JSTEI ONLINE JOURNAL
Journal of Science, Technology & Environment Informatics
Journal BiNET Scientific Publication

Volume 01, Issue 01, Article No. 2, pp. 16-26
http://www.journalbinet.com/0201v114.html
Original Research Paper

Karim R. *et al*., 2014

Impact of Climate Change on Agriculture in the Flood Plain Area of Chauhali Upazila, Sirajgonj, Bangladesh

Rezaul Karim*, Sayka Jahan and Md. Shariful Islam

Department of Environmental Science and Technology, Jessore University of Science and Technology, Jessore, Bangladesh

Article Info

Key Words:
Climate Change
Temperature
Rainfall intensity
Flood
Cropping Pattern
Agricultural Systems

Received: 05.10.2014
Accepted: 20.10.2014
Published: 30.10.2014

***Contact author:**
r.karim@just.edu.bd

ABSTRACT

The study was conducted on flood plain area of Chauhali upazila, Sirajgonj, Bangladesh. The objective of the study was to find out the existing agricultural production system and how climate change is affecting agricultural systems. Primary data were collected using multiple approaches, e.g. key informant interviews, 25 interviews of each village of two. According to the resource map, there have very small amount of forest cover and forest reserve areas in the study areas. The stratification of the surveyed villages indicated that there were three wealth groups in both villages. On the context of the status of the three wealthy groups, it implies that vulnerabilities and adaptive capacities among groups vary accordingly in the two villages studied. From the field survey, it was clear that that the local responses on climate changes were more significant on their perceptions. It has been reported that the area becomes extremely hot during the day but during the night it remains very cold. This study also showed variation on rainfall patterns in different seasons. The average minimum temperature is decreasing but the average maximum temperature is increasing. The Rabi crops are less vulnerable to change rainfall rate in winter as the production rate of potato, vegetables and groundnuts are increasing trends or constant. In Kharif season, paddy, mustard and wheat production varied with the rise and fall of rainfall intensity. In Kharif-II season, transplanted aman production showed the constant trends of production but the vegetables production fluctuated with the fluctuation of rainfall and temperature.

Citation (APA): Karim, R. Jahan, S. & Islam, M. S. (2014). Impacts of Climate Change on Agriculture in the Flood Plain Area of Chauhali Upazila, Sirajgonj, Bangladesh. *Journal of Science, Technology & Environment Informatics, 01(01), 16–26*.

I. Introduction

The economy of Bangladesh is based on agriculture and agricultural activities. 76 percent of total population is living in the rural areas and 90 percent of the rural populations are directly related with these economic activities. It is required to ensure sustainable agricultural growth to increase food production and attain food security in Bangladesh (Bangladesh Economics Review, 2009). Agriculture contributes about 12% of the national GDP and provides 44% workforce of the country and it is the main contributor of income and employment for generations in Bangladesh; therefore, the lives and livelihoods depend mainly on agriculture as the rural poverty is directly related to the better agriculture (Planning Commission, 2010).

Bangladesh is widely considered as one of the most climate vulnerable countries. The vulnerability to climate change is high due to a number of hydro-geological and socio-economic factors of Bangladesh (Ahmed, 2004 & 2006). The effects of climate are deprived not only in developing countries but also in developed countries. There are also several environmental impacts due to climate change on all over Bangladesh (Ahmed, 2006).

Agriculture, already under pressure for increasing food demand, problems associated with land and water resource depletion, is always vulnerable to changing climate conditions and unfavorable weather events (Planning Commission, 2010). The issues of climate change make the pressure more acute for the sector. The impact of climate change on agricultural food production are global concerns but for Bangladesh that matter is exposed to a great danger. Although climate change is expected to have many impacts on various sectors of the economy, few sectors are as important as agriculture (Dinar and Mendelsohn, 2009). But riverbank erosion has a great impact on agriculture (Halcrow, 1994). It is evident that the crop diversity is production. Therefore, the cropping intensity is also changing.

The main objective of the study was to investigate the operation of agricultural production system in the flood plain area of Bangladesh, and how this may be or are affected by climate change. The objectives are (i) to identify existing agricultural systems and factors influencing production in the flood plain area at Chauhali upazila, Sirajgonj, Bangladesh, (ii) to establish the patterns and trends of climatic conditions e.g. temperature and rainfall and assesses their impacts on agriculture production and (iii) to find out adaptation measures to reduce the impacts on agriculture production.

