CWP REPORT FROM BANGLADESH WATER PARTNERSHIP (BWP)
BANGLADESH: WATER, AGRICULTURE AND CLIMATE CHANGE

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1.0 Brief Description of Bangladesh

Bangladesh is a South Asian country located in the northeast of the Indian sub-continent and covers a total area of 147,570 sq. km (56,977 sq. miles). It has a common border in the west, north and east with India, a short border with Myanmar in the southeast and is bordered by the Bay of Bengal in the south. The landmass of Bangladesh is flat, with some upland in the northeast and the southeast. The great plain lies almost at sea level along the southern part of the country and rises gradually towards north. Land elevation in the plain varies from 1 to 90 meters above sea level. The maximum elevation is 1230 meters (4035 ft.) above sea level at Keocaradong hill in the Bandarban district. The geo-morphology of the country comprises of a large portion of flood plains (79.1%), some terraces (8.3%) and hilly area (12.0%). About 6% of the country's landmass is under vegetation. The cultivable area is estimated at 9.03 million hectares (ha) (22.30 million acres), which is about 61% of the total land area. Of this amount, 7.56 million ha (18.67 million acres) is suitable for irrigation. The population of Bangladesh currently exceeds 150 million of which about 75% are rural. Bangladesh is one of the most densely populated countries of the world with about 1000 persons/km^2. About half of the population lives below poverty line.

According to statistics, there are more than 230 rivers in Bangladesh. 57 of those are trans-boundary rivers or international water courses. Of these, 54 rivers are common with India, while 3 are common with Myanmar. Most of Bangladesh is located within the floodplains of three major international (trans-boundary) rivers: the Ganges, the Brahmaputra and the Meghna. About 93% of the catchment area of the major river basins of the Ganges, the Brahmaputra and the Meghna is located in China, India, Nepal and Bhutan. On an average 1068 Billion Cubic Meters (BCM) of water enters Bangladesh from across its boundaries annually. But 80% of this annual flow comes during the 4 monsoon months between June and October often causing serious floods. With its flat topography, Bangladesh does not hold the prospect of any large-scale storage of monsoon water for use during the dry season.
In the last two decades Bangladesh has been facing a major problem of contamination of its ground water resources by Arsenic beyond tolerable limits (i.e. >0.01 mg/liter) in almost 80% of the land mass of country. It needs to be noted that Bangladesh uses more than 80% of its irrigation water for agriculture from the ground water sources during the dry season (Nov-May).

2.0 CWP Report on Water Agriculture and Climate Change

The following Report has been prepared by Desk studies, Literature research and discussions with some of the Experts in the relevant Departments and Agencies under different Ministries which are related to activities concerning climate change in Bangladesh.

The main Ministries and Departments involved in matters relating to climate change in Bangladesh are

1. Ministry of Environment and Forests (DOEF)
   i) Department of Environment (DoE)
   ii) Department of Forest (DoF)

2. Ministry of Food and Disaster Management
   i) Disaster Management Bureau (DMB)

3. Ministry of Water Resources
    i) Bangladesh water Development Board (BWDB)
    ii) Water Resources Planning Organization (WARPO)
    iii) River Research Institute (RRI)
    iv) Bangladesh Haor and Wetland Development Board (BHWDB)
    v) Joint Rivers Commission (JRC)
    vi) Centre for Environmental and Geographic Information Services (CEGIS) and
    vii) Institute of Water Modeling (IWM)

4. Ministry of Local Government, Rural Development and Cooperatives
    i) Local Government Engineering Department (LGED)
    ii) Department of Public Health Engineering (DPHE)

5. Ministry of Agriculture
    i) National Agricultural Research System (NARS)
    ii) Bangladesh Agricultural Research Council (BARC)
    iii) Bangladesh Rice Research Institute (BRRI)
    iv) Bangladesh Agricultural Research Institute (BARI)
    v) Department of Agricultural Extension (DAE)

6. Ministry of Defense
    i) Bangladesh Metrological Department (BMD)
    ii) Space Research and Remote Sensing Organization (SPARRSO)

7. Ministry of Livestock and Fisheries

8. Ministry of Power, Energy and Mineral Resources

9. Ministry of Health and Family Welfare

10. Ministry of Communication

11. Ministry of Foreign Affairs

12. Planning Commission of the Ministry of Planning

The person responsible for preparation of this CWP report has held quite elaborate discussions on the issue of climate change and its implications particularly on the Water Resources and Agricultural Sectors of Bangladesh. The discussions were made between 22 and 25 January, 2012.

