Adaptation to Climate Change for Sustainable Development of Bangladesh Agriculture[1]

Bangladesh Country Paper

by

M. Harun-ur-Rashid[2]
and
M. Shirazul Islam[3]

Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701
November 2007

---

[1]Paper for presentation in the 3rd session of Technical Committee of Asian and Pacific Center for Agricultural Engineering and Machinery (APCAEM) on November 20-21, 2007, Beijing, China

[2]Director General, Bangladseh Agril. Res. Institute (BARI) and [3]Principal Scientific Officer, Irrig. and Water Mgt. Divn, BARI

Adaptation to Climate Change for Sustainable Development of Bangladesh Agriculture

Abstract

Like many other countries, Bangladesh will face a tremendous challenge from the climate changes. Among other sectors, its agriculture will face the deadliest experience from floods, droughts, tornados, cyclones, tidal surges and soil salinities. The risk associated with climate change lie in the interaction of several systems with many variables that must be collectively considered. Agriculture, including crop production, animal husbandry, forestry and fisheries, can be defined as one of the systems that will be affected adversely due to climate change. Natural disasters like high soil salinity, frequent floods and droughts, tornado and cyclones - all affect directly or indirectly agricultural operations and productions. In many of the agricultural operations like quick harvest and seeding, intercultural operations, irrigation and water management, disease and pest management, agricultural engineers have to contribute to work out solutions matching the nature of the problems in the above sub-sectors of agriculture.

Introduction

'World Watch Institute' an international research organization, published a report on 22 October 2007 realizing that due to rise of sea water level for climate change 21 countries of the world including Bangladesh are under serious risk. According to the report, during last 100 years, the rise of sea water level has been recorded to be 9-20 cm. This level may further rise to about 88 cm by 2100. The report adds, due to climate change, frequent small or large disasters have become evident. These lead to sufferings as well as financial losses to human beings (Prothom Alo, 2007).

Climate change mainly refers to temperature rise; other associated changes which may result from climate change are in precipitation, evaporation and humidity etc. All these changes again cause the most threatening impacts in natural, social and economic systems. The agents of climate changes have impacts on several natural system processes, such as: inundation, storm surges, low river flows, salt water intrusion and river and coastal morphology changes (Koud staal, 2007). Human induced changes in the global climate and associated sea level rise are widely accepted with policy markers and scientists. With the climate change, these factors will affect agriculture most.

Bangladesh is an agro based country. Agriculture contributes 22.7% to GDP (BBS, 2005). With the sea level rise, a vast land in the southern coastal belt will go under water and salinity will grasp new land areas. This will reduce the existing crop area severely thereby hampering agricultural productions. Obviously, the densely populated country may face acute food shortage to feed her people. Cultivation of rice, a staple food, has suffered most, while the production of wheat, pulses, rape seed and coconut has also been affected by climate change.

Climate changes have impacts on Bangladesh agriculture, especially in the North Eastern districts (Selvaraju, 2006). These are increased evapotranspiration resulting in more water demand and exploitation of groundwater, scarcity of surface and groundwater resources, increase in winter temperature affecting areas suitable for wheat and pulse, increased spikelet sterility and reduced crop yield, less animal comfort and reduction in milk yield and higher infestation of pest and diseases to crops.

According to the Intergovernmental Panel on Climate Change, Bangladesh is slated to lose the largest amount of cultivated land globally due to rising sea levels. A 1m rise in sea levels would inundate 20 percent of the country's landmass.

Prolonged inundation, increased drought, salinity and loss of land due to erosion are the enhanced risks that agriculture is facing due to climate change. Increased drought and salinization in the dry season and prolonged inundation in the wet season will change the areas suitable for growing crops. Since agriculture is the mainstay for the economy, Bangladesh is very sensitive to impacts of climate change on the agricultural sector.

Agricultural engineers working in different fields of agriculture will need to consolidate their best efforts as to how agriculture could be made sustainable by working out appropriate adaptation measures for the mitigation of the probable disasters generated from climate change.