II. Materials and Method

Study area: The study was carried out at Chauhali upazila, Sirajgonj, Bangladesh (Figure 1). It is located on the bank of Jamuna River. There are 7 Unions in the Chauhali upazila having an area of 232 km^2. The region was affected by soil erosion and flood and frequent food shortage due to uncertainty of rainfall. Therefore, the region is susceptible to climate change and the ultimate effect goes on agricultural production (Banglapedia, 2010).

Methodology: Both primary and secondary data were collected in order to address the objectives of this study. Problems are discussed on the basis of secondary sources available online. The problems are discussed on expected climate changes, consequences for Bangladesh, e.g. its most vulnerable climate change-induced impacts. Rainfall and temperature data were collected from the nearby meteorological station, Bogra, Bangladesh and other relevant sources. Others sources include books, government and international reports, scientific articles and news articles that painted about climatic issues. Primary data were collected using multiple approaches including both quantitative and qualitative participatory rural appraisal (PRA) methods. The methods used included key informant interviews, 25 interviews per village, historical mapping of different climate related events over the past years that could be remembered, wealth ranking of different social economic groups based on local criteria they use and then direct field observations through transect walks.

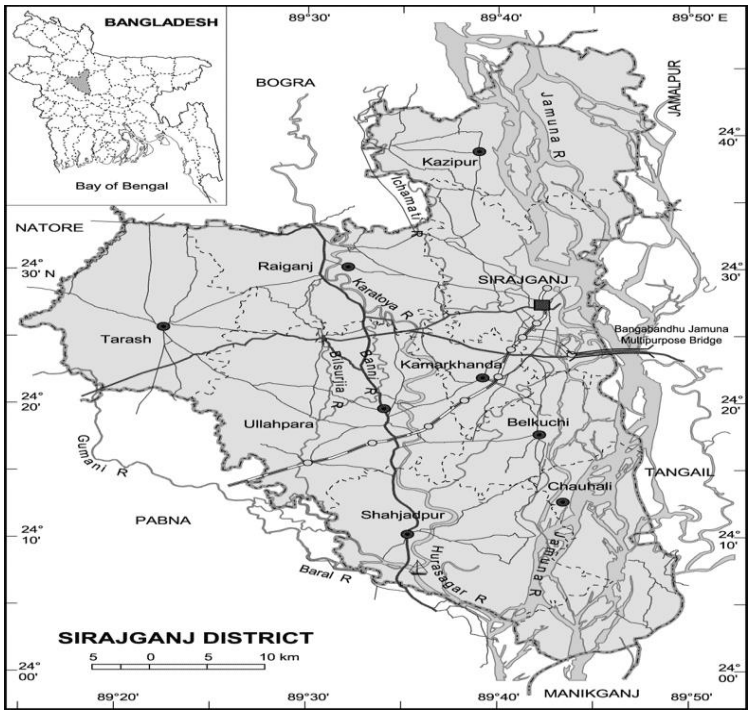

Figure 1. Map of Chauhali upazila, Bangladesh

Multiple response questions were analyzed so as to give frequencies and percentages. To present different variable in the context of the report, Tables and bar charts were used. Cross-tabulation allowed a comparison of different study parameters in the two villages. Temperature and rainfall data from meteorological stations were analyzed using Microsoft Office Excel 2007 to present patterns and trends of rainfall and temperature in the form of graphs.

Climate of study area: Chauhali upazila has a tropical monsoon climate as the whole Bangladesh enjoys the same. Three agricultural seasons are clearly dominating among six weather seasons. Rainfall is the major source of the water in this area. March and April are the summer, when temperature remains very high and the humidity is low. Sometimes there are storms (Bengali named as Kal Baishaki*).* The monsoon prevails from May to October and 90 percent of the annual rainfall occurs during this period. The highest rainfall occurs during May-September and the wettest month is July. Winter starts in November and ends in February. This season is very dry and cool. There is little rainfall in this period. The minimum temperature can be seen during December and January. The mean of that period is 18° centigrade. The highest temperature of 42.8° centigrade can be seen in April or May. The lowest temperature of 5° centigrade occurs in January and April is the hottest month (Banglapedia, 2008).

