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www.banglajol.info/index.php/JSF

Journal of Science Foundation, January 2013, Vol. 11, No. 1 ISSN 1728-7855

REVIEW ARTICLE

Sustainable Agricultural Development under Climate Change in Bangladesh

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Abstract

Climate change is no more an environmental concern it has emerged as biggest developmental challenge for the most vulnerable Bangladesh. The whole international community is also scared of catastrophic adverse effects of future climatic changes on different spheres of man and nature, e.g. deglaciation and sea level changes, submergence of lands, nations and major coastal lowlands, atmospheric dynamics including evaporation and precipitation, global radiation balance, photosynthesis and ecological productivity, plant and animal community and many more. This paper tries to focus the adverse impacts of climatic changes on the crop production, food security, yield gap and sustainable agriculture by crop intensification and diversification. The impact of climate on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends and thrives. Hilly committed research efforts showed technological progress as evidenced by release of 684 high yielding varieties of various crops and about 769 management technologies by NARS institutes, and universities. The greatest challenge for the future agriculture under climate change, we need improved and modified warning system, developed climate impact modules, build sufficient resilience of food system, comprehensive climate resilience strategies, develop database on climate. Also need top priority to mitigate the impact of climate change on agriculture through weather services, more research and extension service, agro advisories, insurance, community bank, intensify and diversify crop production system, modern high yielding varieties and management technologies for future sustainable agriculture.

Keywords: Sustainable, agriculture, climate change, Bangladesh

[Cited as: Faroque MAA, Asaduzzaman M, Hossain M. Sustainable Agricultural Development under Climate Change in Bangladesh. J Sci Found, 2013;11(1): 17-28]

1.0. Introduction

Agriculture is the backbone of the country and is synonymous to the food security of the country. Attaining food self sufficiency by 2013 along with ensuring food to all is adopted in the 'Vision 2021' of the Government of Bangladesh. Pressure for increased crop production is triggered by the rapid population growth and it is the most important challenge. Agriculture is the single largest productive sector of the economy and it contributes about 20.83% to the total gross domestic product (GDP) of the country in 2007-08 (BER, 2009) and employ

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48.4% workforce of the country. For these reasons, the government has put topmost priority to the agriculture sector.

Bangladesh is one of the most climate vulnerable countries in the world. Located between the Himalayas and the Bay of Bengal, the country is very prone to natural disasters. Climate change accelerated the intensity and frequency of occurrences of salinity, storms, drought, irregular rainfall, high temperature, flash floods, etc. that resulted from global warming that is directly and indirectly related to crop production. Ensuring food security for all is one the major challenges that Bangladesh faces today. Despite significant achievement in food grain production and food availability, food security at national, household and individual levels remains a matter of major concern for the Government mainly due to climate change. Bangladesh attained self-sufficiency in food production in 2010-2011 with a gross production of rice and wheat of 35.0 million metric tons where 10.46 million metric tons in 1971 (BER, 2011) which marginally met the country's requirement of 24.62 millions metric tons for the population of 148.69 million, taking slandered 453.6 g per capita per day requirement.

However, Bangladesh is endowed with a favourable climate and soil conditions for the production of a variety of crops all the year round. The rich genetic diversity, the richness in ecosystem diversity, and the vast untapped human resources can learn and adopt new skills have been the major points of comparative advantage in Bangladesh. Thus, there are ample opportunities for crop intensification and diversification balancing the production of major crops with that of minor crops. The crop diversification programme (CDP) was launched in the country during the early 1990's. A systematic arrangement of growing a variety of crops in rotation with rice was undertaken, based on farmers' own choice and performances with respect to soil and climatic conditions, thereby ensuring a variety of diverse dietary standards and nutritional status of the rural households. To enhance farmers' income through the production of high-value crops and to help maintain a better soil structure for long-term sustainability, a recent policy statement on crop agriculture has called for a departure from "rice-led" growth to a more diversified production base that includes several non-rice crops. The government is also implementing programmes to promote crop intensification and diversification involving high-value crops, fruits and vegetables, potatoes, oilseeds, pulses and spices through appropriate packages of seed-fertilizer-irrigation technologies as well as credit support.

