Agricultural Research Priority : Vision-2030 and beyond

# Sub-sectoral Study on ICT in Agriculture and Disaster Management

Sk. Ghulam Hussain

Bangladesh Agricultural Research Council
June 2010

**Sectoral Study in connection with the preparation of Vision Document-2030 and beyond**

# ICT in Agriculture and Disaster Management


| | | |
|---|---|---|
| **Group Leader** | : | **Sk. Ghulam Hussain**<br>**Member-Director, BARC** |
| **Member-Secretary/ Rapporteur** | : | **Md. Abeed Hossain Chowdhury**<br>**Director (Computer), BARC** |



**Bangladesh Agricultural Research Council**
**June 2010**

## Abbreviations and Acronyms

| | |
|---|---|
| ADPC | Asian Disaster Preparedness Center |
| AEZ | Agro-ecological Zone |
| AF | Adaptation Fund |
| AIS | Agricultural Information Service |
| AOGCM | Atmosphere-Ocean General Circulation Models |
| APT | Agricultural Planning Tools) |
| AR4 | Fourth Assessment Report |
| ARI | Agricultural Research Institute |
| BAF | Bangladesh Air Force |
| BARC | Bangladesh Agricultural Research Council |
| BARI | Bangladesh Agricultural Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| BCCSAP | Bangladesh Climate Change Strategy and Action Plan |
| BCCSAP | Bangladesh Climate Change Strategy and Action Plan |
| BDT | Bangladeshi Taka |
| BFRI (Fisheries) | Bangladesh Fisheries Research Institute |
| BFRI (Forest) | Bangladesh Forest Research Institute |
| BIID | Bangladesh Institute ICT in Development |
| BINA | Bangladesh Institute of Nuclear Agriculture |
| BJRI | Bangladesh Jute Research Institute |
| BLRI | Bangladesh Livestock Research Institute |
| BMD | Bangladesh Meteorological Department |
| BRKB | Bangladesh Rice Knowledge Bank |
| BRRI | Bangladesh Rice Research Institute |
| BSRI | Bangladesh Sugar Research Institute |
| BTCL | Bangladesh Telecommunications Company Limited |
| BTRI | Bangladesh Tea Research Institute |
| BTTB | Bangladesh Telegraph and Telephone Board |
| BWDB | Bangladesh Water Development Board |
| CD | Compact Disk |
| CDMP | Comprehensive Disaster Management Programme |
| CGIAR | Consultative Group on International Agricultural Research |
| CGP | Competitive Grants Program |
| CIG | Common Interest Group |
| CIMMYT | Centro Internacional Mejoramiento Maiz y Trigo/International Center for Wheat and Maize Improvement |
| CIP | International Potato Center |
| CPP | Cyclone Preparedness Programme |
| CT | Conservation Tillage |
| DAE | Department of Agricultural Extension |
| DAM | Department of Agricultural Marketing |
| DEM | Digital Elevation Model |
| DFID | Department for International Development |
| DIRA | Disaster Impact and Risk Assessment |
| DLS | Directorate of Livestock Services |
| DMB | Disaster Management Bureau |
| DOF | Department of Fisheries |
| DRAS | Drought Assessment Framework |
| EIA | Environmental Impact Assessment |
| EIGS | Environmental Geographic Information Services |
| EO | Earth Observations |

| | |
|---|---|
| FAO | Food and Agriculture Organization of the United Nations |
| FAP | Flood Action Plan |
| FCD | Flood Control and Drainage |
| FD | Forest Department |
| FFWC | Flood Forecasting and Warning Centre |
| GCM | General Circulation Model/Global Climate Model |
| GDP | Gross Domestic Product |
| GIS | Geographic Information System |
| GMS | Geostationary Meteorological Satellite |
| GOB | Government of Bangladesh |
| GP | Grameen Phone |
| GPCIC | Grameen Phone Community Information Center |
| HadRM2 | Hadley Centre Regional Model |
| Hortex | Horticultural Export |
| HRD | Human Resource Development |
| HYV | High Yielding Varieties |
| ICT | Information and Communication Technology |
| IMDMCC | Inter-Ministerial Disaster Management Coordination Committee |
| IPCC | Intergovernmental Panel on Climate Change |
| IPGRI | International Plant Genetic Resources Institute |
| IPR | Intellectual Property Rights |
| IR | Infrared |
| IRRI | International Rice Research Institute |
| ISP | Internet Service Provider |
| ITU | International Telecommunication Union |
| KM | Knowledge Management |
| LAN/WAN | Local Area Network/Wide Area Network |
| LDCF | Least Developed Countries Fund |
| MDG | Millennium Development Goal |
| Mha | Mega or Million Hectare |
| MIS | Management Information System |
| MMD | Multi-Model Data sets |
| MoA | Ministry of Agriculture |
| MoEF | Ministry of Environment and Forest |
| MoFDM | Ministry of Food and Disaster management |
| MoP | Ministry of Planning |
| MoSICT | Ministry of Science and Information & Communication Technology |
| NAPA | National Adaptation Programme of Action for Climate Change |
| NARS | National Agricultural Research System |
| NATP | National Agricultural Technology Project |
| NCA | Net Cropped Area |
| NDMC | National Disaster Management Council |
| NGO | Non-Government Organization |
| NOAA | National Oceanic and Atmospheric Administration |
| NWMP | National Water Management Plan |
| PBTL | Pacific Bangladesh Telecom Limited |
| PO | Producers' Organization |
| PRSP | Poverty Reduction Strategy Paper |
| PSTN | Public Switched Telephone Network |
| RCM | Regional Climate Model |
| RMIS | Research Management Information System |
| RS | Remote Sensing |
| SAARC | South Asian Association for Regional Cooperation |
| SLR | Sea Level Rise |
| SMME | Small, Medium and Micro Enterprises |

| | |
|---|---|
| SMS | Short Message Service |
| SoD | Standing Order on Disasters |
| SOLARIS | Soil and Land Resource Information System |
| SPARRSO | Space Research and Remote Sensing Organization |
| SPGR | Sponsored Public Goods Research |
| SRDI | Soil Resources Development Institute (Bangladesh) |
| SRES | Special Report on Emission Scenarios |
| TAR | Third Assessment Report |
| UCS | Union of Concerned Scientists |
| UNDP | United Nations Development Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UUCP | Unix-to-Unix Copy |
| VSAT | Very Small Aperture Terminal |
| VSAT | Very Small Aperture Transmission |
| WiMAX | Worldwide Interoperability for Microwave Access |
| WSIS | World Summit on the Information Society |

# CONTENTS

**List of Tables**



**List of Figures**

## Executive Summary

The economy of Bangladesh is based on agriculture, industry and services. The agriculture sector contributes a major share in the GDP, which is about 20.0% and employs about 48.07% of the working force. According to Intergovernmental Panel on Climate Change (IPCC), Bangladesh will be one of the worst victims of climate change. Sea level will be increased due to rise in temperature and the frequency of cyclone-storms will also be increased. As a result, food security will be in jeopardy and different types of natural calamities will put lives at risk. On top of these, high population density in will make the problem more serious.

The people of Bangladesh have been adapting to the risks of floods, droughts and cyclones for centuries. Heavy reliance of rural people on agriculture and natural resources increases their vulnerability to climate change. Therefore, supporting rural and urban communities to strengthen their resilience and to adaptation to climate change will remain a high priority in coming decades.

Disaster management, climate change and other related issues in agriculture are cross-cutting in nature. All the sub-sectors of agriculture are vulnerable to natural hazards, shocks and stresses. Although, all the sub-sectors might not be impacted equally, but it is likely that some would be more susceptible.

Basically, Information Communication Technology (ICT) is a tool that can be used for many different purposes and fields. ICT plays a vital crosscutting enabler role in addressing many problems. This tool can be used in solving problems, increasing efficiency and providing effective service delivery in agriculture and disaster management. The proposed National ICT Policy-2008 of Bangladesh states that ICT is one of the most important tools to achieve economic prosperity of a country through improving the management and efficiency in every sphere of life.

Although, computer was introduced in Bangladesh more that 50 years ago, application of ICT in agriculture initiated only in 1979 when the FAO/UNDP Agricultural Development Advisor Project was undertaken by the Ministry of Agriculture. Under this project the information on landforms, soils, inundation regime and climate were computerized during 1980-86. As follow up of this, several ICT initiatives were undertaken, especially at BARC and SRDI and the outputs of these were used for agricultural research, development and extension. Services are being provided to the Ministry of Agriculture and other Ministries, various NARS institutes, and extension agencies, Universities, International Organizations, and GOs and NGOs by catering to their needs.

Media is emerging as an important instrument to disseminate the knowledge, success story and technology. Both electronic and print media are organizing regular programs on agriculture and much awareness has developed among the policy makers and growers. Extension service may be strengthened with the help of ICT at the grassroots level. Public private collaboration may be established for quick dissemination of agricultural technology.

Bangladesh has made reasonable progress in meeting the Millennium Development Goal 8's indicators 8.14, 8.15 and 8.16. ICT services like telephone services have increased remarkably in the country with the wider use of cellular phones. However, the growth of land phones

was steady. Internet services are mostly available in metro city areas and at best the district head quarters. Only three connections were available per 1000 population in 2008, but in the base year, it was almost nil. As a consequence of this Public and Private sectors are developing service oriented application of ICT in agricultural development and technology dissemination.

Current status of ICT in Bangladesh in respect of infrastructure and applications has made significant progress during the last two decades. Review of various National policies and other relevant documents showed that importance of ICT in agricultural research and development has been recognized. Further, disaster management is the topmost priority of the Government. In performing the task, recommendations of the four regional workshops and the national workshop organized in this connection eleven other sub-sectoral report concerning ICT and disaster management were consulted. Government's policy towards development of infrastructure and enabling condition is highly positive.

As ICT can play a significant role in research and development of agriculture and disaster management, the Bangladesh Agricultural Research Council appropriately has chosen the area as one of the sub-sectors for detailed study. This report is the outcome of the effort made by the Bangladesh Agricultural Research Council to conduct a sectoral study in connection with the preparation of 'Vision Document-2030 and beyond'. The main focus of this study is to elaborate how ICT can be applied in agriculture sector and its research and development, technology dissemination, and disaster management. The methodology followed in preparing this report is a bit different from that followed in case of commodity based sub-sectors. However, the prescribed ToR and Group Work Guidelines were followed wherever applicable or possible.

Several National policies and other relevant documents were reviewed. Besides, many other secondary information were colleted from consultancy reports, internet resources and were reviewed. The most of the policies formulated after 2002 have stressed need for using ICT. Four Regional (Rajshahi, Chittagong, Barisal and Dhaka) Stakeholders Consultation Workshops on Agricultural Research Priority Setting were held during December 2009 to February 2010. The number of participants varied from 100-170, but the proportionate mix was more or less the same. In all the Regional Workshops participants were drawn from/among Extension personnel from DAE, DOF and DLS (55%); Researchers from NARS and Universities (25%), NGOs, POs (included private entrepreneurs, fertilizer dealers, etc), Others included participants from BADC, BWDB, KGF, etc. (10%); Above all, to get the first hand inputs from the fields farmers (10%) participation was ensured. Breakout Groups varied with the context of the regional importance.

Based on the information provided by and gathered from different agencies on researchable problems at various levels were analyzed for setting the priorities in the field of ICT in agriculture and disaster management. The following sources were considered:

i. Research priorities of different ARIs
ii. Outcomes of discussions with researchers form ARIs and Universities
iii. Response from all extension agencies (DAE, DOF, DLS), who were requested to provide information on field problems
iv. Researchable problems extracted from Upazila Micro Extension Plan
v. Researchable issues on sub-sectoral commodities received from Hortex and
vi. Outcomes of four regional workshops which provided valuable inputs on regional issues

vii. Finally, synthesis and finalization of the Research priorities in the field of ICT in agriculture and disaster management was done in the National Workshop held during 01-02 June 2010.

Research themes in ICT in Agriculture and Disaster Management are quite varied from those in case of commodity based sub-sectors. Since ICT is a tool for information generation and dissemination, its outputs is basically service-oriented in nature. However, computer based modeling research could be undertaken to solve problems. The studies may cover both short and long-term objectives including future projections or forecasts/predictions through development of Expert Systems (ES) and Decision Support Systems (DSS) for food security and disaster management. ICT should be used as a carrier of dissemination of technologies generated by the ARIs. The technology should be used as a tool for monitoring and evaluation. It could also be used to manage institutional human resources, resource inventories, database development (both spatial and textual).

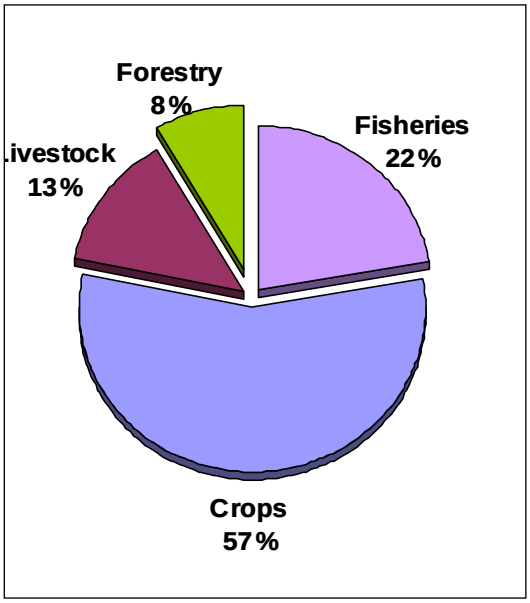
Twenty-six researchable issues under six thematic areas have been identified by the above efforts. The thematic areas are as follows:

i. Development of MIS and Research Management Systems
ii. Development of Databases
iii. GIS and Remote Sensing
iv. Disaster Management
v. Human Resource Development

In order to address all the above mentioned problems and issues activities in ICT must be institutionalized in the NARS and other affiliated organizations. Enabling conditions must be created at the Institution and at National levels. This should be both in the context of infrastructure and trained and devoted human resources.

# 1. Introduction

Bangladesh is one the most densely populated countries of the world. The country has a land area of 14.83 million hectares (Mha), population of over 149 million with a density of more than 1000 persons per km2, which is one of the highest in the world. The effective land area of the country is roughly 12.31 Mha, about 0.98 Mha is occupied by rivers and 2.19 Mha are under forest cover (BBS, 2008). The country is predominantly flat with almost 80% of the land area occupied by floodplains and piedmont plains, about 8% by slightly uplifted fault blocks (terrace) and about 12% by hills. During the last three of decades the population has grown rapidly, which has put intense pressure on the scarce land resource of the country. The land-man ratio is decreasing at an alarming rate; the current estimated per capita arable land stands at 0.05 ha only.




The economy of Bangladesh is based on agriculture, industry and services. The gross domestic product (GDP) expressed as purchase power parity is US$209.2 billion, which is equivalent to more than BDT 14600 billion. The agriculture sector contributes a major share in the GDP, which is about 20.0% and employs about 48.07% of the working force. Services sector is also an important sector in the economy of the country about 50% of the GDP is generated through this sector and engages 43.28% of the work force. Again, among the sub-sectoral contributions of agriculture sector is dominated by crops (57 %), followed by fisheries (22%). Figure 1 depicts the sub-sectoral contributions to agricultural GDP.

**Figure 1. Sub-sectoral Contributions to Agricultural GDP**

According to Intergovernmental Panel on Climate Change (IPCC), Bangladesh will be one of the worst victims of climate change. Sea level will be increased due to rise in temperature and the frequency of cyclone-storms will be increased. As a result, food security will be in jeopardy and different types of natural calamities will put lives at risk. On top of these, high population density will make the problem more serious.

Globally, the impact of climate change on agriculture has been studied extensively for various crops at many different scales. Available information shows that the tropical and subtropical countries would be more vulnerable to the potential impacts of global warming. Bangladesh is likely to be one of the worst hit countries of the globe, being a humid-tropical country.

The people of Bangladesh have been adapting to the risks of floods, droughts and cyclones for centuries. High population density, very frequent occurrence of natural disasters, poor infrastructure and fragile economic resilience to shocks, makes the country especially vulnerable to climatic risks. Heavy reliance of rural people on agriculture and natural resources increases their vulnerability to climate change.

Therefore, supporting rural and urban communities to strengthen their resilience and to adaptation to climate change will remain a high priority in coming decades.

Disaster management, climate change and other related issues in agriculture are cross-cutting in nature. All the sub-sectors of agriculture are vulnerable to natural hazards, shocks and stresses. Although, all the sub-sectors might not be impacted equally, but it is likely that some would be more susceptible.

Over the last decade, the direct annual cost (damage and lost production) of natural disasters to the national economy is estimated to be between 0.5% and 1% of GDP. As the economy grows, these costs are likely to increase in absolute terms and as a proportion of GDP, if climate change is not factored into long-term economic planning.

Globally, the development of Information and Communication Technology (ICT) has proven its potentials for enhancing development efforts, but also virtually reduced the distance and turned the world into a global village (O'Farrell, 2003). Worldwide, ICTs are playing a vital cross-cutting enabler role to address many problems. In countless ways ICTs leveraged as a tool for e-Governance. It is necessary for ensuring government accountability, decentralization and providing effective service delivery. Additionally, bidirectional information flow between citizens and government can provide the power of consensus building within a society. Mr. Ban Ki Moon, UN Secretary General, stated that

*"...let us use all our energy and innovation to harness ICT to our work towards the Millennium Development Goals. Let us turn the digital divide into digital opportunity. Let us promote new business models, public policies and technology solutions in the global approach to development. The United Nations family is a willing and able partner in that process"*

Dr. M. S. Swaminathan (2008) in his speech at the International Conference on Science – based Agricultural Transformation towards Alleviation of Hunger and Poverty in SAARC Countries indicated climate change as a mega threat to human security.