Cropping patterns: Although different varieties of crops are grown in Bangladesh, rice is overwhelmingly the dominant crop in terms of acreage and importance as the staple food. Rice alone accounts for about 75 per cent of the cropping area in the country. In terms of acreage, other important crops grown in the country are wheat (4.4 %), jute (3.9 %), potato (1.1 %), pulses (2.79 %), sugarcane (1.12 %), chilli (1.05 %), and oil seeds (3.08 %). Additionally, there are small scale cultivation of onion, gram, garlic and groundnut etc. (Mainuddin et al, 2011). Various factors that control the agricultural production are yield season, numbers of dry days, heavy rainfall, high temperature and potential evapo-transpiration. According to these criteria, Chauhali thana has three agricultural seasons named rabi (October-February), Kharif-I (March-June) and Kharif-II (July-September). Boro rice is cultivated with the help of irrigation in the medium low land. Mustard, maskalai, wheat, groundnut, potato, khesari and vegetables are mainly cultivated in the Rabi season. Boro rice, jute, oil seed and autumn rice are cultivated in the Kharif season (Banglapedia, 2008).

III. Results and Discussion

Resource and Socio-economic status of study area

Land Resource: Peoples' livelihoods depend on various resources available in the study area. Approximately 70 percent of the land is cultivated and the remainder is made up of homesteads and homestead forests, roads, and permanent water bodies like rivers and hills. Total cultivable land is 7,250.76 hectares, uncultivated char land 7,389.64 hectares; single crop land is 60%, double crop land is 30%, triple crop land is 10 % and in the study area (Web-1, undated). There have very small amount of forest cover and forest reserve areas in the study areas. Therefore, in terms of land resource (farmland) as well as forest cover, Chauhali area is vulnerable to impacts of Climate change and variability.

Wealth stratification: There are 25,300 family involving in agriculture, with 4,313 landless families. The rich family of agriculture is 814. The small family of agriculture is 5,541.The middle family of agriculture is 2,979. In the Chauhali upazila, 25% of its populations are living below the food poverty line (DAE, 2009). From the study, the same figure was focuses, as there are identified three major social groups i.e., the rich group; the medium rich group and the poor group. Their proportions of the groups were provided by the local people as presented in Table 1.

Generally the stratification of the surveyed villages indicated that the poor group embodying the largest number of households. The percentage of rich category is low in both villages which implies that a high level of vulnerability of communities in these villages (Table 1). For comparison, the household numbers in the medium rich group in Voalkandi were higher than those in Estholchore. Parallel to that, Estholchore led with the number of households in the poor group but also has a higher number of households falling in the rich group. Based on the characteristics of the three wealthy groups, it implies that vulnerabilities and adaptive capacities among groups vary accordingly in the two villages studied.

Table 1. Distribution of Wealth Groups, in Voalkandi and Estholchore village

Village name	Total number of households (studied)	Rich group	Medium rich group	Poor group
Voalkandi	26 (100)	3 (11.54)	9 (34.62)	14 (53.84)
Estholchore	24 (100)	2 (8.33)	7 (29.17)	15 (62.5)
Total	50	5	16	29

Economic activities in study area

From the survey data, the major economic activities are figured out as the same of the literature reviews (Table 2). According to the data analysis, farming was the major economic activity for (60%) of the respondents in Voalkandi and (56%) in Estholchore (Table 2). Although livestock was the second major economic activity in Voalkandi (30%) and Estholchore (34.0%), all livestock keepers are also farmers and none of the respondents was keeping livestock alone. Small business ranked as the third economic activity. However the activity appeared to be of less important in Voalkandi (5.25%) compared to that of Estholchore (6.75%). Fishing was the fourth major economic activity in Voalkandi (4.75%) and Estholchore (3.25%). Farming and livestock keeping was the main economic activities in both villages this implies that climate change and variability will have a far-reaching effect on the livelihoods of these communities.

Table 2. Proportion (%) distribution of respondents' main occupation

Main occupation	Voalkandi (%)	Estholchore (%)
Farming	60	56
Livestock keeping	30	34
Business	5.25	6.75
Fishing	4.75	3.25
Total	100	100

In the study area, there are existing various farming system in the economic activities e.g. crop farming (referring to production of crops alone), mixed farming (referring to crop farming and livestock keeping), shifting cultivation and agro-forestry (Table 3).

Table 3. Present farming system in the study area

Systems	Voalkandi （%）	Estholchore （%）
Crop farming	50.5	52.8
Mixed farming	30.8	29.5
Shifting cultivation	12.2	13.5
Agro-forestry	6.5	4.2
Total	100	100

Climate Change in study area

From the field survey, it is clear that the local responses on climate changes are more significant on their perceptions. It was perceived that there was an increase in temperature over the last 6 years. It has been reported that the area becomes extremely hot but during the night it is very cold. There were also perceptions on rainfall. The rainfall patterns in seasonal variations are also observed in the study area. Local perceptions by farmers with respect to changes in temperature as well as increasing rainfall variability are closely related to empirical analysis of rainfall and temperature trends using the data obtained from meteorological station. In the next section, we will figure out the drifts of rainfall and temperature from the empirical data. We also try to set-up the trends of the other climatic parameters.

