CONVERGENCE OF POLICIES AND PROGRAMS FOR SUSTAINABLE AND CLIMATE RESILIENT AGRICULTURE

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Mainstreaming Climate Change

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MAINSTREAMING CLIMATE CHANGE
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1 INTRODUCTION

Climate Change has been one of the major threats to Bangladesh economy. The potential impact of climate change is going to be much greater on Bangladesh from 2030 and onwards than what it has been observed or experienced today (Asian Development Bank, 2011). Hertel, Burke and Lobell in their research predicted that Bangladesh would experience a net increase in poverty by 15% by 2030 while food exporting countries like the Philippines and Thailand would benefit from food price rises due the climate change (Hertel, Burke, & Lobell, 2010). IPCC AR5 documents produced by the Working Group II also predicted that coastal area of Bangladesh and the rice agriculture in both the floodplains and in coastal deltaic regions will be affected. The report says:

… rice cultivation period will be prolonged by approximately 25–30 days. This will allow greater flexibility in the cropping season than at present, resulting in a reduction in the frequency of cool-summer damage in the northern districts. Sea-level rise threatens coastal and deltaic rice production areas in Asia, such as those in Bangladesh and the Mekong River Delta. (IPCC AR5, 2014)

Similarly, a World Bank report asserted that periodic inundation in the coastal regions of Bangladesh by saline water due to climate change is likely to affect livestock production as the grazing fields are submerged with water (The World Bank, 2000). This is also true in the floodplains of Bangladesh where grazing land will be increasingly under threat of flood due to climate change. At the same time, during cyclones and floods, it is livestock, poultry and fisheries sectors which are severely affected due to inundation and breach of embankments in Bangladesh.

The above preamble on the consequences of climate change on Bangladesh stipulates that Bangladesh should take 'action' in order to deal with both the current and future threats of Climate Change on its agriculture. It is also important to recognize that future impacts of Climate Change will be much larger that what is currently being felt in Bangladesh. Therefore, there is a need for realigning policies and programs of agriculture in Bangladesh. This paper examines the policies and programs on agriculture in Bangladesh and suggests strategies to build a more climate resilient agriculture.

2 OVERVIEW OF BANGLADESH AGRICULTURE[1]

The agriculture sector is the single largest contributor to income and employment generation in Bangladesh. The contribution of all sub-sectors of agriculture

[1] Part of this section is adapted from the CSEED Report on Agricultural Inputs and Food Safety in Bangladesh.

(includes crop and horticulture, animal farming, forest, and fishing) to the total GDP is about 19% (2014-15) and to country's export earning is about 9 percent. The government has accorded highest priority to this sector to enable the country to meet the challenge of food security and to make this sector commercially profitable. Special emphasis has been given on maintaining the fertility and productivity of soil – the country's most important natural resource at optimum level at any cost to face the challenges of growing more food in the country. The country has been also facing regular threats of natural disasters throughout its decades of progress. Despite the challenges significant progress was achieved in terms of the productivity of our agriculture.

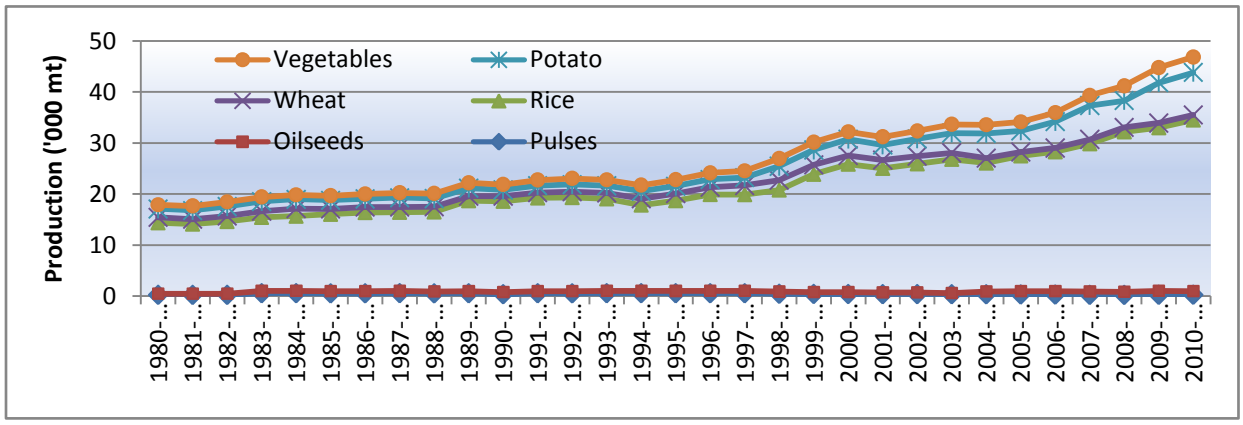
The National Agricultural Policy 2013 stipulated that the agricultural sector should ensure food and nutrition security of the people of Bangladesh through a gradual transformation process whereby it will be more commercialized and also is sustainable (Government of Bangladesh, 2013). The policy prescribed that Bangladesh's agricultural sector should be made resilient to climate change through adaptation measures.

2.1 Crop and Horticulture

The crop and horticulture sub-sector in Agriculture contributing to 8.99% of GDP (2013-14) plays a major role in Bangladesh economy and receives the utmost importance in various agriculture related programs. Rice agriculture tends to dominate the sub-sector because of land-coverage (nearly 80% of the total cultivated land area) and employment effects. The production of main staple rice has shown a long term growth trend of 2.8 percent per annum over the period from 1981/82 to 2006/07. Over the past decade, total rice acreage changed very little. However, the boro rice acreage has increased substantially with reduction in aus rice acreage and increased irrigation coverage. Boro rice accounts for nearly 60 percent of total food grain production in Bangladesh.

During the same period (1980-2011) production of potato and vegetables also increased considerably (Figure 1). For other crops growth remains unsatisfactory for a long period. During recent years both production and area of wheat, pulses and oilseeds have been greatly reduced.

FIGURE 1: TREND IN PRODUCTION OF RICE AND NON-RICE CROPS FROM 1980-81 TO 1010-11



Source: (CASEED, 2014) using data from BBS, 2007, 2009, 2011

A similar study by Miah and Haque found that while the overall rice production and yield has been growing in Bangladesh, it is mostly driven through boro rice cultivation. Acreage of land under aus and aman were falling (although production was rising for aman rice) over the last two decades (see Table 1). Growth rate for boro rice production over the past two decades (1990-2009) was 6% while it is only 1.7% for aman rice. It also shows that a very high growth rate for maize production while a negative growth for wheat (Miah & Haque, 2013). Overall, it shows the changing nature of our agriculture. Furthermore, this study also estimated geographical distribution of growth rates and found that while yield for all the major crops has shown a statistically significant positive trend, the rate of growth is not homogenous across the divisions of Bangladesh. Barisal, Khulna and Chittagong (the coastal belt), and Rajshahi (the drought prone region), and Rangpur (the flood-prone region) had experienced lower growth rate in rain-fed rice production and yield, for example (Table 1).

The study also analyzed the agricultural diversity and found that Bangladesh has been less diverse than that of India and Pakistan. This further provides evidences that challenge to deal climate change through agricultural diversity is higher in Bangladesh than that of India and Pakistan.

TABLE 1: GROWTH RATE OF AREA, PRODUCTION AND YIELD BY DIVISION AND BY CROPS FROM 1990 TO 2009

Crop	Barisal	Chittagong	Sylhet	Dhaka	Khulna	Rajshahi	Rangpur	Bangla desh
1. *Aus* rice								
Area	0.4^{ns}	-1.9***	-3.8***	-8.3***	-5.4***	-1.8*	-19.5***	-4.3***
Production	3.2***	0.2^{ns}	-1.9**	-6.1***	-2.8***	1.5^{ns}	-15.2***	-1.7***
Yield	2.8***	2.1***	2.0***	2.2***	2.5***	3.3***	4.3***	2.6***
2. *Aman* rice								
Area	-0.1^{ns}	-1.1***	-0.8**	-0.4^{ns}	-0.6***	-0.2^{ns}	-0.4^{ns}	-0.5***
Production	1.0^{ns}	0.3^{ns}	1.5***	1.8***	1.3***	1.4***	0.7^{ns}	1.1***
Yield	1.2*	1.4***	2.3***	2.1***	1.9***	1.6***	1.1***	1.6***
3. *Boro* rice								
Area	5.1***	1.5***	1.6***	3.3***	6.7***	4.1***	6.4***	3.8***
Production	7.3***	3.6***	5.2***	5.3***	8.8***	6.3***	8.5***	6.0***
Yield	2.3***	2.2***	3.7***	2.0***	2.1***	2.1***	2.0***	2.3***
4. Wheat								
Area	-2.2^{ns}	-5.4***	-1.9***	-2.8***	-3.0***	-0.7^{ns}	-0.6^{ns}	-1.9**
Production	-0.7^{ns}	-6.5***	-9.5***	-2.5*	-2.3*	0.5^{ns}	-0.2^{ns}	-1.2^{ns}
Yield	1.4**	-1.1^{ns}	1.4**	0.3^{ns}	0.7^{ns}	1.3***	0.3^{ns}	0.7^{ns}
5. Maize								
Area	38.4***	6.4***	--	30.4***	44.0***	29.7***	40.6***	25.5***
Production	45.4***	13.8***	--	41.1***	52.4***	43.9***	55.1***	37.9***
Yield	7.0**	7.5**	--	10.7***	8.4***	14.2***	14.5***	12.5***

Note: Area in acre, production in metric ton and yield in ton per acre
'***', '**' and '*' indicate significant at 1%, 5% and 10% level respectively, ns = Not significant

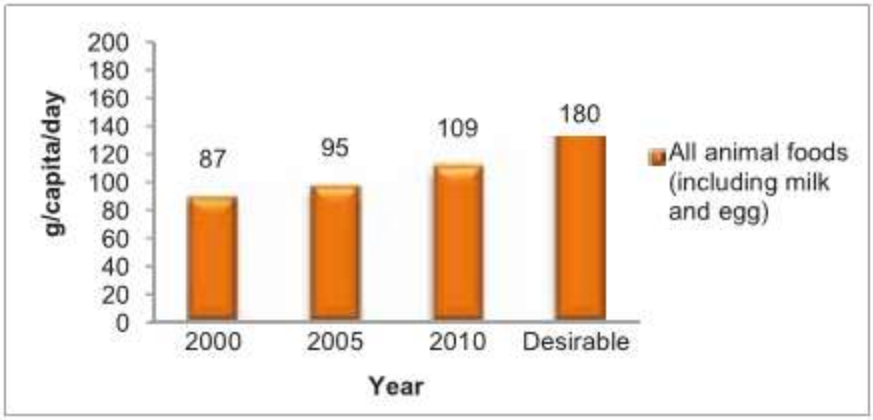
Source: Miah & Haque, 2013

Miah and Haque (2013) further analyzed the changing pattern of consumption of food in Bangladesh by using HIES data and showed that the trend in per capita consumption in rice is falling (from 471gm in 1990 to 459 gm in 2010) while per capita consumption in vegetables, fruits were growing. Consumption of maize, potato, egg, fish, milk, and meat also increased over the past two decades. As such, the future challenge for Bangladesh agriculture is more to deal with crops and non-crop agriculture beyond rice. Climate change, in this case, increases the risk of sustainability.

2.2 ANIMAL FARMING

Livestock and poultry or animal farming sub-sector in our agriculture plays a very critical role in supplying nutritional security to rural households. Its contribution to GDP is around 2.15 percent while its growth rate has been 1.78% in 2013-14. It is a major source of self-employment for people without cultivable agricultural land in rural areas. Contribution of Figure 2 shows that the overall trend in consumption of animal content in our food has been increasing but it is still below the desired level.

FIGURE 2: TRENDS IN CONSUMPTION OF ANIMAL FOODS IN BANGLADESH



Source: (NFPCSP, 2014); Note: Analysis using HIES data.