This paper aims to provide background information for a discussion on role of agricultural technologies and its transfer against climate change the smallholder farmers in Bangladesh. It gives a brief account of the transformation of the agriculture sector in Bangladesh from the 1971 to 2012, which was characterized by a dramatic increase in agricultural production and productivity through major breakthroughs in technological innovations, and the more recent transformation, which is characterized by significant changes in diets brought about by increases in incomes, urbanization and globalization, and the resulting changes in production of high-value commodities and major transformation in the agro food industry. The paper then discusses the challenges faced by smallholders in addressing the problems related to sustainability of food production as well as agricultural diversification. Following this, the paper highlights some of the technological and institutional innovations that have been tested to address such challenges. It identifies some measures that the governments, the private sector and international development partners can take to support small farmers in dealing with emerging challenges and to promote cooperation for mutual learning and sharing experiences.

2.0. Climate Change And Crop Production

Agriculture is the most vulnerable sector as its productivity totally depends on climatic factors like temperature, rainfall, light intensity, radiation and sunshine duration, which are predicted to be erratic. Incidences of floods, droughts, high temperature, flash floods and floods, etc., are predicted to be more frequent and intense. Salinity intro could be more acute problem in future due to sea level rise.

2.1. Impact of Temperature on Crop Production

Every crop has a temperature range for their vegetative and reproductive growth. When temperature falls below the range or exceeded the upper limit then crop production faces constraints. A study found that 1°C increase in maximum temperature at vegetative, reproductive and ripening stages there was a decrease in *Aman* rice production by 2.94, 53.06 and 17.28 tons respectively. With the change in temperature (by 2°C and 4°C), the prospect of growing wheat and potato would be severely impaired (Islam *et. al*. 2008). Production loss may exceed 60% of the achievable yields (Karim, 1993). Higher temperature has negative effect on soil organic matter also.

2.2. Impact of Rainfall on Crop Production

Rainfall is one of the major climatic factors for crop production. All crops have critical stages when it needs water for their growth and development. Moreover excessive rainfall may occur flooding and water logging condition that also lead to crop loss. It was found that 1mm rainfall increased at vegetative, reproductive and ripening stages decreased *Aman* rice production by 0.036, 0.230 and 0.292 ton respectively. Scarcity of water limits crop production while irrigation coverage is only 56% as delivered by the Bangladesh Agriculture Development Corporation (BADC).

2.3. Impact of Sea Level Rise on Crop Production

Sea level rise affects agriculture in three ways, i.e., by salinity intrusion, by flooding and by increasing cyclone frequency and its depth of damage. Combined effects of these three factors decrease agriculture production in the coastal zone. Salinity intrusion due to sea level rise will decrease crop production by unavailability of fresh water and soil degradation. Salinity also decreases the terminative energy and germination rate of some plants (Rashid *et al.* 2004; Ashraf *et al.* 2002). The loss of rice production in a village of Satkhira district was investigated and it was found that rice production in 2003 was 1,151 metric tons less than the year 1985, corresponding to a loss of 69%. Out of the total decreased production, 77% was due to conversion of rice field into shrimp pond and 23% was because of yield loss (Ali, 2005). Sea level rise cause inundation of more area which is already reported by scientist. Therefore damage of agricultural crops will be more in future. About 1/3 of Bangladesh or 49,000 sq. km. area are influenced by tides in the Bay of Bengal. Through study it is clear that the inundation coastal inundation area will be increased in future with an adverse effect on crop production. In a study found that if sea level rise up to 1 meter, normal flood waves can be expected to increase from presently 7.4 meters to 9.1 meters (Butzengeiger and

Horstmann, 2004). In Bangladesh, about 15-17 million people will be displaced from the land inundation by sea level rise that will cost 12-16% of total land area (World Bank, 2000).