Seasonal patterns of rainfall: The seasonal variations were observed in the study area. In Rabi season, there was a sharp decrease in rainfall; it had the lowest in 2011, indicating the draught phenomena. The incidence of rainfall decreased from 2007 to 2012 in Kharif-I season and that is also continued the same trends in Kharif-II seasons but in 2011, after the drought conditions the rainfall trends is increased.

Temperature trends in the study area: In Rabi season, the average minimum temperature was constant in October – November but it was decreasing in the next season. On the other hand, the maximum temperature of Rabi season was constant over year. In Kharif-I, the average minimum temperature was higher in 2007 than the proceeding years and overall became constant over the rest of the time. But the average maximum temperature was constant over the season over years. In Kharif-II, interestingly, the average minimum and maximum temperature is constant over the whole time over years.

Flooding and Erosion trends in the study area: The analysis of low and high water level data collected from Water Development Board (WDB), Sirajgonj for the past 22 years. Results indicate that lower water level and higher water level showed an increasing trend of flood level through the years (Figure 3).

Draught trends in the study area: The information of historical pattern of draught reveals an increase in area affected by drought by 6 % over the period of 1951-79 (i.e. 28 years) (Figure 4). In this study area, drought is also common due to position, and recent agro-climatic changes in the prone area.

Climate change and crop production

Increasing unpredictable rainfall and crop production: Water is one of the most important climatic factors that control the nutrient cycle in soil and their availability to crops; then affecting their morphology and physiology. Finally, it is required in minimum level for their growth and development in the critical stages (Shukla and Chandel, 2003). Moreover, excessive rainfall may cause flood and water logging condition leading to crop loss. Variations of rainfall pattern over the growing period have also been found to affect rice yield (Bashak, undated). There were significant differences in rainfall amount, variability and trend and have various effects on different crops in different ways (Bewket, 2009). Seasonal amount of rainfall and the number of raining days in rainy season or even in winter have effects on crop production. For example, there were delay and/or early occurrence of rainfall than the normal, and that cause poor germination of seeds, requiring multiple sowing of seeds by farmers (Mary and Majule, 2009). But there were also reported that experiencing long dry spells and drought, providing to low yield thereby, total crop failure of the world demand (Mary and Majule, 2009).

The changing pattern of rainfall–crop relationship in the study area was also observed. The Rabi crops were less vulnerable to changing rainfall rate in winter as the production rate of potato, vegetables and groundnuts had increasing trends or constant. The paddy yields fluctuated with changing rainfall due to its dependency on irrigation but the wheat and pulse production were decreasing over years. The paddy, mustard and wheat production are fluctuated with the rise and fall of rainfall rate. The production rate of spices, pulse crops and ground nuts are in increasing trends. In Kharif-II season, transplanted aman production is in similar but the vegetables production fluctuated with the fluctuation of rainfall.