In terms of production this sub-sector had an average growth rate between 3 to 4 percent over the past decade. This growth had contributed heavily in terms of supplying nutrition to the people as well as in terms of promoting maize production in the country. This sub-sector's direct contribution to the economy was between 2 to 3 percent over the past five year but its impact in terms of raising agricultural income is much higher. The sub-sector was growing at a rate above 4 percent in the last decade but its growth rate suffered due to outbreak of avian-influenza in the country.

Studies have revealed that this subsector has been not only been a source of food and nutrition security of the country, it has also been a stable source of employment and income for rural women in Bangladesh (NFPCSP, 2014). The sector also contributes immensely in earning foreign currencies for Bangladesh through export of hides and leather.

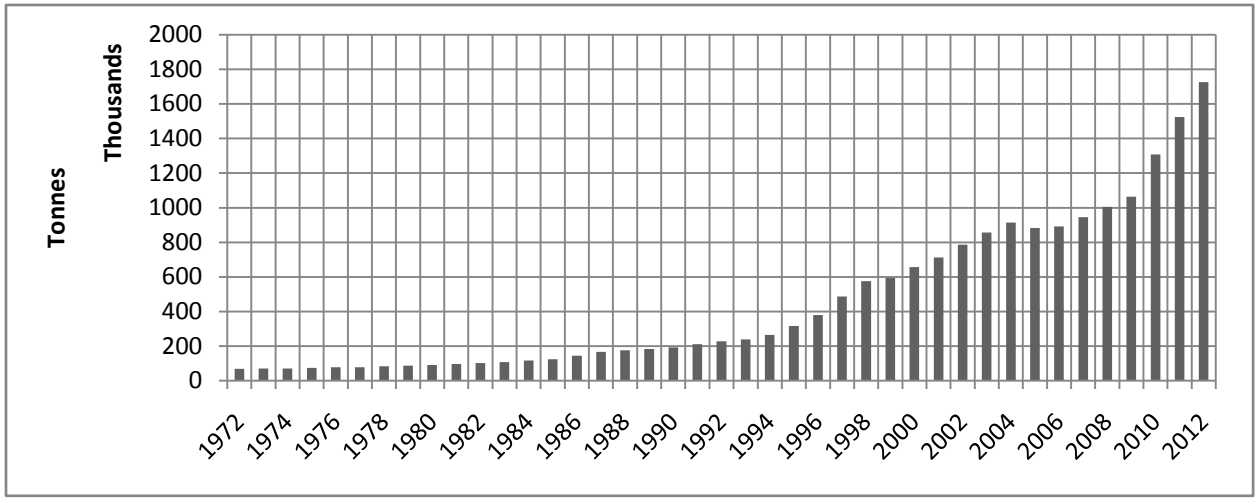
2.3 FISHERIES

Fisheries have been a very important contributor to the economy as well as a major source protein in our diets. Share of fisheries sub-sector to GDP has been between 3.19 and 3.32 percent over the past 5 year period. Its average growth rate varied from 4.6 to 6.5 percent during the same period. It has also been a source of our foreign exchange earnings. One of the major thrust of this sector has been to gradually shifting its production from capture to culture fishing with major emphasis on production of fishes in ponds and lakes. However, nearly 43.5% of the total production is coming from aquaculture (FAO, 2005-15). In culture fisheries there are major variations starting from pond fisheries, to shrimp fisheries, to integrated fisheries, to cage fisheries, to lake fisheries. Over the past decades inland fishing has not been expanding very much but there are significant growth of fishing in culture, coastal and marine fishing.

According to a statistics of 2009-10, nearly 17.85% of fishes in Bangladesh are produced from the Bay of Bengal, 46.6% are from culture fishing and the rest 35.5% are from inland freshwater capture fishing sector (Ministry of Environment and Forests, undated).

The Ministry of Fisheries and Livestock (MoFL), Department of Fisheries (DoF), Bangladesh Fisheries Development Corporation (BFDC) and the Bangladesh Fisheries Research Institute (BFRI) are the main organizations responsible for development of this sub-sector. Figure 3 shows the changes in production of fish over time from 1972.

FIGURE 3: TRENDS IN FISHERIES PRODUCTION IN BANGLADESH



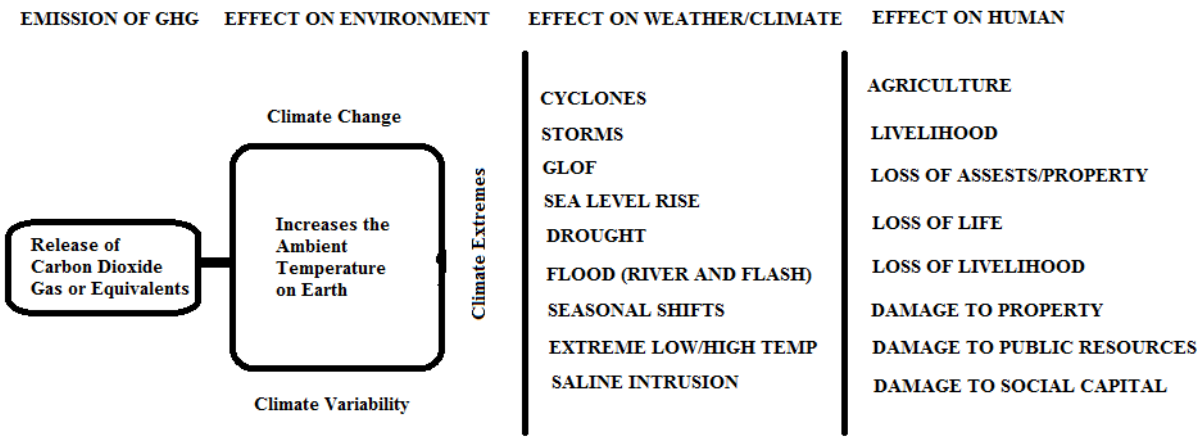
Source of Data: (FAO, 2005-15)

3 CLIMATE CHANGE REVISITED

Climate Change is a change in the long term pattern of the weather and hence it is often difficult to ascertain from layman's eye. It is linked to emission of carbon or equivalent gases into the atmosphere by human and natural reasons. However, it is the human or anthropogenic factors which are blamed by scientists for causing havocs in our life. In particular, release of excess CO2 produces a green-house like situation on earth resulting in rise in the ambient temperature. Such a rise in temperature has been responsible for changes in our climate and so it has consequences on our daily life.

The pathway through which climate change affects our daily life can be illustrated through the following Figure 4.

FIGURE 4: IMPACT PATHWAYS DUE TO GHG EMISSIONS



Note: Illustration by A.K. Enamul Haque, 2015

Figure 4 shows that release of CO2 or its equivalent gases (known as GHGs) into the atmosphere has primarily three effects – a) climate change, b) climate variability and c) climate extremes. These three events although are not mutually independent would cause changes in the natural weather and climate through various ways. These ultimately affect the life and livelihood of people in various ways. **Climate Change** or **Climate Variability** or **Climate Extremes** ultimately creates additional risks by changing the environment around us and so risk on human life and livelihood are increased. People who are unable to deal or cope with such risks become vulnerable.

According to Ali (1999) predicted possible impacts of climate change in Bangladesh through tropical cyclones, storm surges, coastal erosion and back water effect. The study looked at cyclone data of 119 years and shows that possible increase in cyclone frequency in the Bay of Bengal due to climate change. Different scenarios of storm surges under different climate change conditions (based on IPCC forecasts) were studied and examined possible loss of land through beach erosion due to sea level rise on the eastern coast of Bangladesh.

A World Bank study (2013) shows that Bangladesh will be among the worst affected countries in South Asia if an expected 2°C rise in the world's average temperatures occurs in the next decades. This is due to rising sea level rise, extreme heat, increased cyclones which will severely threaten its food production, livelihoods and infrastructure.

The report cited Bangladesh as one of more "potential impact hotspots" threatened by "extreme river floods, more intense tropical cyclones, rising sea levels and very high temperatures". A potential 10 year return cyclone in 2050 could expose 9.7 million people to more than 3 meters of inundation affecting agriculture and lives. (World Bank, 2013).

3.1 Risks to Agriculture

Taking queue from these, the following section analyses the threats that agriculture sector as a whole in Bangladesh is likely to face due to global warming. The analysis below follows the pathway explained in Figure 4 above starting from effects on weather and climate and its impact on Bangladesh agriculture. Furthermore, it shall be noted that although Bangladesh is territorially a medium-sized country in the world[2], it has 30 distinct agro-ecological zones (

Figure 6). The diversity in its agricultural zone, make Bangladesh more vulnerable to changes in climate.

The vulnerability of Bangladesh agriculture begins with its land classification. Table 2 shows that nearly 70% of its agricultural land is regularly flooded up to 90cm of water. As such, climate change with its possibility of sea level rise makes most of its agricultural land vulnerable to flooding.

Table 2: Land class in Bangladesh

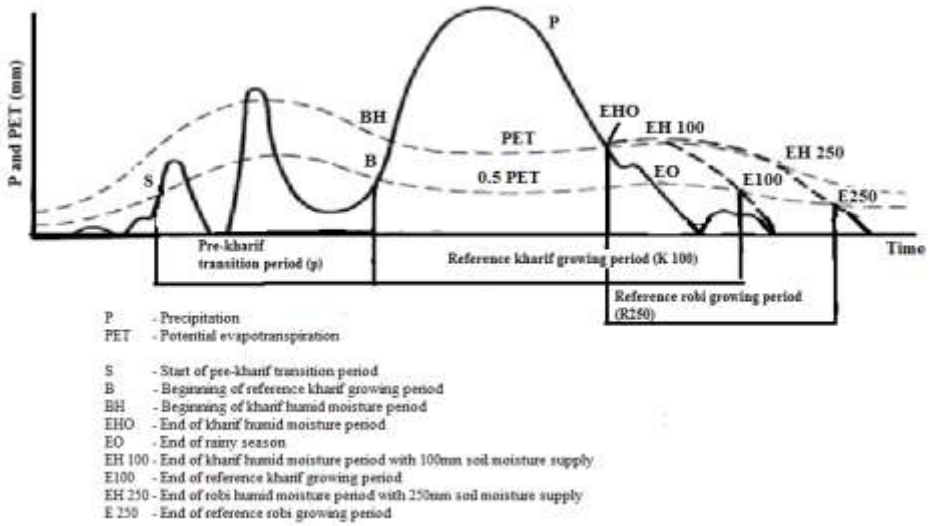
Land class	Land Characteristics	Area (ha)	% of land area
Highland (H)	Land which is above normal flood-level	41,99,952	29
Medium Highland (MH)	Land which normally is flooded up to about 90 cm deep during the flood season	50,39,724	35
Medium Lowland (ML)	Land which normally is flooded up to between 90 cm and 180 cm deep during the flood season	17,71 ,102	12
Lowland (L)	Land which normally is flooded up to between 180 cm and 300 cm deep during the flood season	11,01,560	8
Very Lowland (VL)	Land which normally is flooded deeper than 300 cm during the flood season	1,93, 243	1
Total		61,41,284	89

Figure 5 shows the cropping seasons of Bangladesh for a given year. It shows how intricate the relationship of our agriculture with the level of precipitation. As climate change is likely to shift the rain-fall pattern in a

[2] Area-wise Bangladesh is 82nd largest country in the world (out of 192 countries).