2.4. Impact of Flood on Crop Production

Flood has most deleterious effect on crop production of Bangladesh. The 1988 flood caused reduction of agricultural production by 45% (Karim *et al.* 1996). Higher discharge and low drainage capacity, in combination with increased backwater effects, would increase the frequency of such devastating floods under climate change scenarios. Prolonged floods would tend to delay *Aman* plantation, resulting in significant loss of potential *Aman* production, as observed during the floods of 1998. Loss of *Boro* rice crop from flash floods has become a regular phenomenon in the *haor* areas over the recent years. Considering all the direct and induced adverse effects of climate change on agriculture, one may conclude that crop agriculture would be even more vulnerable in Bangladesh in warmer world (World Bank, 2000).

2.5. Impact of Cyclone on Crop Production

Cyclone cause huge damage to production of crop. FAO/GIEWS Global Watch (2007) reported at the time of the passage of cyclone SIDR, the main 2007 "*aman*" rice crop, accounting for about 70% of the annual production in the most affected area, was nearing harvest (FAO, 2007). According to the estimate by Department of Agricultural Extension of Bangladesh, the loss in rice equivalent is at some 1.23 million tonnes, with 535,707 tonnes in the four severely affected districts, 555,997 tonnes in badly affected 9 districts and 203,600 tonnes in moderately affected 17 districts in Bangladesh.

2.6. Impact of Drought on Crop Production Due to Climate Change

Drought mostly affects Bangladesh in pre-monsoon and post-monsoon periods. During the last 50 years, Bangladesh suffered about 20 drought conditions. During 1981 and 1982 droughts affected the production of the monsoon crops only. The drought condition in north-western Bangladesh in recent decades had led to a shortfall of rice production of 3.5 million tons in the 1990s.

2.7. Resultant Impact and Economic Losses

Natural calamities intensified by climate change, damage field crops in every year. Unprecedented flash flood in the *haor* areas had accounted for a loss of about 150,000 metric tonnes of rice at the beginning of 2010. According to the World Bank and OECD, climate change may risk 40% of the overseas development assistance (ODA) to Bangladesh. Increase in country's GDP requires an increased growth in agricultural sector.

It has been reported that salinity affected areas in coastal Bangladesh have increased from 0.83 million hectares in 1973 to 1.05 hectares in 2009. Another study estimated that in eastern Bangladesh alone 14,000 tons of grain production would be lost to sea level rise in 2030 and 252,000 tons would be lost by 2075 (current agricultural production for the country is 30 million tons) (Karim and Iqbal, 2000).

3.0. Existing Adaption Mechanisms and Constraints

Adaptations to climate change for agricultural sectors includes the resilient variety, cropping pattern, irrigation techniques, sustainable land management, early warning, research, subsidies, supply of inputs etc. The country is trying to develop coping mechanism against natural hazards like floods, droughts, tidal-surges etc. through support of the Government.

3.1. Research

Researchers of institutions under National Agricultural Research Systems (NARS) are engaged to innovate technologies that will be resilient to climate change and ensure expected crop production. Research and developments of stress (salt, submergence, drought, high temperature) tolerant rice and wheat varieties can ensure food security by an increase in yield of up to 20%. Bangladesh Rice Research Institute (BRRI) has released salt-tolerant rice varieties like BRRI dhan 40/41/53/54, Submerge-tolerant varieties BRRI dhan 51/52, Drought tolerant BRRI dhan 42/43, and Salt-cold-drought tolerant BRRI dhan 56/57 using gene-marker technology. Seeds of BRRI dhan -47 varieties are multiplied by the Bangladesh Agricultural Development Corporation (BADC) and disseminated by the Department of Agriculture Extension (DAE) to the farmers for cultivation in the salinity prone southern districts. Innovation of short duration varieties like BR -33 by BRRI and BINA -7 by the Bangladesh Institute of Nuclear Agriculture (BINA) is successfully cultivated to avert so called *monga* situation in the northern Bangladesh. Bangladesh Agriculture Research Institute (BARI) is working with heat tolerant wheat and tomato varieties.