i) Dr.Wais Kabir, Executive Chairman, Bangladesh Agricultural Research Council (BARC), Dhaka.
ii) Dr. Sultan Ahmed, Chief Scientific Officer, BARC, Dhaka.
iii) Mr. Hasanul Haque, Director General. Department of Agricultural Extension (DAE), Dhaka.
iv) Mr. Md. Azizul Haque, Director General (in-change), Bangladesh Water Develoopment Board (BWDB), Dhaka,
v) Mr. Dhali Abdul Qaium, Water Resources Consultant, Water Management Improvement Project (WMIP), BWDB. Dhaka.
vi) Mr. Md. Shahidul Haque, Project Director, (PSSWRDP), Local Government Engineering Department (LGED), Dhaka.
vii) Mr. Saiful Islam, Principal Scientific Officer, Water Resources Planning Organization (WPARPO), Dhaka.
viii)
ix)

3. THE REPORT

3.1 Water Resources of Bangladesh

The unique characteristics of the Bangladesh Water Resources situation is that the water availability varies widely between the Dry (November through May) and the Wet monsoon (June to September) seasons. The Ganges river which carries about 2.6 million cubic feet per second (cusec) at Hardinge Bridge site in Bangladesh during peak floods (July-August) dwindles to a mere 20 to 40 thousand cusec during the dry summer months like February, March, April at the same location. Similarly, the Brahmaputra, which carries about 3.5 million cusec during peak floods in July-August, carries only about 130,000 cusec during dry months like February and March. Of the total surface water resources available in the country during the dry season, 67% is contributed by the Brahmaputra river and 18% by the Ganges, both of which are transboundary international rivers. Besides, other rivers like the Teesta, Dharla, Dudhkumar, Mohananda etc. which exceed more than 230 in number also make significant contributions in different parts of the country. Of the 230 rivers flowing through Bangladesh, 57 rivers are transboundary in nature. 54 of these are rivers common to both Bangladesh and India.

The statistics regarding the wide seasonal variations of river flows indicate the extent of the major hazards (monsoon floods and dry season water scarcities) in the water resources sector of Bangladesh. The Ground Water Resources available in Bangladesh (which has its limitations relating to safe yield - according to some up to about 30 Billion Cubic Meters) has been and still is the major source of water supply in the country for supply of water particularly in the domestic and agricultural sector. This ground water resource which is normally recharged mostly by the monsoon rainfall however is facing a major hazard now a days in the form of arsenic contamination beyond tolerable limits in many parts of the country. According to many Bangladeshi Experts, over exploitation of ground water resources have led to such a situation. Massive amounts of irrigation by Ground water have already led to the transfer of arsenic in some leafy and other vegetables grown in some parts. This is of course a warning signal to all concerned. The government of Bangladesh has now adopted a policy to increase its use of surface water more and more and reduce the use of ground water as much as possible. Being a flat alluvial country, Bangladesh unfortunately does not hold any prospect of large scale storage of monsoon waters for use in the dry season. On the other hand, Bangladesh is watching with great alarm the progressive reduction of the precious dry season flows through its transboundary rivers due to increasing upstream diversions across its boundaries. This phenomenon is giving rise to ingress of salinity from the Bay of Bengal more and more inland of the country with increasing intensity. During the monsoon months the floods which inundate about 20% to 30% of the country often inundates more than 60% of the whole land mass of Bangladesh in events like 1987, 1988, 1998, 2004 catastrophic floods with disastrous consequences to the life and living of the whole country. Hydrological statistics indicate that more than 90% of the flood flows which cause large scale inundations in Bangladesh are coming from the upstream across the borders of this country.