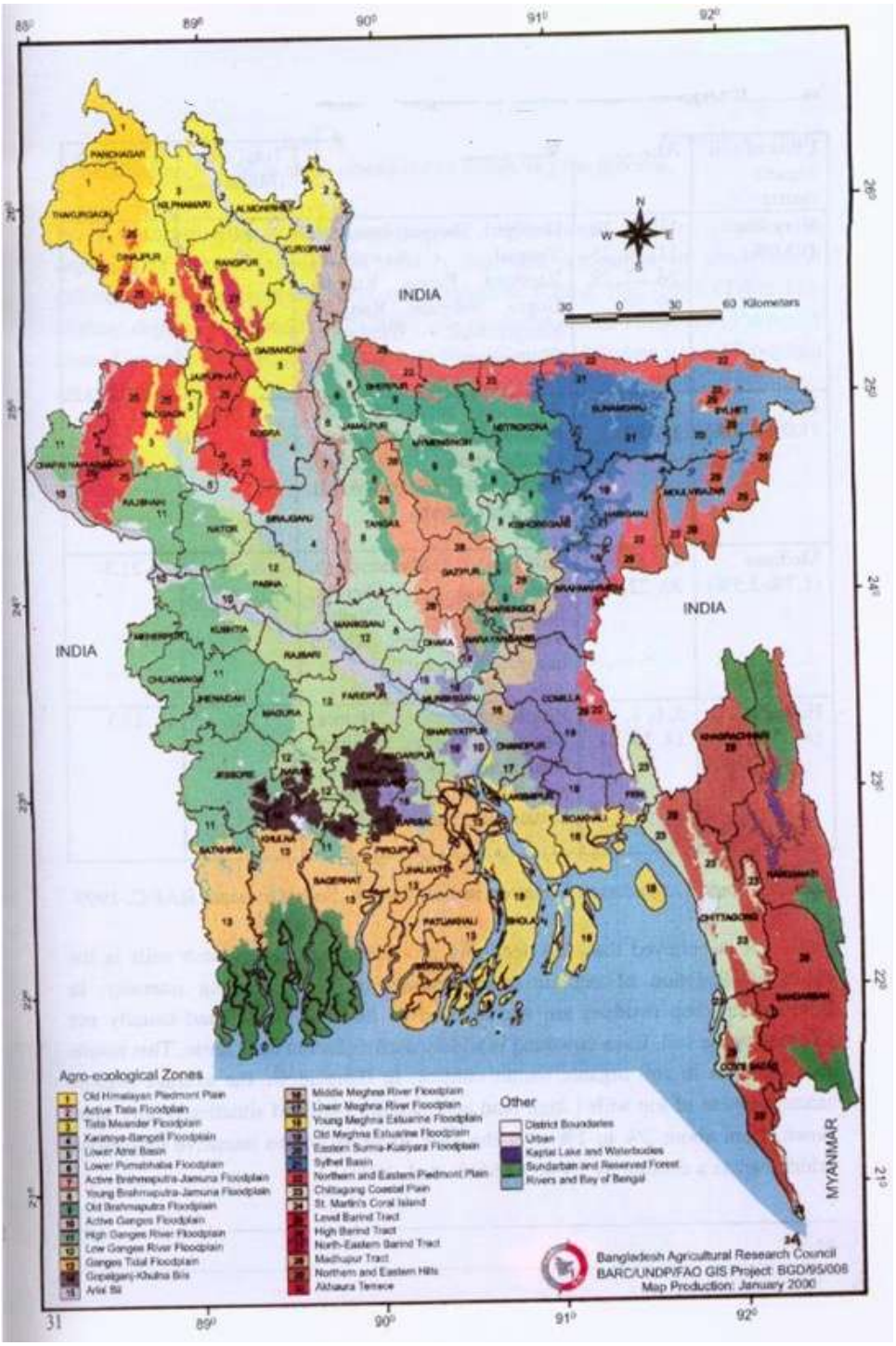
year or more specifically it is likely to make the pattern less predictable, it will increase the vulnerability of our agriculture.

FIGURE 5: RAIN-FED GROWING PERIOD UNDER DIFFERENT MOISTURE REGIME



Source: (Karim, 2015)

FIGURE 6: AGRO-ECOLOGICAL ZONES OF BANGLADESH

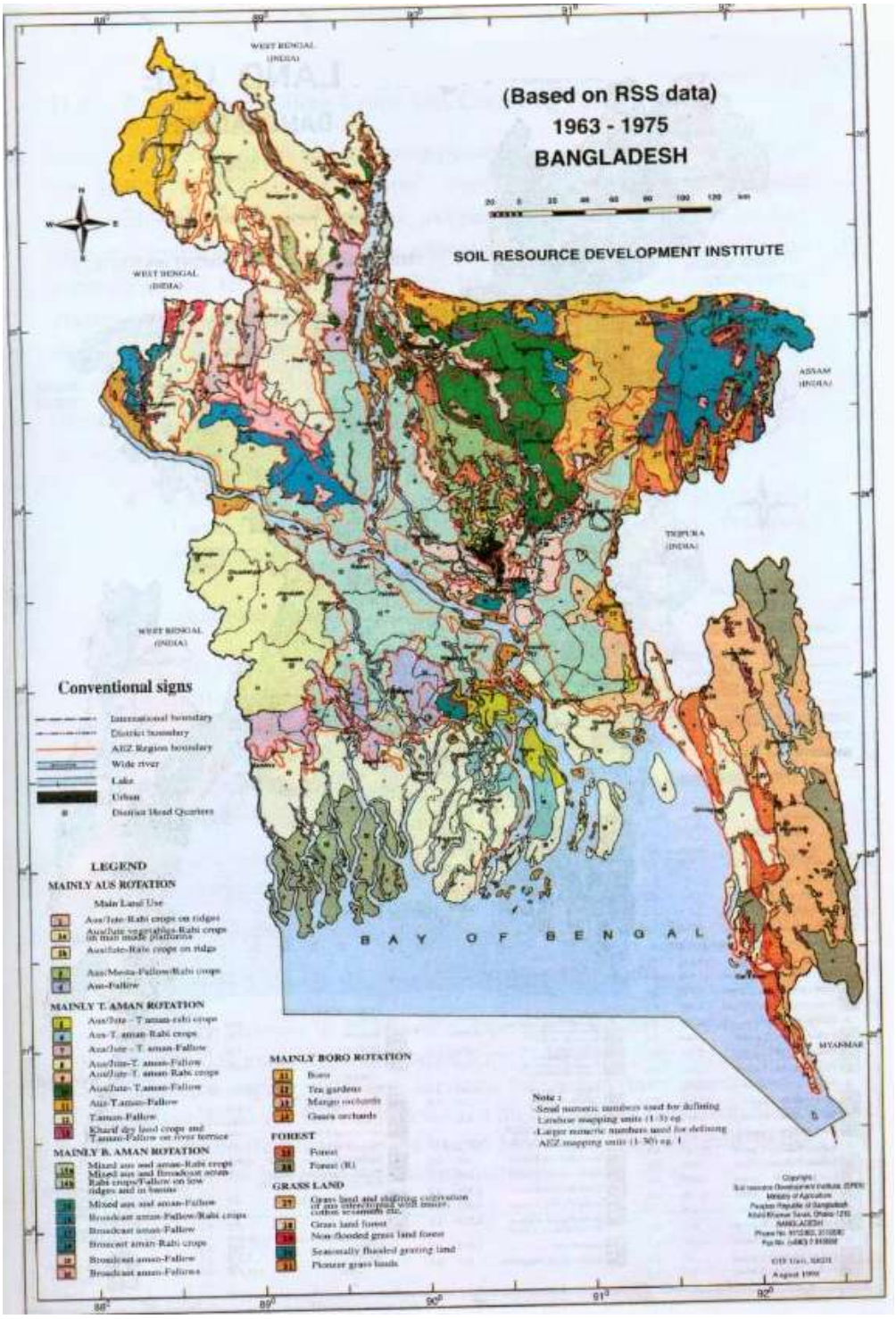


Source: BARC, 2000

Figure 7 further shows the diversity of Bangladesh's crop agriculture in terms of Agro-ecological zones. It shows Bangladesh agriculture is diverse in terms of its cropping seasons (based on precipitation pattern

shown in Figure 5) and so any changes in the precipitation pattern would make Bangladesh's crop sector highly vulnerable.

FIGURE 7: LAND USE IN AEZS OF BANGLADESH



Source: BARC, 2000

ON CROP AND HORTICULTURE

The crop and horticulture sub-sector of has been growing consistently since the independence of the country. At the time of independence, rice dominated the sub-sector and it is still the same. However, the rice varieties grown in the 70s were mainly indigenous varieties. Its yield was low and rain-fed rice (aman) was the season for rice cultivation. In the 80s, with expansion of irrigation technology and with introduction of HYV rices, rice farming gradually moved away from local varieties. This resulted in increased use and, of course, supply of agricultural inputs by the governments using subsidies. Now, boro rice has become the dominant rice season and it is dependent on use of water through irrigation, on fertilizer and on pesticides. In short, rice production in Bangladesh transformed from a totally nature-dependent production system to a modern-agriculture through a process of green revolution that began in the early 70s.

Governments of Bangladesh over a period of few decades built infrastructure to supply water, protect crop-land from flooding and developed market linkages in order to boost income of the rural people. The success was also evident – Bangladesh has been able to reduce its poverty from near 60% in the 70s to 26%.

All of these successes are now at risk due to climate change. The embankments / polders / dykes built in the 60s and 70s were not designed keeping in view the climate change in perspectives. As a result, food and nutrition security of the poor people of Bangladesh are at risks.

Crop and horticulture production in Bangladesh now faces the following additional risks due to changed climate, climate extremes, and climate variability:

a) Crop fields in the floodplains of Bangladesh (nearly 70% of total agricultural land) faces the risk of frequent flooding due to erratic pattern of precipitation in the catchment areas of the rivers (in the Ganges-Brahmaputra-Meghna basins);

b) Aman rice season which supplies nearly 40% of the total rice production in Bangladesh faces the risk of crop failures due to extreme or untimely rain and/or dry spells;

c) Crop and horticulture production is extremely sensitive to temperature during the flowering periods. Global warming and global dimming[3] together causes prolong periods of low temperature

[3] "Global dimming is thought to have been caused by an increase in particulates such as sulfate aerosols (a GHG) in the atmosphere due to human action. It has interfered with the hydrological cycle by reducing evaporation and may have reduced rainfall

and this would make the agriculture susceptible for crop failures. This is true for both amon and boro rice as well as for many horticultural products like winter vegetables and fruits.

d) Saline water intrusion in coastal crop lands making the crop and horticultural production at risk due to higher salinity in soil and in water.

e) Southern agricultural lands in Bangladesh will be facing shortage of sweet water for irrigation during boro season and so investments in polders to recover coastal floodplains for agricultural production are at risk. Most of the reclaimed or protected coastal agricultural land will face severe sweet water shortage during winter months.

f) Coastal agricultural lands during monsoon and late monsoon months (July – November) will be suffering for the risk of breach of polders and embankments due to increased incidences of storms and cyclones. Such storms and cyclones may not be of higher intensity but earthen embankments and polders were not built keeping in view the increased frequency of storms and cyclones. For example, cyclone Aila was a very low level cyclone (category 1) and yet it breached embankments in Khulna and Satkhira in 2009. Incidences like this might occur more frequently and southern agricultural production will be at risk.

g) Pattern of rainfall is also predicted to become erratic in the short run and this will create a problem for aman rice production. Aman rice may require supplementary irrigation for which agricultural irrigation system is not fully prepared.

h) Prolonged and frequent episodes of climate variability and climate extreme events (including saline water intrusion and drought) will force rural people to migrate outside and probably to urban locations (Ericksen, Ahmad, & Chowdhury, 1996).[4] This will create critical shortage of labor for agriculture and so the existing agricultural practices will be at risk.

i) Coastal agricultural lands in Bangladesh are protected by embankments or polders. Polders are designed with sluice gates which exploit the natural tidal cycles to drain excess water out of agricultural land during rainy seasons. Sea level rise (SLR) will

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in some areas. Global dimming also creates a cooling effect that may have partially counteracted the effect of greenhouse gases on global warming" (from Wikipedia).