Impacts of Climate Change

Impact of climate change on ecology is manifold. It affects soil salinity, drought, crop survival, irrigation economy, fresh water availability and so on. Some of the major elements related to crop agriculture are discussed here.

i. Impact on soil salinity

In Bangladesh, soil salinity is only observed along the coastal belt. Tidal flooding during wet season (June-October), direct inundation by saline or brackish water and upward or lateral movement of saline groundwater during dry season (Nov.-Jan.) are the causes of soil salinity development. Increased salinity affects soil fertility. In 1973, 1.5 million hectares of land had mild salinity. In 1997, this expanded to 2.5 million hectares. It is believed that the figure may be more than 3 million hectares to date (FAO, 2007). The severity of salinity problem in Bangladesh increases with the desiccation of soil due to shortage of rainfall. This will further aggravate the situation due to the effect of temperature rise and rainfall reduction. Bangladesh has a coastal area of 2.5 million ha. of which about 0.83 million ha., along the coastal belt, are under salinities of different magnitudes. With the sea water rise, as predicted by the researchers, Bangladesh may lose a major portion of her coastal areas to sea. This will, definitely, cause fresh lands under salinity as a result of tidal surge and salinity intrusion.

ii. Impact on drought

Drought is a very well known natural disaster to the people of Bangladesh. Every year, 3 to 4 million hectares of land are affected by droughts of different magnitudes (Miah et al., 2003). For drought, average rainfall becomes less during the critical growth stages of crops and they suffer from soil moisture deficits. Drought stress caused by higher evapotranspiration and reduced rainfall may override any growth benefits from the higher CO_2 levels, unless irrigation can be stepped up to compensate (Warwick, 2007).

Table 1 Intensity of drought and yield loss of T.Aman.

Intensity of drought	Area of land (ha)	Locations	Average yield (t/ha)	Yield loss due to drought (%)
Very severe	3,42,990	Rajshahi, Nawabgonj (Barind area)	1.7-2.5	70-90%
Severe	7,37,028	Barind area, Gangetic alluvium	2.0-2.5	50-70%
Moderate	31,54,950	Western, central and southern regions; Modhupur tracts, Kustia & Jessore	2.5-3.5	30-50%
Slight	28,67,895	Teesta, Brahmaputra & Gangetic alluvium; Alluvium soils of Meghna & Surma-Kushiara rivers	3.0-4.0	10-30%

Among 8.3 million ha of cultivable lands, 60% are used for Aman rice cultivation. But this rice is grown rain fed. During drought, a heavy loss to Aman production affects the farmers economy. Every year 5.0 million ha of lands are cultivated by Aman rice. A survey by BARC (Miah et al., 2003) shows 4.2 million ha of lands are prone to droughts of different intensities. In table1 is given the intensity of drought, area and yield loss of T.Aman.

iii. Impact on crop variety and cropping pattern

The impact of climate change on the existing crop cultivars and crop patterns are expected most. Due to temperature and humidity changes, some crops will be eliminated or produce less yields requiring that either new varieties of the existing cultivars are to be developed or the whole cropping patterns should be changed as per demand of the time. Increased insect infestation and pest and disease infections of crops will appear as great problems. Obviously, some improved and appropriate management aspects will come in to consideration.

iv. Impact on irrigation water use

Climate change will affect water use in several wages: loss of water from crops (crop ET) will be greater due to warmer, sunnier weather, but yields could go up or down with higher temperatures. For example, due to temperature rise, wheat yields will reduce substantially.

Water use efficiency (WUE), from growers perspective, is the output per unit of water applied. Water use efficiency is only important if crop yield is limited by the amount of water available. Except a very few areas like High Barind Tract so far no problem has been found to get higher WUE by applying optimal water to crops.

But due to erratic climatic conditions, more area are also expected to come under water restrictions in near future. Already some areas like capital city Dhaka, Joydebpur and Comilla are showing rapid declination of static ground water levels. This leaves a huge number of suction mode tube wells inoperable (Bhuiyan, 1983; MPO, 1987; Khan and Islam, 1999). In most parts of Bangladesh, water table shows natural annual fluctuation from 3.6 m but failed to return to its pervious years' level at the end of the rainy season (Hyde, 1979; Hoq and Sattar, 1987). The dry period groundwater table fluctuation largely depends on the amount of monsoon rainfalls. With change of climate, the reduced rain fall availability will further

deteriorate the groundwater availability. The result is the scarcity of both drinking and irrigation waters creating acute health and food problems.

v. Impact on irrigation economy

Present food production of around 30 million tons/year is mostly contributed by irrigated agriculture (56% irrigated area). For irrigated crop production there are a number of Deep Tube Wells (DTWs), Shallow Tube Wells (STWs), Low Lift Pumps (LLPs) and other indigenous irrigation equipments. A status of these equipments are given in Table 2 (BADC, 2005).

