Climate Change Impact Modeling

Institutional Road Map

Abu Mostafa Kamal Uddin

Climate Change Cell
Department Of Environment

Comprehensive Disaster Management Programme
Government of the People's Republic of Bangladesh

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About Climate Change Cell

The Climate Change Cell has been established in the Department of Environment in 2004 under the Comprehensive Disaster Management Program (CDMP) of the Government. It responds to the recognition that Bangladesh is particularly vulnerable to the effects of climate change, and that the number and scale of climate-related disasters is likely to increase.

Climate change will have far-reaching effects across many sectors. The Cell provides the central focus for the Government's climate change related work, operating as a unit of the Department of Environment (DoE) under the Ministry of Environment and Forests (MoEF).

Its objective is to enable the management of long term climate risks and uncertainties as an integral part of national development planning.

This will contribute to the primary objective of the wider Comprehensive Disaster Management Programme, which aims to strengthen the capacity of the Bangladesh disaster management system to reduce unacceptable risks and improve response and recovery activities.

Meeting these objectives will enable more effective and sustained poverty reduction through the reduction of disaster and climate risks within the overall development process.

The Climate Change Cell's work program focuses on four main areas:

Building the capacity of Government to coordinate and integrate climate change issues in mainstream development activities across government. It also acts as a secretariat to coordinate other national climate change activities such as National Communication preparation, the NAPA process, and the Clean Development Mechanism.

Strengthening existing knowledge and availability of information on impact prediction and adaptation to climate change. This includes compiling and synthesizing existing studies, and filling some of the gaps, as well as improving information exchange between science and policy-makers

Awareness raising, advocacy and coordination with partners across government, NGOs, civil society, private sector and donor organizations. Using a variety of mechanisms and information products, the Cell is working to promote the integration of climate change adaptation and risk reduction in development activities, especially within climate sensitive sectors and the disaster risk reduction process.

Improving capacity to adapt livelihoods to climate change in the agriculture sector. Working with FAO, we are field-testing livelihood adaptation strategies with farmers to better respond to disasters and climate change risks. This includes translation of climate change modeling into agricultural response options and livelihood adaptation practices. The initial focus is on drought conditions, with a view to facilitating replication elsewhere.


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Preface

Bangladesh is already experiencing climate related hazards like floods, droughts, cyclones and others which are being aggravating following climate change (and variability). A significant part of the coastal region is threatened by salinity intrusion and submersion due to sea level rise. The general predictions are: more floods, untimely floods, more droughts, drainage congestion, salinity intrusion, more cyclones with higher intensities.

Climate related hazards impede/hinder the development process and reduce life and livelihood security. To eliminate or reduce risks from the climatic hazards a number of actions need to pursue. To treat risks originating from climate change (and variability) one has to identify hazards in the context of livelihood systems and respective water setting and locate spatially and temporally. Around the globe modeling is being practiced for projection of the hazards spatially and temporally.

Climate change impact modeling is a recent development around the globe and in Bangladesh. Streamlining existing practice and enhancing efforts in this regard is essential to pursue ‘climate resilient sustainable development processes. As such the Climate Change Cell, DoE, facilitated a process identifying needs of the development process and existing capacity of the modeling community in the country through a workshop and bilateral discussion meetings with the modeling community.

To streamline and mainstream modeling practice this road map along with a business plan has been prepared. Implementation of the road map in a partnership mode shall enable us establishing a mechanism that will support climate resilient development processes in country.

The Climate Change Cell, August 2006

Acknowledgement

I express my gratitude to all the experts and professionals who provided valuable insight on matching needs with modelling results, and guidance to sustain the modelling initiative to support overall development processes through a systematic and institutional approach.

In this respect I extend my thanks to Ian Rector, Chief Technical Adviser, CDMP, Mohammad Reazuddin, Director, DoE and Component Manager, Climate Change Cell, Ralf Ernst, Technical Adviser, and Nasimul Haque, Information and Communication Expert, Climate Change Cell for their motivation and support that has served as the basis to develop the road map to institutionalize Climate Change Impact Prediction Modelling in Bangladesh.

Acknowledgement is due also to professionals, particularly Mirza Shawkat Ali and Ziaul Haque of DoE, and Mamunur Rashid of CDMP, who devoted their attention in understanding the need and expectation for this road map.

Finally, and most of all, I thank Malik Fida A Khan of CEGIS who shared the outcome of the Modelling Workshop with relevant organizations, prepared organizational profiles for those applying and contextualizing different models in Bangladesh. Fida also helped in scoping the various roles and capacity of organizations in impact modelling.

Abu M. Kamal Uddin

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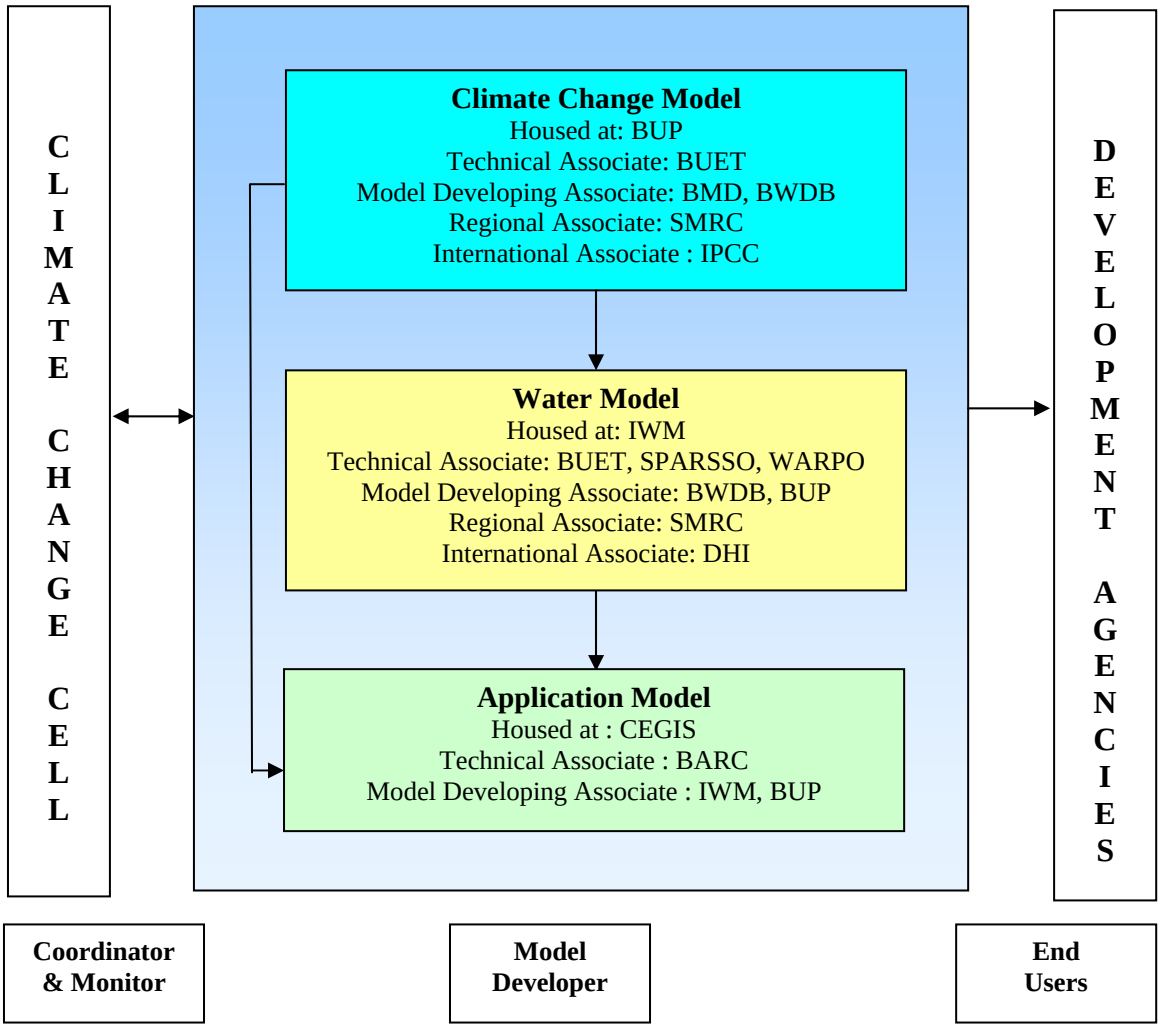
Executive Summary