[4] Ericksen, Ahmed and Chowdhury suggested "intensified migration from high to low density rural areas and to cities" due to climate change in Bangladesh in the next 50 years.

reduce the capacity of the sluices to drain excess water out of crop lands and so it might lead to prolonged water-logging in rainy seasons.[5] Therefore, aman rice cultivation in thousands of acres of coastal lands inside polders will be at risk (rainfall is a natural method of salinity reduction and so during aman rice season these lands are still suitable for cultivation).

j) Agricultural lands in the Surma, Kushiara, and Monu River basins have been facing flash floods during early monsoon months (April-May). These low lying agricultural lands in the haors of Sylhet and Mymensingh regions used to grow one crops of rice during winter seasons. Farmers in these areas use rice varieties which are of shorted duration than rice varieties in other parts of Bangladesh. Changes in precipitation in the GBM basins (including areas in the Himalayas) might bring the pre-monsoon floods earlier than expected or it might delay it (both of these situations are possible). The erratic nature of flooding will create significant uncertainties will increase risks of rice production in these regions. The picture here depicts the intricate relationship between rivers and flood plains in the haor basins.

k) Agricultural lands in northern parts of Bangladesh bordering India will be at risks of increased flow of water due to changes in the pattern of rainfall in upper riparian regions (including India, Bhutan, Nepal and China). Since GBM basin is the ultimate drainage route for these water and since the terrain through which these rivers flow are hilly and full of alluvial soils and these terrains are susceptible to erosions, all of the northern rivers entering into Bangladesh will bring additional volume of silts and sands to Bangladesh. As a result, many of the existing river channels will be filled threatening acres of agricultural lands with sand deposits, as well as threatening the capacity of our flood control infrastructure. This will put thousands of acres of agricultural land alongside the GBM basins at risk of bank erosion, flooding and accumulation of sands. Thereby, Bangladesh agriculture might lose fertile agricultural land. A World Bank report has confirmed this apprehension and suggested that

"climate change is expected to disturb the sediment balance. It is difficult to forecast whether there will be a net accretion or erosion. However, it is important to remember that newly accreted land along the coast may take

[5] An ADB study on drainage system of Khulna city using climate models predicted that due to SLR the existing sluice gates will be unable to drain water out of the city limits and so additional pumping capacity will be required to keep Khulna city free from water-logging (IWM and Alterra, 2010).

up to 15 years to develop full production potential, whereas land lost to erosion is in most cases valuable agricultural land" (The World Bank, 2000)

l) Other agricultural crops like sugarcane, jute, potato, winter vegetables and fruits will also be facing risks of production failure due to climate change. climate variability and extreme events.

m) Increase in the day temperature and decrease in the winter precipitation will severely reduce moisture content in the soil leading to severe moisture stress in the topsoil. At the same time, higher temperature would increase evapo-transportation leading to severe droughts in several parts of Bangladesh in winter months. Conequently, December would severely retard wheat and boro crops both in terms of germination and vegetative growth (The World Bank, 2000).

On Animal Farming

The animal farming in Bangladesh includes livestock and poultry farming which are currently growing and provide both income and employment to women. At the backyard level such farming is dependent on women's labor for rearing of their animals.

Bangladesh has been prone to flooding, cyclones and storms for many years. As such there is a high degree of tolerance and resilience in our agricultural towards these disasters. Animal farming is of no exception. For example, cattle farmers collect and store straws from rice fields, use water hyacinth and other aquatic plants and vegetations to feed their animals during rainy season every year. However, if the rice crops are affected by climatic events, it will create acute shortages of feed for animals and will increase the cost of livestock farming. In most likely cases, it will reduce the profitability of livestock farming, thereby, increase poverty in rural areas.

Keeping these in mind, the following paragraphs describes specific risks and threats for animal farming in Bangladesh as a result of changes in the climate change, climate variability and climate extremes.

a) Increased precipitation in many parts of Bangladesh will create shortage of food for livestock and so livestock farmers will face increased risks.

b) Increased rainfall or increase in the number of rainy days will increase the risk of diseases for their livestock, in particular for cattle and goat farmers.

c) Frequent flooding and shortage of feed supply in the floodplains will increase the price of feed and will force many farmers (particularly marginal households who are likely to stay at flood-shelters during

episodes of flooding) to sell their animals (hence reduction in prices due to over-supply) at a lower price or give away price. This will significantly affect the successes in our poverty alleviation programs (many marginal households were given goat, cows, and chickens). Therefore, in addition to poverty reduction programs, the food and nutrition security programs are also at the risk of failure.

d) Livestock farmers in the coastal belts will face increased threat of feed shortages due to saline water intrusion in their lands. The picture here was taken two years after the cyclone Aila hit Satkhira. It shows how scarce the grass is even in the winter season. This means increased threat of saline intrusion due to frequent cyclones or storms will put livestock farming at risk in coastal regions.

e) Drought prone regions will suffer from shortages of water needed for animal rearing. As a result, both coastal and drought regions of Bangladesh will be facing a new challenge in terms of livestock farming.

f) Flood and cyclone hit regions of Bangladesh are equipped with shelters to protect human life and properties. However, animals are left at the mercy of the nature to survive through the events. Well-to-do farmers often share their house with animals in order to protect them. However, poor households who take refuge at the flood and cyclone shelters cannot do so because these shelters are neither designed for animals nor are animal friendly. Therefore livestock farmers will be facing more risks due to climate change, climate variability and climate extreme events.

g) Both extreme low or high temperature are responsible for diseases in animals. As climate change, climate variability and climate extreme events are likely to generate spells of colder days and hotter days, the risk of diseases in animal farming (both for poultry and livestock) increases. In addition, poultry produces fewer eggs during high temperature and livestock has less milk and meat during high temperature (Ministry of Environment and Forests, undated).

ON FISHERIES

Many people perceive that climate change, climate variability and climate extremes are unlikely to have significant negative impacts on our fisheries sector. There are 1.3 million fish ponds in Bangladesh covering nearly 0.151 million ha of land. 55.3% of these ponds are under culture fishing

and the rest are not (FAO, 2005-15). According to this report, Barisal district has the highest number of ponds (12.11 percent) followed by Comilla (9.36%), Sylhet (9.1%), Chittagong (8%) and Noakhali (7.75%). The report further reveals that more than 200,000 ha of land in coastal areas are under shrimp farming. Nearly 260 different species of fishes are cultured in these areas and in cages, lakes and ox-bow lakes in Bangladesh. Most of the production system is traditional implying a production system with little or no feed. The fish in these farms entirely rely on natural feed.

On the other hand, capture fishing in Bangladesh is also widespread and it is of two different types: a) inland fishing and b) marine and coastal fishing. Most of the inland fishing is currently under severe pressure due to overfishing, habitat loss, water abstraction, drainage of wetlands, habitat loss, pollution in rivers and lakes, and so climate change is often hard to detect (IPCC AR5, 2014).

The following section discusses the risks to fisheries sub-sector due to climate change, climate variability and climate extreme events in Bangladesh.

a) Flood and tidal surges are responsible for washing away culture fish into the rivers and lakes. This situation poses two risks: a) fishers lose their capital and hence incur losses; and b) fresh water ecosystem becomes exposed to risks of contamination by new diseases and possible threats of being extinct (if any alien invasive is released due to this).

b) Hot weather spells in winters might dry-up the rivers and lakes causing the mother fisheries to either die due to shortage of water or of dissolved oxygen level in water or being caught by people. This increases the risk of extinction of many already threatened species.

c) Additional reduction of water level in a flowing river due to hot weather and increased evapo-transportation might also fragment the river into pieces of stagnant water bodies in the dry season. This will lead to closure of migration routes and hence mother fisheries fail to reach their spawning ground during the early months of rainy season (the spawning season of fresh water fishes).

d) Fisher communities engaged in capture fishing from large rivers and from coastal or marine areas are likely to be affected due to frequent cyclone or storm warnings. This will reduce their average number of days of work for fishing and will reduce income of millions of fishers.

e) Increased salinity in water due to sea level rise will affect the spawning ground for fishes in the mangrove areas and so total stock of fish population will be reduced.

f) Similarly, higher sea-surface water temperature will increase the risk of losing spawning and fishing grounds in coastal and marine ecosystems. As such, fish productivity is likely to be affected by climate change.

SUMMARY OF VULNERABILITY OF AGRICULTURE DUE TO CLIMATE CHNAGE

The overall summary on the vulnerability of our agriculture is summarized below. It emanates from several factors and these are: (Karim, 2015)

- Bangladesh a least developed country with predominantly low-lying alluvial plain and is defined to be the most vulnerable countries in the world as per IPCC/UNFCCC reports.
- Average temperature has registered an increasing trend of about 1^0C in May and 0.5^0C in November during the 14 year period from 1985-1998.
- The annual mean rainfall exhibits trends in Bangladesh. Decadal rain anomalies are above long term average since 1960s.
- Serious and recurring floods have taken place during 2002, 2003, and 2004. Cyclones originating from the Bay of Bengal have been noted to decrease since 1970 but the intensity has increased.
- Frequency of monsoon depressions and cyclones formation in Bay of Bengal has decreased.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season.
- The precipitation decline and droughts has resulted in the drying up of wetlands and severe degradation of eco-system

Crop and Horticulture

- Climate change will bring major change in reference growing periods, necessitating restructuring of crops and cropping pattern.
- Crop modeler/World Bank predict 7.4% loss of annual rice production.
- Temperature increase will drastically affect wheat area and productivity- decrease of 400 kg /ha for 1^o c increase.
- All other temperate crops are also susceptible to rise of temperature during Jan-Feb.

- Increase in fogginess and relative humidity increase incidence of pest and diseases and some times causes devastating failure of potato, pulses, etc.

- Due to unpredicted and erratic rainfall pattern crops yields are expected decrease 30% in 2100. Production of rice & wheat will reduce 8.8%, and 32% within 2050 respectively.

- 13% areas of Bagerhat, Khulna & Satkhira of southern coastal districts are salinity affected which will increase up to 16% in 2050 and 18% in 2100

Fisheries

- Most deleterious effect ~ Loss of Floodplains and destruction of habitat;

- Death rate of shrimp's fingerlings will increase if the water temperature is more than 32°C (CEGIS).

- Diseases of fish may increase.

- Carps culture may reduce due to saline water intrusion in the ponds and open water bodies.

- Production of sweet water fish will shrink and extinct if the sea level rise.

- Corals are vulnerable to thermal stress, if the sea surface temperature increases 1-3°c corals bleaching will occur frequently.

- Habitat damage of Hilsa fish.

Livestock

- Reduction in the quality and availability of feed and water;

- Heat and other environmental stresses arising from warmer, drier or more wet conditions;

- Preponderance of livestock parasites, pests and disease vector.

4 Review of Policies and Programs of the Government of Bangladesh

The Government of Bangladesh in 2011 adopted a 5-year country investment plan to revive its agriculture through effective public investment and support programs. In additional the Government has been building a number of national policies related to agricultural production, input supplies, research and development, agricultural extension services, and market access in order to ensure food and nutrition security of the people of Bangladesh. Since many of these policies are drafted in recent years so in theory, they had taken cognizance of climate change and its impacts into consideration either explicitly or implicitly.

This section provides a brief summary on these policies in terms of the policies and programs to be undertaken in the next 5 years to develop a comprehensive understanding on the extent to which these programs and policies embedded the threats to agriculture due to climate change.

4.1 Country Investment Plan

The Government of Bangladesh has adopted and updated a Country Investment Plan (CIP) for agriculture in 2011 considering agriculture, food security and nutrition to be major priorities. The policy and investment document took cognizance of the fact that over the last 40 years period, Bangladesh agriculture has tripled it rice production but it is now facing new challenges like higher density of population, climate change, and scarcity of water and land for agriculture. At the same time *persistent poverty*, malnutrition and vulnerability of poor people to price shocks shall also be confronted with while the country strive to become a middle-income country.