*"Warmer temperature, drought, floods, sea level rise and higher $CO_2$ in the atmosphere are associated changes. We have the challenge of climate change, challenge of trans-boundary pests and challenge of trade relationship and finally how do we ensure social inclusion of access to technology under era of Intellectual Property Rights (IPR).with the mega threat. He stressed the need to develop genetic shield against adverse*

*…We will have to develop plants for more drought tolerance. Genetic Shield against SLR… We will have more salinity tolerance."*

Dr, Swaminathan also stressed the need for Bridging the Scientific Know How and Field Level Do How Gap. *"….. growing gap between scientific know how and field level do how. How do you bridge this gap between know how and do how. The green revolution was a productivity improvement based production. It was not only yield per hectare rather vertical growth of productivity, is what we need, as land is shrinking resource for agriculture."* He also added that *"India like many countries of this region fairly has strong capacity in information and communication technology…..National Virtual Academy for Rural Prosperity. It emerged the integrated use of world media not only internet, the cable TV, the FM radio,*

*community radio etc. The government of India has liberalized the procedure for using FM radio and above all the cell phone, mobile phone."*

For examples, the fishermen can now communicate through cell phone exactly where the fish are, the fish source etc. In fact the small fishermen can't believe these things can be done and so today what I call technological leapfrogging.

In the context of Bangladesh, the leveraging of ICTs for development may be termed as "e-Development". On the e-Development front, the need to leverage ICT tools for overarching development goals have been well demonstrated globally, and as such the use of ICTs has been mandated in all program outputs UNDP Bangladesh is committed to attain (UNDP, 2008).

The proposed National ICT Policy-2008 states that ICT is one of the most important tools to achieve economic prosperity of a country through improving the management and efficiency in every sphere of life.

The experience of the developed and emerging economies supports the above concept. To effectively exploit the power of ICTs, Bangladesh formulated its first National ICT Policy in 2002. The National ICT Policy 2002 could not reach the perceived levels of success due to lack of appropriate plans to achieve the goals set in the policy as well as poor implementation of the underlying actions. Consequently, the Government took an initiative in 2008 to update the National ICT Policy 2002 and make it befitting with the current and foreseeable future needs of the nation. (MoIST, 2008).

Although computer was introduced in the Bangladesh more that 50 years ago, application of ICT in agriculture was initiated only in 1979. A major ICT initiative was taken during 1979-1985 to computerize the Reconnaissance soil survey information generated through a UNDP/FAO funded project during the period from 1963 to 1975, which is known as the Land Resources Appraisal of Bangladesh. As follow up of this, several ICT initiatives/programmes were undertaken and the outputs of these were used for agricultural research, development and extension and disaster management. Services are being provided to the Ministry of Agriculture and other Ministries, various NARS institutes, various extension agencies, Universities, International Organizations, and GOs and NGOs by catering to their needs.

As ICT can play a significant role in research and development of agriculture and disaster management, the Bangladesh Agricultural Research Council appropriately has chosen the area as one of the sub-sectors for detailed study. This report is the outcome of the effort made by the Bangladesh Agricultural Research Council to conduct a sectoral study in connection with the preparation of 'Vision Document-2030 and beyond'.

## 2. Methodology

Twelve Sub-sectoral Expert Teams were formed by the Bangladesh Agricultural Research Council (BARC) to conduct the Agricultural Sectoral Study in connection with the preparation of 'Vision Document-2030 and beyond'. Each Sub-sectoral Expert Team was composed of three relevant and contributing members and led by the designated Team Leader and assisted by a Member Secretary. The sub-sectoral Expert Team on was ICT in Agriculture and Disaster Management was led by Dr. Sk. Ghulam Hussain, Member-Director, BARC and Mr. Md. Abeed Hossain Chowdhury, Director (Computer), BARC acted as the Member Secretary. The Member Secretary of the team also worked as the Rapporteur form the group at four Regional and one National Stakeholders Consultation Workshops on Agricultural Research Priority Setting. The following Terms of Reference (ToR) of the Group Leaders laid out by BARC was followed in conducting the study (Annex 1)

ICT is basically a tool that can be used for many different purposes and fields. ICT plays a vital crosscutting enabler role to address many problems. This tool can be used solving problems, increasing efficiency and providing effective service delivery in agriculture and disaster management. Therefore, the methodology followed in preparing this report is a bit different from that followed in case of other eleven commodity-based sub-sectors. However, the prescribed ToR and Group Work Guidelines (Annex 2) were followed wherever applicable/possible.

To appraise the future challenges and supportive policy environment for agricultural research and development and disaster management, besides National policies, many secondary information were colleted from consultancy reports and internet resources. The following National policies and other relevant documents were reviewed:

i. Revitalizing the Agricultural Technology System in Bangladesh (2005)
ii. Action Policy Brief (2006)
iii. National Strategy for Accelerated Poverty Reduction (2005)
iv. National Water Policy (2002)
v. National Food Policy (2006)
vi. National Agriculture Policy (1999)
vii. Draft Agriculture Policy (2009)
viii. National Livestock Development Policy (2007)
ix. National ICT Policy (2002)
x. National ICT Policy (2008)
xi. Digital Bangladesh Concept Note (2009)
xii. National Adaptation Programme of Action (NAPA) (2005)
xiii. Bangladesh Climate Change Strategy and Action Plan (2009)
xiv. Standing Order on Disasters (1999)

Four Regional (Rajshahi, Chittagong, Barisal and Dhaka) Stakeholders Consultation Workshops on Agricultural Research Priority Setting were held during December 2009 to February 2010. The workshops were held in the following venues and dates. The number of participants varied from 100-170, but the proportionate mix was more or less the same (Figure 2). In all the Regional Workshops participants were drawn from/among Extension personnel from DAE, DOF and DLS (55%); Researchers from NARS and Universities (25%), NGOs, POs (included private entrepreneurs, fertilizer

dealers, etc), Others included participants from BADC, BWDB, KGF, etc. (10%); Above all, to get the first hand inputs from the fields farmers (10%) participation was ensured. Breakout Groups varied with the context of the regional importance (Table 1). Finally, recommendations drawn in these workshops were taken into consideration and incorporated as relevant to the subject of this particular study.

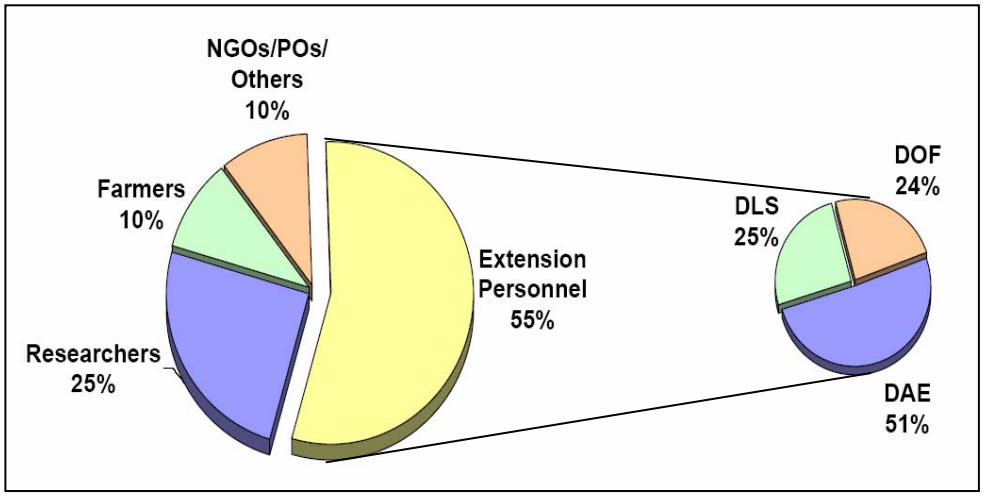



**Figure 2. Share of Stakeholders participation in Regional Workshops**

Researchable problems extracted from Upazila Micro Extension Plan developed by the Common Interest Group (CIG) farmers and Upazila Extension personnel were also consulted. These plans were obtained through DAE, DLS and DOF for crops, livestock and fisheries sub-sectors respectively. Researchable issues on sub-sector agro commodities were also received from Hortex. The outcome of all the four Regional Stakeholders Consultation Workshops was considered in prioritizing agricultural research in the field of ICT and disaster management.

**Table 1. Regions, venues, dates and Breakout Groups in Regional Workshops**

| Region | Venue (Organized by) | Date | Breakout Groups |
|---|---|---|---|
| Rajshahi | Rural Development Academy, Bogra (Jointly organized BARC and KGF) | 29 December 2009 | ▪ Plain Land Agriculture<br>▪ Terrace Agriculture<br>▪ Livestock<br>▪ Fisheries |
| Chittagong | Regional Public Administration Training Centre, Chittagong (Jointly organized by BARC and KGF) | 11 January 2010 | ▪ Plain Land Agriculture<br>▪ Coastal Agriculture<br>▪ Hill Agriculture<br>▪ Fisheries Marine and Freshwater<br>▪ Livestock |
| Khulna, | BRAC Centre, Barisal (Organized by BARC) | 27 January 2010 | ▪ Plain Land Agriculture and Coastal Non-Saline Agriculture<br>▪ Coastal Saline Agriculture<br>▪ Livestock<br>▪ Fisheries Brackish |
| Dhaka, | BINA, Mymensingh (Organized by BARC) | 17 February 2010 | ▪ Plain Land Agriculture<br>▪ Forest, Hill and Terrace Agriculture<br>▪ Haor and Depressed Land Agriculture<br>▪ Livestock<br>▪ Fisheries |

Table 1. Contd.

## 3. ICT and its Current Status in Bangladesh

Information and Communication Technology (ICT) consists of three main technologies. They are: Computer Technology, Communication Technology and Information Management Technology. These technologies are applied for processing, exchanging and managing data, information and knowledge. The tools provided by ICT are having ability to:

i. Record text, drawings, photographs, audio, video, process descriptions, and other information in digital formats,
ii. Produce exact duplicates of such information at significantly lower cost,
iii. Transfer information and knowledge rapidly over large distances through communications networks.
iv. Develop standardized algorithms to large quantities of information relatively rapidly.
v. Achieve greater interactivity in communicating, evaluating, producing and sharing useful information and knowledge.

## Knowledge Management System

Knowledge Management System (KM System) refers to a (generally IT based) system for managing knowledge in organizations for supporting creation, capture, storage and dissemination of information. The design of a KM system is to enable stakeholders to have ready access to the documented base of facts, sources of information, and solutions.

There are many aspects of ICTs. Extensive incorporation of ICTs may have both positive and negative impacts.

**Economic Impacts**

In recent decades, because of widespread incorporation of ICTs into many tiers of business and political processes, they have played an important role in structuring of the global economy. ICTs have increased international interconnectedness and sped up the process of globalization. They have been instrumental in the information revolution, facilitating the transition from industrial economies, driven by the manufacturing sector, to knowledge economies. ICTs, in conjunction with globalization and the information revolution, have reshaped the workforce.

In spite of the international widening of ICTs, the economic impacts have been geographically uneven. They have exacerbated pre-existing disparities between developed countries, which can afford to produce and consume the latest technologies, and developing countries, which cannot. This gap is known as the digital divide.

**Social Impacts**

ICTs have impacted societies on many levels. These technologies have generated to new forms of employment in innovation and production of ICTs and a demand for highly-skilled specialists. However, ICTs have also enabled professionals in certain industries to be replaced by unskilled workers, or even made entirely redundant. People who are in favour of ICTs depict this as a ‘re-skilling’ of the workforce, while to

those who are against consider it as a 'de-skilling' process. The dissemination of ICTs within societies is mixed, access to ICTs varies sections of society, some having greater than others. Even then, it is believed that ICTs can be used to promote equality and empower marginalized groups. These could be a means of providing accessible and affordable information and as a platform for voices that might otherwise go unheard.

In the Millennium Development Goals: Bangladesh Progress Report 2008 (Planning Commission, 2008) under the section 8, ICT services described that in recent years, the use of telephone services has increased remarkably in the country with the wider use of cellular phones. However, the growth of land phones was steady. In 1991, per 1000 people two telephone sets were used, which has increased to nine telephone sets per 1000 people. Information on cellular phone use shows that the use has increased sharply from 0.02 percent in 1991 to 30.8 percent in 2008. Internet services are mostly available in metro city areas and at best the district head quarters. Only three connections were available per 1000 population in 2008, but in the base year, it was almost nil.

The present government has taken holistic initiatives to promote ICT by taking positive steps such as tax and import duty cuts on computers, promoting ISP (Internet Service Provider) services, etc. in order to improve the situation. There needs to be infrastructural development and technology transfer throughout the country to diffuse ICT knowledge to even the remote regions of the country. The present government has been taking interventions to promote ICT among all spheres of people, including the population in hard-to-reach areas, in order to fulfill the government vision of a 'Digital Bangladesh" by 2021.

## Media

Media is emerging as an important instrument to disseminate the knowledge, success story and technology. Both electronic and print media are organizing regular programs on agriculture and much awareness has developed among the policy makers and growers. Extension service may be strengthened with the help of ICT at the grassroots level. Public private collaboration may be established in quick dissemination of farm technology.

### TV Channels

Besides state owned Bangladesh Television which is Bangladesh's only terrestrial TV channel and the satellite version is BTV World, there are 11 TV channels run by private entrepreneurs. All of these channels are air through satellite link. TV channels are: ATN Bangla, Channel I, Ekushey Television (ETV), NTV, RTV, Boishakhi Television, Channel 1, Islamic Television, Diganta Television, Desh TV, My TV and ATN news

### Radio Stations

Bangladesh Betar is the state owned radio which has a national coverage through its 15 mediumwave stations and relay stations (Bandorban, Barisal, Bogra, Chittagong, Comilla, Cox's Bazaar, Dhaka (3 stations), Khulna, Rajshahi, Rangmati, Rangpur, Sylhet, and Thakurgaon). Bangladesh Betar External Service is broadcasted using its shortwave transmitting facilities. Bangladesh Betar has seven FM stations in Dhaka,

Chittagong, Comilla, Khulna, Rajshahi, Rangpur and Sylhet. Bangladesh Betar also makes Traffic Broadcast for in & around Dhaka. Besides these there are private four FM Stations. These are- Radio ABC, Radio Aamar, Radio Foorti in Dhaka, Chittagong and Sylhet, Radio Today in Dhaka, Chittagong and Cox's Bazaar,

**Bangladesh ISP Industry**

In the early nineties, Bangladesh had access to email via dialup to Bulletin Board Systems (BBS) of a few local providers. The combined Internet users of all the email-only service providers were not more then 500. Users were charged by the kilobyte, and mail was transferred from the BBS service providers to the rest of the world by International dialup using UUCP.

In June 1996, the Government allowed VSAT's to be operated in the private sector, but to be provided solely by the Government owned Telephone Operator, BTTB. Only a handful of ISPs were connected within the first year. In the same year, Internet came to Bangladesh with connectivity. The country was connected to the Information Superhighway through submarine cable in the year 2006. Due to this the capacity of telecommunications and data transfer were greatly enhanced, giving a high-speed, low-priced Internet and telecommunications gateway to the users to catch up with the fast-moving world. In Figure 3 the growth of Internet users in Bangladesh is presented graphically.

Nevertheless, in the last few years it has grown dramatically. Now an estimated Internet user base of more than 700,000 by end-2009, representing only a 0.4% user penetration, the local Internet industry has been preparing to move into the next stage of its development.

However, the country must work hard to overcome obstacles associated with the country's still developing infrastructure. Recently, the country has at very early signs of broadband Internet in Bangladesh and its first moves into WiMAX services.

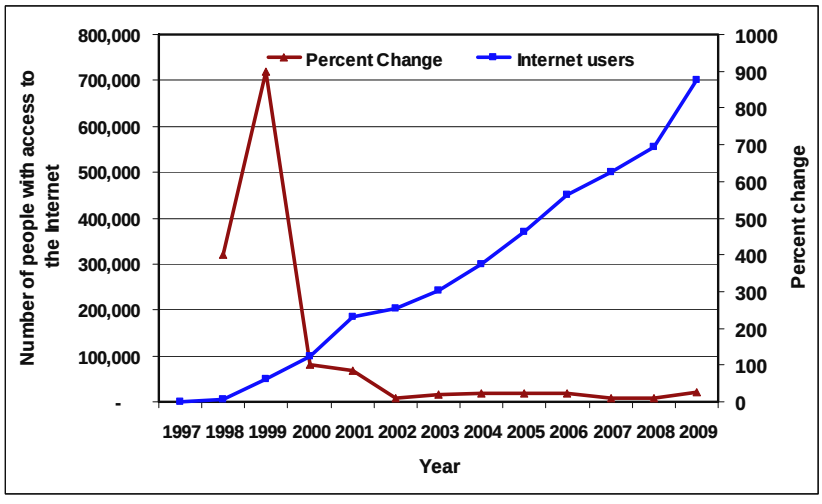



**Figure 3. Growth of Internet users in Bangladesh.**

Data source: World Bank, World Development Indicators, Internet users: People with access to the Internet, URL: http://www.google.com/publicdata?ds=wb- wdi&met=it_net_user&idim=country:BGD&dl= en&hl=en&q=internet+users+in+bangladeshInternet users. Accessed on June 21, 2010.

## Mobile Communications

There are six mobile phone operators in the country and their total number of active subscribers has reached 58.36 million at the end of January 2010, while the landline ones are serving 1.6 million customers. Of the six mobile phone vendors, Grammenphone has now 25.55 million subscribers, Banglalink 15.59 million, AKTEL (Robi) 10.96 million, Warid 3.08 million, Citycell and 1.99 million. During this period the number of subscribers of state-run Bangladesh Telecommunications Company Limited (BTCL)-Teletalk stands at 1.19 million (BTRC, 2010). The Mobile Phone subscribers are shown in Figure 4.