3.2. Irrigation

Irrigation is crucial in the context of climate change. Introduction of ‘Alternate Wetting and Drying (AWD)’ irrigation technique by the DAE has been found to be promising in increasing water use efficiency for crop production. Beside, canal and digging program is introduced by BADC and Water Development Board (WDB) to remove salt from soil. In the comparatively dry Rajshahi and Rangpur division (Barind region), Barind Multipurpose Development Authority (BMDA) ensures irrigation for rice where 100 hour free electricity bill for irrigation of last year’s *aman* season were provided to the farmers from the Ministry of Agriculture (MoA) in 2009. A 20% rebate in the electricity bills for irrigation throughout the country to encourage irrigated cropping has also been provided by the government. Both the BADC and BMDA are in pursuit of increasing irrigation coverage by taking newer projects and programmes in every year.

3.3. Sustainable Land Management Practices

Soil resources of the country are experiencing pressure for increased food production. Increasing cropping intensity and mineralization of soil organic matter exhausts the soils capacity to support crops. Soil Resources Development Institution (SRDI) is working to improve soil health and preserve it for future generation. The institute prepared Upazilla Land and Soil Resources Utilization Guide for 459 upazillas throughout the country that will help farmers to apply fertilizers according to the need based on fertility status of the soil. Moreover, MoA is working with the Ministry of Land to enact proposed Agricultural Land Conservation and Land Use Act, 2011 to safeguard agricultural lands from encroachments for developments. The MoA is encouraging farmers to use organic fertilizers like compost, farmyard manure to safeguard soil health. The farmers are advised to use green manure and biofertilizers instead of chemical fertilizers to sustain soil health. Agronomic practices like intercropping with leguminous crops, reduced tillage, alternate cropping, soil mulching, etc. are applied by the farmers to maintain soil fertility.

4.0. Crop Production and Consumer Demand Trend

4.1. Domestic production

Food grain production, particularly rice production has tripled in the last 40 years with the use of Green Revolution technology (high yielding varieties, fertilizers, irrigation and pesticide) coupled with growth of institutional infrastructure and a positive shift in public policy and market forces. As a major staple, rice occupies 77.0% of the gross cropped area and accounts for over 95.0% of food grain production (BARC, 2011).

Remarkable progress has been made in rice production during the last ten years. In 2001-02, rice production was 24.30 million tons, which has steadily increased to 33.54 million tons in 2010-11 (Table 1). Wheat production also decreased from 1.6 million tons in 2001-02 to 0.97 million tons in 2010-11. Similarly, pulses and oilseed production steadily declined mainly because of the loss of areas under these crops to Boro rice and other remunerative winter crops. Production of vegetables and fruits has increased, but at a slow pace from 1.59 million tons and 1.47 million tons in 2001-02 to 11.19 million tons and 3.56 million tons in 2010-11 respectively. Spectacular success has been achieved in the production of potato. It has made a quantum jump from 2.90 million tons in 2001-02 to 8.30 million tons in 2010-1 (Table 1). Fish production increased from 1.89 million tons in 2001-02 to 2.89 million tons in 2010-11 (Table 2). Meat, milk and egg production has also increased significantly over the last ten years (Table 2). But the shortage is still present.

Table 1: Domestic Production (Gross) Trend of Food Grains, Potato, Pulses, Oilseeds, Vegetables and Fruits (2001-02 to 2010-11)

(Million MT)

Years	Food grain		Potato	Pulses	Oilseeds	Vegetables	Fruits
	Rice	Wheat					
2001-02	**24.30**	**1.61**	**2.90**	**0.35**	**0.39**	**1.59**	**1.47**
2010-11	**33.54**	**0.97**	**8.30**	**0.72**	**0.84**	**11.19**	**3.56**

Sources: BBS, DAE 2011

4.2. Growth

Crop sub-sector growth has been highly unstable varying from 5.23% in 2005-06 to 4.82% (estimated) in 2010-11(Bangladesh Economic Review, 2011). This shows that it is possible to enhance growth of crop agriculture with appropriate use of production inputs under favourable climatic conditions. On the other hand, growth instability in certain years indicates that crop agriculture is highly vulnerable to natural disasters and unpredictable climate behaviour. Growth of crop agriculture also depends on input availability, input quality and input-out price. Growth potential is high in livestock sub-sector. According to partial figures from the Bangladesh Economic Review, 2011 the livestock growth rate in 2010-11 was 3.54% and 5.44% for fisheries sub-sector.