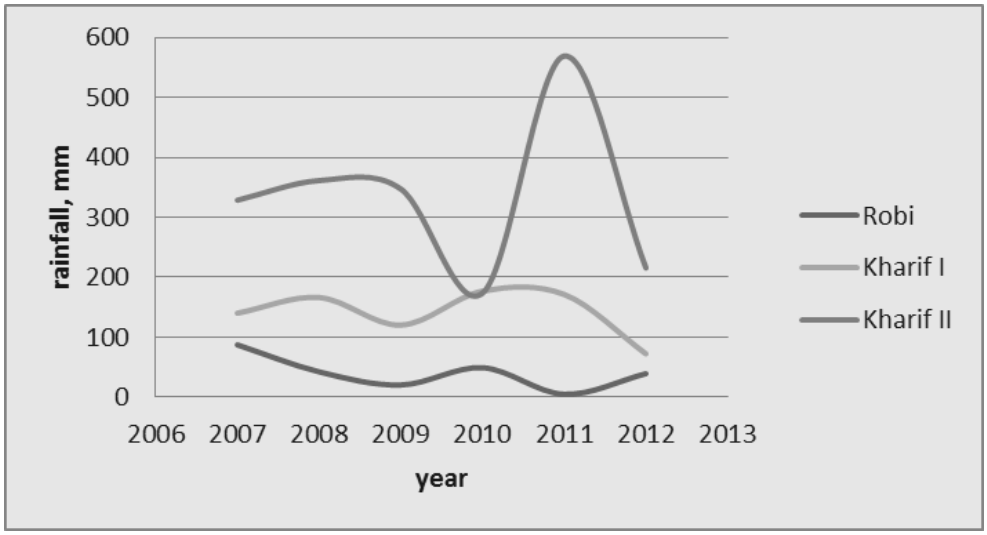

Figure 2. Seasonal rainfall trends during the years from 2006 to 2013

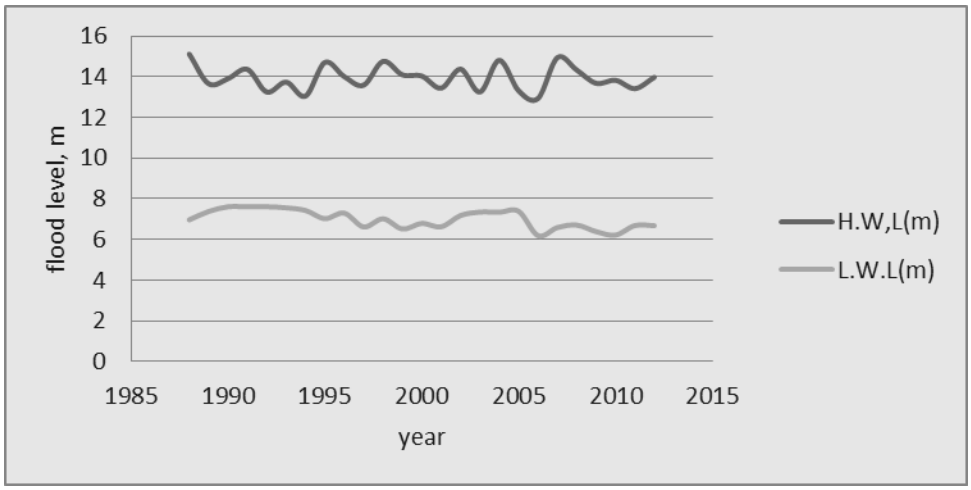

Figure 3. Flood level trends during the years from 1985 to 2015

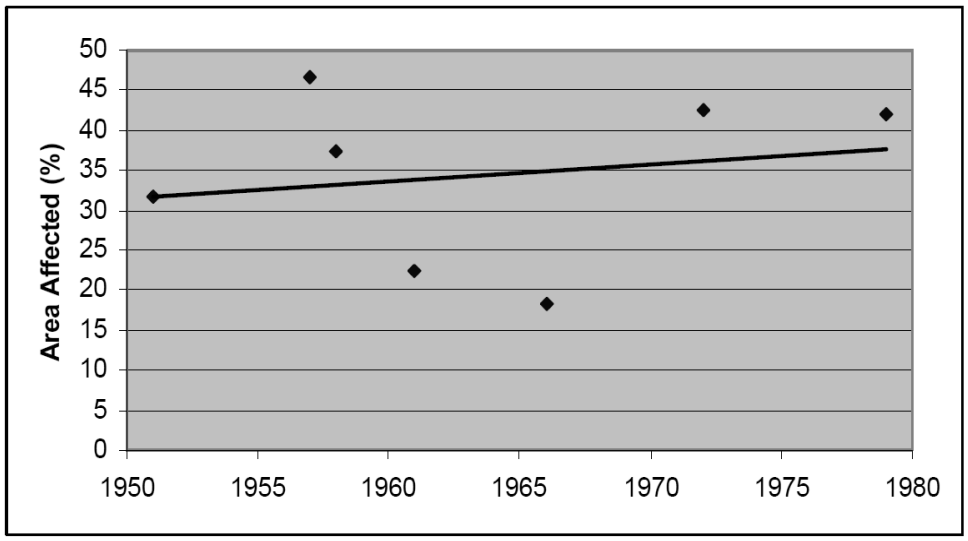

Figure 4. Drought affected areas in Bangladesh (Hasan, 2008)