Most of the water resources projects of Bangladesh in terms of Flood Control and Drainage (FCD) and Flood Control, Drainage and Irrigation (FCDI) have been and are being implemented by the Bangladesh Water Development Board (BWDB). BWDB has implemented hundreds of kilometers of flood embankments both inland and along the coastal belt of Bangladesh, coupled with thousands of appurtenant structures like regulators, flushing sluices etc. Besides, BWDB has constructed a large barrage project across the river Teesta in the north-west of country for irrigating more than a million hectares of land. Feasibility and detailed Engineering studies are rapidly progressing for another large multipurpose project across the river Ganges called the Ganges Barrage Project. The Water Sector Improvement Project (WMIP)), which is concerned with the future operation, maintenance and rehabilitation of some of the existing FCDI schemes, is another priority project which is ongoing, to improve rain fed cropping. The governments' concern is to find the appropriate combination of rain fed and irrigated production to meet the target of food grain self-sufficiency.

Another water sector project of relevance is the Small Scale Water Rescues Development project (SSWRDP), being executed by the LGED with donor funding, covering many parts of the country both in the west and the east with areas of each project under 1000 ha. with a strong bottom up participatory

approach. A new phase of this project with ADB funding has also now started. Apart from LGED, some NGOs are taking up, on a limited scale however, flood proofing schemes for raising homesteads in vulnerable areas and community flood shelters etc.

3.2 Agriculture:

Agriculture is the mainstay of Bangladesh economy. It is the single largest producing sector of the economy and it contributes about 22% of the total Gross Domestic product (GDP) of the country. This sector also accommodates around 48% of Labor force. GDP growth rate in Bangladesh mainly depends on the performance of the agriculture sector. Due to natural calamities like flood, cyclone, drought loss of production in both food and cash crops are almost a regular phenomenon. Yet in recent years, there has been a substantial increase in food grain production. With the weather condition helping, Bangladesh has been lucky to produce rice exceeding 34 million tons during 2011. Agricultural holding in Bangladesh is generally small but use of modern machinery and equipment is gradually increasing. Rice, Jute, wheat, sugarcane, potato, pulses, tea, and tobacco are the principal crops of Bangladesh. Crop diversification program, credit supply, extension work and research and input distribution policies by the government are yielding positive results . Aus, Aman and Boro are produced as the main rice varieties in Bangladesh. The Aus and Aman are vulnerable to floods. So, over the periods, people are shifting from this high risk crops to low risk crops and Aus is slowly being replaced by Boro. As a result to meet the cereal demand farmers are mainly depending in Boro production which demands more inputs such as water, energy, fertilizer, labour etc. In 2008-09, total Boro production was 18.7 million metric ton which used 1,500 megawatt of electricity,One billion litres of diesel and about 1.9 million metric ton of fertilizer (The Daily prothom Alo, 2010). Currently Boro contributes more than 60% of total rice production (BBS,2008). On the other hand, Karim et al , 1990, suggested Transplant. Aus , Transplant Aman with high valued Rabi crop as highly water efficient cropping pattern in the high land and medium high land which is able to reduce ground water abstraction, as well as diversified crops also reduce dependency on Boro (single crop). Contribution of Aman is 32% to the total rice production, though almost equal amount of land is used for both Aman and Boro cultivation. Farmers traditionally do not irrigate Aman field. Their perception is that Aman is a rain fed crop which does not need irrigation. As a result it frequently suffers from moisture stress, which decreases yield as well as total rice production of the country. But Transplant Aman yield can be increased by reducing the stress through providing supplementary irrigation.

For further improvement in the agricultural sector, the govt. is pursuing a wide ranging set of policies and strategies. These include continued emphasis on private sector participation in minor irrigation and other agro- activities, together with: (i) improving input supplies, especially improved crop varieties and seed quality, fertilizers and pesticides, and credit, (ii) improving agricultural support services such as research , extension, education and training , marketing and processing, (iii) increased mechanization, (iv) better plant protection and the widespread adoption of integrated pest management (IPM) (v) better maintenance of soil fertility under the intensive irrigated farming technologies and an integrated land use policy, (vi) crop diversification with increased production of minor crops and horticultural crops for export and (vii) enhanced development of farmers groups and associations.

3.3 Climate Change:

Bangladesh has been identified by the UN Climate Change Conference held at the Copenhagen Summit as the most vulnerable country. Temperature is likely to rise according to all emission scenarios. The annual mean temperature is likely to increase by $2^{o}C$ by 2050. This increase will be accompanied by rising sea levels, more intense precipitation events, more erosion, increased risk of drought with serious implications on sectors like agriculture, environment, health and water resources. About 75% of the population lives in rural areas and is mainly engaged in agriculture and related to non-farm activities. More than two thirds of the rural population is landless (owning less than 0.2 hectares of land); 44% are classified as very poor. Endowed with limited land and other natural resources and with a high population density, poverty in one pervasive problem in Bangladesh. All these factors combined, makes Bangladesh more and more vulnerable.