Bangladesh is already experiencing climate related hazards like floods, droughts, cyclones and others which are being aggravating following climate change (and variability). A significant part of the coastal region is threatened by salinity intrusion and submersion due to sea level rise. The general predictions are: more floods, untimely floods, more droughts, drainage congestion, salinity intrusion, more cyclones with higher intensities.

To understand climate impacts and risks, some key questions need to be answered: Will these hazards become more frequent and intense? Will their magnitude increase? Which locations are most vulnerable? When will hazards occur? And what shall be possible impacts? For example: A farmer would like to know likely precipitation patterns while planning his crop calendar, preparing his land, sowing, harvesting, etc. Obviously the development practitioners, professionals and policy makers need to gather this knowledge to provide extension and other services to the primary stakeholders. Worldwide, modeling provides useful scenarios of impacts of climate change in seeking answers to the questions.



The Climate Change Cell of the Department of Environment under the Comprehensive Disaster Management Programme organized a Workshop on Climate Change Impact Modeling at BIAM Foundation, Dhaka, during 26-27 February 2006.

Collective works pursued during the workshop has been analyzed and is being presented in this document. Specific needs of different sectors from the impact modelling exercise to pursue 'sustainable climate resilient development' have been compiled. Activity based modelling presentations in the workshop indicated what different modelling exercises could offer to meet these needs. It became clear that climate modelling, water modelling and application modelling are necessary to support a 'climate resilient development' process. Another milestone finding of the workshop was that the quality of the data from BMD and BWDB used for calibration of climate modelling as a baseline data needs to be improved.

Following the workshop further consultations were held with the institutions and professionals engaged in the modelling activities. Discussions with the professionals and institutions focused on two major areas:

- Output formats including spatial (e.g. used mesh size in the model) and temporal (e.g. defined spells over the seasons) resolutions; compatibility of climate models with water models and application models in practice in the country.
- Developing profiles of the relevant modelling institutions including capacity, experience, exposure, networking and willingness to achieve and contribute in this regard.

It became evident that there is a need to establish institutional homes separately for climate modelling, water modelling and application modelling. Each of the modelling exercise requires input and contribution from a number of organizations for each model and partnerships have to be strengthened and/or developed. And again institutional arrangements have to be established among institutional homes so that output from climate modelling could be utilized as input for water and application modelling.

The profile of the model practicing institutions reveals that BUP could be considered for housing climate change models with BUET as technical associate, BMD and BWDB as model developing associate, SMRC as regional associate and IPCC as international associate. IWM could be home for water modelling with WARPO and SPARSSO as technical associate, BWDB, and BUP as model developing associate, SMRC as regional associate and DHI as international associate. CEGIS could be home for application modelling with BARC as technical associate and IWM and BUP as model developing associate. It should be mentioned that these arrangements can be adjusted over time. Rather these are initial arrangements with an open approach, as the capacity of the modelling practice shall increase in the country and new professionals and institutes shall emerge and shall join the team in any areas relevant to. All the institutions involved in climate change impact modelling shall adopt latest technology and customized for the country.

In the context of overall risk management the climate risk management is a substantial area to deal with. Accordingly modelling shall provide us present climate hazards and trends (past hazards) for specific water systems and corresponding livelihood systems shall allow us to assess climate risks at this point in time and shall be used in risk reduction initiatives of the country. There shall also be climatic hazards scenarios following global warming at local level which shall be used to initiate risk reduction initiatives in the coming future. These hazards scenarios shall also be used to deal with climate risk management in the development process of the country.

The vision is to establish an integrated climate change impact modelling approach to incorporate climate risk management in the development process of the country for ensuring safety of human lives and properties. However, the mission is outlining pathways for climate change (and variability) modelling matching development needs and existing modelling practices, strengthening capacity where needed and establish institutional arrangements that shall ensure appropriate impact scenarios to the development stakeholders in Bangladesh

The following business plan is suggested to operationalize the roadmap following business plan shall be followed. The Climate Change Cell intends to carry forward the activities of the business plan from now through 2008. However, policy advocacy for mainstreaming shall continue beyond.

Business plan

- BMD base line (1961 to 1990) precipitation and temperature data quality improvement
- Acquire localized hazard trends for seven CDMP districts to support Community Risk Assessment and Action Plan Development and initiate Local Disaster Risk Reduction
- MoU among the modelling homes and CDMP
- MoU among partners of specific models
- Validation runs PRECIS with improved data
- Validation runs RegCM with improved data
- Comparative analysis of validation results for PRECIS and RegCM
- Outline training plan for climate modelling
- Training module development for climate modelling
- Capacity building training for climate modelling
- Localized precipitation and temperature scenarios through modelling for CDMP districts
- Localized climatic hazard scenarios through biophysical and application modelling for CDMP districts
- Policy advocacy for mainstreaming use of climatic modelling products for development persuasion by all relevant agencies
- MoU among modelling house and development agencies
- Streamlined and mainstream use of modelling products down the road

This road map has been finalized addressing written comments and suggestions and sharing and discussing and incorporating all aspects with the modelling community in a meeting held on 18th June 2006 at DoE.

Chapter 1

Background

1.1 Vision

The vision is to establish an integrated climate change impact modelling approach to incorporate climate risk management in the development process of the country for ensuring safety of human lives and properties.

1.2 Mission

The mission is outlining pathways for climate change (and variability) modelling matching development needs and existing modelling practices, strengthening capacity where needed and establish an institutional arrangement that shall ensure appropriate impact modelling to the development stakeholders in Bangladesh

1.3 Context

Bangladesh has initiated a Comprehensive Disaster Management Program (CDMP) to strengthen the country's capacity in disaster management, to reduce unacceptable risks and improve response and recovery activities. CDMP aims to establish a mechanism that facilitates management of long term climate risks and uncertainties as an integral part of national development planning and increases the effectiveness of responses during both 'normal' time and emergencies.