CIP was a document prepared through a joint effort of 14 different ministries of the Government of Bangladesh in order to secure investment in 12 priority programs to improve food and nutrition security in the country (see Table 3). The program costs were estimated to be US$7.8 billion over the period of 5 years and were aligned with the 6th Five Year Plan of the government. CIP has also been developed consistently with the National Food Policy and was built on National Seed Policy, Flood Action Plan, National Agricultural Extension Policy, National Water Policy (1999), Food and Nutrition Policy (1997), National Plan of Action for Nutrition (1997), Livestock Sector Road Map (2006), Fisheries Sector Road Map (20060, and the National Disaster Management Plan (2007-2015) and the Bangladesh Climate Change Strategy and Action Plan (2009).

TABLE 3: LIST OF 12 PRIORITY AREAS IN CIP 2011-15

Area		Priority Areas
Food Availability	1	Sustainable and diversified agriculture through integrated research and extension
	2	Improved water resource management and infrastructure for irrigation purposes
	3	Improved quality of inputs and soil fertility
	4	Fisheries and aquaculture development
	5	Livestock development with a focus on poultry and dairy production
Food Access	6	Improved access to market, value addition in agriculture and non-farm incomes
	7	Strengthened capacities for implementation and monitoring of NFP and CIP activities
	8	Enhanced public food management system
	9	Institutional development and capacity development for more effective safety nets.
Food Utilization	10	Community based nutrition programs and services
	11	Orient food and nutrition actions through data
	12	Food safety and quality improvement

Source: (GoB, 2011)

CIP addressed the issues related to sustainability and climate change in several manners. Firstly, it has explicitly emphasized on developing sustainable agriculture in its priority area 1. Second it has developed recognized climate change, disaster risks in the programmatic approach under the same area (see chapter 8 of GoB, 2011). Furthermore, the document says:

"... strategies for adaptation include: development of a master plan for accelerating the development and dissemination of climate resilient technology for unfavourable eco-systems; support to agro-climatic and ecological data bases; and the management of dry, wet and char land and biodiversity." (GoB, 2011)

In terms of enhanced food management system, the document further stipulates:

*"Priority interventions are building of modern storage facilities that are better equipped to adapt to the **climate change impacts** and **resist disaster shocks**, repair and rehabilitation of existing warehouses and improving ambient environment of stocks to maintain quality and increase shelf life". (GoB, 2011).*

Furthermore, CIP emphasized on strengthening research, extension services, infrastructure to copy with climate change situation, building capacity and creating awareness on climate change impacts and strengthening dissemination of e-technology for rapid adaption of climate

change vulnerabilities. On research the document stressed on research on developing stress tolerant variety, adaptation trial in the vulnerable climatic regions based on the priority of NAPA and BCCSAP, strengthening research on new insects and diseases due to climate change and developing new flexible HYVs to meet climatic hazards plus enhance livestock research for adaptation to climate change.

On climate change related adaptation the document mentioned development of master plan for accelerating climate resilient technology for un-favorable eco-systems, establishment of specialized food storage facility in disaster-prone areas, dissemination program on climate resilient sustainable technology, digitizing agro-climatic and ecological database and localize agricultural content, creation of a database on agricultural resources to determine climate change impact.

On water and irrigation issues, the document gave emphasis to developing strategies to reduce saline intrusion in coastal areas (including dredging of the Gorai River), increase efficiency of irrigation technology (including re-excavation of rivers), improved flood management, and erosion control etc.

On animal farming and fisheries related issues, the program called for using DRR strategies, and research and extension services to cope with risks of diseases.

4.2 National Agricultural Policy

The National Agricultural Policy was finalized in 2013 and like CIP it has also taken cognizance of the Environment Policy of 1992, Forest Policy of 1994, Fisheries Policy of 1998, Agricultural Land Use Policy of 2001, National Jute Policy of 2002, Livestock Resources Policy and Action Plan 2005, National Livestock Development Policy of 2007, National Food Policy of 2008 and National Poultry Development Policy of 2008 (GOB, 2013). One of the stated objectives of the Policy is to make Bangladesh agriculture sustainable and climate resilient in order to deal with climate change related threats. It has emphasized on research, extension services, technology transfers and information in order make this to happen.

4.3 National Food Policy

The National Food Policy Plan of Action (2008-15) has also recognized the threats of climate change and emphasized on developing long and short term forecasts or developing climate change related early warning system (EWS) to deal with risks on food production. (GOB, 2008).

4.4 National Water Policy 1999

The National Water Policy was developed in 1999 keeping in view the fact that water is essential for human survival and for economic

development of the country. The policy, therefore, called for actions to manage water resources in a comprehensive, integrated and equitable manner in order to ensure progress towards national goals of economic development, poverty alleviation, food security, public health and safety, and for protection of environment (GOB, 1999).

The policy did not explicitly cited the climate change related challenges in it but it had raised concerns about water scarcity during wet and dry seasons, sedimentation in rivers and bank erosion, managing surface and ground water resources through promotion of efficient technologies, responsible water use and also maintenance of water for eco-systems. It has also discussed about de-silting rivers, flood control and erosion control in order to improve water availability and reduce flood risks.

As a follow up of the National Water Policy of 1999, the government passed the Water Act in 2013 whereby authorities for various usages of water were defined. The Water Resources Ministry under the BCCTF undertook several projects to deal with re-excavation of water bodies, control of river bank erosion, protecting the edges from wave-erosion in the haors, improving coastal polders and so on.

4.5 Southern Master Plan

The Southern Master plan has been developed by the Government of Bangladesh in collaboration with FAO and covers 14 districts in the coastal region of Bangladesh. The objective of the plan was to provide a road-map for developing an integrated agriculture aiming at food security, poverty reduction and livelihood development for the poor. Since coastal regions are also susceptible to climate risks, this plan has considered issues related to climate change. It focused on increasing agricultural productivity, managing degraded land, developing climate resilient infrastructure and improving surface water irrigation systems, improving productivity of brackish water shrimp and capture fisheries, and developing smallholder dairy and poultry farmers (Ministry of Agriculture, 2013).

The plan explicitly considered issues like sea level rise, water logging, salinity, erosion and water stress in the region to develop the future plan and suggested activities to deal with these climate change effects.

5 Climate Change Related Policies and Actions

Climate Change in Bangladesh is not something for which we have to wait in future; it is already an ongoing phenomenon with which millions of Bangladeshis are grappling. It is precisely for this reason, every documents produced by the Government of Bangladesh had explicitly documented. To understand the gravity of the problem, Bangladesh is

also one of the first countries to produce the Climate Change Strategy Action Plan in the world in 2009. In the following sections, a few of these documents are analyzed in terms of the listed threats to our agriculture.

5.1 BCCSAP AND AGRICULTURE

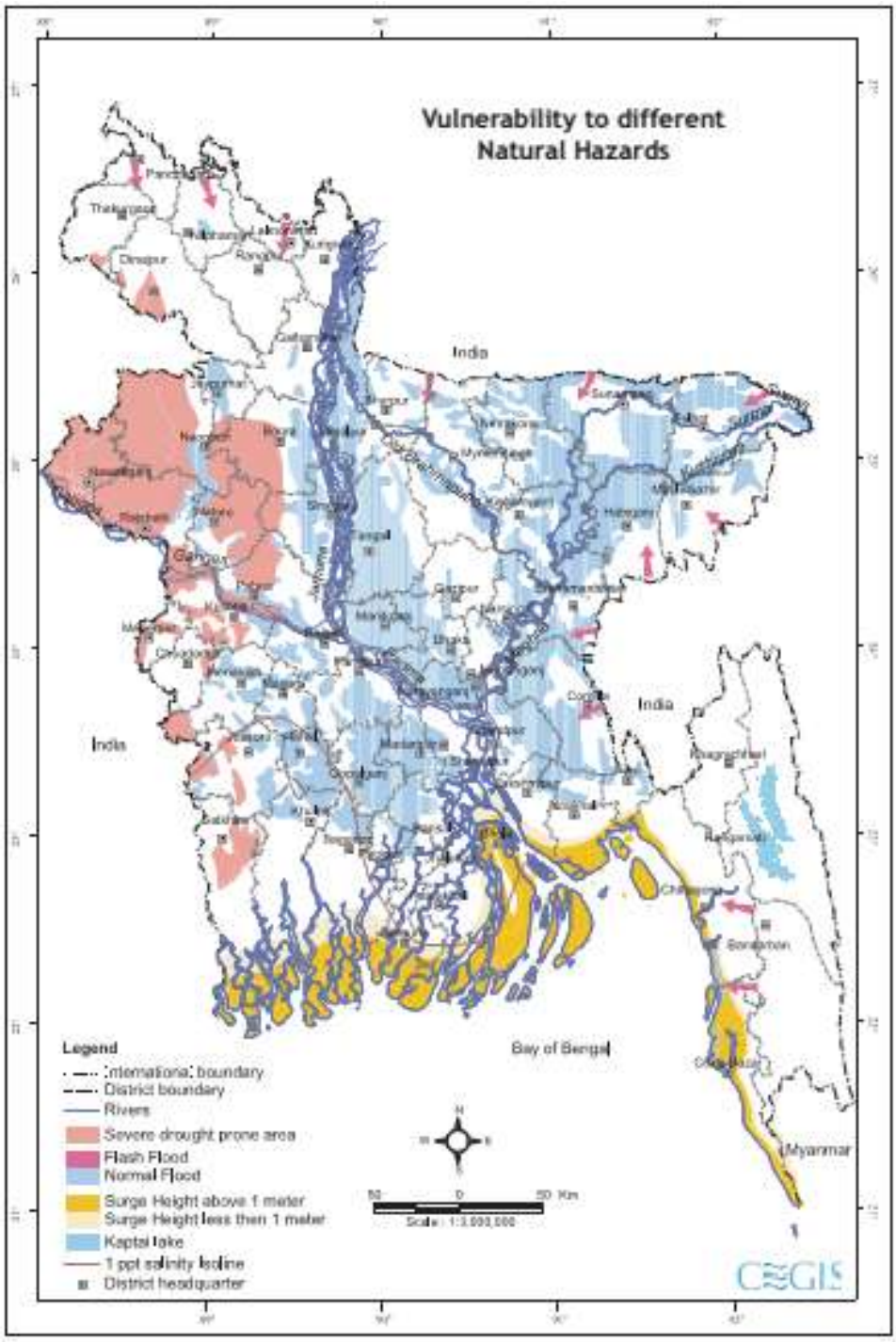
Using the 4th Assessment Report of IPCC, the document provided predictions on vulnerability of Bangladesh (see Figure 8). NAPA and BCCSAP identified few priority activities and programs on agricultural adaptation which are too general in nature. Effective adaptation measures must be specific to locations and local environmental conditions. Moreover, since climate change increases the **risk** and so make agriculture **vulnerable**, adaptation measures must be participatory in nature. While the farming communities are the among the most vulnerable communities in Bangladesh due to climate change, adaptation measures must be designed with caution to ensure that they are adapted voluntarily by the farmers and it increases the resilience of the community in dealing with climate change, climate variability and climate extremes.

The Figure 8 provides vivid illustration on risks that Bangladesh is currently facing in terms of natural hazards. The listed disasters shown in the figure include Flood (flash and river), tidal surges, and drought regions. The document assessed Bangladesh in terms of long-term consequences of climate change using IPCC framework and its Assessment Report #4 (AR4).

This Action plan is a 10 year program and was built on six themes/pillars: 1) Food security, social protection and health; 2) Comprehensive disaster management; 3) Infrastructure; 4) Research and knowledge management; 5) Mitigation and low carbon development; and 6) capacity building and institutional strengthening. However, most of these are based on long term predictions of climate change beyond 2030. What is currently missing in this document is that it did not provide an assessment of risks in terms of the three major effects of GHG emissions: namely Climate Change, Climate Variability and Climate Extremes (see Figure 4 above). This is expected from the National Action Plan on Climate Change which is currently being drafted by the Government.

Based on this document, the Government of Bangladesh has established the Climate Change Trust Fund (CCTF) through its own resources in order to make the economy adaptive to the changing climate. In addition, Bangladesh Climate Change Resilient Fund (BCCRF) has been established with support from development partners (like UK) and multilateral donors in order to make the economy resilient to climate change.