Bangladesh is also a disaster prone country. Between 1970 and 2000, more than 170 large scale water induced disasters like Cyclones, storm surges, droughts, floods and river erosions have killed more than half million people and affected millions more of down-trodden people with various degrees and intensities. In the face of the adversities of climate change the poor shall be the most hard hit as they live with great density in lands prone to water related hazards particularly along the 700 km coast, affected by storm surges, ingress of salinity from the Bay of Bengal. Again the rise in Sea-Level shall permanently inundate large chunks of low lying human habitats in the south of the country.

3.3.1 Impacts of Climate Change

The impacts of climate change shall result in more frequent and more intense occurrences of natural disasters like flood, cyclones, storm surges, river bank erosion, salinity intrusion and drought.

a) Flooding

Due to its location in the deltaic floodplains, low floodplain gradients, heaving monsoon rainfall, congested drainage channels and tidal flow and storm surges in coastal areas, Bangladesh regularly suffers from moderate to heavy and severe floods. Climate change shall make these flooding more frequent and intense with the change in the rainfall pattern as well. Increased monsoon rainfall shall result in higher flows in the rivers coming into Bangladesh from India, Nepal, Bhutan and Chaina during the monsoon season. These flows are likely to further increase in the medium term due to melting of Himalayan glaciers. Warmer average global temperature means greater evaporation, with a warmer atmosphere able to hold more moisture aloft that can fall as precipitation, increasing the potential for flooding.

b) River Erosion

River bank erosion is a major problem for Bangladesh. The total land eroded along both banks of the Brahmaputra (Jamuna) was 1240 ha per year where more than 20,000 people are permanently displaced every year (CEGIS 2010). The erosion problem along the banks of many more rivers is also alarming. Due to climate change impacts 26% increase in peak discharge of the river Brahmaputra/Jamuna will cause 13% increase of erosion in the right bank and 60% in the left bank. In the Ganges/Padma River, 26% increase in maximum discharge may cause 23% increase in river bank erosion (CEGIS 2010).

c) Cyclones and Storm Surges

Every three years a tropical cyclone hits Bangladesh. Tropical cyclones accompanied by high winds over 150 Kph can cause storm surges upto 7 meters high and flood waves can travel upto 50km inland. It is predicted that countries in temperate and tropical Asia like Bangladesh will have increased exposure to typhoons, tropical storms due to climate change (MOEF 2008). High risk areas in Bangladesh due to cyclone is 23,000 sq.km, which is likely to increase in future (CEGIS 2009).

d) Drought

Bangladesh will be at high risk from climate change induced moisture stress and resulting phonological drought impacts. Given reductions in mean dry seasons rainfall it is likely that dry spells may increase/lengthen with negative consequences for water availability/soil moisture. Higher temperature will contribute to increased evaporation losses and is likely to worsen soil moisture deficits. North western part of the country will be at greater risk of drought during Kharif and pre Kharif seasons (CEGIS 2010)

e) Sea Level rise

According to a study conducted by CEGIS, due to 62 cm rise in sea level by the year 2080, 13% more areas (469,000 ha) will be inundated in monsoon in addition to the inundated area in base

condition. The most vulnerable areas are the areas without polders like Patuakhali, Pirojpur, Barisal, Jhalakati, Bagerhat, Narail. Due to increased rainfall in addition to 62 cm sea level rise, the inundated area will be increased and about 16% (551,500 ha) more area will be inundated in the year 2080. On the contrary, in the dry season due to 62 cm sea level rise about 364,200 (10% more area will be inundated by more than 30 cm) will be submerged in the year 2080 (CEGIS and IWM, 2007). Sea level rise and potentially higher storm surge would result in over-topping of saline water behind the embankments of the polders in the coastal areas. About 25 polders in the south west region may experience severe drainage congestion due to 62 cm sea level rise and 13 polders' embankments will be overtopped affecting 120,200 ha of these polders.