Table 2 Summary of irrigation equipment

Equipment	Number in operation	Area coverage (ha)	% of total irrigated area
DTW	27,117	6,54,189	13.67
STW	11,28,991	31,59,899	66.00
LLP	99,255	8,38,377	17.51
Traditional method	-	25,500	0.53
Gravity flow method	-	1,09,381	2.29
Total	-	47,87,346	100.00

Presently about 80% of total irrigated area is under groundwater irrigation. So, with the climate change, this sector will face terrible shortage of surface and ground waters. Climate change, particularly the higher temperature and lower rainfall will enhance higher rate of groundwater withdrawal but due to lower recharge to the aquifers, most of the suction mode tube wells will go dry in the lean period. As a result, new tube wells have to be installed to greater depths at the expense of higher installation cost which will increase irrigation cost as well. Thus, the climate change will greatly affect irrigation economy.

vi. Impact on fresh water availability

Low river flow and increased evapotranspiration in the dry period will reduce the amount of fresh water availability. In the coastal zone, there is the additional effect of saline water intrusion into the estuaries and into the groundwater as a result of low river flow, sea level rise and local over abstraction. Thus, reduced fresh water availability as a result of reduced supply and growing demand, is a threat to all sectors including agriculture.

vii. Impact on traditional agricultural practices

Climate change, especially the temperature hike will affect the traditional agricultural practices. Prolonged drought or heavy shower may be equally harmful for cultural operations. Prolonged drought will lead to rapid dry up of soil leaving minimum time for land preparation for the next crop. Traditional plows will find difficulty to expedite the operation and meet the demand in time. Equally, unprecedented bad weather may harm ripened crops in the field when a quick harvest can save the crop. At this stage, traditional harvesting methods will not suffice the operation.

vii. Impact on Cyclones and tornadoes

With the climate change, the frequency of natural disasters like cyclones and tornadoes will be much higher causing greater loss to the properties and lives. Cyclone alone is not as devastating as a storm surge accompanied by a cyclone. Traumatic death or injury, diarrhea etc. occur due to lack of safe drinking water, destroyed or damaged housing, food shortage, loss of livestock and crops, destruction to infrastructures etc. The susceptible areas are 14 coastal districts in the southern Bangladesh. Similar losses in life and properties also occur from tornadoes.

viii. Impact on floods

Another probable disaster from climate change is the flood. Three types of floods are usually encountered in this country, river water floods, flash floods and the floods resulting from tide and ebbs. The river water flood usually does not create so problems in the coastal areas as the flash flood does. In Chittagong and Cox's Bazar districts the flash floods is a regular phenomenon. The flood water suddenly inundates vast lands in a short duration and leaves the lands in almost equal speed leaving behind its ferocious footprints. In 2002, flash floods damaged shelters and crops of about 80,000 acres in 12 upazillas of Chitagong and Cox's Bazar districts. Floods from tide and ebbs are not so dangerous except in rainy season when the strong southern wind causes swelling of tidal waves that retards the flooded river waters to flow to the sea at a normal rate. This results in the inundation of a vast coastal land by saline water making additional agricultural lands uncultivable.

ix. Impact on shrimp culture

Shrimp culture is a profitable business to the people of the coastal saline areas. People constructs 'ghers' and draws in saline water in the land for shrimp culture. The repeated practice increase the soil

salinity so high preventing any crop cultivation. The practices are moving towards further inland destroying non-saline crop lands. This movement will further increase with more areas under saline soils due to sea level rise. Unless the trend is retarded, the crop lands in the coastal areas will face serious health problems. Some immediate measures to solve the problem are to be taken so that the shrimp culture is confined to areas of higher salinity and not in non-saline or low-saline crop growing areas.

Adaptation Measures for Climate Change

i. Strategic adaptation to climate change

Climate change offers an additional challenge for policy makers and planners in Bangladesh. Business as usual is no longer good enough and new concepts are required in the management of natural resources and the socio-economic systems.