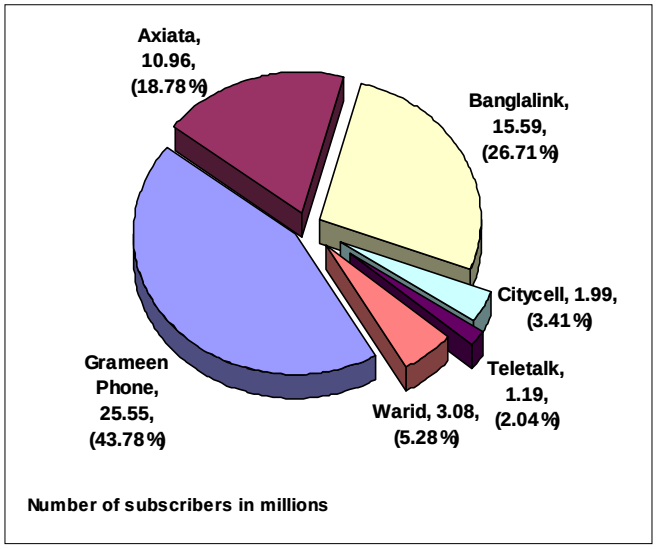



**Figure 4. Mobile Phone Subscribers by Various Operators**

### Public Switched Telephone Network

The total number of Public Switched Telephone Network (PSTN) subscribers in Bangladesh (Table 2) reached more than 1.028 million at the end of April 2010.

**Table 2. Number of Public Switched Telephone Network (PSTN) Subscribers in Bangladesh**

| Operators | Subscribers ('000) |
|---|---|
| BTCL | 872.409 |
| Telebarta Ltd. | 56.424 |
| Jalalabad Telecom Ltd. | 10.900 |
| Onetel Communication Ltd. | 39.576 |
| Westec Ltd. | 17.000 |
| Sheba Phone Ltd. (ISL) | 11.624 |
| S. A. Telecom System Ltd. | 18.033 |
| Banglaphone Ltd. | 2.200 |
| **Total** | **1028.166** |

## 4. ICT in Agriculture

The application of ICT in agriculture is increasingly important. E-Agriculture is an emerging field focusing on the enhancement of agricultural and rural development through improved information and communication processes. (From Wikipedia, the free encyclopedia Accessed on Sunday, January 03, 2010). Food and Agriculture Organization (FAO) defines - "e-Agriculture" as an emerging field, which combines agricultural informatics, agricultural development and entrepreneurship.

More particularly, e-Agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use ICT in the rural domain, with a primary focus on agriculture. E-Agriculture is a relatively new term and we fully expect its scope to change and evolve as our understanding of the area grows. E-Agriculture is one of the action lines identified in the declaration and plan of action of the World Summit on the Information Society (WSIS). The "Tunis Agenda for the Information Society," published on 18 November 2005, stresses the leading facilitating roles that UN agencies need to play in the implementation of the Geneva Plan of Action. The Food and Agriculture Organization of the United Nations (FAO) has been assigned the responsibility of organizing activities related to the action line under C.7 ICT Applications on e-Agriculture. (Source: World Summit on the Information Society, Geneva 2003 – Tunis 2005, Plan of Action. Paragraph 21. (Source: URL: http://www.itu.int/dms_pub/itu-s/md/03/wsis/doc/S03-WSIS-DOC-0005!!PDF-E.pdf)

e-Agriculture helps in dissemination of gathered information to the farmers, mostly lived in rural areas, to use in their routine work. These services are provided and enhanced through the Internet and related technologies. This ensures the effective and efficient use of information and communication technologies for analyzing, designing and implementing existing and innovative applications to help the agricultural sector.

Beside this it aware farmers about the upcoming natural disaster, which gives them a lead time to take necessary measures to protect their products from the disaster.

The information disseminated by e-Agriculture can be divided into several major areas, which is called as services of e-Agriculture. These are:

i. Weather Information
ii. Price Information
iii. Production and Cultivation Techniques
iv. Plant Nutrients and Water Usage
v. Educations and Health Information
vi. Government and Non-government Facilities
vii. Demands and Current Stock Information
viii. Diseases and Insect Information

Among the above services the first four are directly connected with the production system. To establish e-Agriculture, the use of spatial database to store agricultural information that varies according to geographic condition, and use of both Location Based Service and Internet to disseminate information through both wired and wireless technology.

Those who are involved with agricultural industry also need information and knowledge to manage their occupation efficiently. Any system applied for getting information and knowledge for making decisions in any industry should deliver accurate, complete, concise information in time or on time. The information provided by the system must be in user-friendly form, easy to access, cost-effective and well protected from unauthorized accesses. An important role could be played by ICT in maintaining the above mentioned properties of information.

An authentic agricultural database based on soil and climate condition, crop cultivation history, farmers interest, demand of raw material, pest and disease management technologies, storage facilities, marketing system, etc. have to be developed with the help of ICT and GIS (Geographic Information System). Government has prioritized quick dissemination of agricultural technologies to the farmers level. Reduction of yield gap between research and farmers field has been identified as important parameter to increase production.

Number of action plans has been prepared to reduce the yield gap of the pulses, oilseed and spices. The gap between know how and do how of the knowledge based production system is being implemented through target oriented production plans. Action plans are being implemented with improved seed supply, demonstration and imparting training, coordinated by BARC and implemented by the NARS institutes, namely BARI, BRRI, BSRI and BINA as well as DAE.

**Challenges and Supportive Policy Environment**

Developed countries have so far failed to perform their responsibility to address the problem of unfair trade and rationalizing global financial system and transferring new technologies for productive youth employment in developing countries in order to achieve MDG 8: Develop a global partnership for development. Developed countries should come forward and assist the least developed countries in exploiting potentials of international trade and should fulfill their obligation as signatories to the MDGs. It would be a huge challenge to bring together the donors and recipient countries to form an effective partnership to attain MDGs in the stipulated period.

The Paris Declaration promotes partnerships that improve transparency and accountability on the use of development resources. This encourages donors and partners jointly assess mutual progress in Bangladesh in implementing agreed commitments on aid effectiveness by making the best use of local mechanisms. There needs to be infrastructural development and technology transfer throughout Bangladesh to diffuse knowledge as soon as possible to spread information and knowledge to the remote regions of the country. There are national strategies to promote ICT with the recent government vision of “Digital Bangladesh” by 2021 (Planning Commission, 2008).

# 5. Review of National Policies and Other Relevant Documents

In view of the fact that over the last few years, new understanding of ICT as a development enabler has made its way into the various policy documents of the government. A number of National Policies and relevant documents have been reviewed with emphasis on the issues related to ICT, agriculture, disaster management, environment and climate change vis-à-vis their sensitivities towards impacts and adaptation. A total of ten National Policy documents have been reviewed. The documents include the following:

## Revitalizing the Agricultural Technology System in Bangladesh

To enhance the impact of extension services, World Bank (2005) suggested that the line departments (DAE, DOF and DLS) should mainstream the community-led decentralized extension partnership approach learning from the guidelines of a model already pilot tested. The Bank stressed the need to enhance the use of ICT, including internet connectivity, as an aid to extension and capacity building of the District/Upazila/Union level staff of all partners, including farmers. The Bank also identified that funding crisis is affecting the skill-base of scientists due to limited opportunities for further studies and training. Poor working conditions, low salaries and limited scope for career progression means that scientists have little incentive for hard work and innovation. Overall human resource development is also a concern in relation to the use of new sciences such as biotechnology, informatics and ICT in agricultural research.

## National Strategy for Accelerated Poverty Reduction

The National Strategy for Accelerated Poverty Reduction (Planning Commission, 2005) has recognized the importance of ICT in agricultural research and development, ICT Development and Technology Policy and Disaster Management and Environment.

Under the Policy Matrix 13: Development of ICT and Bio-technology of the National Strategy for Accelerated Poverty Reduction document the following strategic goals and actions taken or under way have been suggested:

In order to develop ICT and Biotechnology, formulation of appropriate policies and expansion of infrastructure facilities of the ICT sector have been recommended. For these two areas more investment in Human Resource Development (HRD) has been suggested. Train the poor to act as service provider in the rural areas of the country. Increase access of the disadvantageous groups to ICT to promote ecommerce and create awareness among them through increasing ICT facilities for them.

Promote Use of ICT to ensure Good Governance and also to promote its use in Disaster Management and increasing capacity of the poor to manage disaster.

The facilities for a high speed computing system are provided for enabling Space Research and Remote Sensing Organization (SPARRSO) to develop a long-term numerical Weather forecasting model at this organization.

A concerted action plan to enhance predictive capabilities and preparedness for meeting emergencies arising from floods, cyclones, earthquakes, drought, landslides and avalanches will be drawn up.

Measures will be undertaken to promote research on natural phenomena that lead to disasters and human activities that aggravate them with a view to develop practical technological solutions for pre-disaster preparedness, mitigation and management of post disaster situations.

## Actionable Policy Brief

According to the Actionable Policy Brief (MoA, 2006) the delivery of information services is severely restricted due to acute shortage of professional staff, trained in development communication and information technology. Concerns were expressed due to lack of professional staff in ITC. It suggests to increase the number of professional staff and to create provision for their training in ICT as well as training of the technicians to improve their skills in different areas of information and communication technology. Because of incredible development in information and communication technology, which has tremendously increased the power to access information from anywhere in the world through information superhighway. As a result, information service has evolved as a distinctly and new profession.

In order to make the Agricultural Information Service more effective and efficient in delivering the information services to the farmers for agricultural development, the organization should evolve as a separate Directorate.

## National Water Policy 1999

The Policy measures described in the National Water Policy (MoWR, 1999) include: (1) river basin management, (2) planning and management of water resources, (3) water rights allocation, (4) public and private involvement, (5) public water investment, (6) water supply and sanitation, (7) water and agriculture, (8) water and industry (9) water, fisheries and wildlife, (10) water and navigation, (11) water hydropower and recreation, (12) water for environment, (13) water for preservation of haors (perennial water bodies) , boars (ox-bow lakes), and beels (saucer-like depressions), (14) economic and financial management, (15) research and information management and (16) stakeholder participation. Out of 16 policy measures to be undertaken to achieve the objectives of the National Water Policy special attention has been given on research and information management. As an essential requirement of a dynamic water management policy, providing information to policy makers of the choice of appropriate technology to meet policy goals and making them aware of their significance and impact.

As management decisions become increasingly complex and information-sensitive, the demand for supporting research and information management increases. In order to reach a consensus amongst specialists, planners, politicians and the mass people; information about the changing environment and the optimal ways and means of achieving the national water management goals is important. It is the policy of the Government in this regard to:

Develop a central database and management information system (MIS) consolidating information from various data collection and research agencies on the existing hydrological systems, supply and use of national water resources, water quality, and the ecosystem.

Restructure and strengthen, where appropriate, water resource and agriculture research institutions to undertake systematic research and analysis of water and land management issues and problems arising both nationally and internationally.

Investigate thoroughly important flood control and management issues, such as the efficacy of coastal polders, for guiding future policy on structural interventions.

Investigate important sociological issues, such as the phenomenon of interference withwater structures (e.g. public cuts), and the motives and conflicting interests behind them, toassist the process of building public support and acceptance of government water management programmes.

Strengthen and promote the involvement of public and private research organizations and universities to:

i. Develop and disseminate appropriate technologies for conjunctive use of rainwater, groundwater and surface water.
ii. Develop and promote water management techniques to prevent wastage and generate efficiency of water and energy use.
iii. Produce skilled professionals for water management.

## National Food Policy 2006

The National Food Policy-2006 identified the importance of development and dissemination of early warning and market information system. It states that a well functioning early warning system is an important tool for national food supply management and improved national food security system. The system should be operationalized in coordination with the global early warning system. To achieve this, the Government will accomplish the following:

Provide dependable weather forecasts for disseminating a well coordinated food production outlook both at national and global perspectives

Provide short and long-range forecasts related to climate, food production and expected supply, demand and price situations in both domestic and international markets; and

Conduct research and initiate improved forecasting systems related to natural disaster in order to enhance food information and early warning related analytical capabilities for better management of the food system (MoFDM, 2006).

## National Agriculture Policy 1999

The National Agriculture Policy 1999 (MoA, 1999) emphasized the need for Reliable Database. Under section 20.1 it was stated that successful implementation of a

development programme largely depends on the availability of reliable data and information in time. Following measures will be taken by the government under the National Agriculture Policy to build up a reliable database:

District level DAE offices will collect, compile and preserve all information related to crop sector through their official channels. For this purpose, adequate computer facilities and skilled manpower will be mobilized.

Agriculture related information would be preserved and displayed publicly.

Government, private sector agencies and NGOs involved in agriculture sector will in principle agree to exchange information among them.

Bangladesh Bureau of Statistics will organize training programmes on appropriate methods of data collection and preservation for the concerned agencies and provide advice in this regard.

## Draft Agriculture Policy 2009

In the Draft Agriculture Policy 2009 (MoA, 2009) more emphasis has been given in Informatics under section 4: Research and Development (R&D). It states that BARC and other research units will develop a comprehensive relevant database for agricultural research and development planning. BARC will facilitate functional electronic networking for all the stakeholders under the NARS and with other national, regional and international centres of excellence through Agricultural Research Information System.

On the other hand, to make extension services more efficient and effective, importance has been given on Communication Media. In disseminating extension services both traditional and advanced media and ICT will be utilized. Agricultural Information Service (AIS) will be strengthened both in terms of workforce and modern facilities to enable effective information dissemination and technology transfer. Dissemination of agricultural information and technology through print and electronic media will be strengthened focusing on enhanced collaboration among AIS, state owned Bangladesh TV and Bangladesh Betar (radio) along with other private TV and radio channels.

To accomplish the objectives of the Draft Agriculture Policy 2009, focus will be given on research activities for intensification, diversification and whole farm activities in agriculture. Special attention will be given to post-production technologies, high value crops, value addition, agri-business management and trade. Support will be directed to research on emerging issues like, biotechnology, hybridization of crops, climate change, disaster and stress including flood, drought, cyclone, salinity, upland/hill, deep water crop management, organic farming. To facilitate these the government promises to:

Support and strengthen interventions in rain-fed agriculture emphasizing productivity and sustainability of production. Encourage quality collaborative research to provide solution to specific problems confronting farmers within their farming systems. Support research undertakings that cover trans-boundary and cross-cutting issues having application across one or more production systems and the sustainability of the production systems, poverty alleviation and livelihood improvement, household food

security, off-farm income generation, and rural development. Also support agricultural policy research and technology dissemination systems of unique nature.

## National Livestock Development Policy 2007

The National Livestock Development Policy 2007 (MoFL, 2007) has identified that there is no management information system (MIS) for research at BLRI and Information management is generally weak. There is no systematic marketing network and market information system for milk and milk products to support smallholder dairy farmers in the rural areas. Farmers sell milk either in the local market or to goal as (traditional milk collectors) who continue to render useful services to the rural community, and sometimes work as supplying agents to private firms. Under the Policy framework for Marketing of Livestock Products the following has been recognized:

i. Farmer's information network for price data and processing of trade related information would be established with private sector support;
ii. An Internet-based communication system would be established alongside regular broadcasting of trade related information and monitoring and forecasting of prices of livestock products and
iii. Management Information Systems (MIS) would be established in the DLS on livestock product marketing
iv. MIS (Management Information Systems) would be established in the DLS and MoFL for international trade management of livestock products

## National ICT Policy 2002

The vision of the ICT Policy (2002) aimed at building an ICT-driven nation comprising of knowledge-based society by the year 2006. In view of this, a country-wide ICT-infrastructure will be developed to ensure access to information by every citizen to facilitate empowerment of people and enhance democratic values and norms for sustainable economic development by using the infrastructure for human resources development, governance, e-commerce, banking, public utility services and all sorts of on-line ICT-enabled services (MoSICT, 2002). The vital policies for ICT Sector in Bangladesh were (i) Training and Human Resources Development, (ii) Link to Information Super Highway, (iii) Research and Development in ICT, (iv) Agriculture and Poverty Alleviation, (v) Social Welfare, and (vi) Environment:

The experience of the developed and emerging economies supports the above concept. To effectively exploit the power of ICTs, Bangladesh formulated its first National ICT Policy in 2002. The National ICT Policy 2002 could not reach the perceived levels of success due to lack of appropriate plans to achieve the goals set in the policy as well as poor implementation of the underlying actions. Out of 103 policy directives in 16 areas eight were fully or largely accomplished, 61 were partially accomplished and 34 remained unaddressed.

## National ICT Policy 2008 (proposed)

Consequently, the Government took an initiative in 2008 to update the National ICT Policy 2002 (MoSICT, 2002) and make it befitting with the current and foreseeable

future needs of the nation. The proposed National ICT Policy 2008 (MoSICT, 2008) has incorporated all the ingredients of the National ICT Policy 2002 in a structured manner with requisite updates necessitated by developments since 2002. The revised policy has also incorporated new policy directions in line with the ever changing technological advancements in this area. The most remarkable changes that have been made in the revised National ICT Policy are: 1) a methodical framework of the policy document; and 2) inclusion of planned action items in conformity with policies and strategies.

The proposed National ICT Policy-2008 states that ICT is one of the most important tools to achieve economic prosperity of a country through improving the management and efficiency in every sphere of life. The policy is based on ten broad objectives, 56 strategic themes and 306 action items for maximizing the use of ICTs for national development. The following are the objectives of the policy: (1) Social equity (2) Productivity (3) Integrity (4) Education and research (5) Employment (6) Strengthening exports (7) Healthcare (8) Universal access (9) Environment, climate and disaster management (10) Support to ICTs.

Besides all other objectives, the objectives related to productivity; environment, climate and disaster management; and supports to ICTs are very relevant to this report. Higher productivity across all economic sectors including agriculture and SMME (small, medium and micro enterprises) will be achieved through the use of ICTs.