FIGURE 8: BANGLADESH AND ITS VULNERABILITY TO NATURAL HAZARDS



Source: CEGIS, Dhaka.

Source: (GOB, 2009)

A few activities undertaken under these initiatives include developing early warning systems for communities vulnerable to disasters, afforestation in the coastal belts to reduce tidal surges due to frequent cyclones and storms, research on developing saline resistant crops, development of short-duration crops for *haor* areas, development of drought resistant rice varieties for drought prone regions, and diversification of rural livelihood out of paddy crop.

BCCSAP also emphasized on promoting low carbon development path in its development strategies through strategic adoptions of mitigating technologies in its agriculture, energy and forest policies to reduce emission of GHGs. Reduction of GHG emissions is not a commitment of Bangladesh as it is a very insignificant emitter in the world.

5.2 NAPA

The National Adaptation Programme of Action (NAPA) was launched by the Government in 2005 to develop immediate and urgent priority actions for adaptation programs. NAPA identified projects for coastal communities since they were identified as the most vulnerable communities due to climate change in the IPCC Assessment Report 3 (AR3). However, it has been now replaced by the BCCSAP in 2008 and 2009 (revised version of BCCSAP).

5.3 NAMA

Bangladesh produces less than $1/5^{th}$ of 1 percent of the total GHG emission – as such it is a miniscule emitter of GHGs. Most of the emissions comes from a) large-scale use of flood-irrigation technology in rice production, and b) garbage produced in cities. Our per capital energy consumption is one of the lowest in the world and Bangladesh's energy penetration is also very low.

Agriculture is a major player in Bangladesh economy and national priorities in agriculture lies in ensuring food and nutrition security for its people. The country is losing nearly 1% of its land each year due to conversion into non-agricultural uses and its soil fertility is at risks due to its heavy dependence on rice cultivation. As it has been mentioned earlier that water is a scarce resource in Bangladesh and its sources are shrinking, the emphasis, in future, will be to promote access to irrigation facilities. This has already been suggested in the National Water Policy and in the National Agricultural Policy.

Keeping these in view, policies like reducing extend of flood-irrigation, improvement of carbon sequestration in soil and improving energy and water efficiency in agriculture were suggested under NAMA framework in Bangladesh.

6 STRATEGIES FOR DEVELOPING SUSTAINABLE AND CLIMATE RESILIENT AGRICULTURE

The most important issue, at hand, for Bangladesh in drafting the 7th Five Year Plan is to consider short term and immediate impacts of climate change, climate variability and climate extremes on agriculture so that the Plan can assist and allocate resources to make the agriculture resilient to climate change.

It shall be mentioned here that impact of climate change on Bangladesh shall be viewed from three perspectives separately. These are: a) long term effects of climate change due to global warming – like sea level rise and salinity rise in coastal areas, increased floods due to GLOF[6]; b) abrupt effects of global warming due to climate variability – like shifting of seasons, changes in the frequencies of cyclones and super cyclones, floods (river and flash) due to precipitation increase in the GBM basin, and c) slow onset disasters like frequent storm warnings; salinity increase due to drought or low rainfall, and so on. This is because adaptation actions required to reduce vulnerability against them are significantly different.

The following sections present a list of suggested strategies and actions to make Bangladesh agriculture climate resilient and sustainable in the next 5 years period.

6.1 ADAPTATIONS AGAINST SLOW ONSET DISASTERS

Saline intrusion in agricultural land in coastal areas of Bangladesh, increasing incidences of low intensity storms (preventing fishers to go for fishing) and drought are major examples of slow onset disasters in Bangladesh. All these have significant impact on productivity, income and employment in rural Bangladesh. Since climate change is a major cause of such disasters, Bangladesh in the short run shall be prepared to deal with these events in order to protect its farmers and fishers.

MONITORING AND RECORDING SLOW ONSET DISASTERS

Slow onset disasters are often ignored by policy makers and activists as a part of regular events. However, researches have shown that growing number of such incidents due to climate variability significantly limit ability of the people and make people living in coastal and in drought prone areas vulnerable (Asaduzzaman, et al., 2013). Therefore, government should plan a monitoring and recording mechanism for loss and damage in agriculture related to slow onset disasters like storm surges, low intensity cyclones, agricultural droughts, and saline intrusion.

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[6] Glacier Lake Outburst Flooding (GLOF)

Research and Extension

In order to make agriculture sustainable and climate resilient against slow onset disasters, research activities on developing saline resistant varieties of crops and horticulture, crop rotation to reduce salinity in soil, alternative choice of crops in saline environment, drought resistant crops, development of water storages in drought-prone areas, promotion of drip-irrigation technologies for crops and horticulture, promoting animal husbandry practices for drought and saline regions, shrimp and other fish culture in saline water and so on shall be targeted with special emphasis.

Similarly, the agricultural extension activities (including that of under the Ministry of Livestock and Poultry, and the Ministry of Fisheries) shall be aligned to promote agriculture in areas threatened by slow onset disasters.

Support for small scale coastal and marine fishers

Marine and coastal fishers are among the worst affected groups due to slow onset disasters. For example, due to low intensity cyclone or storm warnings fisher folks are advised to stay back instead of going to the rivers and to the sea. As incidences of such events rises due to climate variability, fishers lose many days of their work and so sea and coastal fishing becomes unprofitable. Special programs to compensate for no-fishing days shall be developed under BCCRF and/or CCTF for them. In this case, programs to promote alternative livelihood for them for these days might become counter-productive because it will gradually lead to reduction of fishing activities from the seas and from coastal areas.

Support for farmers in the drought-prone region

Farmers living in drought prone areas need special assistance to survive through difficult periods. This means they not only need drought resistant varieties but shall also have access to special facilities to purchase inputs at a special price during drought or they can be protected against losses through a nation-wide insurance program against drought (and flood) using a weather index. The fund for this shall be supplemented (in addition to premium) from BCCRF.

Building agri-diversity in coastal and drought areas

Farmer (crop and animal) and fishers in coast and drought prone areas need to build capacity to reduce their exposure to drought and salinity through a program to diversify their production system across the year. This means, specialized assistance in terms of extension services shall be available to them to find alternatives in case of being affected by it. In an ideal situation it means developing ability to mix farming (crop and horticulture), animal husbandry, and forestry production to protect against any one type of crop failure.

PROMOTING CROP SWITCH AND CROP ROTATION

Crop rotation often helps farmers to increase soil moisture or reduce salinity. Farmers in India, for example, use rotation of barley and rice to reduce salinity in soil. Similarly, rotation of shrimp and rice, wheat and rice, cotton and sugar-beet or crop switching from rice to wheat, barley, cotton, sugar-beet, or similar crops which are tolerant to higher degree of salinity can be promoted in coastal areas. At the same time, in drought prone areas, mung-bean instead of rice could be promoted to reduce risks of crop failure during drought.

SMART FARMING PRACTICES

Smart farming practices require making changes in the institutional and support structure of agricultural outfits of the government to reduce vulnerability of agriculture due to loss and damage from climate related events. This means:

- Ensuring access to resources for rehabilitating loss and damage in the sector
- Un-earth the famers' innovations and document into an inventory for upgrading and up-scaling in different Hot-spots;
- Expanding on-farm climate-smart activities and participatory adaptation trials on all agro-ecological niches to address climate change.
- Setting up of climate change Field Schools (CCFSs) in all climate vulnerable regions for quick of technologies and upgrading of farmers' innovations.
- Launching coordinated and joint programs involving field level GOs (DAE, DoF, DLS and FD), Local Government Institutions, NGOs and Private Sector organizations for reconstruction of damages to agriculture due to CC.
- All long-term structural measures to combat the threats of CC must be based on people's opinion and its ownership must be built ahead of implementation.

6.2 ADAPTATIONS TO CLIMATE VARIABILITY AND CLIMATE EXTREMES

Climate variability refers to erratic variation in temperature and rainfall pattern which are caused by climate change and climate extremes are events like cyclones, floods (river and flash), bank erosions, landslides. The literature on climate change is now in agreement that due to climate change these situations will occur in the short run and so adaptation

activities must be geared to deal with them. In the following we propose some activities or actions to make agriculture resilient to such events and hence sustainable.

IMPROVING SHORT TERM FORECASTS AND EARLY WARNING SYSTEM

Improving the predictions on weather is an important first step against losses due to climate variability. If crop and horticulture farms, animal farms and fishing farms are provided with an early warning systems against floods or cyclones it is possible for them to reduce its impacts. Therefore, programs to develop farming specific forecasts (currently Bangladesh Meteorological Department is using port-specific cyclone forecasts and Bangladesh Water Board is using river-point specific flood forecasts) it would help them to reduce losses.

In addition, a 3-day forecast against flood is often no-good for farming households. This shall be extended to at least 15 days and for these BMD, BWDB, and universities shall provided with research funds.

ENSURING SUPPLY OF AGRI-INPUTS FOR ALTERNATIVE CROPS

Erratic behavior of climate increases the risks of crop failure due to shortage of seed / seedlings and might require additional supplies of fertilizer in order to cope with damages due to early flood or droughts or an untimely cyclones. As a result farm households face possible loss of production. In order to deal with this, Bangladesh agriculture extension services and input suppliers may require to build additional capacity to compensate for damaged crops/seed/seedlings/fertilizers etc. Therefore, capacity of BADC, the agriculture extension services, the livestock and poultry extension services and the fisheries extension services must be increased.

CHANGES IN THE QUALITY OF EXTENSION SERVICES

Agricultural extension services in areas throughout the country shall be re-organized in order to ensure that they are equipped with multi-tasking ranging from providing assistance to all types of farmers from a single source. For this, all extension services shall be put under one directorate and technical assistance needed for extension services shall be provided to them through internet. This will reduce costs and at the same time will restore trust for extension services among farming communities.

RESEARCH AND INNOVATION

Research and innovation to develop varieties tolerant to flooding, extreme cold and hot weather conditions, improvement in the quality of embankment against erosion, ability to predict bank erosion, landslides, etc. shall be promoted in the country. For this, universities shall be provided with additional funds to enhance knowledge and research centers shall be assigned to use this knowledge into practices. Universities across

the country shall be mandated to develop appropriate technology and understand institutions relevant for their local conditions. It will help agriculture become sustainable and climate resilient. Similarly, veterinary and pest control research shall be emphasized to develop capacity to deal with increased pest-attacks and diseases due to climate variability.

SHELTERS FOR ANIMALS DURING FLOOD AND CYCLONE

Investment shall be made to build shelters for domestic animals during floods and cyclones to ensure that agricultural output do not suffer significantly during floods and cyclones. This will substantially reduce economic costs of cyclones and floods.

STRENGTHENING FLOOD-CONTROL INFRASTRUCTURE

Flood control infrastructure needs to be strengthened to deal with additional pressure due to climate variability and extremes. This might also require creating a new institutional mechanism to manage these infrastructures by the farming communities during emergencies.

SEED/SEEDLING SUPPLIES FOR CROP REPLACEMENT

Supplies of seed and seedlings or chicks or fish lings shall be ensured throughout the country (as required) to ensure quick recovery from damages during extreme and erratic weather conditions. For this, development of appropriate infrastructure and market linkages are needed and for this, electronic media might be used by extension services to inform farmers about the availability of supplies.

SUPPLEMENTARY IRRIGATION FACILITIES

The current flood irrigation technology in our agriculture use excessive water and it is not sustainable under the threats of climate change. Most of the existing structures are old and require renovation. As such, investments shall be made to reduce use of water in agriculture. Two alternative practices of irrigation like drip irrigation and wet-and-dry irrigation shall be promoted as well as the facilities shall be extended to ensure supplementary irrigation during aman season.

PROMOTING CULTURE FISHING

Inland capture fishing is under severe threat due to erratic weather conditions as a result of climate change. Therefore, capture fishing grounds during spawning seasons and also during winter months shall be monitored against excessive harvests. In addition, fish sanctuaries shall be guarded against harvests throughout the year. In order to do this, promotion of culture fishing to ensure supply of protein in our diets is a must. This is a good adaptation activity and the department of fisheries should be requested to develop elaborate plan for this.