Key adaptations in agriculture would aim at changing agricultural practices to improving water efficiency and crop diversification. This is not only in areas that are affected by climate change but in the whole country. The development and introduction of new varieties and corresponding dissemination measures are important and need to be facilitated by international research. Given the fact that, experience with the new crops and agricultural practices has to be built up and shared on the farm level, and requires investment, the agricultural sector may not be as flexible to climate change as is widely believed.

ii. Change in crop production strategy

Based on the nature of soil, location and climate, crop varieties and cultivation methods are to be selected. Presently, there is no such crop that can withstand salinity in the range of 6-12 dS/m in the country. But improved managements can help overcome this drawback to some extent. Bangladesh Agricultural Research Institute has found that using raised beds, mulches and drip irrigation, it is possible to grow high value horticultural crops like, tomato, chilli, watermelon and cucumber in saline soils of 4.5-11.0 dS/m (Islam et al., 2006). Development of new technology such as crop varieties tolerant to heat and medium to high soil salinity is time demanding. Research is underway to find crop varieties of such characteristics. Until new varieties come up, adequate emphasis is to be given on the crop production management systems. From now on, demonstrations to be done in farmers field with what appropriate technologies are available so that the farmers get acquainted with these technologies and learn to adopt new technologies. Likewise, more emphasis to be given to variety development

and to environment friendly pest and disease controls.

***iii. Mitigation measures for c*yclones and tidal surges**

Efforts have been continuing to construct shelters in the disaster prone areas of the coastal zones since 1960s. In addition, constructions of cross dams, forestation, forecasting, increasing consciousness of the people and building communication systems are some of the on-going activities to mitigate effects of cyclones. The literacy level is very low in these areas compared to those of the non-coastal areas. So, to upgrade educational status, these cyclone shelters are now also being used as educational centres. However, many of these shelters are away from the disaster prone areas.

iv. Introduction of Boro rice and shrimp (Lobster) cultivation

In slightly saline and moderately saline areas, cultivation of Boro rice and sweet water shrimp will help reclaim soil salinity. In Khulna-Bagerhat region it is called “Lockpur model”. It is one kind of fish cultivation where both crops and fishes are cultivated alternatively at the same time. A dyke/ ail/ bund is to be built along the boundary of the plot by digging ditch inside the dyke. The length, breadth and height of the dyke will depend upon the flooding depth in the monsoon season. The ditch will be used as water reservoir for fish culture and small scale irrigation. For Boro rice cultivation good quality of ground water may be used. By adopting this type of land use soluble salts can be leached out easily in a short time.

v. Farm machinery operations in relation to climate change

After harvest of transplanted Aman rice the turn around time left for growing rabi crops is very short. With the desiccation of the soil deep and wide cracks develop and the surface soil becomes very hard and makes tillage operations difficult with traditional plough. Rapid and deep tillage reduces soil salinity by breaking the capillary continuity for upward movement of saline groundwater. Therefore, light mechanized tillage implements such as power tillers should be used to increase the speed and depth of tillage operation. With the climate change, the traditional field operations in agriculture must be substituted by farm machines to expedite operations smoothly. At the end of Aman season, lands will go dry at a faster rate with the rise of temperature leaving a very small period of time for land preparation of the next crop by traditional equipment like local plows. Using tractors or power tillers this problem could be avoided and land can be prepared swiftly and timely for the next crop. Likewise, reapers help quick harvest of crops to save them from changed bad weathers and also the labor costs. Other farm machineries like seeder, reaper, weeder, thresher, winnower, drier, etc. could be used for economic and timely

agricultural operations (Roy et at., 2006). Deep tillage enhances rapid drifting of moisture from the soil to make it dry quickly requiring supply of water for seed germination and for seedlings. Minimum or zero tillage practices can be of very useful operation after T.Aman harvest in areas of high water scarcity. Appropriate seeders/transplanters can be used for the operation. Agricultural engineers can work on planning, design and operation of appropriate agricultural machinery for changed environment.

Conclusion

Climate change is not only an environmental concern but also a development concern for Bangladesh. This means that climate change as an issue must come out of the environmental problems to take center stage as a major development problem. The promising anticipatory adaptations are changes in behavioral patterns, human practices and international actions. However, these types of adaptations meet serious institutional constraints and consequently should be carefully prepared and, if possible, integrated in existing structures and procedures. The main mechanism to gradually overcome these constraints is coordination of climate change activities, integrated planning and information management. Agricultural engineers will look into these matters and apply their best efforts to mitigate the probable disasters on agriculture by integrated as well as individual perspectives. As per AlGore, the Ex-Vice President of the United States, to control climate change or to reduce the rate of change by 2010, all countries of the world should reach an agreement (Prothom Alo, 2007).