Temperature and crop relationship: Temperature is a variable factor which is influenced by time, season, latitude, altitude, slope, direction, soil texture, plant cover and human activities. Crop production is very sensitive to changes in temperature. There has a temperature range for their vegetative and reproductive growth for each crop (Shukla and Chandel, 2003). When temperature falls below the range or exceeded the upper limit then crop production faces restraints. The crop production in Bangladesh are effected due to the change in temperature e.g. by increasing 1ºC maximum temperature at vegetative, reproductive and ripening stages, Aman rice production was decreased in by 2.94, 53.06 and 17.28 tons/ha respectively (Islam et al, 2008). There were also found the severe effect on potato and wheat growing with the change in temperature. By change of 2ºC and 4ºC), it may reduce production 60% of the achievable yields (Karim, 1993). In the study of the flood plain region of Bangladesh, there is also a positive relation of crop production with temperature change. In Rabi, due to decreasing average minimum and maximum temperature, paddy, wheat and potato production are decreasing. But pulse and spices production is still rising. The vegetable production is at the constant rate. It is also observed due to decreasing average minimum and increasing maximum temperature in Kharif-I, paddy, and pulse production are decreasing. But mustard and spices production are still rising. The production of vegetable is decreasing due to decreasing minimum and maximum temperature; increasing with increasing temperature both. Transplanted Aman production is not affected due to change in temperature.

Other Factors affecting crop production

Based on household surveys, climate change related factors are the most important constraints to crop production. Other factors are increasing pests and diseases incidences linked to warming; and declining soil fertility associated with frequent drought and increase river erosion due to the flood.

Declining soil fertility: There are a number of factors that contributes to declining soil fertility (Majule, 1999). Normally, this is due to excess mining of soil nutrients for plant growth. It is reported that soil degradation is enhanced by several factors e.g. excessive harvesting, river erosion and burning of crop residue (Majule, 1999), invasion of salinity and water-logging (Rahman, 2011). On the other hand, increasing temperature is contributing to a rapid decomposition organic matter and thus a loss through the production of CO_2. Estimates of area affected by nutrient depletion and other forms of degradation are about 5.6 million ha in Bangladesh. With the climate change saline water may intrude into non-saline land which ultimately affects crop production (Rahman, 2011). But the study area is less vulnerable as it is far away from the Bay of Bengal.

Increase river erosion due to the flood: Riverbank erosion is one of the major natural calamities of Bangladesh that took place in almost every year. There are a number of factors that contribute to increase river erosion. These are heavy siltation in the south-western part of Bangladesh and newly formed char land; deforestation along with the major river system of Bangladesh etc. River erosion response to reduce crop production as a vast area of agricultural land goes into the river (Uddin and Bashak, 2012).

Increased pest and disease: The two most important climatic elements i.e. moisture and temperature are determinant of the occurrence and localization of pests and diseases. In general pests and disease vectors do better when the temperature is high under conditions of optimum water supply and vulnerability may increase the incidence of pests and diseases. FAO (2007) reported that changing temperatures and rainfall in drought-prone areas are likely to shift populations of insect pests and other vectors and change the incidence of existing vector-borne diseases in both humans and crops. Shao (1999) reported that pests and diseases are among the critical factors contributing to unsustainable agriculture. Increased pest damage may arise from changes in production systems, enhanced resistance of some pests to pesticides and production of crops in warmer and more humid climatic regions where plants are more susceptible to pests (Shao, 1999).

According to the household surveys, the other constraints to crop production include lack of farm implements; high price of farm implements; low access to farm inputs; shortage and high price of labor; poor agricultural practices and inadequate farm land. The factors influencing crop productions are ranked in the order of their importance (Table 4).

Table 4. Factors influencing crop production by proportion (%)

Factors Influencing crop production	Voalkandi (n=42)	Estholchore (n=41)	Total
Impulsive rainfall	32.9	30.7	31.8
River erosion due to flood	34.7	37.8	36.25
Increased pests and diseases	14.4	15.4	14.9
Low soil fertility	4.9	3.5	4.2
Lack of farm implements	3.2	2.6	2.9
High price of farm implements	2.3	3.2	2.75
Low access to farm inputs	2.1	1.5	1.8
Shortage and high price of labour	3.5	2.5	3
Poor agricultural practices	1	1.55	1.275
Inadequate farm land	1	1.25	1.125
Total	100	100	100

Adaptation to climate change

In response to the impacts associated with climate change and variability, communities in study villagers are implementing different adaptation measures as discussed below:

Integrated pest management: Integrated Pest Management (IPM) is an approach of pest management very effectively and environmentally practises with a combination of current and comprehensive way. Thereby, IPM programs acquire and result from the information on the life cycles of pests and their interaction with the environment (EPA, 2012). IPM gets facilities of all appropriate pest management options including the sensible use of pesticides. In contrast, organic food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources (EPA, 2012).