f) Salinity Intrusion

The salinity front will move towards inland from the south which will be further aggravated by the reduction of upland fresh water flows through the Trans Boundary Rivers. In the base year about 6.0 million people are exposed to high salinity (>5ppt) which will increase to 13.6 million in 2050 and to 14.8 million in 2080(CEGIS, 2006).

g) Coastal Communities and their Livelihood

Agriculture contributes about 30% of the GDP in coastal areas. This contribution will decrease by 2% by the year 2050. The employment opportunity in producing rice (Aman and Boro) will reduce by 7% by the year 2050. The farming opportunity of farmers in the coastal areas will decrease by 13.5% and 25% in years 2050 and 2080 respectively. In the year 2050, farming opportunity will decrease by 14% and fishing opportunity will decrease by 8%. The groups of vulnerable women in the coastal zone mainly depend on livestock, cottage industries. In 2050, the livelihoods of about 8 million women will be at risk as less and less area will become suitable for livestock and cottage industries (CEGIS and IWM 2007).

4.0. Bangladesh Climate Change Strategy and Action Plan (BCCSAP)

Bangladesh has launched a climate change action plan to help itself adapt to threats such as rising sea level, water-logged land and increased salinity. The Climate Change Action Plan is a 10 year program (2009-2018) to build the capacity and resilience of the country to meet the challenges of climate change. Bangladesh vision is to eradicate poverty and achieve economic and social well –being for her people. Bangladesh adopted a pro-poor, climate resilient and low carbon development strategy. The strategy is based on four building blocks of Bali Action Plan:

- Adaptation to Climate Change
- Mitigation
- Technology transfer
- Adequate and timely flow of funds for investment

The BCCSAP is presented in two parts. In the first part, the background based on physical and climatic contexts, core socio-economic realities and policies in the country and the consequent rationale for a strategy on climate change is given. The thrust of the strategy is on sustainable development, poverty reduction and increased well-being of all vulnerable groups in society with special emphasis on gender sensitivity. The second part provides a set of programs based upon six pillars or broad areas of intervention. (MOEF, 2008). The six pillars are -

(1) food security, social protection and health;
(2) comprehensive disaster management;
(3) infrastructure development;
(4) research and knowledge management;
(5) mitigation and low-carbon development; and
(6) capacity building and institutional strengthening.

The BCCSAP sums up Bangladesh's current thinking on desirable activities to build climate resilience into the economy and society of Bangladesh through adaptation to climate change as well as mitigation for a low carbon development path. The relevant ministries and agencies along with civil society and the business community will be responsible for implementing the various components of the BCCSAP. The implementation of the BCCSAP will be financed through Government's own resources and external support that may be available from the development partners as well as the specific international funds created for the purpose. The Ministry of Environment and Forests will be responsible for coordinating activities under the Action Plan. The BCCSAP will provide a framework for adapting to climate change as part of a national effort. (MOEF, 2008).

To finance the action plan, Bangladesh has established a National Climate Change Fund with 45 million dollars of its own cash, which will focus on adaptation initiatives. Under the Trust Fund, projects from both government and non-government organizations (NGOs) would be accepted for undertaking projects on adaptation with the climate change for a maximum period of two years. For the government projects, maximum 250 million taka (3.57 million U.S. dollars) would be allocated from this fund, while the highest allocation for any project by NGO would be 50 million taka (about 714,000 U.S. dollars). (MOEF, 2008).

The Government is aware that changes in the climate will push away people now living in the coastal areas to floodplains and dry areas in the northwest to become climate/environmental refugees, making millions of people vulnerable to poverty and hunger. Many of those displaced persons would ultimately migrate to urban areas thereby doubling the urban population in the near future that would contribute to political and socio-economic instability. The issue is really grave as it would ultimately result in large scale displacement and even cross-border migration.

To face the impending challenges, the Government of Bangladesh has adopted a 6 - point program that includes-

1) Determination of mitigation and adaptation techniques;
2) Establishment of an international centre for research in adaptation and strategy for Bangladesh
3) Identification of climate change factors and development of a national poverty reduction plan
4) Development of projects for implementation of adaptive plan to cope with climate change
5) Creating awareness about possible risk and consequences among the general public, government officials, scientists and professionals, and
6) Involvement of mass media nationally and internationally to publicize effects of global warming and climate changes in Bangladesh.