The Climate Change Cell has been established in the Department of Environment in 2004 under the CDMP, with the objective of "Establishing an Integrated Approach to Climate Change Risk Management at National and Local Levels." It responds to the recognition that Bangladesh is particularly vulnerable to the effects of climate change, and that the number and scale of climate-related disasters are likely to increase. The Cell provides the central focus for the government's climate change related work, operating as a unit of the Department of Environment (DoE) under the Ministry of Environment and Forests (MoEF). The Climate Change Cell's work broadly focuses on three critical areas: building the capacity of MoEF/DoE to coordinate and mainstream climate change issues in development activities; strengthening existing knowledge and information accessibility on impact prediction and adaptation to climate change; and awareness-raising, advocacy and coordination to promote climate change adaptation and risk reduction in development activities.

1.4 Concern

The global climate is changing, impacting all spheres of the earth including physical, natural, social and economic domains and life and livelihoods of people. Bangladesh is particularly vulnerable to the impacts of climate change. However, the extent, intensity and magnitude of impacts are not known exactly. Bangladesh is a deltaic country; some 70% of the country is at risk of flooding and over 20% of the country experiences 'normal' floods during the monsoon period every year. Storm surges, cyclones and tornadoes occur frequently and cause huge destruction. Tropical cyclones and tornadoes have serious and adverse impacts on livelihoods and the environment causing loss of lives, property, crops, infrastructure and damage to natural resources.

Bangladesh is already experiencing climate related hazards like floods, droughts, cyclones and others which are aggravating because of climate change (and variability). Climatic changes in Bangladesh will include changes in temperature and precipitation patterns. Related risks include the likely increase in periods of drought, increase in frequency of severe flooding and increasing duration of the floods due to drainage congestion following sea level rise. Climate change will also affect water availability for households and agricultural consumption: increased precipitation and fluxes combined with sea-level rise will mean that coastal waters become more saline and ground water aquifers may face saline intrusion.

Climate change therefore threatens both previous achievements and future efforts to reduce poverty in Bangladesh, particularly by threatening water and food security and damage to essential infrastructure during more frequent disaster events.

1.4 Rationale

To cope and adapt with climate change (and variability), it is necessary to know the location, nature, intensity and magnitudes of impacts. Knowledge in this arena is growing. Globally there are more initiatives in this regard and though the globe essentially has a single climate system, climatic changes need to be identified regionally and nationally.

Modelling exercises are being practiced worldwide including Bangladesh to predict impacts of climate change (and variability). IPCC is preparing its Fourth Assessment Report, which will include latest modelling results in climate change (and variability). There are some 23 global circulation/climate models (GCM), around 7-8 regional models (RCM) and numerous country specific models in operation.

Two approaches need to be followed to provide the relevant actors, institutions and stakeholder groups in Bangladesh with models of the impacts of climate change (and variability). One is down scaling global/regional climate models to a user level and the other is interfacing climate model outputs with water models (flood, drought, cyclones etc) as well as water models with application models (drought assessment model, livelihood models, economic models).

It is essential that respective professionals from different sectors identify their specific needs of impact predictions from the modelling. The modelling exercises could then concentrate addressing these needs. The resolution and precision of the outputs from models can thus be more user-specific and demand driven.

Chapter 2

Needs Assessment

2.1 Workshop

A two day workshop on Climate Change Impact Modelling was arranged at the BIAM Foundation in Dhaka, Bangladesh, on February 26-27, 2006. The aim of the workshop was outlining pathways for climate change (and variability) modelling in Bangladesh matching development needs and existing modelling practices. It was organized by the Climate Change Cell of Department of Environment under the CDMP.

2.2 Participants

A large number of professionals from government and non-government organizations participated in and contributed to the workshop. Participants included both the demand side (representing the sectors that shall use modelling output) and the supply side (modelling community). A total of 54 participants from BUET, BWDB, SPARSSO, BMD, DMB, LGED, BIDS, WARPO, PWD, MoWR, DoE, DAE, BARC, FD, IPSU, DEFRA, UBINIG, Practical Action, IWM, CEGIS, NSU, BCAS, BELA, KU, JU, DEBTEC, ICZMP, IUCN and SUB actively participated in and contributed to the workshop.

2.3 Needs and Expectation

The workshop was arranged to create a platform between the users and the modelers so that there is a perfect blend of what the users need and what the modelers can provide. Key Questions in the workshop were: Will climate related hazards be more frequent, more intense, and increase in magnitude? Which locations are vulnerable? When are these hazards likely to occur? And what shall be possible impacts? For example: The farmer would like to know the precipitation pattern while planning his crop calendar, preparing his land, sowing, harvesting, etc. Participants of the workshop specified demands from the modelling for their respective sectors.

Based on the workshop findings the following needs and expectations have been identified:

- Location specific climate change impact (precipitation, temperature, flood, drought, salinity intrusion, erosion) projections at a sub district level
- Climate change impact projections for crops, livestock, fisheries, forestry.
- Information related to crop tolerance for salinity intrusion, pest management, soil moisture and crop adaptability, assessing loss of agro-biodiversity, potential of agricultural diversification, management of land resources, sustainable farming practices, agro-economic modelling and strategic planning for food security
- Disaster Management Bureau specifically requires scientific information on climate change impacts (e.g. flood, drought and riverbank erosion) on all sectors like agriculture, education, health, infrastructure, communication and livelihood security and others to manage disasters
- Determine the actual progress that has been made so far on climate change prediction modelling
- Upgrade and interface existing models where applicable
- Develop reliable models with provisions for regular updates
- Create database on climate change to pursue climate risk management
- Develop processes drawing on a set of experts, researchers, analysts, etc to address the specific needs and demands
- Integrate climate modelling, bio-physical modelling, application modelling and user.
- Explore mechanism for establishing such integration.
- Coordination of all relevant sectors/departments
- Creation of database in respective government departments, and make it accessible, so that any individual or agency can obtain relevant data as and when required