Encourage maximum utilization of ICT services nationwide to boost productivity of small, medium and micro enterprises and agriculture sector, and focus on innovation and competitiveness.

Ensure dissemination and utilization of latest know-how and market information to increase production capability and supply chain management of agriculture through ICT applications.

Ensure better monitoring, skills gap determination, appropriate training and modern enterprise operations to enhance productivity of large enterprises by encouraging immediate implementation of end to end applications.

Ensure sustainable productivity in the service sector through increased automation of operations and management information systems.

Encourage e-commerce, e-payments, and e-transactions in general bringing in a new dimension of productivity to the economy at the earliest.

Through use of ICTs creation and adoption of environment-friendly green technologies will be enhanced, safe disposal of toxic wastes ensured, disaster response times minimized and enabled effective climate change management programmes.

Protect citizens from natural disasters through ICT-based disaster warning and management technologies Utilize remote sensing technologies for disaster management and mitigation.

Web-based environmental clearance certification system

Promote cell phone/SMS-based disaster warning systems targeted to the population likely to be affected

Develop appropriate infrastructure including power, and regulatory framework for effective adoption and use of ICTs throughout the country.

The ninth objective of the ICT Policy 2008: Environment, climate and disaster management is to enhance creation and adoption of environment-friendly green technologies, ensure safe disposal of toxic wastes, minimize disaster response times and enable effective climate change management programmes through use of ICTs as Bangladesh is facing the double curse of environmental pollution due to mounting industrial and consumer wastes and also global-warming-induced climate-change due to excessive carbon emissions of the industrialized nations.

More specifically it states to accomplish the following:

i. Protect citizens from natural disasters through ICT-based disaster warning and management technologies. Utilize remote sensing technologies for disaster management and mitigation.
ii. Utilize GIS based systems to monitor flood & cyclone shelters (including equitable distribution in vulnerable areas)
iii. Promote cell phone/SMS-based disaster warning systems targeted to the population likely to be affected
iv. Promote efficient relief management and post disaster activities monitoring
v. Utilize GIS based systems to ensure equitable distribution of relief goods with special focus on the hard-to-reach areas.

The proposed National ICT Policy -2008 was revised as ICT Policy 2009 incorporating specific direction and guidelines reflecting most of the priorities of the Digital Bangladesh agenda. The policy has been approved in the cabinet. The 9th Parliament has already passed the Right to Information Act. The act has required legal imperatives that corroborates and promotes the overall context of Digital Bangladesh vision. The cabinet has already approved the ICT Act 2009. After approval of the Parliament and promulgation, provisions required for initiating electronic signature and e-Commerce will be institutionalized. Steps taken thus far to introduce such charter and related lessons learned would be useful inputs in implementing Digital Bangladesh (PMO, 2009)

## Bangladesh Climate Change Strategy and Action Plan 2009

In early 2000 Bangladesh started to implement some of the UNFCCC initiatives. A National Adaptation Programme of Action (NAPA) document has been prepared in November 2005. NAPA document identified 15 immediate and urgent priority projects. The first priority project, "Community Based Aforestation in Coastal Areas" is being implemented by Forest Department. The 4.5 million US$ (about BDT 315 million) fund for implementing the project is being provided from Least Developed Countries Fund (LDCF). Other NAPA projects are expected to be funded by LDCF, Adaptation Fund (AF) or other bilateral or multilateral funds.

In 2002 Bangladesh prepared the Initial National Communication, which included among others Green House Gas inventory. At present the country has started

implementing the project activities of Second National Communication, which is expected to incorporate, apart from Green House Gas inventory, adaptation and mitigation activities in the country and will also try to incorporate potential project concepts for both adaptation and mitigation activities.

To combat the forthcoming climatic risk, the Ministry of Environment and Forest has formulated Bangladesh Climate Change Strategy and Action Plan-2009.

As NAPA addressed immediate and urgent adaptation needs it didn't cover the major concerns of all the sectors. The Government felt the need to develop a comprehensive package to address climate change issues. Accordingly, Climate Change Steering Committee, which is headed by Environment and Forest Minister, took decision to develop a Climate Change Strategy in early 2008. Finally, Bangladesh Climate Change Strategy and Action Plan, 2009, 2(BCCSAP 009) [MoEF, 2009] was prepared drawing experts from all the respective fields. Though field level consultation was absent while preparing the document. Extensive discussion was held exclusively with government officials, civil society representatives and private sectors and even with Development Partners. The document was finalized through a National Consultation. BCCSAP has proposed six pillars based on 6 thematic areas and under six thematic areas has proposed 44 programmes to be implemented by respective line Ministries and Departments. The six pillars of Climate Change Action Plan are as follows:

i. Food security, social protection and health
ii. Comprehensive disaster management
iii. Infrastructure
iv. Research and knowledge management
v. Mitigation and low carbon development
vi. Capacity building and institutional strengthening

BCCSAP to date is the single most comprehensive document that will be the guide while implementing any kinds of Climate Change related projects or activities. The time horizon for BCCSAP has been suggested 10 years but periodic review can be made and readjusted according to the needs of the time. Besides, in FY 2008-09 the Government has created a fund of Tk.300 crore or roughly US$43 million to combat climate change risk, adaptation and mitigation.

## Standing Order on Disasters 1999

Bangladesh has developed a comprehensive and effective disaster management system. The Government has also issued the Standing Orders, which have been prepared with the affirmed objective of making the concerned persons understand their duties and responsibilities regarding disaster management at all levels, and accomplishing them. All Ministries, Divisions/Departments and Agencies shall prepare their own Action Plans in respect of their responsibilities under the Standing Orders for efficient implementation.

The Standing Order on Disaster provides guidance to local communities and the authorities, at various levels, on their roles and responsibilities during and immediately after a disaster has struck. It also lays out procedures for alerting local communities when a disaster such as a flood, cyclone or storm-surge is likely to occur. Despite this, there is a need to raise awareness among communities and officials at all

levels on the likely increased incidence of natural disasters. Some areas where urgent attention may be given include shelter management, search and rescue and health issues during and after disaster.

The National Disaster Management Council (NDMC) headed by the Prime Minister and Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) will ensure coordination of disaster related activities at the National level. Coordination at the District, Upazila and Union (three-tire administrative units) levels is done by the respective District, Upazila and Union (lowest community level) Disaster Management Committees. The Disaster Management Bureau renders all assistance to them by facilitating the process.

The Ministries, Divisions/Departments and Agencies organize proper training of their officers and staff employed at District, Upazila, Union and village levels according to their own action plans so that they can help in rescue, evacuation and relief work at different stages of disaster.

The local authority shall arrange preparedness for emergency steps to meet the disaster and to mitigate distress without waiting for government help.

The Standing Orders are followed during Normal times, Precautionary and Warning stage, Disaster stage and Post-disaster stage.

As part of the paradigm shift earlier, the Disaster Management Bureau (DMB) was created as a professional unit at national level back in 1992 under the then Ministry of Disaster Management and Relief. As a technical arm to the Ministry of Food and Disaster management, DMB overview and coordinate all activities related to disaster management from national to the grass-root level. It is also entrusted to maintain an effective liaison with government agencies, donors and NGOs to ensure maximum cooperation and coordination in all aspects of disaster management.

As a continuation of the paradigm shift process, the Comprehensive Disaster Management Programme (CDMP) has been designed as a long-term programme of the Ministry of Food and Disaster management with multi-agency involvement. Funded jointly by the United Nations Development Programme (UNDP) and the Department for International Development (DFID), the programme was launched in November 2003. CDMP is a strategic institutional and programming approach that is designed to optimize the reduction of long–term risk and to strengthen the operational capacities for responding to emergencies and disaster situations including actions to improve recovery from these events.

### *Comprehensive Disaster Management Programme*

CDMP is a whole-of-country strategy. Communities within high risk areas are the immediate beneficiaries of program interventions. The direct beneficiaries of the program are:

i. Communities and community based organizations through improved capacities, both at national local level, to design and implement disaster management programmes that are based on formal and traditional community risk assessment

ii. Key national , district, Upazila and Union officials (including NGOs ) who have disaster management programming and operational response coordination responsibilities
iii. Key government decision-makers, politicians and elected local Government officials through advocacy and awareness programmes
iv. National planning officers and all line government departments or agencies involved in development planning activities, through the promotion and incorporation of risk management measures within the development project validation process by way of Disaster Impact and Risk Assessment (DIRA) like the Environmental Impact Assessment (EIA) which has been incorporated in all development project analysis
v. NGOs, through their formal involvement in disaster management programme design and implementation

# 6. Disasters and Vulnerabilities

## Vulnerabilities

Bangladesh owing to its unique geographical location is highly vulnerable to natural disasters. Major disasters and environmental vulnerabilities are floods, droughts, cyclone, tidal surges, river erosion, salinity, extreme temperatures and low light intensity, earthquakes, pest and diseases etc. which often affect millions of people. These have direct or indirect implications on agriculture sector. These problems are very likely to aggravated due to climate change and climatic variably. Agriculture would be the worst affected sector, which would have great impact on food security and livelihood of the major part of the population. This sector is composed of three sub-sectors namely, crops, fisheries, and livestock and directly or indirectly employs over 60 percent of the work force. Therefore, this sector deserves the prime attention, so that in the event of changed climatic conditions, people can cope and adapt with the adverse situations and thereby reduce the vulnerabilities. Following are the major vulnerabilities are faced by the people of the country:

**Floods**

Different types of flood occur in Bangladesh. Normally, almost every year 22% of the land area is inundated and in extreme cases, about 80% of the land can go under water. About 1.32 Mha and 5.05 Mha of the net cropped area (NCA) is severely and moderately flood prone, respectively. The flood of 1998 inundated over 65% of the country's land area for a period of over 60 days. Crop loss was enormous, besides loss of human life and infrastructure.

Floods of different nature and magnitude occur in Bangladesh. It appears from mid May until October. Flood, inundation and water stagnation cannot be separated in the crop production viewpoint. Floods occur in different modes. These are flash floods (associated with sudden rainfall in the undulated catchment and breaching embankment and appears during April-September), monsoon flood, floods due to storm surge in the coastal areas, and local floods due to excessive rain. Each type has unique characteristics in terms of loss of crops, livestock, fisheries and agro-forestry and other livelihood.

Overflowing of hilly steams and rivers of eastern and northern regions of the country causes flash flood. The reason for rain flood is localized heavy rainfall and drainage congestions. Monsoon floods are caused by overflowing of major rivers in the floodplains. Besides tidal inundation, storm surges aggravate the coastal floods. The nature and causes of floods are varied; therefore, the magnitude of damage varies with timing, location and intensity. Monsoon floods from the rivers are caused when the major rivers rise slowly over a period of 10 to 20 days, or more. Overflow from rivers and tributaries cause extensive damage particularly when the water level of the three major rivers— the Ganges, the Brahmaputra and the Meghna rise simultaneously. Heavy rainfall accompanied by on-rush of water from the upper catchments in India very often cause catastrophic flood in Bangladesh (Hossain et. al. 1987, Anonymous. 2003). These types of floods mainly affect rice crop at different growth stages.

According to the extent of damage inflicted, Bangladesh floods can be categorized as early, normal and late. In particular, late dry season crops such as Boro and the early kharif crops such as Aus and jute, can be damaged by flooding; and later river floods and flash floods from adjoining hill areas can damage transplanted Aman. On the other hand, early and mid-dryland rabi crops are not normally affected. Disastrous flooding can be caused by river spilling over their banks, eroding land or depositing fresh alluvium on neighbouring land. These problems are extensive in the young charlands (sandbars) along the Ganges, Jamuna and Tista, river systems.

Both rainfall and river water contribute to floods. Inundation starts with accumulation of water in the lowest depressions, derived either from run-off from heavy, local, pre-monsoon showers or the inflow of flash floods from neighboring hill regions. Excess rainfall amounts are highest between June and August. Flooding of the land is normal and farmers' cropping practices are finely attuned to differences in the depth and duration of seasonal flooding on the different kinds of land, which they cultivate. Damaging floods mainly occurs when water levels rise earlier, higher, abruptly or later than normal.

**Table 3. Flood vulnerable areas by river basin**

| Name of the basin/area | Total area within the basin ($km^2$) | Flood vulnerable areas ($km^2$) | Fraction of basin area (%) | Fraction of total area of Bangladesh (%) |
|---|---|---|---|---|
| Brahmaputra | 41,082.19 | 26,561.25 | 64.65 | 18.58 |
| Ganges/Padma | 53,773.11 | 23,183.74 | 43.11 | 16.22 |
| Meghna | 22,237.63 | 17,704.04 | 79.60 | 12.40 |
| Southeastern hill | 25,799.17 | 6,570.97 | 2.46 | 4.60 |
| Coastal area | - | 8,134.01 | - | 5.70 |
| **Total** | **-** | **82,154.02** | **-** | **57.50** |

Source: Bangladesh Agriculture Research Council, 1998.

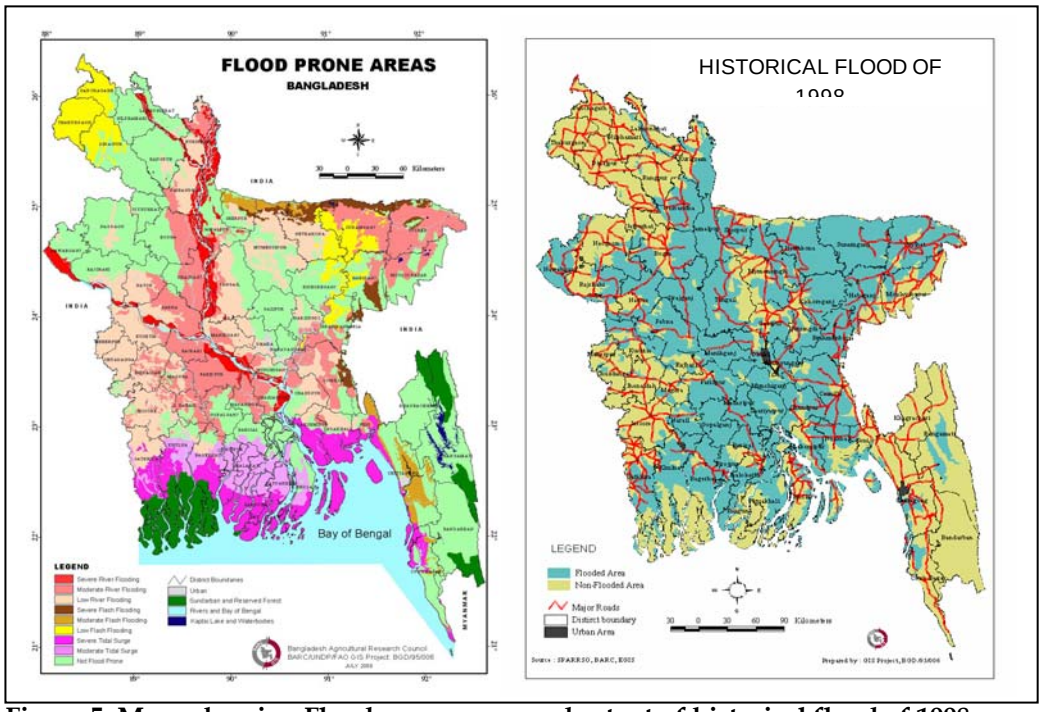



**Figure 5. Maps showing Flood prone areas and extent of historical flood of 1998**
Source: BARC

Experts said that the frequency, extent, depth and duration of floods could increase because of more monsoon rains triggered by climate change. As a consequence of this significant decrease in crops and food security is likely to occur.

**Droughts**

Drought refers to a condition when the moisture availability at the root zone is less than adequate. In Bangladesh context, drought is defined as the period when soil moisture content is less than the required amount for satisfactory crop-growth during the normal crop-growing season. Like floods, occurrence of droughts is also an annual event. Although, drought is slow, but its costs and indirect effects add up to devastation that rivals that of hurricane or floods. The impacts of drought on agricultural production causes a great harm for Bangladesh, as agriculture is one of the largest sectors of economy. Drought prevails during pre-kharif, late kharif and rabi season. Extent and magnitude of drought during the three cropping seasons again differs spatially and temporally. Severe drought occurred in Bangladesh in 1966, 1969, 1972, 1978, 1979, 1982, 1989, 1992, 1994 and 1998. During the period starting from 1961 to 1977, six droughts of moderate nature occurred in the country. During the kharif and rabi seasons 2.20 Mha and 1.2 Mha, respectively are affected by droughts of varying intensities.

Food grain production could be drastically reduced as a consequence of a drought. Transplanted Aman paddy is primarily cultivated as a rainfed crop, which contributes nearly 50% of the total rice production. This crop is most affected by drought resulting yield loss of more than 45% of the achievable yield. During dry and pre-monsoon season, wheat, potato, and broadcast paddy also suffer yield loss.

Brammer (1999) claimed that the 1987-89 drought reduced rice production by an estimated two million tons. It directly affected about 42% of the cultivated land and 44% of the population (Ericksen et. al. 1993). Ahmed and Bernard (1989) and Hossain (1990) contend that during the 1973-87 periods, crop losses to drought were almost as severe as the losses attributed to floods. About 2.18 million tons of rice was damaged due to drought in the above period. In North-Western regions during rabi (dry winter) season, 1.2 million ha of cropland faces droughts of various magnitudes. A very severe drought can cause more than 40 percent damage to broadcast Aus (pre-monsoon) rice. During the kharif (monsoon) season, drought causes significant damage to transplanted Aman (T. Aman) crop in about 2.32 Mha area annually (Sajjan et al., 2002).

Rainfall, the most important input for crop production, occurs abundantly in Bangladesh. But the distribution it holds is extremely skewed in time. As a consequence, water availability may become super and/or sub normal with respect to its requirement at many places. The northwestern (NW) region of Bangladesh has been affected largely due to the shortage of water normally available for irrigation. In addition, water shortage for domestic consumption is usually identified as principal constraint for the people during the dry season. Lack of water or drought in the region has profound impact that can be listed as economic, social and environmental (Sajjan, 2002; Brammer, 1987).