BUFFER STOCKS OF FEED IN DISASTER PRONE REGIONS

Erratic and extreme weather conditions leads to crop failure and so it is responsible for shortages in supply of feed for animals and fishes in many areas. In most cases, rehabilitation programs often remain oblivious to this situation and so animal and fish farmers suffer the most. With increased demand for food throughout the country, it would create pressure on government to maintain stable supply of food. The trade-off is to develop buffer stock of feed for animal farmers who can quickly recover from the disasters and begin to supply animal products to the market.

DISEASE AND PEST CONTROL IN AGRICULTURE

Erratic and extreme weather conditions or climate variations are responsible for changes in the soil nutrients and soil quality. At the same time, temperature and precipitation changes might affect growth of pest population in crop and horticulture fields and increases disease attacks on animals. Managing such conditions shall be put to priorities by the ministries and departments in the agricultural sector. This requires develop capacity and deliver control of pests and diseases in agriculture.

6.3 ADAPTATIONS TO LONG TERM CLIMATE CHANGE

Threat to agriculture due climate change also occurs due to gradual rise of temperature over a long period of time. Studies including IPCC AR5 report have documented that such threats to agriculture will be greater and greater over time and by 2030 or later it will be evident in many parts of Bangladesh. This means sea level rise, water logging, floods and droughts will be a permanent feature in many parts of Bangladesh. Therefore, Bangladesh agriculture shall be made resilient through strategic changes. While some of the consequences will be more prominent after 2030, preparation against such threats shall begin now. The following strategies are suggested keeping in view the long-term threats to agriculture posed by climate change.

ADJUSTING FLOOD CONTROL INFRASTRUCTURE AGAINST SLR

Coastal polders and flood control infrastructure throughout the country shall be adjusted against higher level of flooding and tidal surges. Currently, these infrastructures are built keeping in view the past 20 years cycles of floods and tidal surges. However, future floods and tidal surges will be much higher than the past if sea level rise and GLOF or melting of the ices in the Himalayas are kept in mind. Rebuilding such infrastructures will require investment over a decade or more. Therefore, the Bangladesh Water Development Board shall develop an action plan for adaptations against such floods and tidal surges.

ADJUSTING IRRIGATION INFRASTRUCTURE

Irrigation infrastructures in the country are currently meant to provide irrigation during winter months for boro season. In future, there will be need for supplementary irrigation during aman season. In addition, there will be need for more water if the current strategy of irrigation (flood irrigation) continues. Keeping this in mind, irrigation infrastructure shall be rebuilt within the next two decades using a master plan to provide water for agriculture. This might require a switch in the technology of irrigation from flood irrigation method to drip or wet-and-dry irrigation methods.

EDUCATION AND TRAINING

Farming communities across the country shall be made prepared to manage their production system under a completely different environment as long term climate change effects takes place. This might require a complete change in the structure of agriculture including animal and fish farming practices. This means, farmers shall be prepared with elaborate programs of training to deal with this. The ministries within the agricultural sector, therefore, develop new curriculum for education and training keeping in view the long term consequences of climate change.

FACILITATING MIGRATION

Studies on the effect of cyclone Aila confirm that migration will remain an important strategy to manage our agriculture from long term effects of climate change. In future, urban agriculture, in terms of animal farming and cage fishing, be a strategy to deal with threats of climate change. Migrant households coming from rural areas shall be provided with access to capital and other facilities as a part of adaptation activities to promote urban agriculture. At the same time, such migration will reduce pressure on land in rural areas and will make agriculture capable to deal with climate risks.

PROMOTING ALTERNATIVE LIVELIHOOD STRATEGIES

Off-farm activities in rural areas will be required to support agricultural farming (crop and horticulture, animal farming and fisheries) through supplies of inputs, feed, seed, pesticides, medicines, fertilizer, etc. Since agriculture will require quick recovery strategies, rural areas shall be promoted to produce and supply various inputs for quick recover of agriculture and adaptation against climate change.

RESEARCH AND INNOVATION

Research and innovation are needed to make agriculture survive against long term impacts of climate change. This includes developing alternative crops, shifting away from current practice of animal farming, and fishing

activities. This requires research and innovation to solve the problems for farmers.

For this, universities shall be provided with additional funds to enhance knowledge and research centers shall be assigned to use this knowledge into practices. Universities across the country shall be mandated to develop appropriate technology and understand institutions relevant for their local conditions. It will help agriculture become sustainable and climate resilient.

Institutional changes to coordinate post-disaster programs

Long term climate change consequences require a complete re-orientation of programs related to agriculture including possible changes in cropping pattern, changes in the cropping system, changes in the varieties of animals and also fishes. It will therefore, require institutional changes and changes in their orientation to deal with post-disaster rehabilitation program. For this, each department of the ministries under the agricultural sector need to develop elaborate plan of action and develop capacity for future.

Promoting access to finance through commodity exchange and insurance markets

Agriculture, in future, will become more and more capital intensive and so there is a need to improve access to financial resources for agriculture. Connecting the agricultural sector to commodity exchanges, insurance markets will become important to ensure a sustainable and climate resilient agriculture. Currently, commodity trading does not exist in Bangladesh and similarly insurance programs to protect agriculture against weather abnormalities are also absent. Bangladesh needs to understand and develop strategies to spread its risks beyond the agricultural sector. Commodity exchanges and insurance markets are two most important strategies used in many countries including India. Bangladesh needs to start developing these institutions in order to be prepared for brace against long term consequences of climate change.

Combining mitigation with adaptation

Although Bangladesh is not required to reduce greenhouse gas emission, it can profitably use the avenues created by the global agreements like Kyoto Protocol, Clean Development Mechanism and also through REDD+ to combine mitigation options to reduce GHG emissions from our agriculture (crop agriculture, animal farming and fisheries) and use the additional cash supports for adaptation purposes.

6.4 General Measures for Building Resilience

As Bangladesh economy and its food security is largely dependent on sustainable agricultural practices, climate change vulnerability must be addressed by the government rapidly in order to avoid short term catastrophe. In order to ensure this, the following measures shall be adopted and implemented by the government immediately.

Capacity building in Government Institutions

Government institutions such as the department of agriculture, fisheries, livestock and poultry, fisheries and also relief and disaster management must be prepared to deal with climate induced natural disasters. For this, capacity building in project design, seed production, extension services for alternative crops, assessment of loss and damage due to disasters and a capacity to quickly provide assistance in terms of both compensating for the losses and to support alternative production must be ensured.

For this, these departments must be ready with climate-smart technology packages and should be able to support and extension services for farmers. At the same time, strategic and wise use resource utilization plan must bhe developed through R&D activities.

Varietal Development

To help farmers with ready-made substitutes during abrupt climate events, farmers must have access to stress tolerant varieties of crops, fishes and livestock. For crop farmers, it means salt and flood tolerant varieties of crops.

Salt tolerant variety

Already some development has taken place at the BRRI. BRRI has developed BRRI Dhan 47, 61 and 67, Bina Dhan 8 and 10 are so far more tolerant to salt in Boro season while BRRI 40, 41, 53 and 54 are few of the Aman season salt tolerant varieties, and BRRI 65 is the salt tolerant variety during Aus season. Research centers should use this success to prepare for more salt tolerant varieties of vegetables, and robi crops in future. BARI Gom 25 an BAU 1059 varieties are salt tolerant varieties of wheat and more such varieties should be developed to deal with climate change.

Flood tolerant variety

BR-22 and BR23, and Bina Sail are few of the Aman season variety of rice that are flood tolerant. Similarly, new varieties of vegetables and spices like pepper and onions (for example), for horticultural crops and fruits should also be developed in order to ensure that livelihood of millions of farmers.

Flash flood tolerant variety

BRRI 51 and 52, and Bina 11 and 12 are few of the submergible varieties of rice developed in Bangladesh which can survive two weeks of inundation. As monsoon seasons are susceptible to shifts due to climate change similar effort shall be considered to develop varieties of fruits and vegetables and other seasonal agricultural crops.

Drought tolerant variety

Certain areas of Bangladesh are prone to water shortages. Structural measures to provide water through irrigation might be under risk due to climate change. Therefore, BRRI has developed BRRI 56, 57 and 66 varieties of rice which are drought tolerant but similar R&D must be promoted to develop other drought tolerant crops and fruits. BARI Gom 26 is a new variety of wheat which is heat tolerant. Similar development are needed for other crops and horticulture. Similarly, poultry and livestock are also susceptible to heat and so new breeds shall be developed to deal with temperature rise due to climate change.

Shorter duration crops

Many areas of Bangladesh are susceptible to work shortage in certain periods of time. Similarly, as intensity of farming increases, farmers are likely to move to 4 crops a year in some areas of Bangladesh. For these farmers, climate change will create significant risk. This risk can be reduced with introduction of shorter duration crops in agriculture.

Management practices to deal with water and saline stresses

Some management practices, such as tillage, mulching, raised bed planting system, floating techniques of vegetables cultivation shall be promoted for crops to deal with climate induced disasters. Similarly, management practices for poultry, livestock and fish farms must be developed to deal with higher temperature due to climate change.

Doses of fertilizer and irrigation per acre for crops shall be revised through research in order to help farmers deal with increased water stress in saline and drought prone regions.

Developing management practices for conserving water and crop calendar for Bangladesh agriculture shall be improved through research in order ensure success of strains of Wheat, Maize Potatoes and Leafy vegetables.

Management practices like delaying the season to take advantage of rains might be promoted in drone-prone regions.

To ensure food security, programs like *ekti bari ekti khamar* shall be aligned in line with climate stress in different regions of Bangladesh.

Revision of water doses and promoting soil conservation practices in areas susceptible to erosion and water stress shall be made through research in order to deal with climate stresses.

Agricultural input supplies

Shortage of supplies of seedlings, fertilizer and pesticides often aggravate the food security as farmers fail to take remedial actions after floods, cyclones, and droughts. In order to reduce vulnerability of agriculture, input supplies shall be dealt with special emphasis. In particular, farmers in high-lands can be trained to become seedling suppliers. If these farmers can supply seedlings in time and are prepared to do this, farmers in flood-prone regions can begin their cultivation immediately after recession of flood water.

Quick remedial crops

The department of agriculture shall be prepared to deal with post-disaster cultivation plan with alternative crops. For this, the Department of Agricultural Extension shall be prepared to provide instruction to farmers to plan quick growing crops like millets, maize, and vegetables.

Water conservation practices

Farmers shall be made aware to conserve water besides their fields and to use water judiciously (like replacing flood irrigation with sprinklers and drip irrigation technology) in their crop fields.

Deep tillage and sowing techniques

Using deep tillage and plant seedlings or sowing seeds in deeper layers of the soil is a good strategy to deal with water stress in robi season. Research to make them robust for different crops is required for this. Similarly, extension services must be prepared for such advisory services.

Crop calendar adjustment

Adjusting crop calendar to avoid flood and drought, promoting relay cropping, using of multi-cropping are few examples which are useful to reduce vulnerability. These can be studied and promoted to deal with climate change in different parts of Bangladesh.

Tidal zone agricultural practices

Special attentions must be given to coastal areas who are susceptible to both rapid and slow onset disasters. Most of these disasters are likely to be on the rise due to climate change.

In order reduce their vulnerability to climate change, salt tolerant alternative crops like ground nut, water melon, knolkhol, maize, potatoes, millets shall be promoted in coastal areas.

At the same time, fish-on-a-cage, floating farming of vegetables, promoting homestead farming (horticulture) must be given special emphasis for coastal zones.

Cultivation of beans, varieties of gourds, okra, and other vegetables on embankments and on raised land surrounding fish farms are also useful to reduce vulnerability of agriculture due to climate change in tidal zones.