Integrated soil fertility management: Providing that, the need to improve soil fertility according to the differing needs and expected returns for different crops, Farmers is habitually aware of using the various sources of nutrients available between crops and soils (Practical action, undated). There are various choices to improve the facilities, such as, which can be followed: direct interventions to improve soil status, strengthening farmer knowledge and skills, and improving organizational linkages which promote better learning and sharing of ideas. One main strategy can be adopted is integrated soil fertility management. The strategy at macro-level is aimed at supporting the evolution of policies bringing greater benefit to the farming sector, while at the same time providing support to networking between various organizations working on soil fertility issues at micro-level (Practical action, undated).

Conservation Tillage System: Conservation tillage can be another approach that excludes conventional tillage operations that overturn the soil and bury crop residues. There are identified five types of conservation tillage systems: no-tillage (slot planting), mulch tillage, strip or zonal tillage, ridge till (including no-till on ridges) and reduced or minimum tillage. The benefits of tillage include seedbed preparation, weed control, evaporation suppression, water infiltration enhancement, and erosion control. This benefit together result in increased and sustained crop yields (Opara-Nadi, 2009).

Staggered seed crop planting: It can be staggered more than one plot for crop production. To avoid crop production risks due to rainfall variability and drought, staggered plating is very common to most farmers whereby crops are planted before rain onset (dry land) on uncultivated land. Others were planted immediately after rain, while still other plots were planted a few days after the first rains (Liwenga, 2003).

Mixed cropping: Mixed cropping or co-cultivation could be another important adaptation measures that involves planting two or more of plants simultaneously in the same field. The process benefits as planting multiple crops at once will allow the crops to work together. The other benefits of mixed cropping are to balance input and outgo of soil nutrients, to keep down weeds and insect pests, to resist climate extremes (wet, dry, hot, cold), to suppress plant diseases, to increase overall productivity and to use scarce resources to the fullest degree.

IV. Concluding remarks

The study areas contains very small amount of forest cover and forest reserve area. The stratification of the surveyed villages indicated that the poor group embodying the largest number of households. The percentage of rich category is low in both villages which implies that a high level of vulnerability of communities in these villages. From the field survey, it is clear that the local responses on climate changes are more significant on their perceptions. In the study area, people reported that they no longer can differentiate one season from the next. Farmers can no longer count on the monsoon rain coming at the right time, making it difficult to know when to plant crops. The unpredictability of rainfall and fluctuating temperature is causing massive problems for farmers, whose main crop is rice, which requires large amounts of water and right temperature for productivity.

V. Acknowledgement

We thank all teachers and stuffs of the Department of Environmental Science and Technology, Jessore University of Science and Technology for support to this work. Moreover, we also thank to the personnel of Meteorological Station, Bogra and Water Development Board for providing data on weather and flooding. Many thanks to unknown reviewer (s) for their worthy comments and suggestions on the article.

VI. Reference

Ahmed, A. U. (2004). Adaptation to climate change in Bangladesh: learning by doing. UNFCCC Workshop on Adaptation, Bonn, 18 June.

Ahmed, A. U. (2006). Bangladesh: Climate Change Impacts and Vulnerability - a Synthesis. (Dhaka: GoB, MoEF, Department of Environment, Climate Change Cell, July).

Bangladesh Economics Review. (2009). Government of the People's Republic of Bangladesh. Ministry of Finance, Dhaka.

Banglapedia, (2008). Climate in Bangladesh. Asiatic Society, Dhaka, Bangladesh.

Banglapedia, (2010). Drought. Asiatic Society, Dhaka, Bangladesh.

Bewket, W. (2009). Rainfall variability and crop production in Ethiopia Case study in the Amhara region. Proceedings of the 16th International Conference of Ethiopian Studies, ed. by Svein Ege, Harald Aspen, Birhanu Teferra and Shiferaw Bekele, Trondheim 2009.

Bashak, J. K., Undated . Climate Change Impacts on Rice Production in Bangladesh: Results from a Model. Unnayan Onneshan, Dhaka 1215, Bangladesh.

DAE (Department of Agriculture Extension), (2010). Upazila Base Crop Production Action Plan 2009-2010. GoB.

Dinar, A. & Mendelsohn, R. (2009). Climate change and agriculture: An economic analysis of global impacts, adaptation and distributional effects. Northampton, MA: Edward Elgar Publishing, Inc.

EPA, (2012). Integrated Pest Management (IPM) Principles; Available at: http://www.epa.gov/pesticides/factsheets/ipm.htm (Accessed on 20 Feb, 2010).

FAO/GIEWS Global Watch, (2007). Livelihood of over 8.9 million people adversely affected by Cyclone Sidr in Bangladesh.