Chapter 3

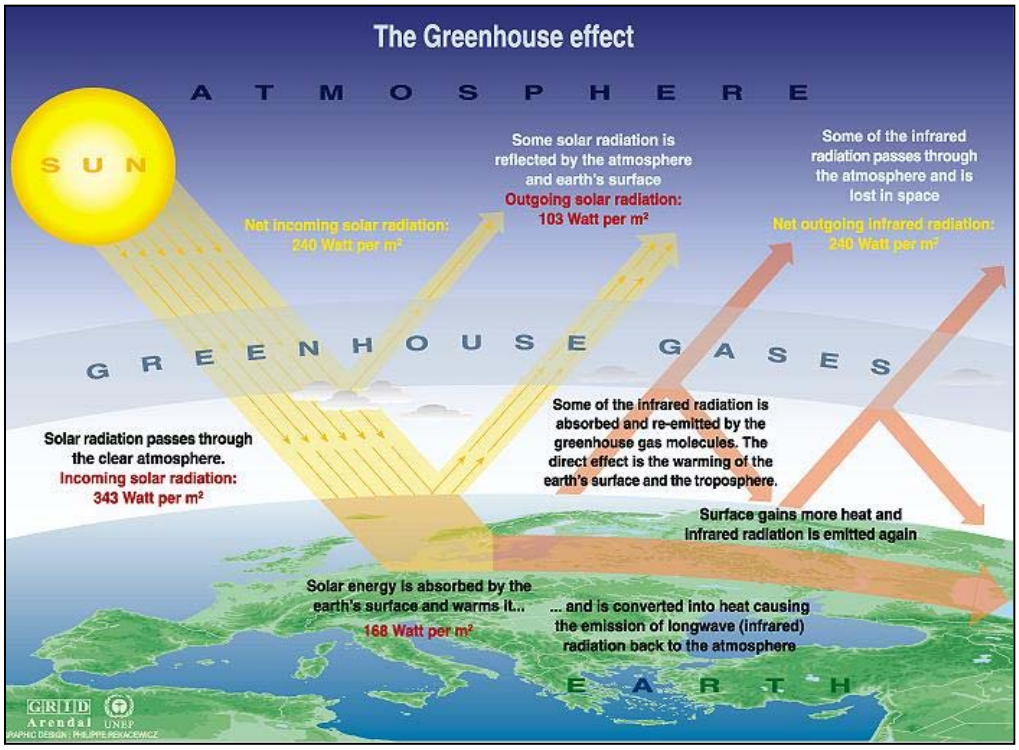
Climate Change Models in Bangladesh

3.1 Climate and Climate Model

Climate may be defined as "The average weather for a particular region and time period (usually taken over a 30-year time period). Climate elements include precipitation, temperature, humidity, sunshine and wind velocity and phenomena such as for, frost, and fail storms[1].

Climate model is a computer program that, when amounts of various gases and various other factors are specified, gives a prediction of what the temperature should be[2]. The most comprehensive climate models include: General Circulation Models (GCMs) with atmospheric and oceanic components. A GCM follows the evolution of all the weather systems, clouds, and rain, and the interactions with the land and ocean.

There are free atmospheric modes of circulation that have time-scales of up to about two years (quasi-biennal oscillation). There are also coupled ocean-atmospheric modes that have time-scales from weeks to several decades.



Source: Okanagan University College in Canada, Department of Oxford, school of geography: United States Environmental Protection Agency (EPA), Washington; Climate Change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge University press 1996.

Figure 1: Climate system and the green house effect in pictorial form

[1] http://www.everythingbio.com/gols/definition.php?world=climate
[2] http://www.teachmefinance.com/Scientific_Terms/Climate_Model.html

3.2 Status of Climate Models in Bangladesh

***RCMs*:** There is a growing demand from many countries for regional-scale climate change impact models. Global Climate Models (GCMs) operate on relatively coarse scale of a few hundred kilometres, but to study the impacts of climate change we need to model changes on much smaller scales. Regional climate models (RCMs) have a much higher resolution than global climate models and as a result provide climate information with useful local detail including realistic extreme events. RCMs allow to substantially improve assessments of a country's vulnerability to climate change.

***RegCM3*:** In 2003, Bangladesh Unnayan Parisad (BUP) initiated to introduce RegCM3 through Asia Pacific Network (APN) Capacity build-up program. RegCM is a 3-dimensional, sigma-coordinate, 16 vertical levels, primitive equation regional climate model developed by ICTP (International Centre for Theoretical Physics), Trieste, Italy. Version 3 of RegCM is the latest. It is developed and supported by scientists inside and outside of ICTP. RegCM3 is extensively used around the world and at present is running at BUET with different model parameterizations. This model can be updated regularly, offers sensitivity analysis and can generate data usually for 60/60 km or 50/50 km area. DOWNSTEP option provides high resolution output at any demanding resolution say 25/25 km or 20/20 km. Some validation results of RegCM3 with a few cases on extreme events occurred in the last decade is available and generation of future scenarios for Asian Region is on going. In case of predicting temperature RegCM shows a systematic error. But PRECIS shows random errors for low temperatures and systematic errors for high temperatures.

***PRECIS*:** The Hadley Centre of UK has developed PRECIS that can be run on a PC and can be applied easily to any area of the globe to generate detailed climate change projections. PRECIS has a horizontal resolution of 50 km with 19 levels in the atmosphere (from the surface to 30 km in the stratosphere) and four levels in the soil. The present version of PRECIS has the option to downscale to 25 km horizontal resolution. In addition to a comprehensive representation of the physical processes in the atmosphere and land-surface, it also includes the sulfur cycle. PRECIS developers advised to work based on groups of countries, as in many cases they have similar vulnerabilities and face similar impacts from climate change and can configure the model over their own region and run their own regional climate change predictions. The Institute of Tropical Meteorology (IITM), Pune, India runs PRECIS with 50 km horizontal resolution for present climate (1961-1990) using different base line local boundary condition (LBC) and for future scenarios (2070-2100) using IPCC (Intergovernmental Panel on Climate Change) Special Report on Emissions Scenarios (SRES). Department of Physics, BUET tested the model simulation for two years run (1979-1980) as the LBC data (ERA40) was available and found the same data output as obtained by IITM.

This model can predict maximum and minimum temperature, rainfall, soil moisture for each of the four seasons and as an annual average, for the period 2071-2100. Further analysis can generate quantities such as change in number of days with heavy rainfall, with temperatures greater or less than a given threshold, or changes in the number of droughts.

The Climate Change Cell, DoE with support from the Hadley center installed PRECIS at BUET, BMD and SPARRSO and formed a working group with these organizations and SMRC. Precipitation and temperature data (1961-1990) validation using PRECIS has been tried and found that regional analysis provides overestimation because of downgrading observed data when girded from asymmetric data network. Data extracted at some particular locations (observational points) provide better performance. PRECIS shows systematic cold bias for the maximum temperature and random bias for minimum temperature. The PRECIS can be used in predicting rainfall and temperature in Bangladesh using a look-up table. However, it is suggested to use clean data as the present data set from BMD and BWDB has considerable numbers of outliers.

3.3 Status of Water Modeling in Bangladesh

Institute of Water Modelling (IWM) is the only institution of its kind established by the Government of Bangladesh under the Trust Act to function as a Centre of Excellence and learning in the field of computational hydraulics, water modelling and allied sciences. IWM owes its genesis to the Surface Water Simulation Modelling Programme (SWSMP) that was launched in 1986 by the Ministry of Water Resources under the then Master Planning Organisation with the assistance of UNDP and the World Bank to develop sustained high level of analytical capabilities by use of state-of-the-art mathematical water modelling. With an added impetus generated by the two disastrous floods of 1987 and 1988, for developing a sustainable professional institution in carrying out mathematical water modelling tasks in Bangladesh, including hosting of all Flood Action Plan models the SWSMP continued in its 2nd and 3rd phases with the assistance of DANIDA. By the end of 1996, IWM (the then SWMC) was transformed into an independent self-sustained organisation under the Trust Act 1882 by a Cabinet decision.

Quasi two dimensional hydrodynamic models

- Compiled and structured the new "General Model", for the main rivers network and all the watersheds of Bangladesh by 1D hydrodynamic model developed by 1D hydrodynamic modelling system MIKE 11 of DHI
- Developed hydrodynamic models for different studies, design purposes and flood risk mapping. Flood Forecasting Modelling (72 hrs lead-time) for major and main rivers of Bangladesh.
- Upgraded and updated (***MIKE11-RR, NAM***) hydrologic and hydrodynamic models developed for 6 regions covering entire country. These were updated for last 20 years.
- Application of MIKE11 to develop watershed models and scenario studies on e.g. Jamuna Dependent Area, Salinity Intrusion in the coastal zone, Local Flood Forecasting in the flushy rivers, impact of land use changes on drainage effectiveness at the existing bridges and culverts during severe flood and incessant rainfall.