Table 2: Fish, Meat, Milk and Egg Production Trend (2001-02 to 2010-11)

Year	Fish (MnT)	Meat (MnT)	Milk (MnT)	Egg (Million)
2001-02	**1.89**	**0.78**	**1.78**	**4424**
2010-11	**2.89**	**2.95**	**1.98**	**6078**

Sources: DLS, DoF 2011

4.3. Per capita Availability

In estimating the per capita availability of food items, BARC calculated on the population size of 119, 130 and 148.69 million for the year 1994-95, 2004-05 and 2010-11 respectively and the per capita food intake figure published by BBS in 2010 (Household Income and Expenditure Survey, 2010). Accordingly, per capita availability of cereals (rice and wheat) has been found to increase from 374 g/day in 1994-95 to 647 g/day in 2010-11 (Table 3). Sharp increase in per capita availability of potato and vegetables is seen in the last four years, while the per capita availability of pulses and oilseeds has remained stagnant or declined. Availability of meat, milk and egg has also increased as shown in Table 4. Per capita fish availability increased from 27 g in 1994-95 to 56 g in 2010-11.

Table 3: Production and Availability of Major Food Items (1994-2011)

Food Items	Production (million tons)			Availability (g/capita/day)		
	1994-95	**2004-05**	**2010-11**	**1994-95**	**2004-05**	**2010-11***
Cereals	18.08	26.13	35.0	374	464	647
Potato	1.50	5.95	8.30	32	108	153
Pulses	0.53	0.31	0.72	11	10	13
Oilseed	0.48	0.56	0.84	10	10	15
Vegetable	1.21	6.50	11.19	21	108	207
Fruits	1.41	4.60	3.56	24	68	65
Fish	1.17	2.10	2.89	27	41	53
Meat	0.48	1.06	1.90	11	21	35
Milk	1.52	2.14	2.95	35	42	54.60
Egg (Million)	2400	5623	6078	19**	41**	41

Source: BBS 2011, DAE, DLS, DOF, BARC * Population 148.69 million in 2011, ** per year

4.4. Current Availability and Gaps

People of Bangladesh take more rice rather other cereals, vegetables & fruits and animal protein. The total requirement of cereals in 2010-11 is estimated to be 23.64 million tons, based on 453.6 g/capita/day consumption (BBS Household Income and Expenditure Survey 2010) for a population size of 148.69 million. Against this, production of cereals (cleaned rice and wheat) in 2010-11 is estimated at 31.50 million tons after deduction of 10% for seeds, feed and wastage. Potato production is reported to be surplus by 6.25 million tons. Gap between requirement and production of other important food crops and livestock products are wide (Table 4). These gaps are likely to be widen by 2015, if appropriate policy and development interventions are not taken with urgency.

Table 4: Projected requirements and production of major food items in 2015

(Million MT)

Food Items	Food Production in 2010-11 (mT) (less 10%)	Requirements in 2015 (mT) (less 10%)	Production in 2015 (mT) (less 10%)	Surplus (+) Gaps (–) (mT)
Rice & wheat	31.5	25.29	35.00	+9.71
Pulses	0.65	2.32	0.97	-1.35
Oilseeds	0.76	1.28	0.90	-0.38
Vegetables	10.07	9.58	9.82	-0.24
Fruits	3.52	2.90	5.15	-2.25
Potato	7.47	3.48	10.00	+6.52
Fish	2.8	3.25	4.00	+0.75
Meat	1.71	0.98	2.45	-1.47
Milk	2.66	14.29	4.54	-9.75
Egg (million)	54702	16297	11052	-5245

Source: BBS, DAE, BARC, DLS, DOF, Requirent food in 2015 calculated by population 159.07 million