4.1. **Adaptation to Climate Change**

Technical measures shall be very important to deal with climate change, as they are responsible for so many of the infrastructures, systems and products that shape our daily lives. The engineering departments/agencies have significant role to play for adaptation to climate change in the following sectors:

- Water resources management
- Water supply and sanitation
- Agriculture
- Disaster management
- Energy
- Forest
- Industry
- Health etc

In light of the BCCSAP, 2009 the actions recommended for immediate or long-term action, which requires technical concerns, can be broadly categorized under the following areas:

- Research and study
- Planning, design and construction
- Awareness creation
- Capacity building

The relevant technical departments and agencies of Bangladesh have already swung into action in this regard. A brief description of some of the actions follows-

i. BWDB is now planning and designing all its water sector projects to cater to the changed circumstances to be forced by climate change.
ii. BWDB has already started to implement projects like River bank erosion control projects, Coastal embankment and polder management projects. Some of these projects are now being financed from the Climate Change Trust Fund as well as Climate Change Resilience Fund.
iii. BWDB is contemplating more projects like Char Development and Settlement Projects (CDSP) for the coastal and estuarine areas.
iv. In order to help accretion of more land in the south/coastal belt, BWDB is preparing and Estuary Development Project. In this connection BWDB has already identified locations of 18 cross-dams that would expedite the natural land accretion process along the coast.
v. BWDB is also preparing a Delta Development Plan for the year 2100.
vi. The different Agricultural Research Institutes of the country are now busy in developing more flood tolerant, drought tolerant, Salinity tolerant varieties of rice and other food crops.
vii. WARPO is going to undertake soon the process of revising and updating its National Water Management Plan in the light of the Climate Change impacts.
viii. WARPO is also preparing a Project Implementation Plan for Coastal areas. It has already prepared the Integrated Coastal Zone Management Policy (ICZMP) which addresses the climate change aspects adequately.
ix. The Water Resources Department of the LGED is now addressing the relevant climate change issues in designing and implementing its Small Scale Water Resources Development Projects. Same is being done for Urban as well Rural Infrastructure Development.
x. The Government has recently embarked upon an ambitious program of Capital Dredging in the main rivers as well as some other important medium rivers to improve the drainage system of the country.

4.2. Adaptation in Agriculture

The main challenge for the agriculture and irrigation sectors under the threat of climate change is to attain self sufficiency in food production through optimum use of inputs such as water, energy and fertilizer. Research and Development (R& D) activities need to be greatly enhanced in the agricultural sector to have more clear ideas on the intricate details of climate change impacts like on plant diseases, pest attacks and etc. R&D activities should be targeted to develop a framework to meet the future food grain demand safeguarding the ecosystem and ensuring less-energy use with particular emphasis on the following specific objectives-

- Opportunities to grow more food grain considering protection of environment
- Reduction of risks from flood and drought
- Optimal use of input (i,e. less use of energy and fertilizer)
- Increase resilience by increasing input cost saving.

To achieve the above stated objectives the following adaptation measures may be taken –

1. **Change mindset on Aman cultivation**
   - Change the mindset "Aman is a rain-fed crop " to "Aman is a rain-fed crop, but it needs Supplementary irrigation"
   - With supplementary irrigation of 1.5 to 2 times. Aman production can be increased from 2-3 t/ha to 5- 6 t/ha.
   - Reduce vulnerability of Aman to flood by limiting HYV Aman cropping in highland and medium highland
   - Use of submergence tolerant varieties (eg. BR 11 sub1, IR 64 sub1, Swarna sub1) of rice
   - Community level long term flood warning.
   - Increase extension activity to build awareness.

2. **Increase input efficiency for Boro**

   - Reduce energy use by increased irrigation efficiency. Currently 2000-2400 mm of irrigation is used in the boro field whereas requirement is 1000-1400 mm of water (EGIS, 2001). Using 'Optimal Water Use' technology developed by CEGIS this additional use of water can be saved which can reduce energy use by 25%-30%.

   - Establish farmer's Help Desk and call centre for suggesting optimal fertilizer use to farmers.

   - Increase extension activity to build awareness and popularize optimal use of water and farmer's call centre and demonstrate the benefits.