Crop Water requirement of rice varieties varies under water stress conditions at different growth stages. Islam et. al. (1994) observed that yield losses resulting from

water deficit are particularly severe when drought strikes at booting stage. Water stress at or before panicle initiation reduces potential spikelet number and decreases of grains, which results low in gain weight and increases empty gains (RRDI, 1999). Three days drought around the critical time (from 11th days to 3rd days before heading) reduced high percentage of yield (De Datta et. al., 1975). So an estimation of water required for irrigation before planting is needed. For transplanted rice, seedlings are grown in nurseries. After transplanting the rice crop, the land is usually kept under submerged conditions for almost the whole growing period. Due to the submergence, a considerable amount of water is lost because of percolation from the rice fields. Rice crop water requirement therefore, includes the combined effect of evapotranspiration of the crop and percolation losses, and the requirement for land preparation and nursery.

Currently, 10322 $km^2$ land of the country is drought prone. The severity of flood and drought is expected to increase and also the extent. Number of days with >40 °C would increase to the tune of 10 to 20 days especially in the north-western and some south-western parts of the country. Again these parts of the country would also experience more droughts because of even lower rainfall during the Rabi and Pre-kharif seasons. It is likely that the Madhupur and Barind Tracts would be the hardest hit areas as agriculture of these areas are already constrained by low soil moisture conditions. The south and southeastern part of the country is affected by varied degrees of salinity.

To cope with the anticipated climate change scenarios almost nothing has been done by the NARS (National Agricultural Research System) institutes of the country. Therefore, it has become imperative to undertake research and develop mechanism to cope with the changing situations. Salinity and drought tolerant varieties need to be developed for which it is very much essential to have comprehensive understanding of the mechanisms and pathways responsible for the impact and tolerance. In doing so, tracer techniques and soil moisture measurement by neutron scattering probes could be employed.

**Salinity**

The country is bounded by India in the north and west, in the east by India and Myanmar and in the south by the Bay of Bengal. Primarily the country is a deltaic floodplain. Coastal area of Bangladesh lies between 20° 25′ and 23°20′ N latitude and 88° 25′ and 92° 24′ E longitude. The coastline of Bangladesh is 3,306 km facing the Bay of Bengal. The country has the longest beach and largest mangrove forest in the world. About 55% of the population is within 100 km of the coast as because the country is elongated from north to south. (Table 4). More than 30% of the cultivable land in Bangladesh is in the coastal area. Out of 2.86 Mha of coastal and offshore lands about 1.056 Mha of lands are affected by different degrees of salinity. Out of 151 Upazilas (sub-districts) in 19 districts coastal 93 Upazilas under 18 districts are affected by salinity.

Bangladesh has a vast coastal area covering about 20 per cent of the country. As the cropping intensity and crop yields are well below the country average, the contribution to agriculture sector is not proportional to its land mass. The reason behind this is unfavourable agroecological conditions of the region. These include

coastal flooding in the monsoon, higher levels of soil salinity in the winter and higher water salinity in winter reduces its potential for irrigation.

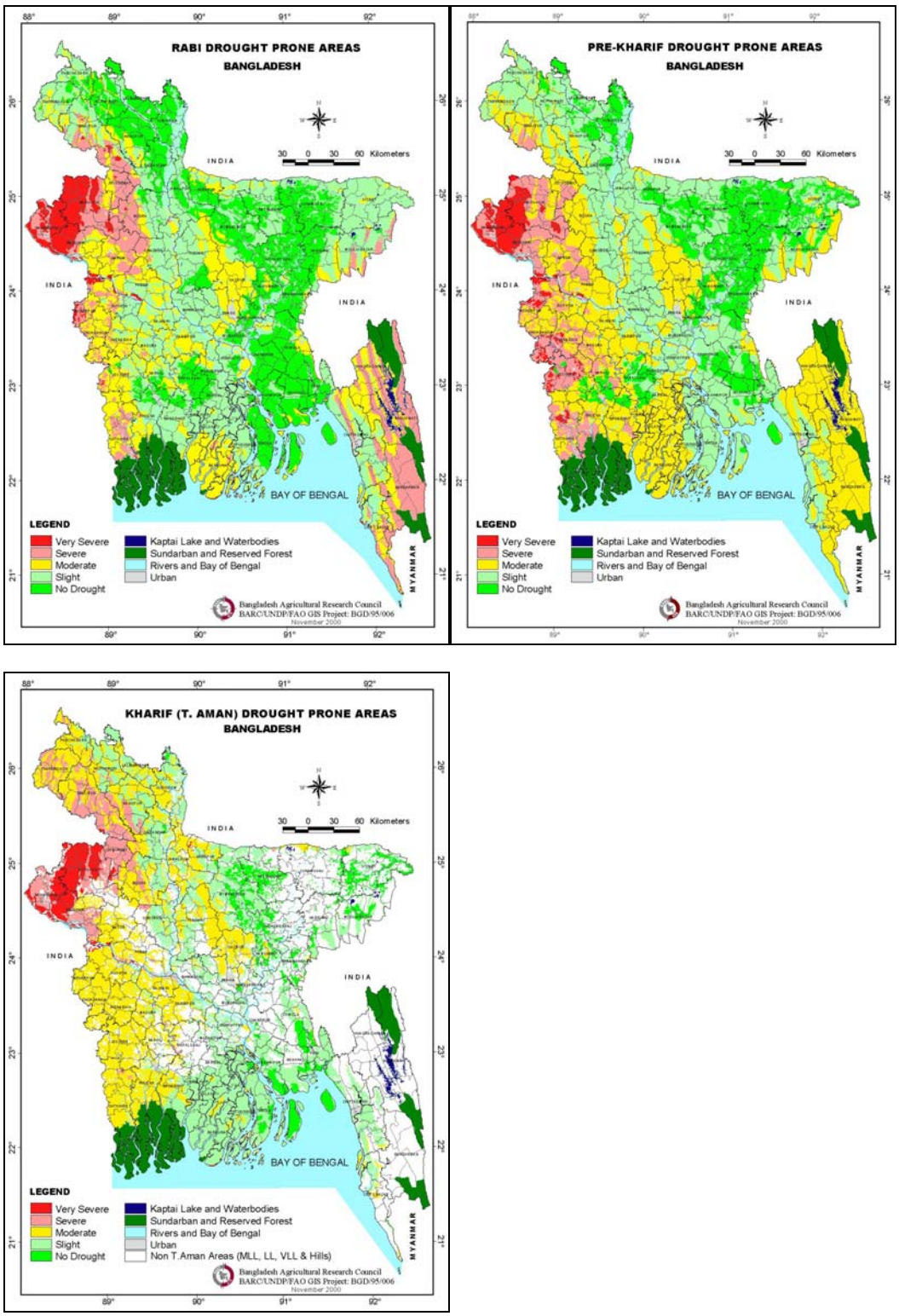



**Figure 6. Maps showing Drought prone areas in different crop growing seasons.**
Source: BARC

Global Climate Change and Sea Level Rise are major concerns for the countries in the Tropical Asia. The impact of Global Climate Change on agriculture has been studied extensively for various crops at many different scales in various countries of the world.

Available reports show that the tropical and subtropical countries would be more vulnerable to the potential impacts of global warming. Bangladesh is likely to be one of the worst-hit countries of the globe, being an Asian as well as a Third World country.

It is very likely that the soil salinity would increase due to climate change and consequential effects. Increased salinity would significantly decrease food grain production. This loss can be minimized by varietal and agronomic manipulations. Reduction in food grain production would put additional pressure to the food security of the country (Habibullah et al., 1999)

Climate change in combination with sea level rise would aggravate the soil salinity in the coastal region of the country. A GCM modeling approach has indicated that, under predicted climatic conditions the index of aridity will increase during winter (Ahmed et al., 1996).

According to the Third Assessment Report of IPCC (2001) it is likely to have a 45 cm of sea level rise. Under this scenario, if no adaptation is assumed about 11 % of land area of the country would be lost and also 5.5 million people would be vulnerable.

**Table 4. Some important statistics of the Coastal Zone of Bangladesh**

| | |
|---|---|
| Total Land Area (000 ha)[1] | 14400 |
| Population in 2010 (millions) | 141.82 |
| Population in 2020* (millions) | 181.18 |
| Percent of population within 100 km of the coast | 55% |
| Coastline Length (km) | 3306 (710 km coastal belt) |
| Territorial sea (up to 12 nautical miles) ($km^2$) | 40,257 |
| Claimed Exclusive Economic Zone ($km^2$) | 39,868 |

*Estimated population, [1] FAO (2008).
Source: WRI (2000). Coastline=This entry gives the total length of the boundary between the land area (including islands) and the sea

**Salinity Intrusion**

In the winter months the areas suffer due to salinity related problems. In absence of appreciable rainfall the soil in the coastal areas starts to desiccate, and because of capillary actions salt comes up at the surface of the soil and accumulates in the root zones of crops. Many of the crop varieties are not tolerant to salinity, and as a result, a large area in the coastal districts becomes virtually unsuitable for a number of crops, while the production of a few other crops is lesser under saline conditions.

Most of the land remains fallow in the dry season (January- May) because of soil salinity, lack of good quality irrigation water and late draining condition. Farmers cultivate mostly low yielding, traditional rice varieties during wet season. The process of salinization is governed by many factors among which the dominant ones are land characteristics and drainage of tidal flooding through a network of tidal creeks and drainage channels inundates the soil and impregnates them with soluble salts thereby rendering the topsoil and subsoil saline. Within the embankment the sedimentation and inundation process with saline water in brackish water shrimp cultivation area are still active. Only about six percent of the land types in coastal area are highland and 13% medium low land. The dominant land type in this region is medium highland, which is about 64%. A comparative study of soil salinity maps of 1973, 2000 and 2009

shows the extents of soil salinity intrusion in the coastal region. The map shows that soils of Jessore, Narail, Madaripur, Gopalgonj, Pirojpur, Barisal and Jhalakati were newly salinized during the last 36 years.

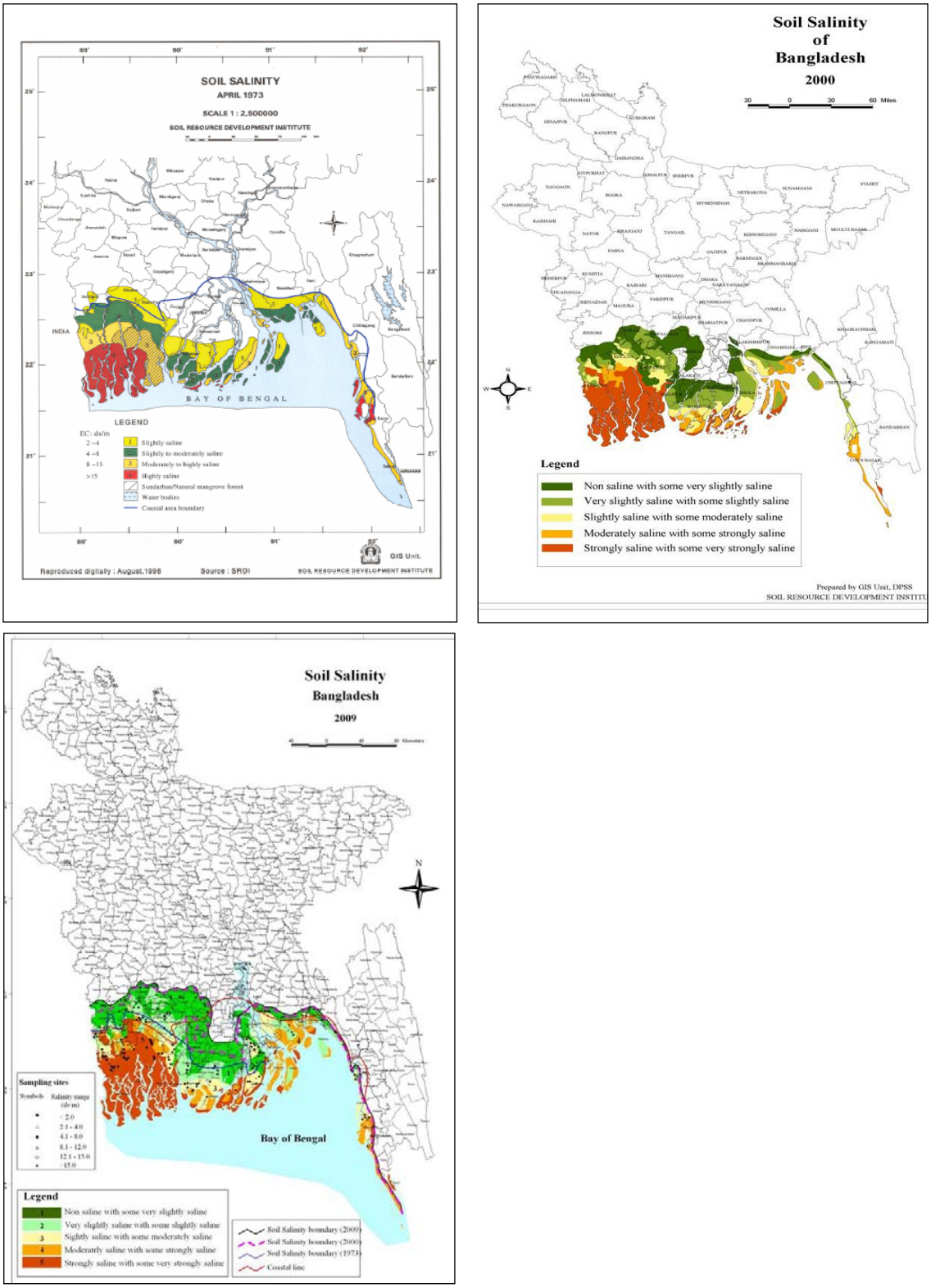


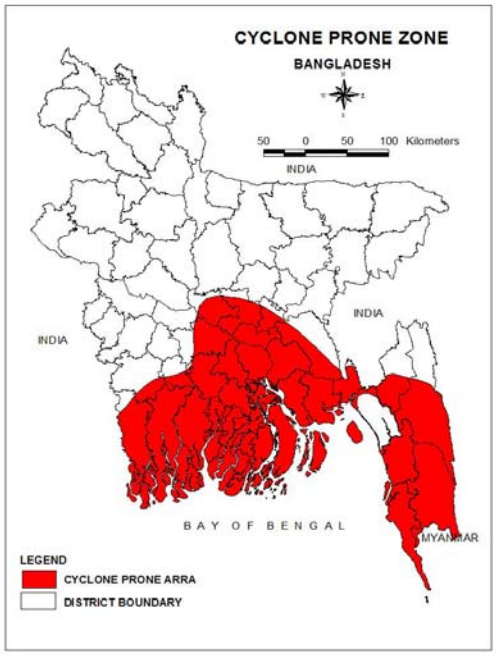

**Figure 7. Soil salinity maps of 1973, 2000 and 2009**
Source: Ahsan 2010.

**Table 5. Extent of soil salinity during about last four decades (1973-2009) in coastal areas**

| Year | Total Salt affected area ('000' ha) | Salinity Class | | | |
|---|---|---|---|---|---|
| | | S1 2.0-4.0 dS/m | S2 4.1-8.0 dS/m | S3 8.1-16.0 dS/m | S4 >16.0 dS/m |
| 1973 | 833.45 | 287.37 | 426.43 | 79.75 | 39.90 |
| 2000 | 1020.75 | 289.76 | 307.20 | 336.58 | 87.14 |
| 2009 | 1056.19 | 328.39 | 274.21 | 351.68 | 101.14 |
| Per cent increase (+) or decrease (-) during 2000-2009 | + 35.44 | + 38.63 | - 32.99 | + 15.1 | + 14.0 |

Source: Ahsan 2010.

## Cyclones and storm surges




Tropical cyclones are important features of the weather and climate of south Asia. The major cyclogenesis of this region exists in the northern Indian Ocean, which particularly affects Bangladesh and parts of India. Because of the funnel shape and geographic location of Bangladesh, severe cyclone and tidal surges are common along the 710 km coastal belt causing severe damage to life and property. Figure 8 depicts the cyclone prone zone of Bangladesh. Records of last 200 years show that at least 70 major cyclones hit the coastal belt of Bangladesh. During last 35 years, nearly 900,000 people died due to catastrophic cyclones. The Noakhali- Chittagong coast received 40 percent of the cyclones, which is the most vulnerable area for the landfall of cyclones.

**Figure 8. Cyclone prone zone of Bangladesh**

The Chittagong-Cox's Bazaar coast received around 27 percent, while Khulna / Sundarban and Barisal-Noakhali coasts are relatively less vulnerable (Rahman, 2001). Some examples of severe tropical cyclones are the Barisal cyclone of 1584, the Bakerganj cyclone of 1876, the 12 November 1970 cyclone, the May 1985 Urir Char cyclone, and the April 1991 cyclone. High intensity storm surges jeopardize the expansion of energy-recovery activities in the coastal areas and supporting industries, especially in the offshore areas (Islam & Ahmad, 2004).

## Low-flow conditions

Low-flow conditions in the rivers are often observed in the winter months (lean period) when surface water irrigation becomes severely constrained. Under such conditions, the farmers have to take necessary actions to ensure irrigation by exploiting groundwater resources. Low-flow conditions do not cause direct vulnerability to crop production, but cause economic hardship to the farmers of

Bangladesh. In the recent past, such a situation was observed in the upland areas in the northwest (Barind Tract) and in the lower Ganges flood plains.