5.0. TECHNOLOGY DVELOPMENT & YIELD GAP

5.1. Present Status of Technological Development

There was a magnificent technological progress, as evidenced by release of 58 HYV rice varieties and 582 high yielding varieties of various crops by NARS institute. In addition to varietal improvement, research institutes developed 597 management technologies for high performance of high yielding varieties to maximize the yield (Table 5). These technologies contributed to increase productivity, intensification and diversification of farming systems.
Besides institutional research, public universities and other public institutes have so far developed 102 varieties and 172 management technologies to contribute the sustainable development of agriculture (Table 6). In addition to research institutes and universities, some agricultural private companies imported 174 varieties to contribute in the agricultural economy (Table 7).

5.2. Productivity and yield gap

Farmers had generally grown crops with low inputs and less use of appropriate management technologies. As a result production is lower than expected or potential. Considerable yield gap exists between the potential yield and farmer’s actual yield under different cropping pattern (Table 8). It is possible to minimize the yield gap and demand gap by the use of improved varieties, increase in area of crops, and adopting improved management technologies. The reduction of such production gap will reduce import crop from foreign countries and will make sustainability in production to face the challenges. It may be mentioned here that the minimization of yield gap would be possible through participatory research and development. Attaining of food self-sufficiency is possible through proper adaptation of existing generated technology available in the country.

Table 5: Technology Developed By the National Agricultural Research Institutes

Research Institute	Variety Technology (no.)	Management Technology (no.)	Total (no.)
Bangladesh Agricultural Research Institute	330	293	623
Bangladesh Rice Research Institute	62	50	112
Bangladesh Jute Research Institute	39	23	62
Bangladesh Sugarcane Research Institute	41	5	46
Bangladesh Fisheries Research Institute	1	35	36
Bangladesh Forest Research Institute	0	44	44
Bangladesh Tea Research Institute	17	2	19
Bangladesh Institute of Nuclear Agriculture	45	32	77
Bangladesh Livestock Research Institute	1	59	60
Soil Resource and Development Institute	0	33	33
Cotton Development Board	12	10	22
Bangladesh Sericulture Research and Training Institute	34	11	45
Total	**582**	**597**	**1179**

Sources: *Kashem et al.(2008-10)*

6.0. Challenges, Opportunities and Prospects of Crop Intensification and Diversification

As Bangladesh is endowed with favorable climate and soils for the production of a variety of crops all the year round, so ample opportunities exist for crop intensification and diversification, balancing major crops production with minor crop production. Minor crop production has tremendous potential if seasonal fallow land is brought under irrigation with technology packages given to the farmers. Per acre yield of minor crops can be increased by improving agronomic management practices with the existing crop varieties. The main problems/constraints facing CDP relate to a variety of factors. These are marketing problems, ineffective agriculture credit supply, lack of the right kind of technology and low level of investment, non-availability of quality seed, shortage of draught power, lack of maintenance of soil fertility, lack of irrigation coverage, and ineffective research-extension linkages.

Introduction of the Crop Diversification Programme in agriculture has created a golden opportunity to commercialize the production by small holding farmers of those minor crop varieties which are highly profitable and remunerative and which are import substituting and export-oriented through the establishment of community storage and easy transportation facilities. This commercialization of CDP crops can help promote the establishment of joint-venture enterprises in Bangladesh and around the world that will buy, process and export those labour intensive crops and increase economic activity and the creation of employment opportunities at home and abroad.

Table 6: Technology Developed By the Universities and Other Public Institutes

Name of Universities/Institutes	Variety Technology (no.)	Management Technology (no.)	Total (no.)
Bangladesh Agricultural University	58	14	72
Sher-e-Bangla Agriculture University	02	0	02
Bangabandhu Sheik Mujibur Rahman Agricultural University	08	00	08
Bangladesh Sericulture Research and Training Institute	34	24	58
Farming System and Environmental Studies, BAU, Mymensingh	0	80	80
Bangladesh Agricultural Development Corporation	0	27	27
Rural Development Academy	0	13	13
Bangladesh Rural Development Board	0	14	14
Total	**102**	**172**	**274**

Sources: *Kashem et al.(2008-10)*

Research on agriculture is given the priority thrust to support the increasing population with food, nutrients, clothing and housing from the decreasing land resources. In order to carry out research on CDP crops, Bangladesh Agricultural Research Institute (BARI) was given the top priority to develop variety and management technologies. The Department of Agricultural Extension (DAE), being the lead Government agency in the dissemination of technologies to the farmers, is playing an active and vital role with the help of some concerned NGOs to disseminate those extension messages to the farm families.