Hydrodynamic, river erosion and morphological modelling

- Completed courses on the 2D hydrodynamic & Digital Terrain Model (DTM) and its applications for the different parts in the 6 regions.
- Curvilinear Morphological Model (MIKE21) for the region of the Bay of Bengal, Jamuna, Ganges, Upper & Lower Meghna, Surma, Pasur, Sangu etc.
- Salinity, wave and sediment transport, cyclonic surge model, turbulence in flow and fluvial-morphological modelling for the Meghna estuary and Pasur river.
- Oil spill modelling for *Akram* point of estuary mouth at Pasur river.
- MIKE21C Quasi-3D model for bed and bank erosion, almost all the national and regional rivers are modeled.
- Delft3D model of *Aricha* confluence, MIKE-GIS for Flood mapping in a dynamic approach.

Ground Water Modeling

- Simulated ground water table for ground water abstraction, contamination modeling for the Dhaka City.
- MIKESHE full 3D model of the ground water flows and dynamic coupling with surface water flow- for entire Barendra area and Thakurgaon Teesta Project area.

Morphological Quasi 3D Modeling

- MIKE21C of DHI has been applied to analyse river bed and bank movement Brahmaputra, Jamuna, Ganges, Upper & Lower Meghna, Surma, Pasur, Sangu and several major regional rivers and forecast one to five year and devising appropriate mitigation measures.
- MIKE21C has also been used for river bank and island erosion forecast (one to successive five years)
- This model has also been used for hydraulic designs of road and rail infra-structures and bridges.
- Delft 3D of Delft Hydraulics with limited application has been used in *Aricha*-confluence.

Urban Water Modeling

- Water distribution modelling for Dhaka city by MIKE URBAN of DHI
- Drainage Model for *Segunbagicha-Dholai Khal* link project by MOUSE and MOUSE Flood of DHI.

Ground Water and Surface Water Interaction Modeling

- Simulated ground water table by **MODFLOW** for ground water abstraction and contamination modeling for the Dhaka city.
- Provided DSS for several irrigation projects like North Bangladesh Tubewell Project, Teesta Project, Pabna Project, Meghna-Dhonagoda project, Chandpur Irrigation Project and Barendra Development project by MIKESHE and MIKE11 of DHI."

Basin Model

- Basin wide modelling of the Indo-Gangetic plains by MIKE-Basin of DHI

3.4 Status of Application Models in Bangladesh

DRAS: DRAS (Drought Assessment) is a computer based computational framework linked with GIS analytical tools developed by CEGIS for quick assessment of drought. This model assists in making strategies for national level planning as well as determining the requirement of irrigation water for different types of soils at different agro-ecological climates. DRAS consists of two models, the Water Availability Assessment Model and the Crop Water Demand and Yield Reduction Model.

Erosion Prediction Model: CEGIS developed techniques for monitoring and predicting bank erosion along the Jamuna River using time-series of dry season satellite images in the late 1990's. CEGIS is monitoring and predicting the morphological development as well as bank erosion at various reaches of the Jamuna River under the framework of a number of BWDB and WARPO projects such as the RBPP, JMREMP, FAP 21 and EMIN Projects.

Integrated Water Resources Management (IWRM): CEGIS developed computation framework for IWRM focusing on inter-sectoral resource balance; management and improvement of cross-border flows; basin wise development; and an optimal mix of the various structural and non-structural measures.
CROPSUIT: CEGIS developed Crop Suitability Model CROPSUIT that projects suitability of crops and shrimps with changing sea level rise scenarios. This study will show future pathway of sustainable landuse planning in environmentally vulnerable regions.

Chapter 4

Institutional Profiles

4.1 Bangladesh Unnayan Parishad

Bangladesh Unnayan Parishad (BUP) is a non-profit organization that promotes basic and applied research on socioeconomic development and environment in Bangladesh since 1980. Over the years BUP has acquired and developed required expertise for carrying out research and studies. Presently the strength is 22 core full-time professional including senior scholars, research directors, senior specialists/fellows, fellows, senior associates, associates. Besides, BUP maintains a roster of resource personnel/experts and field staff.

Since 2001, BUP is involved in the development of climate change impact modelling for Bangladesh in collaboration with national and international scientific communities. This organization has the licensed version of RegCM and PRECIS, both recommended by IPCC. BUP is also a member of the IPCC working group 1 which is responsible for improvement and update of climate change models.

Presently BUP is involved in development of different scenarios for Bangladesh for 2100 in collaboration with Pakistan and Nepal. These member countries are working with RegCM to validate the model and prepare different scenario for Southeast Asia. Simultaneously, model validation of RegCM has also been carried out by Bangladesh University of Engineering Technology in collaboration with BUP.

BUP has collaborative relationship and working partnership with organizations of high international repute both within and outside Bangladesh. Currently the BUP has international linkages either as a member or as a working partner with:

- Inter-governmental Panel on Climate Change, UN Environment Program
- Intergovernmental Panel on Climate Change (IPCC)
- Association of Development Research and Training Institutes of Asia and the Pacific (ADIPA), which is headquartered in Kuala Lumpur, Malaysia;
- Asian Network of Human Resource Development Planning Institutes, coordinated by ILO/SAAT, New Delhi, India;
- Climatic Research Unit (CRU), East Anglia University, U. K.;
- International Global Change Institute (IGCI), former Centre for Environmental and Resource Studies (CEARS), University of Waikato, Hamilton, New Zealand;
- Centre for Policy Research (CPR), New Delhi, India;
- Institute for Integrated Development Studies (IIDS), Kathmandu, Nepal; and
- Global Infrastructure Fund (GIF) Research Foundation, Tokyo, Japan.
- Cooperative Monitoring Center (CMC), Sandia National Laboratory, USA.
- Global Water Partnership (GWP), Stockholm, Sweden.
- International Water Resources Association (IWRA), Mexico City, Mexico.

4.2 Institute of Water Modelling

IWM is a trust set up by the Government of Bangladesh as a Centre of Excellence in the field of water modeling and allied sciences. IWM provides world–class services in the field of Water Modeling, Computational Hydraulics & Allied Sciences for improved integrated Water Resources Management. It is a unique organization in the region having sustainable technological capability in developing mathematical models and decision support systems for both surface and ground water and related environment in a holistic approach. The applications of IWM modelling tolls cover a wide range of water related aspects such as : flood control, flood forecasting, irrigation and drainage, water resources management, river morphology, salinity and sediment transport, coastal hydraulics, port, coast and estuary management, environmental impact assessment, bridge hydraulics and related infrastructure development. In developing the models, IWM undertakes its own data campaign and has earned a high reputation for fast and cost effective river surveys in large rivers using state-of-the-art techniques and equipment. Presently systematic campaigns are undertaken to produce GIS based topographic maps. IWM has developed a very comprehensive database covering almost the entire country for a long period; the database is computerized and is maintained online. IWM conducts applied research in collaboration with academic institutes and agencies likely to contribute and benefit from the research findings. IWM provides training at home and abroad for the water management professionals.