References

BADC. 2005. Minor Irrigation Survey Report 2004-2005. Ministry of Agriculture, Government of the.People's Republic of Bangladesh, Bangladesh Secretariat, Segun Bagicha, Dhaka.Bangladesh Bureau of Statistics. 2005.

Bhuiyan, S.I. 1983. Groundwater Irrigation in Bangladesh: Development at the Crossroads. Paper presented at the Institute of Engineers, Dhaka, Bangladesh.

Statistical Year Book of Bangladesh. Ministry of Planning, Government of the People's Republic of Bangladesh. Bhuyan, S.I. 1983. Groundwater Irrigation in Bangladesh: Development at the Crossroads. Paper presented at the Institute of Engineers, Dhaka, Bangladesh.

Food and Agriculture Organization (FAO). 2007. Case Study. Climate Variability and Change: adaptation to drought in Bangladesh. A Resource Book and Training Guide. FAO of the United Nations,Rome, Italy. An internet FAO Corporate Document Repository.

Haq, K.A. and M.A. Sattar. 1987. Groundwater Table Fluctuation and Response to Rainfall on a Micro Level Basin. Bangladesh Journal of Agril. Engineering. 1(1):45- 48.

Hossain, M.A., S.M.Shirazi, M.S.U. Talukder, M.A. Hye and A.K.Ghosh. 2001. The Impact of Climatic Changes on Crop Production. Bangladesh J. of Agril. Sci. 28(1): 115-124.

Hossain, M.A., M.S.U. Talukder and S.M.Shirazi. 2002. Probability Analysis of Rainfall and Net Irrigation Requirement of Rice, Wheat and Potato. Bangladesh J. of Agril. Sci. 29(1): 137-144.

Hyde, L. W. 1979. Hydrology of Bangladesh. Consultancy Report of Groundwater Circle, BWDB, Bangladesh.Islam, M.S., M.A.R. Akanda, M.N. Islam and M.A.Hossain. 2006. Development of Integrated Salinity Management Techniques for the Coastal Ecosystem of Bangladesh. Irrigation and Water Management Division, BARI, Joydebpur,Gazipur-1701.

Khan, L.R and A.K.M..M . Islam. 1999. Estimation of Groundwater Recharge for Flood Plain Aquifer in Dhunat Upazila of Bogra District. Journal of The Institution of Engineers , Bangladesh, 26/AE (1):19-27.

Koudstaal, R., S.E. Werners, Atiq Rahman, Saleemuhug and A. U. Ahmed. 2007.Considering adaptation to climate change towards a sustainable development of Bangladesh.Miah, M.M.U, M.A.Sattar, K.M.Haque and M.A.H. Choudhury. 2003. Kharif-2(Transplanted Aman), Drought Map, Easy Read (in Bengali). Bangladesh Agricultural Research Council and CIDATEC Project, Department of Agricultural Extension.

MPO. 1987. The Groundwater Resource and Its Availability for Development. Technical Report 5. Ministry of Irrigation, Water Development and Flood Control, Government of Bangladesh, Dhaka.

Prothom Alo, 2007. A daily newspaper in Bangladesh. CA Bhawan, 100 Kazi Nazrul IslamAvenue, Kaoran Bazar, Dhaka-1215. 23rd October, 2007.

Prothom Alo, 2007. A daily newspaper in Bangladesh. CA Bhawan, 100 Kazi Nazrul IslamAvenue, Kaoran Bazar, Dhaka-1215. 25rd October, 2007.

Roy, K. C., M. A. Sattar, M. H. Rashid, S. Ahmed, M. A. Wohab, M. Amain and M. A.Matin 2006. Developed Agricultural Machinery (in Bangali). Farm Machinery and Post Harvest Process Engineering Division, BARI, Joydebpur, Gazipur, Bangladesh. pp. 1-48.

Sarkar, M.A., A.A. Hassan and M.H Ali. 2007. A research Report on 'The Mega City Dhaka:I. Underground Water Table Condition - Long Term Trend Analysis and Future Prediction. Using a Computer Model. Bangladesh Institute of Nuclear Agriculture, Mymensingh-2200, Bangladesh. pp: 1-28.

Selvaraju, D. 2006. Livelihood Adaptation to Climate Change in Drought Prone Areas. Climate Change Cell. Department of Environment, Component 4B, Comprehensive Disaster Management Programme (CDMP), Government of Bangladesh.The University of Warwick. 2007. Climate Change and its Impact on Water Use in Field Crops. An internet Water Use Article.