**Climate Change**

The atmospheric concentrations of several greenhouse gases ($CO_2$, $CH_4$, $N_2O$, CFC-11, and CFC-12) have increased considerably from those of pre-industrial value of about 280 ppm (parts per million) to 381 ppm in 2006, an increase of 36% due to anthropogenic activities. The increased atmospheric levels of these gases, especially CO2, increase the infrared (IR) energy absorbed by the atmosphere, thereby producing a warming influence on the Earth's surface. Carbon dioxide is responsible for 63% of the global warming effect due to long-lived greenhouse gases affected by human activities (FIPA-WMO, 2009).

The global atmospheric concentration of carbon dioxide increased from a pre-industrial value of about 280 ppm (parts per million) to 385.2 ppm in 2008, an increase of 38%. $CO_2$ is responsible for 63.5% of the global warming effect due to long-lived greenhouse gases affected by human activities. Methane ($CH_4$ ) contributes 18.2 % of the global warming effect due to long-lived greenhouse gases affected by human activities. Methane has increased from a pre-industrial value of about 715 ppb (parts per billion) to 1797 ppb in 2008, an increase of 157%. Nitrous oxide ($N_2O$) contributes 6.2% of the global warming effect from long lived greenhouse gases. The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 321.8 ppb in 2008, an increase of 19%. The primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land use change (deforestation) providing another significant but smaller contribution. It is very likely that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use. More than a third of all nitrous oxide emissions are anthropogenic and are primarily due to agriculture (IFAP-WMO, 2009).

If this is allowed to continue without any restriction then accumulation of these gases would likely to modify the global climate. Emerging science points to the fact that besides increases in mean surface air temperature, increases in global mean rates of precipitation and evaporation, sea level rise, and changes in the biosphere climate change will lead to greater climatic variations and extreme events. Natural hazards like floods, droughts, cyclones and sea level rise will push poorer section of the population to the very margin of survival, making them even more vulnerable (Agarwal, 2001).

Global Climate Change and Sea Level Rise are major concerns for the countries in the Tropical Asia. The impact of Global Climate Change on agriculture has been studied extensively for various crops at many different scales in various countries of the world. Available reports show that the tropical and subtropical countries would be more vulnerable to the potential impacts of global warming. Bangladesh is likely to be one of the worst hit countries of the globe, being an Asian as well as a Third World country.

Agriculture is largely reliant on weather and climate. More particularly, temperature and rainfall are the two important determinants of agricultural production systems. Global climate change will have bearing on the agricultural production systems as a consequence of direct effect on hydrological and plant physiological processes. Even

though climatologists have put much effort, still, there is considerable uncertainty about the potential impact of climate change on this sector. Bazzaz and Sombroek (1996) stated that "little is known as to how, when, where and to what extent climate change will occur; one incontestable fact is the rising concentration of carbon dioxide ($CO_2$) in the earth's atmosphere. An additional certainty is the soundness of the basic greenhouse theory: the composition of the gas mix in the atmosphere strongly affects the planet's temperature." As pointed out by Fajer and Bazzaz in 1992 that definite answers might not be available for at least the next decade, improving scientific knowledge on the agronomic and ecological effects of any climate change, both adverse and positive, and on the ability of humans and ecosystems to adapt, might reduce the uncertainty and help formulate better policy. However, increasingly reliable regional climate change projections are now available for many regions of the world due to advances in modeling and understanding of the physical processes of the climate system. If the model scenarios are realistic, correctly reflecting future realities, such an increase may have serious consequences for agriculture and, in particular, for the regional food security in some regions (Ruttan, 1994).

Climate change is no longer a hype, it is a reality and it is announcing its presence through increasingly erratic behavior. The Fourth Assessment Report of the IPCC (2007) considers agriculture as one of the most vulnerable systems to be affected by climate change in the south Asian region.

The climate of Bangladesh is generally sub-tropical in the north to hot humid in the south. Southwest monsoon influences the climate during June to October, and during the winter the climate is controlled by the northeast monsoon from November to March. The summer is hot and humid and the winter is mild. The country is vulnerable to many environmental hazards, including frequent floods, droughts, cyclones, and storm surges that damage life, property, and agricultural production. On top of these, if the predictions made on the future climate change become true then the situation would be more unwelcoming for agriculture and for the country as a whole.

**Prediction of General Circulation Models (GCMs) and Regional Models**

Until now, no one can predict for sure what the next cropping season will be like. Even at a local level, when it is done at regional and global the chances of correctly reflecting future realities becomes more uncertain. Farmers, all other stakeholders of agriculture, and governments would all like to know for the reason that it is critical to their decision making. Instead they face uncertainty that delivers risk to their business and livelihood (Hammer et al.; 2001).

The IPCC (Intergovernmental Panel on Climate Change) Fourth Assessment Report's Working Group I Summary for Policymakers (IPCC 2007a) synthesizes current scientific understanding of global warming and projects future climate change using the most comprehensive set of well-established global climate models (GCMs). IPCC has projected that global mean annual surface air temperature increase by the end of this century is likely to be in the range of 1.8 to 4.0°C (IPCC, 2007b).

**Global**

The Fourth Assessment Report (AR4) cites evidence from surface temperature records, lower and mid tropospheric temperature records, ocean temperature records, decline

of glaciers, snow cover and sea ice, and an increase in sea levels. The AR4 also identifies evidence from continental-scale climate changes including changes in wind patterns, precipitation, ocean salinity, sea ice, ice sheets, and extreme weather. Specifically, the AR4 identifies the following changes:

i. Arctic temperatures increased at almost twice the global average
ii. Arctic sea ice has shrunk by about 3% per decade
iii. Greenland and Antarctica ice sheets have contributed 0.41mm per year to sea level rise from 1993-2003
iv. The top layer of permafrost has warmed by 3°C since the 1980s and the frozen ground area has decreased by 7%since 1900
v. Significant drying trends have been observed in the Sahel, Mediterranean, southern Africa and parts of southern Asia and increased precipitation has been observed in eastern parts of North and South America, northern Europe and northern and central Asia
vi. The tropics and subtropics have experienced more intense and longer droughts since the 1970s
vii. Extreme weather, including heavy precipitation events and heat waves, has increased in frequency and tropical cyclones have increased in intensity
viii. Better projections are now possible because of the major advancement made in climate modeling and observations. Depending on the emission rate of greenhouse gases to the atmosphere IPCC projects that over the next century it is expect that the temperatures would increase in the tune of 1.1 to 6.4°C.

The climate change projections for the 2050 in the Fourth Assessment Report (IPPC, 2007) were made based on six probable future heat-trapping emission scenarios or SRES (Special Report on Emission Scenarios) scenarios. Sophisticated climate simulation programs run were made for each scenario. The 'B1' scenario assumes a peak in global population during the middle of this century and declines thereafter, a rapid change toward a service and information economy, and a shift toward clean and resource-efficient technologies. The lowest temperatures currently projected for the end of this century represent the lowest scenario. The 'A1FI' scenario assumes a mid-century peak in global population, rapid economic growth, and "fossil intensive" energy production and consumption. These two scenarios predicted the lowest and highest temperatures projected for the end of this century represent the highest scenario (Union of Concerned Scientists (UCS). 2007).

More reliable near-term projections –the ability to predict what is likely to happen in the near future -and all scenarios project a warming of 0.2°C over the next two decades. This inertia in the climate system shows the actions we choose to make today really do have an affect on future generations.

Tropical cyclones are likely to become more intense, with higher peak wind speeds and heavier precipitation associated with warmer tropical seas. Increases in the amount of high latitude precipitation are very likely, while decreases are likely in most subtropical land regions (e.g., Egypt). Extreme heat, heat waves, and heavy precipitation are very likely to continue becoming more frequent.

**Regional**

Increasingly reliable regional climate change projections are now available for many regions of the world due to advances in modeling and understanding of the physical processes of the climate system. Atmosphere-Ocean General Circulation Models (AOGCMs) remain the foundation for projections while downscaling techniques now provide valuable additional detail. Atmosphere-Ocean General Circulation Models cannot provide information at scales finer than their computational grid (typically of the order of 200 km) and processes at the unresolved scales are important. Providing information at finer scales can be achieved through using high resolution in dynamical models or empirical statistical downscaling. Development of downscaling methodologies remains an important focus. Downscaled climate change projections tailored to specific needs are only now starting to become available.

Temperature projections in AR4 are comparable in magnitude to those of the TAR (Third Assessment Report) and confidence in the regional projections is now higher due to a larger number and variety of simulations, improved models, a better understanding of the role of model deficiencies and more detailed analyses of the results. Warming, often greater than the global mean, is very likely over all landmasses. For South Asia, the projections are 0.5 to 1.2°C rise in mean annual temperature by 2020, 0.88 to 3.16°C by 2050 and 1.56 to 5.44°C (Table 6.) depending upon the scenario of future development (IPCC, 2007a).

Overall, the temperature increases are likely to be much higher in rabi (winter) season than in kharif (monsoon) season. It is very likely that hot extremes and heat wave events will become more frequent. The projected sea level rise by the end of this century is likely to be 18 to 59 centimeters.

**Table 6. Projected changes in surface air temperature and precipitation in South Asia Region**

| Season | 2010 to 2039 | | | | 2040 to 2069 | | | | 2070 to 2099 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temperature °C | | Precipitation % | | Temperature °C | | Precipitation % | | Temperature °C | | Precipitation % | |
| | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 |
| DJF | 1.17 | 1.11 | -3 | 4 | 3.16 | 1.97 | 0 | 0 | 5.44 | 2.93 | -16 | -6 |
| MAM | 1.18 | 1.07 | 7 | 8 | 2.97 | 1.81 | 26 | 24 | 5.22 | 2.71 | 31 | 20 |
| JJA | 0.54 | 0.55 | 5 | 7 | 1.71 | 0.88 | 13 | 11 | 3.14 | 1.56 | 26 | 15 |
| SON | 0.78 | 0.83 | 1 | 3 | 2.41 | 1.49 | 8 | 6 | 4.19 | 2.17 | 26 | 10 |

Source: Cruz, et al. 2007

Extracted from Table 10.5. Projected changes in surface air temperature and precipitation for South Asia region under SRES A1FI (highest future emission trajectory) and B1 (lowest future emission trajectory) pathways for three time slices, namely 2020s, 2050s and 2080s.

Overall patterns of projected change in precipitation are comparable to those of TAR, with greater confidence in the projections for some regions. Model agreement is seen over more and larger regions. However, the confidence levels of perditions vary from region to region. For South Asia, heavy precipitation events will become more frequent.

The general findings of AR4 are comparable to those of TAR and now have a higher level of confidence derived from various sources of information. Regional projections

relating to heat waves, heavy precipitation and droughts are made with more confidence. However, projections concerning extreme events in the tropics remain uncertain. The difficulty in projecting the distribution of tropical cyclones adds to this uncertainty. Changes in extra-tropical cyclones are dependent on details of regional atmospheric circulation response, some of which remain uncertain.

The general findings of AR4 are comparable to those of TAR and now have a higher level of confidence derived from various sources of information. Regional projections relating to heat waves, heavy precipitation and droughts are made with more confidence. However, projections concerning extreme events in the tropics remain uncertain. The difficulty in projecting the distribution of tropical cyclones adds to this uncertainty. Changes in extra-tropical cyclones are dependent on details of regional atmospheric circulation response, some of which remain uncertain.

For the A1B scenario, the MMD (Multi-Model Data sets) -A1B models show a median increase of 3.3 °C in annual mean temperature by the end of the 21st century. The median warming varies seasonally from 2.7 °C in JJA to 3.6 °C in DJF, and is likely to increase northward in the area, particularly in winter, and from sea to land. In case of precipitation the median value also varies seasonally from -5 % in DJF to 15% in SON.

Studies based on earlier AOGCM simulations (Douville et al., 2000; Lal and Harasawa, 2001; Lal et al., 2001; Rupa Kumar and Ashrit, 2001; Rupa Kumar et al., 2002, 2003; Ashrit et al., 2003; May, 2004b) support this picture. The tendency of the warming to be more pronounced in winter is also a conspicuous feature of the observed temperature trends over India (Rupa Kumar et al., 2002, 2003).

Downscaled projections using the Hadley Centre Regional Model (HadRM2) indicate future increases in extreme daily maximum and minimum temperatures throughout South Asia due to the increase in greenhouse gas concentrations. This projected increase is of the order of 2°C to 4°C in the mid-21st century under the IPCC Scenario IS92a in both minimum and maximum temperatures (Krishna Kumar et al., 2003). Results from a more recent RCM, PRECIS, indicate that the night temperatures increase faster than the day temperatures, with the implication that cold extremes are very likely to be less severe in the future (Rupa Kumar et al., 2006).

**Bangladesh**

Regional climate models are becoming useful tools in generating future climate scenarios. PRECIS (Providing REgional Climates for Impacts Studies) is a regional climate modeling system developed by the Hadley Centre, UK. PRECIS is being used to project rainfall and temperature in 2030, 2031, 2050, 2051, 2070 and 2071 using SERS A2 emission scenarios as the model input. Projected annual average rainfall were 6.93, 6.88, 6.84, 7.16, 7.17 and 7.33 mm/d for 2030, 2031, 2050, 2051, 2070 and 2071; respectively. It is also reported that in Bangladesh monsoon and post-monsoon rainfall will increase whereas dry season rainfall will not change much. Year to year variability will be much higher for the pre-monsoon rainfall (BRTC-BUET, 2008).

***Climate Change Scenarios***

Ahmed and Alam in 1999 reported that the seasonal fluctuations of values of the climatic parameters and sea level rise for 2030 and 2075 with respect to their values

under base year situation (Table 7). In developing the National Program of Action for Adaptation to Climate Change (NAPA) of Bangladesh, the values for temperature and precipitation change, and sea level rise for the year 2030, 2050 and 2100 were agreed upon by all six Sectoral Working Groups (Table 8). These climate change scenarios were used as the guiding principle for formulating the NAPA.

**Table 7. The fluctuations of values of the parameters considered with respect to their values under base year situation**

| Parameters | 2030 | | 2075 | |
|---|---|---|---|---|
| | Winter | Monsoon | Winter | Monsoon |
| Temperature (° C) | 2.00 | 0.65 | 3.00 | 1.50 |
| Evaporation (%) | 10.00 | 2.00 | 16.00 | 5.00 |
| Precipitation (%) | -3.00 | 11.00 | -37.00 | 28.00 |
| Sea Level Rise (cm) | 30.00 | | 70.00 | |

Source: Ahmed and Alam (1999).

**Table 8. Climate Change Scenarios for Bangladesh NAPA**

| Year | Temperature change (ºC) Mean | | | Precipitation change (%) Mean | | | Sea Level Rise (cm) |
|---|---|---|---|---|---|---|---|
| | Annual | Dec-Jan-Feb | Jun-Jul-Aug | Annual | Dec-Jan-Feb | Jun-Jul-Aug | NAPA |
| 2030 | 1.0 | 1.1 | 0.8 | 5 | -2 | 6 | 14 |
| 2050 | 1.4 | 1.6 | 1.1 | 6 | -5 | 8 | 32 |
| 2100 | 2.4 | 2.7 | 1.9 | 10 | -10 | 12 | 88 |

### *Agricultural Vulnerability*

Water and agriculture are likely to be most susceptible sectors to climate change-induced impacts in Asia. Agricultural productivity in this region is likely to suffer severe losses because of high temperature, severe drought, flood conditions, and soil degradation. Tropical Asian countries are likely to have increased exposure to extreme events, including forest die back and increased fire risk, typhoons and tropical storms, floods and landslides, and severe vector-borne diseases. The stresses of climate change are likely to disrupt the ecology of mountain and highland systems in Asia. Glacial melt is also expected to increase under changed climate conditions. Sea-level rise would cause large-scale inundation along the vast Asian coastline and recession of flat sandy beaches. The ecological stability of mangroves and coral reefs around Asia would be put at risk (Cruz, et al., 2007)

Bangladesh is highly vulnerable to the projected impacts of climate change, as these are likely to increase the already high risk of disasters, and exacerbate existing vulnerabilities. Climate change will cause changes such as higher temperatures, changing rainfall patterns and sea level rise as well as more abrupt effects, such as an increase in the intensity and frequency of extreme events such as floods, storm surges and cyclones. An increase of one degree centigrade in sea surface temperature (SST) could increase tropical cyclone intensity by as much as 10%, while temperature alterations associated with climate change are already affecting the rate of snowmelt in the Himalayas, which is expected to lead to increased flooding. It is predicted that by the year 2030, an additional 14% of the country will become extremely vulnerable to floods, and currently vulnerable areas will experience higher levels of flooding. Indeed,

significant areas may be permanently inundated. At the same time, some areas of the country may be at greater risk of drought and food insecurity during the dry season, and agricultural productivity in coastal areas may be compromised by increasing salinity. The scope and scale of Bangladesh's vulnerability to climate change associated with agricultural practices demands serious assessment.

On top of these, apprehension is that a sea-level rise of just 40 cm in the Bay of Bengal would submerge 11 percent of the Bangladesh's land area of the coastal zone. This would displace seven to ten million people -- who would then be forced into the already densely populated interiors of the country. (Ahmed, 2007).

# 7. ICT Applications Bangladesh

## Current Status of ICT/MIS in BARC and NARS Institutes

Major findings of the ICT/MIS needs assessment in NARS institutes and BARC (Rahman, 2010) revealed that forty percent of the NARS Institutes have permanent ICT setup, while 60% of the institutes do not have. Compared to other institutes, BARC and BRRI are in a better position regarding ICT personnel working in the setup. Except BTRI all other institutes have their own dot gov Government) domain and website under dot gov domain. Among the NARS institutes; BARI, BLRI and FRI have Dynamic Website. All Institutes have Internet connectivity except Forest Research Institute. There is some makeshift arrangement for Internet connectivity at Forest Research Institute. Major MIS activities being run by the NARS institutes are Financial Information System, Personal Management Information System, and Library Information System etc. A summary of the major findings of need assessment is presented in Table 9.