The number of staffs in IWM is about 160, of whom more than 70% are professionals. Regular training programs both at home and abroad are conducted to develop and update their expertise in relevant fields. Some staff is currently pursuing higher studies abroad (MS and PhD) and the Institute encourages such programmes for upgrading expertise.

Over the years IWM has established close linkages with different national and international institutions. DHI Water and Environment of Denmark has been a close partner in the technology transfer. Similar linkages were also established with the Bangladesh University of Engineering and Technology (BUET), Asian Institute of Technology, Thailand, HR Wallingford, UK and Delft Hydraulics of the Netherlands.

4.3 Center for Environmental and Geographic Information Services (CEGIS)

The Center for Environmental and Geographic Information Services (CEGIS) is another supportive quasi Government institute for integrated environmental analysis using geographic information systems and remote sensing, as well as information technology and databases. CEGIS' predecessor, EGIS was launched in 1995 through the integration of the Environmental Studies (FAP 16) and the Geographic Information System Studies (FAP 19), initiated under the FAP in 1991. In 2002 CEGIS has been established as public trust under the Ministry of Water Resources through successful completion of EGIS-I and EGIS-II projects.

Set up under the aegis of the Ministry of Water Resources, Government of Bangladesh (GoB) and supported by the Government of the Netherlands, it became an independent registered organization after 10 years of working as a project. Thus CEGIS, with its services and products relating to consulting, R&D, spatial analysis, information and database, and training, came into full operation from 1st July, 2002. CEGIS is equipped with specialized hardware and soft ware including latest remote sensing and data bases. CEGIS provides required set of reliable, accessible and frequently updated information in the field of over all green environment and natural resources management domains to support a number of GoB agencies and by taking part in projects in response to specific demands.

CEGIS has expertise as well as tools to assess the impacts on economy, society, and environment for different Climate Change conditions. CEGIS has working experience in developing physical models (e.g. hydrological, land and water resource, land and water use suitability). CEGIS have experience with GWAVA, STREAM, CROPSUIT models and other impact models.

CEGIS has over 50 multidisciplinary professionals with expertise in hydrology, water resource management, fisheries, economics, agriculture, sociology, ecology, biology, river morphology, engineering, ground water, soil science, GIS, remote sensing, database and programming. CEGIS continuously support its human resources development through training at home and abroad. CEGIS has a strong systematic research and development (R&D) program.

CEGIS has collaborative agreements and a working relationship with a number of national agencies including WARPO, BWDB, BARC (Bangladesh Agricultural Research Council), BRRI (Bangladesh Rice Research Institute) and DoF. CEGIS also has access to expertise from agencies from abroad including the Netherlands, USA and UK.

4.4 Bangladesh University of Engineering and Technology

Bangladesh University of Engineering and Technology, abbreviated as BUET, is one of the most prestigious institutions for higher studies in the country. About five thousand students are pursuing undergraduate and postgraduate studies in engineering, architecture, planning and science in this institution.

At present Dr. Md. Nazrul Islam of the Department of Physics, BUET works in the area of Atmospheric Physics. His research is concentrated mainly in the field of Satellite Meteorology, Radar Meteorology, Monsoon Meteorology, Climate Modelling and Remote Sensing. At present three Regional Climate Models (RCMs) named MM5 (PSU/NCAR, USA), RegCM3 (Italy) and PRECIS (UK) are installed and running in the Department of Physics, BUET. Dr. Islam and his associates are involved in MM5, PRECIS and RegCM3 activities from BUET.

He was involved in "Japan-Bangladesh Joint Study Project" Phase I and Phase II, in Meteorology Section for investigating rainfall characteristics and diurnal variation of rainfall in Indian Subcontinent. These projects were funded by Japan International Co-operation Agency (JICA). He was also involved in a "Monbusho" project with Disaster Prevention Research Institute (DPRI), Kyoto University; funded by Grant Aid of Ministry of Education, Culture and Sports in Japanese Government, Japan, for investigating cause of natural disaster like flood in this region. Currently he is involved as a Co-Investigator in TRMM-RA4 project to investigate the “Statistical studies on characteristics of cloud and precipitation around Bangladesh during Monsoon period”. He is also working as the Co-Investigator and Team Leader (Bangladesh side) in GEOSS/ MAHASRI project funded by Japan. The aim of these projects is “to develop a hydro-meteorological prediction system, particularly with the time scale up to a season, through better scientific understanding of Asian monsoon variability”.

4.5 Bangladesh Agricultural Research Council

The Bangladesh Agricultural Research Council (BARC) under the Ministry of Agriculture is at the apex of the national agricultural research system (NARS). It has the responsibility to strengthen the national agricultural research capability through planning and integration of resources. This involves cooperative activities in several ministries: Agriculture, Forest and Environment, Fisheries and Livestock, Rural Development, Education, Industries, Commerce, Science and Technology, etc. BARC’s activities generally include crop improvement; soil and water management and land use; plant protection; plant nutrition; animal and fish production; animal health; farming system; post harvest technology; forestry; and socio-economics. BARC uses models such as SCENGEN (generating climate scenario), DRASS, PRECIS, RegCM and DSAT (Decision Support System for agro-technology transfer) which is compatible with RegCM.

4.6 Bangladesh Meteorological Department

Bangladesh Meteorological Department (BMD) is the authorized Government organization for all meteorological activities in the country. It maintains a network of surface and upper air observatories, radar and satellite stations, agro-meteorological observatories, geomagnetic and seismological observatories and meteorological telecommunication system. They maintain precipitation and temperature data among others.

4.7 Bangladesh Water Development Board

Bangladesh Water Development Board (BWDB) is the leading organization for water resources management and development. BWDB mainly deals with, flood control and drainage; irrigation; river bank and town protection; flood forecasting and warning services; hydro-meteorological data management; land reclamation; protection against tidal surge. BWDB collects and maintains data on surface water (water level, discharge, sediment data, and water quality), groundwater (level measurement, quality), morphology (river cross section) and meteorology (rainfall, evaporation, climetrological station).

4.8 Bangladesh Space Research and Remote Sensing Organization (SPARSSO)

SPARSSO has been established in 1980 as an autonomous multisectoral R&D organization of the Government of the People's Republic of Bangladesh. It acts as the centre of excellence and national focal point for the peaceful applications of space science, Remote Sensing and Geographic Information System (GIS) in Bangladesh. It keeps close collaboration with national, regional and international organizations, institutions and agencies. The research results, satellite data and information are disseminated to the relevant public, autonomous and private agencies for their development and policy-making activities. SPARSSO have facilities such as meteorological satellite ground station, image processing and GIS facilities, advanced cartography laboratory, advanced photographic laboratory and trained manpower. SPARSSO has been involved in PRECIS modelling activities along with others. SPARSSO activities among others include following:

- Agricultural research: crop monitoring, crop yield forecasting;
- Disaster monitoring: daily weather, tropical cyclone, storm surge, drought, flood;
- Environment study: climate change, coastal zone, oceanography, EL-Nino, monsoon and ecology;
- Water resources, river course monitoring, erosion/accretion monitoring;
- Forestry and Fisheries;
- Land use, land degradation;
- Cartography - GIS applications, thematic and digital maps;

4.9 Water Resources Planning Organization

The Water Resources Planning Organization (WARPO) is an agency of the Government of the People's Republic of Bangladesh under the Ministry of Water Resources. WARPO came into being in June, 1992 and became key organization of the Government dealing with nation wide water resources planning and management and, thus, forming an apex body in the water sector. WARPO is responsible for three main assignments. First, it prepares and updates the National Water Management Plan. Second, it updates and maintains a National Water Resources Database. Third, WARPO will act as a clearing house for all water sector projects. WARPO is a multi-disciplinary organization with a team of some 35 professionals from a wide range of disciplines.