3. **More fish production and safeguard ecosystem**

   - Restore connectivity between beels and rivers
   - Improve productivity of habitats by re-excavation and dredging of channels and beels
   - Improving water quality by less use of fertilizer and pesticides

In addition to the above adaptive measures, special attention should be given to jute production. Especially market of jute should be expanded and encourage farmers to cultivate jute in Kharif I period. So that balanced distribution of employment opportunity over the years can be achieved and also ensure the use of environment friendly fibers to reduce climate change impacts.

In order to successfully implement the above measures, the following activities should be undertaken

- Awareness and demonstration of supplementary irrigation for Aman and optimal input in cultivation.
- Effective community based early warning for floods.
- Access to Information technology.
- Enhanced supplementary irrigation and improved connectivity and channel capacity through dredging by BWDB.
- Strengthening of Agricultural Extension activities.
- Involve secondary education system to help the farmers.
- Regulating/ controlling over exploitation of fishes

4.3. Research Activities by the Bangladesh Rice Research Institute (BRRI)

BRRI has given thrust to develop high yielding modern rice varieties for diverse agro-ecological conditions of Bangladesh. The BRRI activities are focused to

- Breeding rice varieties of salinity tolerance (Development of BRRI dhan 47 has been a major breakthrough is this department)
- Breeding rice varieties for Flash flood submergence (The newly developed BR11- Sub 1 line can withstand two weeks of complete submergence)

- Development of medium stagnant water tolerant variety (it has been possible to identity some varieties having tolerance against medium stagnant water)
- Development of HYV rice for Tidal Wetland Ecosystem (efforts are being made to develop tall varieties with higher submergence tolerance with higher yield potential for tidal areas of Bangladesh by transferring submergence tolerance genes from traditional varieties to more productive modern rice varieties.)
- Development of Rice varieties from Drought Prone Environment (one advanced breeding line IR 79371-70-1-1 having genetic resistant potential against drought produced consistently better yield).
  (BRRI, 2007)

4.4. Some Structural Aspects of Adaptation in Bangladesh

Adaptation is defined as adjusting decisions, activities and thinking because of observed or expected change in climate in order to moderate harm or take advantage of new opportunities. Adaptation to climate change would involve both structural and non-structural solutions. Integrating climate change impacts into existing planning process such as risk management can be one of the most constructive-approaches to adaptation. Barriers to overcome to make adaptation more strategic include limitations in awareness, availability of information and decision making support tools.

Large scale inundation of coastal areas of Bangladesh is a major threat posed by climate change. There are existing coastal embankments (dykes) in various stretches of the coastal belt. Climate change would mean sea level rise. This would call for raising the protective embankments in the coastal areas and in the chars (accreted lands) in the estuary to take account of the rise in water level in the coast and estuaries. If these embankments are not raised then there will be less secure protection that was provided when they were constructed. However, despite rising sea level, the process of accretion and the formation of new land will continue. Bangladesh, being a land hungry country badly needs more and more land to be accreted along its Southern coasts. Land is no doubt gradually jumping up in the south of the country, but at a very slow rate. This rate however needs to be accelerated through appropriate measures. Intelligent use of cross-dams can definitely provide spectacular results. The rate of accretion now far exceeds forecast future sea level rise. Future sea level rise forecast range from 1 mm to 20 mm per year (IPCC forecast quoted by the CRCHID study, suggest a range between 3 mm and 15 mm per year) while land accretion rates in areas close to Bangladesh Water Development Board's Char Development and Settlement Project (CDSP) have been measured at 40 to 45 mm per year (Feasibility Study of Muhuri accreted area). In fact most coastal land accretion has taken place at times of sea level rise, as the lower stages of rivers flow less fast and deposit more silt in their deltas rather than carrying silt out to sea. What is critical is the balance between accretion and erosion. Whatever the case may be, Bangladesh must make all out efforts to entrap the silts carried by both the inland rivers as well as the sea tides to help accretion of more land. This would also help by buffering coastal erosion through seaward movement of the delta coast.

The Engineers working in the water sector of Bangladesh has a vital role to play in planning, design, implementation and operation and maintenance of physical infrastructures which need to be put up or enhanced in the coastal belt. Specific focus needs to be targeted to the appropriate raising/ construction of the coastal embankments and appurtenant structures with appropriate strengthening and implementation of proper drainage facilities in the embanked areas.

