(6):1407-1410.

Hasan MK, Kumar L (2020). Perceived farm-level climatic impacts on coastal agricultural productivity in Bangladesh. Climatic Change. https://doi.org/10.1007/s10584-020-02708-3.

Holloway G, Shankar B, Rahman S (2002). Bayesian spatial probit estimation: a primer and an application to HYV rice adoption. Agric. Econ. *27*:383-402.

Idrisa YL, Ogunbameru BO, Madukwe MC (2012). Logit and Tobit analyses of the determinants of likelihood of adoption and extent of adoption of improved Soybean seed in Borno State, Nigeria. **Greener** J. Agric. Sci. *2*(2):37-45.

IPCC (2014). Climate Change: Impacts, Adaptation, and Vulnerability. Part A, Cambridge, United Kingdom and New York, NY, USA, pp.1756-1776.

IPCC (2007). Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Jamil M, Rha ES (2014). The effect of salinity (NaCl) on the germination and seedling of sugar beet (*Beta vulgaris* L.) and cabbage (Brassica O*leracea capitata* L.). Korean J. Plant Res. 7: 226-232.

Kabir MH (2017). A project report on use of climate resilient technologies in vegetable farming: determinants and constraints. Sher-e-Bangla Agricultural University Research System (SAURES), Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

Kabir MH (2015). Factors influencing adoption of integrated pest management (IPM) strategies by the vegetable farmers of Narsingdi district, Bangladesh. PhD thesis (published), Universiti Science Malaysia, Penang 11800, Malaysia.

Kabir MH, Ahmed Z, Khan R (2016). Impact of Climate Change on Food Security in Bangladesh. J. Pet. Environ. Biotechnol. 7:306. Doi: 10.4172/2157- 7463.1000306.

Kabir MH, Azad, MJ, Rahman, MM, Alam, MM, Haque MZ (2017). Potato farmers post-harvest problems in Joypurhat district of Bangladesh. J. Exp. Biosci. 8(2):23-28.

Kabir MH, Islam MS, Ali MS, Abdulla MM (2018). Farmers' Perception towards Harmful Effects of Climate Change on Agriculture. Asain J. Agric. Extn. Econ. Soc. 27(1):1-8.

Kabir MTN (2002). Perception of Farmers on the Effects of Barind Integrated Area Development Project towards Environmental Upgradation. M.S. (Ag.Ext.Ed.)Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Kabir MH, Rainis R (2015). Adoption and intensity of integrated pest management (IPM) vegetable farming in Bangladesh: an approach to sustainable agricultural development. Environ. Dev. Sust. 17(6):1413-1429.

Keatinge JDH, Yang RY, Hughes d'A, Easdown WJ, Holme R (2011). The importance of vegetables in ensuring both food and nutritional security in attainment of the Millennium Development Goals. Food Sec. 3:491-501.

Krueger RA, Casey MA (2009). Focus Groups: A Practical Guide for Applied Research. Sage Publications.

Kumar B, Mistry NC, Chander BS, Gandhi P (2011). Indian horticulture production at a glance. Indian horticulture database 2011. National horticulture Board, Ministry of Agriculture, Government of India.

Nasrin S, Kabir MH, Alam, MM, Islam, MS (2019). Farmers' Knowledge on Pesticide Application in Vegetable Cultivation. Int. J. Appl. Agric. Sci. 5(6):144-151.

Nhemachena C, Hassan R (2008). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute. Washington DC.

Obayelu OA, Adepoju AO, Idowu T (2014). Factors influencing farmers' choices of adaptation to climate change in Ekiti state, Nigeria. J. Agric. Environ. Int. Dev. 108(1):3-16.

Parent C, Capelli N, Berger A, Crèvecoeur M, Dat JF (2008). An overview of plant responses to soil waterlogging. Plant Stress 2: 20-27.

Peal MAR, Kabir MH, Mazumder MSU, Debnath P, Biswas A (2020). Farmers' extent of adaptation strategies towards salinity effects in agriculture. J. Sci. Technol. Environ. Inform. 9(1):618-628.

Popoola AA, Wahab B, Magidimisha H, Chipungu L, Adeleye B (2020). Urban Food Production and Climate Variability in Ibadan, Nigeria. Electron. J. Sociol. 17(1):190-207.

Quayum MA, Ali AM (2012). Adoption and diffusion of power tiller in Bangladesh. Bangladesh, J. Agric. Res. 37:307-325.

Rahaman MA, Rahman, MM, Hossain MS (2019). Climate-Resilient Agricultural Practices in Different Agro-ecological Zones of Bangladesh. Springer Nature Switzerland AG 2019 W. Leal Filho (ed.), Handbook of Climate Change Resilience, https://doi.org/10.1007/978-3-319-71025-9_42-1.

Razak MA, Kruse S (2017). The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana. Clim. Risk Manag. 17:104-122.

Rogers EM (2003). Diffusion of Innovations (5th edition). Simon and Schuster. ISBN 978-0-7432-5823-4.

Roy R, Chan NW, Rainis R (2013). Development of indicators for sustainable rice farming in Bangladesh: A case study with participative multi-stakeholder involvement. World Appl. Sci. J. 22(5):672-682.

Sayeed MA (2003). Farmers' Perception of Benefit from Using Manure towards Integrated Nutrient Management (INM) for Sustainable Crop Production. M.S. (Ag.Ext.Ed.)Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Shahbandeh M (2020). Leading global producers of fresh vegetables 2017. Retrieved from https://www.statista.com/statistics/264662/top-producers-of-fresh-vegetables-worldwide.

Sharmin H (2005). Rural Women's Perception of Benefits of Involvement in Income Generating Activities under a Non-Government Organization. M.S. (Ag.Ext.Ed.) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Siddique MA, Azad AK (2010). Prioritization of Research for Horticultural Crops. Final report of a study, BARC, New airport road, Dhaka. p. 56.

Smith JB, Bhatti N, Menzhulin G, Benioff R, Campos M, Jallow B, Rijsberman F, Budyko MI, Dixon RK (2012). Adapting to climate change: an international perspective. Springer Sci. Bus. Media, ch. 3.27-39.

Uddin MN, Bokelmann W, Entsminger JS (2014). Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh. Climate, *2*:223-241.

Ülger TG, Songur AN, Çırak O, Çakıroğlu FP (2018). Role of Vegetables in Human Nutrition and Disease Prevention, Vegetables – Importance of Quality Vegetables to Human Health. Intech Open. DOI: 10.5772/intechopen.77038.

Veisi H (2012). Exploring the determinants of adoption behavior of clean technologies in agriculture: A case of integrated pest management. Asian J. Technol. Innov. 20(1):67-82.

Ward AW (2016). Encyclopedia Britannica.

Yamane T (1967). Elementary Sampling Theory, Prentice-Hall: Englewood Cliffs, NJ.

Zakaria AR, Matsui K (2020). Smallholder Rice Farmers' Adaptation Capacity to Climate Change in the Bawku Zone of Ghana. Int. J. Environ. Sci. Dev. 11(5):258-262.

Zaman ANMMU (2019). Vegetable farming growing rapidly. Published in the Daily Sun 13th January, 2019. Retrieved from https://www.daily-sun.com/post/363732/Vegetable-farming-growing-rapidly