Multi-cropping like fish and vegetable farms, poultry and fish farms, vegetable and horticultural farms could be promoted through special projects to reduce vulnerability in coastal and in other regions.

Agricultural practices in water-logged areas

Farmers can to use pumps to reduce water from water logged areas to prepare land for robi crops in water-logged areas. This can be suggested through introduction of collective efforts or through use of charges by the government institutions like BWDB and LGED.

Aquatic agriculture in water-logged areas shall be promoted and farm schools shall be used to regularly train farmers on this practice.

7 Role of the Planning Commission

The discussion above pointed out a number of strategies to mainstream the activities of development planning for Bangladesh in order to ensure that Bangladesh's development plan is climate resilient and/or climate sensitive. Development projects of the Government of Bangladesh goes through a process of scrutiny from the day of its inception to the final day of approval. The process, in general, begins at the desk of a government institution under a ministry or at the Planning Cell of a ministry. The process is iterated several times between the agency/directorate/authority and the Planning Commission before it is finally processed for ECNEC approval. During the process, the Planning Ministry seek approval from several regulatory bodies of the Government in terms of their compliance towards a) environmental regulations, b) gender and children sensitivity, and c) financial obligations. Unfortunately, however, there is no authority to provide climate clearances for a project for the purpose of testing and evaluating a) the project/activity of the government in terms of Bangladesh's commitment towards promoting mitigation activities, and b) the project in terms of reducing vulnerability against various climate related threats (like climate change, climate extremes, and climate variability).

There are two reasons for such requirements. First, to access global funds available for climate mitigation and climate adaptations, the government must be able to cut out the 'excess' or 'additional' requirements in order to complete a project/activity. The 'additional' cost required to mitigate or to

adapt will be available only after providing 'evidence' of additionality in activities. Second, many existing infrastructure of Bangladesh would require 'climate proofing' in order to withstand the threats and to reduce vulnerability of people due to climate change. This will also require establishment of activities in terms of refurbishing the existing infrastructure, retrofitting the building, taking measures to improve effectiveness and support people and their livelihood against climate related threats.

In this connection, it is also important to note that the Ministry of Environment has been entrusted with responsibilities to deal with environmental protection and conservation of resources, there is a need to integrate climate proofing of projects within the planning commission. There are several reasons for such an argument. This is explained below.

First, the Ministry of Planning is the final negotiator of accessing resources committed under bilateral and multilateral assistance for all projects. In seeking such assistance, a climate proofing mechanism in designing projects, will help the Ministry to seek additional funds pledged under global agreements on climate change.

Second, the master tool or format for project design has been developed and designed by the Ministry of Planning. In addition, the government officers at the Planning Cell in each ministry belong to the 'Economic Cadre' of the government. It is therefore, possible for the Ministry to streamline project design keeping in view the climate vulnerability of Bangladesh.

Third, under the UNSD, the Government of Bangladesh is committed to establish a Commission on Sustainable Development (CSD) which shall be housed in the Ministry of Planning. This commission is responsible for ensuring that the country fulfills its global commitment to mend development activities accordingly. It is, therefore, natural that a climate cell is established under the Ministry of Planning and shall remain attached to the CSD.

7.1 Integrating climate within the planning mechanism

In order to integrate climate within the overall planning mechanism of Bangladesh, we suggest the following actions to be undertaken by the government.

Initial Climate Screening of Projects

We suggest amending the DPP (Development Project Proforma) with additional checklist for the purpose of **initial climate screening** of projects. The tool to be used for such screening shall be developed for the purpose of initial screening only. The sole purpose of such screening is to

test whether a project is required to undergo substantial revision in order to ensure **climate mitigation** or **climate adaptation tests**. The tool for such screening should be simple enough so that it can be used by the project designer without requiring help of a 'climate expert'.

Climate Proofing

If the project fails to pass the initial climate screening, it shall undergo a rigorous **climate proofing** mechanism involving experts. The objective for such proofing is to determine the **additional** activities needed to either reducing emission or reducing vulnerability or both. Both activities and fund requirement for such activities shall be accounted separately in the project document and for this DPP might require a further amendment.

Climate Planning and Vulnerability mapping

In order to develop long term strategies towards climate mitigation and adaptation, the government might need to allocate resources for developing climate related forecasting in terms of a) changes in overall climate b) changes in risks on livelihood of people and c) developing mitigation and adaptation strategies. This can be done through CSD using the research institutions and universities within Bangladesh. The Government of Bangladesh must develop a master plan using local and global resources to ensure that Bangladesh can adapt and mitigate the challenges due to climate change. Such a planning should account for short term, medium term and long term strategies based on continuous updating of climate vulnerability assessment map for Bangladesh.

8 Concluding observations

This report has been written against the backdrop of developing the five year plan for the Government of Bangladesh. It aimed to flag issues related to climate vulnerability of Bangladesh agriculture in order to put climate change in the mainstream of planning for the country. In doing so, this document reviewed government documents. It has also reviewed documents related to climate adaptation and mitigation.

In most of the documents written within the last decade, climate change has been flagged as a major concern. However, so far, the rhetoric remained detached from the mainstream planning mechanism for several reasons.

First, most of these documents were written with long term concerns of climate change in mind but they did not distinguish between long term, medium term and short term climate impacts. As such, most of the remedial or adaptive steps were structural in nature to deal with impacts of sea level rise, salinity and severe cyclones in mind.

Second, impacts of climate change are still uncertain in nature. As such, communities are reluctant to take remedial or adaptive measures immediately. This means, adaptation actions should have been in terms of developing awareness and capacity to deal with abrupt climate change related events.

Third, impacts of climate change are difficult to separate and so adaptive actions are unlikely to be independent in nature. Most of the adaptive actions should have been embedded response while developing future plans. Unfortunately, most of the documents dealt climate change as independent actions and so adaptation activities were stand-alone in nature.

Fourth, majority of actions prescribed in documents are general in nature and did not deal with local problems and local impacts.

Considering these, this report examined them in details and suggested actions to mainstream climate responses for agriculture sector (except forestry). Three separate types of climate change were considered: the term *climate change* referred to long term effects of temperature rise, *climate variability* referred to changes in climate pattern beyond norms due to climate change and these are short and medium terms effects in nature, and *climate extremes* extreme climate related events which are both short, medium and long term in nature. Adaptation actions related to these three types of climate events are different and shall be integrated in the national planning to ensure successful response to reduce vulnerability due to climate change.

Recommendations made in this report are, therefore, divided in terms of these three types of climate change consequences. Building capacity is probably the first and the most important strategy to reduce vulnerability due to climate change when the effects are known but uncertain. The report emphasized on this aspect throughout. Research and Development, has been suggested as an important strategy for developing resilience to climate change in our agriculture. However, research and development should not be limited to varietal development of crops and animals, research in terms of changes in cropping pattern, management practices, are equally important for resilience building. Furthermore, adaptation is a practice at the local level by farmers, and so it has to be participatory and incentive based for farmers. This means, there shall be a structural change in the institutional mechanism to deliver agricultural inputs, support and extension services to ensure that farmers adapt to reduce vulnerability.

The report also provided specific examples to help policy makers understand and develop policies to build resilience to agriculture to reduce vulnerability due to climate change.

WORKS CITED

Ali, A. (1999). Climate change impacts and adaptation assessment in Bangladesh. *Climate Research , 12*, 109-116.

Asaduzzaman, M., Haque, E. A., Islam, K. M., Munir, M. Q., Roddick, S., Roberts, E., et al. (2013). *Assessing the Risk of Loss and Damage Associated with the Adverse Effects of Climate Change in Bangladesh.* CKDN, ICCCAD, GermanWatch, MCII, and UNU.

Asian Development Bank. (2011). *Adapting to Climate Change Strengthening the Climate Resilience of the Water Sector Infrastructure in Khulna, Bangladesh.* Manila: The Asian Development Bank.

CASEED. (2014). *Synthesis of Policies andImplimentation Status to Ensure Supply of QualityAgricultural Inputs and Food Safety in Bangladesh.* Dhaka: Center for Agriresearch and Sustainable Environment & Entrepreneurship Development.

Deschenes, O., & Greenstone, ,. M. (2007). The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather. *The American Economic Review* , 354-385.

Ericksen, N. J., Ahmad, Q. K., & Chowdhury, A. R. (1996). The Implications of Climate and Sea-Level Change for Bangladesh. In R. A. Warrickand, & Q. Ahmad, *The Implications of Climate and Sea-Level Change for Bangladesh.* Dordrecht, The Netherlands: Kluwer Academic.

FAO. (2005-15). *FAO Home.* Retrieved January 4, 2015, from www.fao.org: http://www.fao.org/fishery/countrysector/naso_bangladesh/en

GOB. (2009). *Bangladesh Climate Change Strategy and Action Plan 2009.* Dhaka: Government of Bangladesh.

GoB. (2011). *Bangladesh Country Investment Plan: A road map towards investment in agriculture, food security and nutrition.* Dhaka: Government of Bangladesh.

GOB. (2013). *National Agricultural Policy 2013.* Dhaka: Ministry of Agriculture, Government of Bangladesh.

GOB. (2008). *National Food Policy Plan of Action (2008-15).* Dhaka: Ministry of Food and Disaster Management, Government of Bangladesh.

GOB. (1999). *National Water Policy.* Dhaka: Ministry of Water Resources, Government of Bangladesh .

Government of Bangladesh. (2013). *National Agricultural Policy.* Dhaka: Ministry of Agriculture.

Hertel, T. W., & Rosch, S. D. (2010). *Climate Change, Agriculture and Poverty.* Washington: The World Bank.

Hertel, T. W., Burke, M. B., & Lobell, D. B. (2010). The poverty implications of climate-induced crop yield changes by 2030. *Global Environmental Change , 4*, 577-585.

IPCC AR5. (2014). *Climate Change 2014: Impacts, Adaptation and Vulnerability.* Intergovernmental Panel on Climate Change, UNFCCC .

IWM and Alterra. (2010, August). *Bangladesh: Strengthening the Resilience of the Water Sector in Khulna to Climate Change.* Retrieved November 5, 2014, from Asian Development Bank: http://www.adb.org/projects/documents/strengthening-resilience-water-sector-khulna-climate-change-0

Karim, Z. (2015, January 8-12). Resilient Farming Practices towards Reshaping Climate Change Adaptation in Bangladesh. *Keynote Speech at the Gobeshona - making research on climate change in Bangladesh more effective* . Dhaka, Bangladesh: ICCCAD, Independent University, Bangladesh.

Miah, M. A., & Haque, E. A. (2013). *Policy Options for Supporting Agricultural Diversification in Bangladesh.* Dhaka: National Food Policy Capacity Strengthening Programme.

Miah, M. M. (2010). *Assessing long-term impacts of vulnerabilities on crop production due to climate change in the coastal areas of Bangladesh.* Dhaka: National Food Policy Capacity Strengthening Program, Ministry of Food, Govt of Bangladesh.

Ministry of Agriculture. (2013). *Master Plan for Agriculture Development in the Southern Region of Bangladesh.* Dhaka: Government of Bangladesh and the Food and Agricultural Organization.

Ministry of Environment and Forests. (undated). *Climate Change and Fisheries and Livestock in Bangladesh: information brief.* Dhaka: Bangladesh: Ministry of Environment and Forests.

NFPCSP. (2014). *Role of Small Livestock and Backyard Poultry in Nutrition*. Retrieved January 4, 2015, from www.nfpcsp.org: http://www.nfpcsp.org/agridrupal/content/role-small-livestock-and-backyard-poultry-nutrition

The World Bank. (2000). *Bangladesh Climate Change and Sustainable Development.* Washington: Rural Development Unit, South Asia Region.

World Bank. (2013, June 19). *World Bank News*. Retrieved January 31, 2015, from The World Bank: http://www.worldbank.org/en/news/press-release/2013/06/19/warming-climate-to-hit-bangladesh-hard-with-sea-level-rise-more-floods-and-cyclones-world-bank-report-says