Design of Embankment

Embankment/dykes should be constructed with the objectives (i) to protect the empoldered areas against inundation by sea water due to high tide and wave overtopping during monsoon condition and sea level rise due to climate change; and (ii) to provide protection against loss of life and widespread damages during excessively high cyclone storm surges which is expected to be largely exacerbated by the rising sea level. The design should particularly address the points that (a) the embankment is not overtopped

under any circumstance (heights may be 7.00 m++) (b) embankments are stable and sustainable in the face of wave action and other phenomena. It would also need to be appreciated that expert opinion considers the dynamic nature of the Meghna estuary means coastal embankments have a functional life of only about 20 years. Embankments shall need to be replaced by newer ones further seaward as the coast line accretes away from the existing embankment. It should be appreciated that the embankments should act as arteries of communications. So the crest width of the embankments should be so provided to facilitate motorized transport keeping in view the future expansions. In addition such embankments can be provided with protection of green belt of at least 300 m on the sea side/ river side.

Drainage

The embanked/ empoldered areas must have adequate drainage facilities. Tidal drainage sluices with suitable invert level and flap gates at the river side can be the most appropriate structure in this respect. In order to control the drainage flow and to maintain a certain water level inside the polders, where necessary, the drainage sluice can be equipped with appropriate gates on the country side.

Besides, there shall be need to resuscitate the silted up drainage channels. If necessary fresh drainage channels or khals shall also have to be put in place as per requirement. All such interventions must be undertaken by knowledgeable Experts who can appreciate that development process in the coastal/ char areas are complex and dynamic, completely driven by nature, and full of uncertainties-a formidable challenge indeed.

Further to these interventions, the concerned departments would require to plan and implement climate resilient facilities for adequate potable water supply, smooth communication and appropriate health and hygiene. Moreover, disaster time shelters/ cyclone shelters will also have to be put in place in adequate numbers for multiple uses.

4.5 Policy Development

In order to tackle the upcoming adversities of climate change, Bangladesh needs to modulate its national policy accordingly. Since food security, sustainable development and climate change adaptation and mitigation are strongly linked, policies need to be integrated across levels (from people to departments and ministries) and across sectors. This will avoid latter contradictions between local actions and higher decision making and ensure that National Policies use the benefits associated with international mechanisms to improve the livelihood of people. Awareness raising, permanent monitoring of changing vulnerabilities and capacity building should be the essential components of National climate change policies.

For a country like Bangladesh which is the lowest riparian of more than fifty transboundary rivers and whose water resource availability is largely dependent upon its neighboring upstream countries, it would literally be impossible to face the challenges of climate change all by itself. It is, therefore, essential to integrate climate change as a component of water resources management at National level, basin level and regional level. For that, coordination at the regional level is a must to develop common strategies for adaptation to the impacts of climate change. In this regard development and sharing at regional level, programs to raise awareness amongst people about the impacts of climate change would be important. To implement all these, enhancement of transfer of technologies and basin wide cooperation among the countries of South Asian region shall be necessary. It is important to note that there are limits to adaptation. Due to changing climate, the frequency of floods and droughts may increase so much that agriculture, fisheries and forestry is no longer sustainable in some places. Diversification to other economic activities and relocation will need to be considered under those situations.

5.0 Conclusion:

Climate changes the water rules. This paper highlighted the dilemma confronting the water managers amongst whom the water engineers play the pivotal role. On a global basis, they already face

formidable challenges in planning for a time around the years 2040 when projected global demand for water will exceed availability. Big fluctuations in seasonal rainfall and river flow particularly in Bangladesh would play havoc with all calculations. Analysis of records from 29 of the World's biggest river basins has revealed that 100 year flood (as per present analysis) will become as frequent as once every 12.5 years if and when $C0_2$ levels quadruple in the future. Rainfall extremes even on a daily basis (like that happened in Nagoya of Japan in September, 2000 when 428mm fell in 24 hours whereas the previous such record was in 1890 when 240 mm fell in one day) shall put all calculations in dis-array. No doubt that the whole world today is frantically trying to cut down the greenhouse emission. But for a country like Bangladesh which is not responsible for such emission (beyond tolerable limits), must adequately prepare itself to face the climate change. Precautionary investments in disaster preparedness and adaptation will help to protect developmental progress. Support for local adaptation pays dividends in savings on relief and recovery costs when the extreme event arrives. According to estimates made by International Red Cross, each dollar spent on prevention, saves from four to ten dollars in relief.

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