Table 7: Technology Developed By the Private Companies

Name of Companies	Imported Varieties (no.)	Total (no.)
Lal Teer Seed Company	70	70
Energy Pac Bangladesh	44	44
ACI Crop Production	10	10
Matel Seed Company	30	30
Supreme Seed Company	20	20
Total	**174**	**174**

Sources: *Kashem et al.(2008-10)*

7.0. Mitigation And Adaptation Under Climate Change Scenarios

Agriculture is one of the major sources of green house gas emission. Climate change has been a cause of serious concern if the agricultural sector has to grow in the context of country's overall economic growth, to respond to rural household's livelihood, country's food security and poverty alleviation. It may take some years to fully experiences the devastating effects of climate change on agriculture but the time is ripe for the government, private sector and public to have adequate concern, commitment and accountability to mitigate the impacts of climate change. Improving and modifying warning systems followed by efficient monitoring and watch. Developing climate impact modules that give a better understanding of how climate change may affect crop, livestock and fish farming and forestry at local level in order to be well prepared.

Table 8: Yield gap of major crops (t ha^{-1})

Crop	Potential yield at research	Demonstration	Farmers' practices	Yield gap
Aus rice	9.00	4.85	3.50	1.35
Aman rice	9.00	7.05	4.00	3.05
Boro rice	9.00	7.85	4.80	3.05
Wheat	4.00	3.00	2.12	0.88
Mustard	1.50	1.00	0.73	0.27
Lentil	1.65	1.40	0.75	0.65
Mung	1.17	0.75	0.68	0.07
Black gram	1.50	1.30	0.76	0.54
Grass pea	1.63	1.00	0.84	0.16
Sugarcane*	54.00	48.60	38.47	10.13

Sources: *Kashem et al.(2008-10)*

Building sufficient resilience of food systems to avoid enormous future economic losses in agriculture, livestock, fisheries and forestry. Evolving comprehensive climate resilience strategies comprising risk assessment, developing of varieties that can perform well in stressful and adverse conditions, better land, water and livestock management and bringing about specific changes in agricultural practices that can respond to climate change strongly and effectively. Developing a database on climate, soil and water use and crop yields to assess, map and monitor land use performance under given technology conditions. Assessment of how vulnerable our food system is and how we can adapt agriculture, livestock, fisheries and forestry to future climate related disasters. Increasing coastal inundation, stalinization and erosion as a consequence of sea level rise and human activities and contaminate and reduce the size of productive agricultural lands, thereby threatening household's livelihood and country's food security. Steps to mitigate the impacts of climate change on agriculture need top priority. Assisting farmers in coping with current climatic risks. By providing weather services, agro-advisories, insurance, community banks for seed and fodder. Intensifying and diversifying food production systems. Technology, input delivery systems and market links should be encouraged to restructure and revitalize as well as improving land and water management. Strengthening research extension and farmer linkage for enhancing adaptive capacity.

8.0. Conclusion

The climate change as realized through trends of temperature increase and rise in the concentration of carbon dioxide is a major concern. Multiple environmental changes will have consequences for global vegetation. To the extent that crop yields and ecosystems are affected, there can be important economic consequences. We are now experiencing the adverse effects of climate change. This paper also suggests suitable mitigation options and techniques to sustain the agricultural productivity. Because almost all the developing and developing countries suffer some social and technical constraints that may not necessarily result in sustainable production over long time frames. But a concerted adaptive strategy which is politically appropriate, socially viable, culturally acceptable and environmentally sustainable is need of hour for vulnerable climate.

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