**Table 9. Major Findings of Need Assessment**

| Issues | NARS Organizations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BARC** | **BARI** | **BRRI** | **BJRI** | **BSRI** | **BINA** | **SRDI** | **BLRI** | **FRI** | **BTRI** | **BFRI** |
| Class-1 Employee | 81 | 778 | 270 | 163 | 67 | 121 | 150 | 47 | 84 | 40 | 106 |
| Total Employee | 261 | 2007 | 531 | 343 | 325 | 352 | 343 | 90 | 257 | 182 | 578 |
| Permanent ICT Setup | Y | Y | Y | Y | N | N | N | Y | N | N | N |
| ICT Personnel | 7 | 3 | 5 | 2 | N | N | N | 1 | N | N | N |
| Total Personnel | 9 | 8 | 8 | 5 | N | N | N | 1 | N | N | N |
| Computers | 50+ | 225 | 161 | 42 | 58 | 64 | 70 | 93 | 55 | 21 | 26 |
| Printers | 50+ | 50 | 91 | 30 | 51 | 38 | 53 | 44 | 25 | 14 | 20 |
| Own dot gov domain | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y |
| Website (dot gov domain) | Y | DYN | Y | Y | Y | Y | Y | DYN | DYN | N | Y |
| E-mail (dot gov domain) | 50+ | 325 | 50 | 5 | 16 | 15 | 37 | 0 | 1 | N | 26 |
| Internet Connectivity | 50+ | 170 | 60 | 5 | 15 | 25 | 9<br>25 | 82 | N | 14 | 26 |
| Connection Type | DDN | DDN | DDN | FO | Dialup | FO<br>R/Link | BB<br>Dialup | R/Link | N | R/Link | FO |
| Bandwidth | 1 M | 1 M | 256 k | 128 k | 4K/pc | 4K/pc | 4K/pc | 1 M | N | 256 k | 4K/pc |
| LAN in the campus | 100+ | 170 | 5 | N | N | N | 11 | 82 | 15 | N | N |
| Power Backup/ UPS | 3 KVA | 1.5 K | 6 K | N | N | N | 3 K | 2x2 K | 2 K | 250 K (Gen) | N |
| MIS Activities | Next Slide | Fin Train | P/Roll<br>RMIS | Fin (SMS) | Fin MIS | P/Roll | OFR<br>CDP<br>FRTS | LMIS<br>PMIS | Fin<br>Lib<br>MIS | N | N |

Y=Yes, N=No, DYN=Dynamic, FO=Fiber Optic, R/Link=Radio Link, K=KVA
Source: Rahman, 2010

It is expected that the ICT/MIS System of BARC and NARS Institutes should have the following features in near future:

i. Own dot gov domain
ii. E-mail under dot gov domain
iii. Website under dot gov domain
iv. LAN in the campus
v. Electronic filing system through LAN
vi. Internet connectivity through LAN
vii. Database system (in-house hosting)
viii. Connectivity between BARC & NARS

The BARC ICT/MIS System will be the hub of all ICT/MIS activities of NARS. It will be developed around the following expected features:

i. Data Center
ii. Enhanced LAN facilities
iii. Limited Wireless LAN facilities
iv. Intranet facilities for BARC/NARS
v. Network redundancy and security
vi. Power backup & redundancy
vii. Data storage solution (SAN) with security
viii. High-speed Internet connectivity
ix. Database system (in-house hosting
x. Connectivity with NARS Institutions

The major problems for the NARS institutes are inadequateness of present ICT/MIS infrastructure and lack of professional ICT manpower. To make ICT/MIS activities at NARS sustainable it should be institutionalized as core activities and should not be project based. For a sustainable system setting-up of permanent ICT-MIS units at each organization with proper/trained manpower and required infrastructure is essential.

## Status of ICT/MIS in other organizations

Besides NARS, sporadic ICT initiatives have been undertaken by GO-NGOs. Some of the efforts are presented here. The agriculture sector of Bangladesh has adopted ICT for development in a remarkable scale which is very stimulating to note. Most of the agencies in agriculture sector have launched websites highlighting their activities. Among the agencies, Ministry of Agriculture, all research, extension and allied agencies are actively operating their websites successfully (Abedin, 2009)

**Rural ICT Centres**

In 450 upazillas 556 Grameen Phone Community Information Center (GPCIC) have been established, where Grameen provides services, GOB provides contents; local entrepreneurs provide office space and manpower. Pallitathay Kendra (Village information centers are in operation. The Government is providing contents and internet facilities at reduced cost and office space where required. The Pallitathay Kendra disseminates the services to the farmers/inhabitants. Most of these Centers are operating profitably.

e-Information Center based 'Batighar' and 'e-Krishok' campaign was launched in November 2008 jointly by of Bangladesh Institute ICT in Development (BIID), Grameen Phone (GP) and Katalyst Bangladesh. e-Krishok was with the aim to deliver the benefits of ICT to the farmers so that they can take advantage of ICT in each village of Bangladesh in gaining access to new production techniques, technology and other essential inputs like seed, pesticides and fertilizer. BIID and Zanala Bangladesh deliver benefits of ICT to the Farmers. In the last few months, e-Krishok has grown to become one the very best campaign to bring the benefits of ICT to rural Bangladesh (Singha, 2008).

Bangladesh Institute of ICT in Development (BIID) signed an MOU with Pacific Bangladesh Telecom Limited (PBTL) to establish 500 "Batighar" by 2011, and to have a presence in each Union Parishad by 2015. This "Batighar" project will utilize the power of ICT to promote development of rural people, farmers by providing them with information and advisory services and as well as create an enabling environment for local rural enterprises to flourish. The two parties agreed to make Batighar a leading and sustainable telecenter network in Bangladesh, where farmers will be trained to use Batighar as the preferred point to receive agricultural related information services. Besides they agreed to develop content for agriculture, MSME, education, health, environment and citizen services (Singha, 2008).

## Remote Sensing & Geographic Information System

A GIS is a specific information system applied to geographical data and is mainly referred to as a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems. The GIS is characterized by a great diversity of applications and concepts developed in many areas- agriculture, statistics, computer science, graphics, mathematics, surveying, cartography, geology, geography, database technology, resource management and decision making etc.

A key characteristic of geographic systems analysis is that location of an observation is known. The addition of location information adds value to the impact assessment of agricultural research (Nelson, 2003). Wood and Chamberlin (2003) affirmed that one attraction of spatial analysis is its capacity to represent simultaneously the spatial variability of many key factors influencing agricultural production decisions and performance: climate, terrain, soils, water resources, and the physical accessibility of infrastructure and markets. In the same framework, these factors can be juxtaposed against the spatial distribution of ecosystems, people, crops, livestock, and the threat of pests and diseases. In theory, this analytical capacity holds great promise for our ability to better understand the ranges and combinations of socioeconomic and environmental conditions under which agriculture takes place and, therefore, to make more informed assessments of the potential impacts of specific policy, institutional and technological innovations. In practice, there are very few impact assessment applications, at the meso or macro scale, in which GIS has played a significant analytical role -rather than serving simply as a data mapping tool. Geographic Information System and remote sensing are also used for Precision Farming or precision agriculture

The type of information that farmers need are not directly generated from remote sensing data. Rather data/information are provided to the "information multipliers" or the "value-added vendors" such as agricultural business dealers, extension personnel, crop consultants, and special agricultural information services who in turn analyze and interpret the data and deliver it to the farmer. In developed countries, advances in remote sensing technology are changing the way we will look at agriculture. The success of remote sensing will be measured by the type of information that is provided to the farmer, how quickly the information is delivered and the fee that is charged for the information (Johannsen, 1996)

Hudson and White (2003) stated that despite advances in software usability, data access and analytic approaches, GIS is still only utilized by a fraction of potential users. This is particularly true in developing countries. However, an increasing number of software options and data sources are becoming available, and the situation is rapidly changing. They also highlighted that a selection of widely accessible GIS tools, coupled to geographic datasets are now available. These include the Africa Maize Research Atlas (International Maize and Wheat Improvement Center-CTMMYT, incorporating ArcExplorer from ESRI Inc.), DIVA (International Potato Center-CIP/lnternational Plant Genetic Resources Institute-IPGRI), and the Almanac Characterization Tool (Mud Springs Geographers Inc.). These tools represent increasing levels of complexity in entry-level GIS systems, but all permit non-GIS experts to analyze and interpret geospatial data. The tools provide a means to improve spatial awareness amongst researchers that, in turn, can foster more efficient use of higher-level GIS resources. Additionally, such tools typically require a minimal amount of training.

To encourage GIS data access, CIMMYT has promoted the distribution of such tools, including data sets, to agricultural researchers. Climatology, soils, topography, infrastructure, demographics, and crop production data are typical inclusions. Additionally, these tools have considerable utility for the advanced GIS analysis, namely, accessibility surfaces or poverty maps.

Several examples are given of real world applications of these tools, including how they can assess impact. The adoption of conservation tillage (CT) technologies in the rice-wheat region of the Indo-Gangetic Plains is highlighted. Nearly two decades of research on tillage options now appear to be driving a substantial increase in the adoption of reduced tillage practices.

Through the Rice Wheat Consortium; researchers are using hand-held GPS units to rapidly record field locations where farmers have adopted different CT technologies. These locations, and all associated attribute data, can then be transferred directly into a GIS to produce an accurate spatial and temporal record of technology spread across the region. This is possible in near real time, is undertaken entirely by researchers in the region, and requires an investment of less than BDT 14,000 (US$200) in GIS/GPS hardware and software.

Developments in computer technology over the past few years have resulted in the availability, at relatively low cost, of compact, high performance computers, which are well suited to the demands of satellite Earth Observations (EO) or remote sensing data processing. Together with the emergence of a range of commercial GIS packages and other software tools for the manipulation of spatially referenced datasets. This has

facilitated the emergence of a range of new applications of satellite EO data which have been developed or have entered operational service over the past decade (Rai, 2010).

Remote sensing data is a classic source of data on natural resources for a region and provides a record of the continuum of resource status because of its repetitive coverage. Remotely sensed data in the form of satellite imageries can be used to study and monitor land features, natural resources and dynamic aspects of human activities for preparation of thematic maps.

Since1997 remote sensing technology has improved by increasing spatial, spectral and temporal resolutions. Efforts are being made to provide real-time after it has been acquired. Besides remote sensing that will help in improving answers and interpretation will be GIS. The ability to merge soil maps with remotely sensed data to understand crop variability is a great asset to interpretation. The ability to take other data such as terrain data, slope, aspect or even other remotely sensed data and look at crop variability makes many people to see many opportunities for better understanding of what is causing the variability.

The application of Geographic Information System (GIS) as a computer assisted spatial information system in Bangladesh started more than a decade ago in early 1990s. There are about 30 GIS installation in the country so far but GIS installations in different organizations work with their specific mandates. Still the farmers are not getting the modern agricultural information when needed (Rashid and Ali, 1997)

**GIS at BARC**

A reconnaissance soil survey, carried out between 1963 and 1975, provided comprehensive information on soil, seasonal inundation and landuse and interpretation in terms of land capability and crop suitability. The land resources activity in Bangladesh was initiated in 1979 under the FAO/UNDP Land Use Advisory Project to make Soil Survey information as a basis for more rational planning of agricultural development.

During the period 1980 to 1986 a national Agroecological Zones (AEZ) based computerized land resources database system was successfully developed. This physical resources database on land, soils, climates, hydrology and land suitability was used for national and subnational agricultural research and development planning.

***Land Resources Appraisal of Bangladesh:*** Under the FAO/UNDP Agricultural Development Advisor Project (BGD/81/035) the information on landforms, soils, inundation regime and climate were computerized during 1980-86.The main objective of the project was to make the land resources data base and crop suitability assessments available to agricultural and forestry research, extension and development planners at national, regional and District levels. Thirty agroecological zones and 88 sub zones have been created by analyzing the above mentioned four major data layers namely landforms, soils, inundation regime and climate. A computerized system has also been developed to assess the land suitability potentials for 48 crops under rainfed and irrigated condition. The system is capable of being continually updated and extended as new information is provided by future soil and

land use surveys, agricultural and forestry research, and field experience with individual crops and management practices.

Geographical Information System (GIS) for Agricultural Development: In one hand, GIS facilities in the country have been developed in many time-bound projects and lost on project completion. On the other hand, GIS installations in different organizations work with their specific mandates. Most of the developed facilities did not cater to the needs, relevant to agricultural resource management and planning. This necessitated institutionalization of GIS facilities. BARC as the apex body of the National Agricultural Research System (NARS) and maintaining and utilizing the AEZ database system developed a GIS facility though a five-year project "Utilization of Agroecological Zones Database and Installation of GIS for Agricultural Development" BGD/95/006 was launched in 1996 with UNDP funding and technical assistance from FAO. Through this project all previous data has been transformed into a GIS format and a GIS based computerized land information system for the whole country was established.

The AEZ/GIS database is used for crop production technology generation and transfer, crop diversification and disaster preparedness program planning considering the socioeconomic aspects of the stakeholders. In pursuing one of the major objectives of the project people involved in planning, decision-making process, research, extension and education were sensitized about the importance of AEZ/GIS as a planning tool and developed manpower on GIS/decision support system, land resources and computer use.

Several applications were developed; namely, The Land Resources Inventory (LRI) Application allows for the classification and mapping of soil characteristics from the LRI database. The LRI contains several attributes describing physical soil characteristics. Since LRI attribute data has a many-to-one relationship to soil mapping units. The data has been summarized by the mapping unit and the resulting mix of LRI characteristics classified for mapping purposes. Soil/Land Type Mapping Model is an ArcView GIS-based application developed to dynamically combine a user-specified digital elevation model (DEM) with the national (reconnaissance level) soil association layer to create a more detailed Soil/Inundation Land Type layer. The application is written in Avenue and uses the ArcView Spatial Analyst extension. It has been programmed to handle future updating of both the soil and the DEM layers.

***Climatic Modeling:*** Much effort has been made to expand existing historical climatic data involving different types of data with recent records obtained from various institutions. Procedures have been developed to perform quality control and enhance database management and modeling capabilities. Meteorological station data is analyzed using the Agricultural Planning Tools (APT) calculator, and the resulting data is then used to create GIS surfaces showing important climatic properties related to plant growth by season as well as the variability of these properties (e.g., average starting date of the kharif growing season).

***Hydrologic Modeling:*** On average, approximately 60 to 70 percent of Bangladesh is inundated by rising water table levels between July and September of each year. Previous AEZ assessments indicated that the year-to-year variation in inundation regime is affecting the long-term suitability and productivity of the land. The enhanced system now in place enables quantification of the year-to-year variation in

extent, depth, and timing of inundation. This information will greatly improve the assessment of single crop and cropping pattern suitability in individual inundation land types.

***Crop Suitability Mode:*** The system also includes a component that permits the evaluation of crop suitability. Individual crop suitability ratings are analyzed, and then suitability categories for various cropping patterns are rated using a database of known and potential cropping patterns (rotations). This suitability modeling takes into account individual crop characteristics, input/management levels, the soil's physical characteristics, hydrologic and climatic conditions, and seasonal variability.

***Research Management Information System:*** Huge amount of information/data are generated by these organizations on various aspects of agriculture. Until very recently, there has been no concerted effort to create databases for their proper storage and easy retrieval. A Research Management Information System (RMIS) has been developed for BARC and other NARS Institutes following the methodology developed by ISNAR, the Netherlands.

***Bangladesh Country Almanac***: A joint BARC-CIMMYT (Centro Internacional Mejoramiento Maiz y Trigo) activity on Bangladesh Country Almanac (BCA) was implemented during 2002-2005 through USAID funding. The idea of developing the BCA was to enable the non-GIS users to readily get spatial and non-spatial information/data in CD. It also includes an easy to use GIS software, Awhere ACT (Almanac Characterization Tool) which can be used in PCs.

***Poverty mapping and its implications on the agricultural R&D&E in Bangladesh:*** A BARC-IRRI (International Rice Research Institute) joint activity on "Poverty mapping and its implications on the agricultural R&D&E in Bangladesh" was conducted during 2002-2004. Major biophysical resources combined with the socio-economic situation were used to delineate the vulnerability areas or poverty related hot stops. The output can be used for developing interventions in priority poverty stricken areas.

**RS-GIS at SPARRSO**

The Bangladesh Space Research and Remote Sensing Organization (SPARRSO) acts as the national focal point for the peaceful applications of space science, remote sensing and GIS in Bangladesh. Among many activities the organization is also involved in agricultural, disaster monitoring, environment, fisheries, forestry, etc. related studies.

***Agricultural studies:*** Survey and monitoring of the agricultural crops. Estimation of yield of the major crops like rice, wheat etc. particularly the winter crops. This forecast is used to plan the food situation in the country. The role of SPARRSO in this regard has been commended by the Government. Vegetation indices are calculated for the entire country or for a particular location.

***Disaster monitoring:*** Satellite data on cloud formations in the region is received hourly and any impending disaster like depression; cyclone, floods etc. are reported to the Government, and also to BMD, BWDB, BAF and other relevant agencies. Cyclones of 1970, 1985, and 1991 were monitored. Floods of 1987, 1988, 1998 and 2004 were monitored. Through the help of RS and GIS SPARRSO is conducting research of Climate change, Global warning, EL-Nino, Monsoons and Ecology. They have also prepared the following maps of Bangladesh. Landuse/Land cover Maps of different

ecological zones, Coastal Afforestation Map, Administrative Unit Map, Accretion and Erosion Map, Infrastructure Map of different Upazila, Forest cover map, Drainage pattern map, Small & large water bodies were mapped for Fisheries Resources Survey Project of the Department of Fisheries, etc.