Halcrow, (1994). River training studies of the Brahmaputra River. Master plan report, Technical annexes, Design and construction.

Hasan, A. (2008). The historical climate risks in Bangladesh, CEGIS, Dhaka, Bangladesh

Islam, M. and Islam, A., (1985). A Brief Account of Bank Erosion, Model Studies and bank Protective Works in Bangladesh. REIS Newsletter, 2: 11-13.

Islam, M. N., Baten, M. A., Hossain, M. S. and Islam, M. T. (2008). Impact of few important Climatic Parameters on Aman Rice Production in Mymensingh District. *J. Environ. Sci. & Natural Resources*. 1(2): 49-54.

Karim, Z. (1993). Preliminary Agricultural Vulnerability Assessment: Drought Impacts due to Climate Change in Bangladesh. IPCC Eastern Hemisphere Workshop on Vulnerability Assessment to Sea-Level Rise and Coastal Zone Management, 3-6 August 1993, Tsukuba, Japan.

Liwenga E. T. (2003). Food Insecurity and Coping Strategies in Semi-arid Areas: The Case of Mvumi in Central Tanzania. PhD Dissertation No. 11. Stockholm Studies in Human Geography, Stockholm University, Stockholm, Sweden.

Madulu, N. F. (1996). Changes in Marital Fertility in Relation to the HADO Project Activities in Kondoa District. In Changing Environ., Res. on Man-Land Interrelations in Semi-Arid Tanzania, Regional Soil Conservation Unit, Report No. 13. Edited by Christiansson, C and Kikula, I. S. Published by Sida's Regional Soil Conserv. Unit, RSCU, 1996. Nairobi, Kenya pp.84-95.

Mainuddin, K., Rahman, A., Islam, N. and Quasem, S. (2011). Planning and costing agriculture's adaptation to climate change in the salinity-prone cropping system of Bangladesh. International Institute for Environment and Development (IIED), London, UK.

Majule, A. E. (1999). The Effects of Organic Residues and Elemental Sulphur Additions to Soils of Southern Tanzania. PhD Thesis, Reading, United Kingdom: Reading University.

Mary, A. L. & Majul, A. E. (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. African Journal 0f Environmental Science and Technology, Vol. 3(8), pp.206-218.

Opara-Nadi, O. A. (2009). Soil tillage in Africa: needs and challenges, Chapter 8 Conservation tillage for increased crop production, Available at: http://www.fao.org/docrep/t1696e/t1696e09.htm (Accessed on 20 Feb 2013).

Planning Commission, (2010). Outline Perspective Plan of Bangladesh 2010-2021- Making Vision 2021 A Reality, Final Draft. General Economics Division, Planning Commission, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Practical Action, Undated. Integrated soil fertility improvement in semi-arid areas: Available at: http://ncrs.fs.fed.us/pubs/jrnl/1997/nc_1997_juzwik_002.pdf (Accessed on 20 Feb 2013).

Rahman, M. M. (2011). Country report: Bangladesh1. ADBI-APO Workshop on Climate Change and its Impact on Agriculture Seoul, Republic of Korea, 13-16 December 2011.

Shao, F. M. (1999). Agric. Res. and Sustainable Agric. in Semi-arid in Tanzania. In Sustainable Agric. in Semiarid Tanzania. Edited by Boesen, J. Kikula, I. S. and Maganga, F. P. Dares Salaam Univer. Press. ISBN 9976- 60-311-8.

Shukla, R. S. and Chandel, P. S. (2003). Plant ecology and soil science. 14th ed. New Delhi: S. Chad and Company ltd.

Uddin, A. F. M. A. & Bashak, J. K. (2012). Effects of Riverbank erosion on livelihood. Unnayan Onneshan, Dhaka 1215, Bangladesh.

Web -1. Undated. http://www.mapsofbangladesh.com/Chauhali-Upazila.php

World Bank, (2000). Bangladesh: Climate Change and Sustainable Development. Report No. 21104 BD (Dhaka: World Bank, South Asia Rural Development Team, October); Available at: http://go.worldbank.org/CW8WDU9WQ0. (Accessed on 22 March 2009).

Citation for this article (APA Style):

Karim, R., Jahan, S. & Islam, M. S. (2014). Impacts of Climate Change on Agriculture in the Flood Plain Area of Chauhali Upazila, Sirajgonj, Bangladesh. *Journal of Science, Technology & Environment Informatics, 01(01), 16–26*. Retrieved October 30, 2014, from http://www.journalbinet.com/0201v114.html.