4.10 SAARC Meteorological Research Centre

SAARC Meteorological Research Centre (SMRC) was established in 1995 to carry out research, to support mitigation of natural disasters and to help this region to achieve and continue the sustainable socio-economic development of SAARC Member countries. The Centre is responsible for: Undertaking research relevant to weather predication and better understanding of various aspects of monsoon and other weather phenomena of particular interests to the region; compiling climatological information for the region required for weather forecasting and agricultural activities; organizing special observation or observing periods for monitoring special weather phenomena of interest to the region for collecting data and undertaking research; developing a networking system between the Centre and the member countries in order to get data to undertake its activities and to provide the processed information to the members.

Chapter 5

Road Map for Climate Change Model

5.1 Basis

Collective works pursued during the workshop has been analyzed and is being presented in this document. Specific needs of different sectors from the impact modelling exercise to pursue 'sustainable climate resilient development' have been compiled. Activity based modelling presentations in the workshop indicated what different modelling exercises could offer to meet these needs. It became clear that climate modelling, water modelling and application modelling are necessary to support a 'climate resilient development' process. Another milestone finding of the workshop was that the quality of the data from BMD and BWDB used for calibration of climate modelling as a baseline data needs to be improved.

Following the workshop further consultations were held with the institutions and professionals engaged in the modelling activities. Discussions with the professionals and institutions focused on two major areas:

- Output formats including spatial (e.g. used mesh size in the model) and temporal (e.g. defined spells over the seasons) resolutions; compatibility of climate models with water models and application models in practice in the country.
- Developing profiles of the relevant modelling institutions including capacity, experience, exposure, networking and willingness to achieve and contribute in this regard.

It became evident that there is a need to establish institutional homes separately for climate modelling, water modelling and application modelling. Each of the modelling exercise requires input and contribution from a number of organizations for each model and partnerships have to be strengthened and/or developed. And again institutional arrangements have to be established among institutional homes so that output from climate modelling could be utilized as input for water and application modelling.

5.2 Institutional home for modelling exercise

*Climate Change Model***:** Climate modelling has been introduced recently in the country and is in a beginning stage. The PRECIS model has been installed at BUET, BUP, BMD, SMRC and SPARSSO and these organizations have been working with this model and engaged to run a data validation for base condition. The effort however did'nt yield expected output because of limited coordination, quality of data and missing of a home base. An institutional home is necessary with devoted commitment to pursue the climate modelling in the country. Institutional capacity in this regard has scope to strengthen further. A capacity building initiative will be undertaken soon to increase the number of professionals who shall be able to run the climate models and use outputs of the models.

Since 2001, BUP is involved in the development of climate change impact modelling for Bangladesh in collaboration with national and international scientific communities. This organization has the licensed version of RegCM and PRECIS, both recommended by IPCC. BUP is also a member of the IPCC working group 1 which is responsible for improvement and update of climate change models. RegCM and PRECIS are compatible with the water models practiced in Bangladesh. Climate modelling activities shall continuously be improved through technical guidance from BUET and shall join hands with BWDB and BMD receiving data for modelling and remain linked with SMRC and IPCC.

*Water Model***:** Mathematical modelling for the water parameters has gone a considerable way in Bangladesh and has the capacity and experience of one and two dimensional mathematical modelling using MIKE products developed by Danish Hydraulics Institute, Denmark. Institute of Water Modelling (IWM), a public trust, is the organization working since 1990 with Mike products and developed the basic models required for flood elevation computation for flood forecasting and warning in Bangladesh. It also provides support on river modelling to study river flow and floods, morphology, sediment transport, salinity, water quality, off- take dynamics etc. The modelling system forms the basis also for the assessment of environmental impacts, such as, discharge of pollutants, dumping of spoils or land reclamation, salinity intrusion, cooling water discharge, floods and storm surges. Presently the off the shelve water models are presented below:

Table 1: Water model available at IWM

Name of the model	Extent	Major Output/product (for union, upazila and district)	MIKE Modules
Rainfall Runoff model	All hydrological regions of Bangladesh (including information of union level)	rainfall, evaporation, runoff, catchments flow	NAM MIKE11
Hydrodynamic model	All hydrological regions of Bangladesh (including information of union level)	water availability, water level, discharge, velocity, flood level inundation depth and duration map, water quality	MIKE11/MIKE-GIS/MIKE FLOOD
Morphological Model/Sediment Transport model	Major river system: Jamuna, Padma, Ganges and Meghna, Pussur Sibsa system Lower Meghna, Karnafuli and Sangu river	sediment transport, erosion/deposition pattern, long-term morphological changes	MIKE11
Flood Forecasting model	Flood forecasting, All regions except coastal area	flood scenarios (flood level, depth and duration), flood map for rural and urban areas	MIKE11
Hydrodynamic & Digital Terrain model and Morphological model	Region of Bay of Bengal. Jamuna, Padma, Ganges, Upper & Lower Meghna, Surma Pussur-Sibsa river system	erosion vulnerability for characteristic flood, erosion-prone areas, riverbank erosion forecast , erosion mitigation measures, impacts of erosion mitigation measures.	MIKE21 & MIKE21C Delft3D
Salinity, Wave, Sediment Transport and Cyclonic Surge model, Turbulence in flow and Fluvial Morphological model	The coastal zone, Meghna estuary and Pussur Sibsa river system	salinity level and extent in chart/graphs and tables, salinity zoning map for agriculture, fisheries and household use, sediment budget, erosion/deposition pattern, sedimentation in harbour and navigation channel, navigability of river and assessment of maintenance dredging storm surge inundation depth and duration and risk map	MIKE21 MIK21FM
Groundwater Modeling	Dhaka city and other projects at regional level	groundwater availability, groundwater and its potential for future use, aquifer response, recharge mechanism, zoning for STW and DTW, groundwater quality	MODFLOW and MIKESHE

IWM updates the recent development of water models around the world through Network with Danish Hydraulics Institute. IWM would be the appropriate institute for housing water modelling in Bangladesh. Water models will be developed by IWM from technical support from WARPO & SPARSSO shall provide the technical support. BMD and BWDB will be model development associate through providing necessary data and information. SMRC will act as the regional associate and DHI will be the international associate.

*Application Models***:** Center for Environment & Geographic Information Services (CEGIS) has extensive experience in the field of integrated environmental analysis through development of application models using input data and information from the available climate change and water models in Bangladesh.

Recently, CEGIS has developed an applied hydrological model using GWAVA model to assess the availability of water resources for the whole country with input information from PRECIS model under the CLASIC project. CEGIS has also recently developed a Climate Change application model to see the impact of sea level rise on landuse suitability and different adaptation options in the south west region of Bangladesh. A CROPSUIT model has been developed to determine the physical suitability of crops and shrimps based on land characteristics. The input data for these model has been taken from water model developed by IWM for simulating river system under the present and future condition.

CEGIS has also developed Drought Assessment application (DRAS) model in collaboration with Bangladesh Agriculture Research Council (BARC) for rapid assessment of the drought and its management guidelines for the country. This model has two parts: Water availability assessment model and crop water demand with yield reduction assessment. The Water availability assessment model was developed based on water model information and climate change data. This model is capable of providing drought information on an average of 30 years and recent year.

CEGIS can provide following information from the available application models:

Table 2: Application models available at CEGIS

Name of the model	Major Output	Product Description
DRAS	Thana wise water availability, crop water demand, and yield reduction for current year and also the trend.	Customized GIS based software using model output from water model of IWM and ground water model of WARPO.
Erosion Prediction	Probability of erosion prediction for main river systems (Jamuna, Padma, Ganges and Meghna) for one year ahead.	Empirical model based on remote sensing, hydrological and water quality data
CROPSUIT	Landuse suitability mapping showing the impacts on agriculture fisheries and forest for current and projected year.	It can produce mapping under different sea level rise scenarios
GWAVA	Grid based daily availability of water resources.	Distributed GIS based hydrological water balance model which can run under different climatic scenarios.

GEGIS will be the institutional home for the application model in association with BARC as the technical partner. BUP and IWM will also work as model development associate.

5.2 Institutional arrangements for modeling exercise

The profile of the model practicing institutions reveals that BUP could be considered for housing climate change models with BUET as technical associate, BMD and BWDB as model developing associate, SMRC as regional associate and IPCC as international associate. IWM could be home for water modelling with WARPO and SPARSSO as technical associate, BWDB, and BUP as model developing associate, SMRC as regional associate and DHI as international associate. CEGIS could be home for application modelling with BARC as technical associate and IWM and BUP as model developing associate. It should be mentioned that these arrangements can be adjusted over time. Rather these are initial arrangements with an open approach, as the capacity of the modelling practice shall increase in the country and new professionals and institutes shall emerge and shall join the team in any areas relevant to. All the institutions involved in climate change impact modelling shall adopt latest technology and customized for the country.

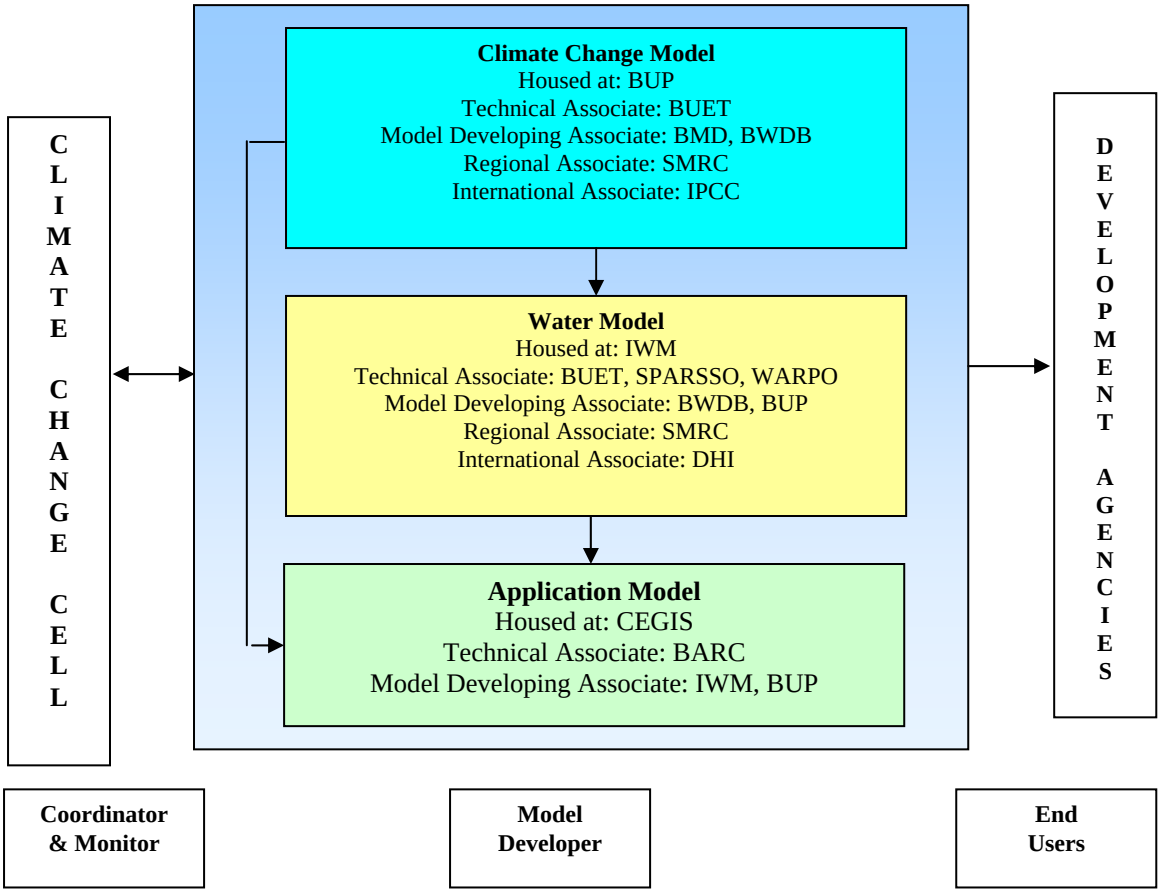


Figure 2: Road Map for future coordination of Climate Prediction Model in Bangladesh

*Coordination***:** Climate Change Cell, established at DoE within the frame work of CDMP shall coordinate modelling practice for development persuasion. Climate Change Cell could be used as a platform where model developers (BUP, IWM & CEGIS) and end users (CDMP and development agencies) can come together for better understanding, coordination and building of partnership. The available models shall be further enhanced with the state of the art techniques and technology from different scientific communities working at national, regional and international level and shall be customized for Bangladesh and continue to support information need for climate risk management. To achieve this climate change cell shall continue to pursue policy advocacy along with awareness raising and capacity building to mainstream CRM.

5.2 Business plan

The following business plan is suggested to operationalize the roadmap following business plan shall be followed. The Climate Change Cell intends to carry forward the activities of the business plan from now through 2008. However, policy advocacy for mainstreaming shall continue beyond.

Business plan

- BMD base line (1961 to 1990) precipitation and temperature data quality improvement
- Acquire localized hazard trends for seven CDMP districts to support Community Risk Assessment and Action Plan Development and initiate Local Disaster Risk Reduction
- MoU among the modelling homes and CDMP
- MoU among partners of specific models
- Validation runs PRECIS with improved data
- Validation runs RegCM with improved data
- Comparative analysis of validation results for PRECIS and RegCM
- Outline training plan for climate modelling
- Training module development for climate modelling
- Capacity building training for climate modelling
- Localized precipitation and temperature scenarios through modelling for CDMP districts
- Localized climatic hazard scenarios through biophysical and application modelling for CDMP districts
- Policy advocacy for mainstreaming use of climatic modelling products for development persuasion by all relevant agencies
- MoU among modeling house and development agencies
- Streamlined and mainstream use of modelling products down the road

This road map has been finalized addressing written comments and suggestions and sharing and discussing and incorporating all aspects with the modelling community in a meeting held on 18th June 2006 at DoE.