SPARRSO has also completed monitoring of Coastal Mangrove Afforestation of the Forest Department and conducted survey of Modhupur Sal forest & other forests and prepared the Timber Volume Inventory of Sundarban forest and updated the Inventory of Inland Waters of three Districts. Studied Shrimp farming in Satkhira and Chokoria in the coastal region and developed model on Suitable Site Selection of Shrimp farming using RS and GIS in Coastal Areas. Determined morphological changes of the Major rivers and Mapped small & large water bodies of the country and provided support to NWMP & FCD projects (SPARRSO, 2010). This public sector organization needs to be handled by professionals with the creation of required logistics and resources to run their activities.

**RS-GIS at CEGIS**

Center for Environmental and Geographic Information Services (CEGIS) predecessor of the Environment and GIS Support Project for Water Sector Planning (EGIS) was launched in 1996 through the integration of the Environmental Study (Flood Action Plan (FAP) 16) and the Geographic Information System Study (FAP 19). The then EGIS had performed a number of environmental, GIS and RS studies and developed and acquired valuable assets that included very useful analytical tools and models along with hardware and peripherals, and most importantly a group of trained professionals of different disciplines (CEGIS, 2010).

CEGIS integrated latest ICT solutions in different national projects from very beginning. In fact, it is CEGIS who introduced the GIS and RS technology at application level in Bangladesh for better planning of water management and environmental impact assessment projects. During the course of its activities, CEGIS developed dozens of software for exploiting the cutting edge technology to conduct project activities with highest level of efficiencies. CEGIS maintains a sophisticated and up-to-date network system equipped with the latest technology. CEGIS has a strong systematic research and development (R&D) programme. The R&D activities aim to develop new analytical tools, investigate new approaches and methodologies to address existing problems, and research application of new satellite images. Besids, CEGIS has developed a huge database comprising temporal and spatial data. Among them three are national level database: National Water Resources Database, Integrated Coastal Resource Database and Climate Change database. CEGIS developed numbers of software for Water Management, Environment Management, Management Information System, Decision Support System, Disaster Warning System and Resource Management System, and also developed dozens of web portals. The quality of software and the skills of the CEGIS IT professionals have already earned reputation at national and international level though real application. This publication is a brief description of some CEGIS software which contributed in nation building activities as planning and monitoring tools to several national organizations (CEGIS, 2009).

**GIS at SRDI**

Soil Resources Development Institute (SRDI) in collaboration with CEGIS, a not-for-profit Geographic Information System (GIS) based research organizations, developed a massive 2GB database that stores soil data using primary information from Upazila Nirdeshika. The system is called 'The Soil and Land Resource Information System' or SOLARIS. Customized GIS software SOLARIS-GIS is also developed to map soil data based on classification (Soil Texture, Land type, Landform, Drainage, Slope, Surface Water Recession) and condition (Crop Suitability, Land Zoning, Nutrient Status and Fertilizer Recommendation). The system can analyze data at the Upazilla, District, and national level. Given the current context of Bangladesh, the system has a wide range of potential use and benefits. These satellite based precision maps can assist the farmers to determine the optimal use of fertilizer for each type of crops in each season and thereby reducing the cost for the farmer and limit environmental hazards from unplanned usage. Additionally, the system can be used to assess drought for each soil map units and the associated 'Drought Assessment Framework' (DRAS) can be used for assessing the irrigation water requirements (when and how much). The DRAS was developed by CEGIS and BARC (UNDP, 2007)

With the objective to increase crop production, reduce misuse of fertilizer, reduce crop production cost by reducing current practice of using excessive fertilizer and maintaining soil fertility the Soil Resource Development Institute (SRDI) used to provide location specific fertilize recommendation through manual interpretation of its national nutrient database. Recently, SRDI in collaboration with KATALYST (a Foreign NGO) developed web based software named Online Fertilizer Recommendation System. The system is capable of generating location specific fertilizer recommendation for selected crops by analyzing the national nutrient database developed by the institute. The software needs only location and land type information to generate crop specific fertilizer recommendation.

The software can accessed through internet using user name and password. Considering the farmers limitation to access to internet, due to easy accessibility, mobile phone is selected as the service delivery channel. Banglalink Jiggyasa 7676 and GP-CIC is currently giving the service using the software. In order to make this service efficient, SRDI in collaboration with eGeneration is imparting training to the Banglalink Call Center Operator, GP-CIC Trainer and Farmer's Motivation Team on use of the software. To make the farmers familiar and develop confidence on the service farmers motivational activities are being carried out involving KATALYST and DAE (Hossain, 2010)

Moreover, SRDI is involved in data processing and GIS based map preparation this include the following:

i. Physiography and Land Typewise Union level Nutrient Status data of 100 Updated Upazila Nirdeshika,
ii. Soil and Land Characteristics data of all Upazilas under Chittagong and Sylhet Division, National level Land Type,
iii. Soil Texture, Drainage and Water Recession Data
iv. Salinity 2009, Land Use 1975,
v. Soil Association Map of Noakhali District and Chandpur Subdivision of Comilla District

vi. Updated pH and Organic Matter Status Map using Nirdeshika Data
vii. Updated Nutrient Status Map of Phosphorus, Sulfur, Potassium, Zinc, Boron
viii. Acidic Soils of Bangladesh

**ICT in BRRI**

The Bangladesh Rice Knowledge Bank (BRKB) is a repository of rice knowledge. It is a dynamic source of knowledge that is updated regularly to keep consistency with the latest innovations and users' feedback. IRRI is providing technical support for developing BRKB. It is managed by a content group at the Bangladesh Rice Research Institute. The BRKB contains rice knowledge to address the regional as well as national issues associated with rice production and training. It started with rice but extends promise to be expanded to non-rice technologies in future. Senior scientists of the institute have prepared the contents of fact sheets and other training and communications materials. Most of the contents are easily understandable to farmers and extension workers. It includes fact sheets, training manuals, booklets, leaflets, brochures, posters, videos. All the contents are in Bangla. Below are the main sections of BRKB:

i. Rice cultivation methods
ii. Boro Rice varieties and production methods
iii. Aman Rice varieties and production methods
iv. Aus Rice varieties and production methods
v. Soil and fertilizer management
vi. Rice insects and their management
vii. Rice diseases and their management
viii. Quality rice seed production and preservation methods
ix. Irrigation and water management
x. Training
xi. Photo Gallery

BRKB uses three different ways for communication. These are Internet, CD and Print. The extension service providers are the immediate beneficiaries of the BRKB. However, ultimately farmers will be benefited from it.

## ICT and Disaster Management

Complete definition of disaster by United Nations International Strategy for Disaster Reduction UN/ISDR: A social crisis situation occurring when a physical phenomenon of natural, socio-natural or anthropogenic origin negatively impacts vulnerable populations and their livelihoods, production systems infrastructure and historical heritage, causing intense, serious and widespread disruption of the normal functioning of the affected social unit. The impacts and effects cannot be overcome with the resources autonomously available to the affected society. Impacts are expressed in different forms such as the loss of life, health problems, the destruction, loss or rendering useless of the totality or part of private or collective goods and severe impacts on the environment. These negative impacts require an immediate response from the authorities and from the population in order to attend the affected and to re-

establish acceptable thresholds of wellbeing and life opportunities. (Source: Living with Risk: A global review of disaster reduction initiatives, (UN/ISDR, 2004).

A hazard may not necessarily result in a disaster. For example, an undersea earthquake might not result in the loss of any lives or damage to property, and a typhoon is not a disaster until heavy rain and wind cause damage or disruption to inhabited areas (to human life, infrastructure, production, etc.).

There are no hard and fast rules in defining the different phases of the disaster management cycle. Different agencies use different cycles depending upon their objectives. However, while approaches vary, it is agreed that disaster management activities should be carried out in a cycle. Figure 9 illustrates the phases of the disaster management cycle, which are described as follows:

***Mitigation:*** any activity that reduces either the chance of a hazard taking place or a hazard turning into disaster.

***Risk reduction:*** anticipatory measures and actions that seek to avoid future risks as a result of a disaster.

***Prevention***: avoiding a disaster even at the eleventh hour.

***Preparedness:*** plans or preparations made to save lives or property, and help the response and rescue service operations. This phase covers implementation/operation, early warning systems and capacity building so the population will react appropriately when an early warning is issued.

***Response:*** includes actions taken to save lives and prevent property damage, and to preserve the environment during emergencies or disasters. The response phase is the implementation of action plans.

***Recovery:*** includes actions that assist a community to return to a sense of normalcy after a disaster. These six phases usually overlap. ICT is used in all the phases, but the usage is more apparent in some phases than in others.

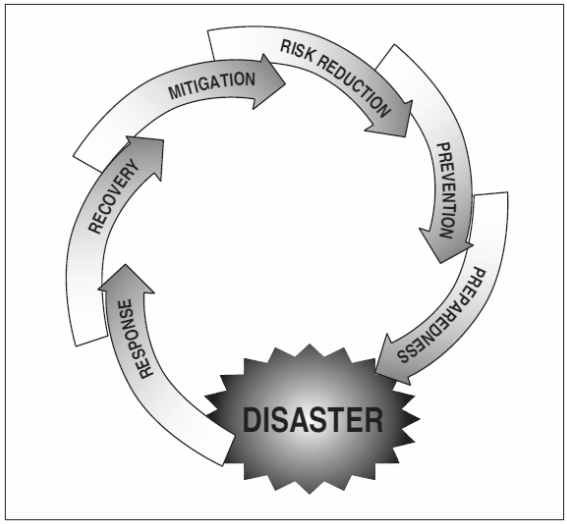



**Figure 9. The Disaster Management Cycle**
Source: Chanuka, (2007)

These six phases usually overlap. ICT is used in all the phases, but the usage is more apparent in some phases than in others (Chanuka, 2007).

In the last five years alone, the Asia-Pacific region has been susceptible to more natural disasters than in the last three decades. Earthquakes, tsunami and typhoon caused considerable physical damage and loss of life in many Asian countries.

In the last five years alone, the Asia-Pacific region has been susceptible to more natural disasters than in the last three decades. Earthquakes, tsunami and typhoon caused considerable physical damage and loss of life in many Asian countries. The vulnerabilities to which populations are exposed to because of natural and man-made disasters can be mitigated if they are targeted proactively. However, it is not always possible to completely eliminate a risk. Lessons learned from the past few decades, showed that the damage caused by any disaster can be minimized largely by careful planning, mitigation and prompt action. In this context, ICT can potentially play a crucial role in disaster prevention, mitigation and management. Remote sensing for early warning is made possible by various available technologies, including telecommunication satellites, radar, telemetry and meteorology. ICT covers both traditional media like radio and television and new media such as cell broadcasting, Internet, satellite radio, etc. All of these can play a major role in creating awareness among the people about the potential risks or looming disaster and thereby making it possible to take the necessary precautions to mitigate the impact of these disasters. Application of ICT can also play an important role in the immediate aftermath of a disaster and in facilitating the reconstruction process.

Since December 2004, the Asian Disaster Preparedness Center (ADPC) together with the International Telecommunication Union (ITU) has taken initiatives to assess the current status of emergency communications in the Asia-Pacific countries including Bangladesh and to give recommendation on national emergency telecommunication and national early warning system setups.

To enhance early warning systems, ADPC, also introduced the Tsunami Alert Rapid Notification System Programme with emphasis on robust ICT systems to disseminate information and warnings from the national to the community level.

**ICT in Disaster Management**

Bangladesh Meteorological Department 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. Major services provided by BMD include: observing different meteorological parameters both for surface and upper air all over Bangladesh round the clock and analyzing them. Providing weather forecasts for public, farmers, mariners and aviators on routine basis and also to issue warnings for severe weather phenomena such as tropical cyclones, tornadoes, nor'westers, heavy rainfall, etc (Source: http://www.bmd.gov.bd/.)

The Space Research and Remote Sensing Organization has the mandate for conducting survey and monitor the agricultural crops, estimation of major crop yield: rice, wheat etc. particularly the winter crops. This forecast is used to plan the food situation in the country and helps attain food security. For disaster monitoring, satellite data on cloud formations in the region is received hourly and any impending disasters like depression, cyclone, floods etc are reported to the Govt. and also to BMD, BWDB, BAF and other relevant agencies. Cyclones of 1970, 1985, 1991 were monitored. Floods of 1987, 1988, 1998 and 2004 were monitored (Source: http://www.sparrso.gov.bd/activity.html).

The Flood Forecasting and Warning Centre of the Bangladesh Water Development Board operates "Flood information Centre" as focal point in connection with Disaster Management both for Cyclone & flood. They collect data through HF wireless network, Mobile telephone, Telemetry System, Satellite Imagery (GMS, NOAA-12 & NOAA-14) and on-line data from Bangladesh Meteorological Department, including satellite and rainfall radar data. They also manage real time data and issues daily monsoon bulletin & river situation report, river level forecasts (for 24, 48 and 72 hours), current warning messages, special flood situation report, and produces Upazila inundation status map and flood forecast maps. These information are disseminated via media like Internet, Email, Fax, telephone and wireless, radio and television to a number of destinations including Ministry of Relief & Rehabilitation, Disaster Management Bureau, News Agencies and Radio & TV. [Flood Forecasting and Warning Centre (2010) http://www.ffwc.gov.bd/]

In recent years, Avian Influenza (Bird Flu) has become a global and regular hazard to the poultry industry. Bangladesh is not free from this hazard. Outbreak of this disease leads to great economic loss, as a significant number of people depend on the poultry sector. For rapid reporting and archiving of suspected Highly Pathogenic Avian Influenza (HPAI) cases the Food and Agriculture Organization (FAO) of the United Nations engaged CEGIS to develop a serviceable operational SMS Gateway System. The SMS Gateway System makes HPAI information dissemination easier using modern telecommunication networks. The developed SMS Gateway System was initially implemented in three upazilas (Kaliakair, Bhuapur, and Narsinghdi Sadar), however, it is capable of providing nation-wide service. The major outputs of the assignment are SMS gateway software and a GIS-based poultry database for pilot upazilas CEGIS (2008).

In the year 2009 Bangladesh Government has signed an agreement with two mobile operators in the country to provide disaster early warning alerts to subscribers. Grameenphone and state-owned Teletalk will send instant messages to their subscribers in two of the most vulnerable areas -- flood-prone north-central Shirajganj district and cyclone-prone Cox's Bazaar district on the coast. This new initiative will allow people to get an alert on their phones warning them that they are likely to face flooding or a cyclone. The messages would not be the usual SMS format, but would flash automatically on the screen of mobile phone sets. This way, people would not have to even push a button on their handsets, making it very user-friendly. So they will then be able to take action like evacuate their homes and seek shelter in assigned places. Officials of the Disaster Management Bureau said that the new service aims to strengthen the existing early warning mechanism, reduce the number of casualties or injured and minimize loss of property (Reuters (2010).

## Institutionalization of ICT in NARS

In early 2009, as a part of the effort to institutionalize ICT within NARS, BARC issued a memorandum to form a 5-7 member ICT/MIS cell in each of the ARIs (ten excluding BARC). Prior to this, a Committee was formed at BARC with members from its all technical divisions and focal points from all ARIs. The Computer & GIS Unit of the BARC organized a workshop on ICT/MIS at NARS institutes on 04 June 2009. The objectives of the workshop were:

i. To review of existing ICT/MIS status of NARS institutes;

ii. To identify key issues related to future development of ICT/MIS activities at NARS; and
iii. To recommend measures for strengthening of ICT/MIS activities within NARS institutes and to cater information needs of different stakeholders.

The members of ICT-MIS Cell of all NARS institutes and BARC attended the workshop. Other participants from BARC and World Bank also participated in the workshop.

Director (Computer & GIS Unit) of BARC to presented the status paper on the ICT/MIS activities at BARC and NARS. The present status of ICT/MIS activities of NARS institutes and BARC were highlighted. Specifically, the strength and weaknesses of ICT/MIS facilities at BARC and other NARS institutes were pointed out and a number of required steps/measures for strengthening ICT/MIS activities of NARS were suggested.

In the technical session, the focal points from ten NARS institutes presented the respective institute's status papers. The focal points of NARS institutes in their presentations pointed out opportunities and many different problems that most of the institutes are facing in smooth running of ICT/MIS activities at the institute level. Particularly, these include lack of trained manpower, paucity of computer hardware and software, absence of LAN setup, Internet connectivity and email facility and above all non-existence of ICT-MIS unit. The focal points in their deliberation strongly expressed their arguments in favour of setting-up of permanent ICT-MIS units at their respective institutes and emphasized on the importance and usefulness of such unit for making the ICT/MIS activities functional and to provide required information towards improved agricultural research planning and management. After threadbare discussion useful recommendations were made by the workshop participants.

Some specific recommendations such as (a) establishment of a data centre at BARC (b) set up of LAN/WAN facilities within NARS institutes (c) development of necessary databases and websites towards strengthening of ICT/MIS facilities for better organizational management, efficient planning and development, and improved decision making in the field of agricultural research and management and to (d) render electronic services to various stakeholders came up at the end. These are elaborate as under:

***Recommendations:***

i. As a part of the strengthening of ICT/MIS activities in the NARS the following recommendations were made:
ii. LAN should be established at each of the NARS institutes where it does not exists and at the same time WAN facility needs to be created for linking BARC with the NARS institutes
iii. A central data depository or data centre should be established at BARC for maintaining various type of databases and information systems of NARS which are vital for improved agricultural research planning and management and overall agricultural development of the country.
iv. Information systems like fertilizer recommendation guide, land resources datasets should be made online.

v. Internet connectivity and email facilities should be established, and website in all the NARS institutes needs to be enhanced and necessary measures should be taken for regular updating of the website.

vi. There should be a permanent ICT-MIS Unit at each institute for smooth running of ICT/MIS activities in a useful and sustainable manner. In this respect, all NARS institutes should act on this issue with highest priority. This is vital as the present Government has given top most priority on the subject.

vii. The Executive Council of BARC may recommend and the Governing Body of BARC may please take up the issue with the Government.

viii. Allocation of budget for ICT/MIS activities should be ensured.

ix. The personnel involved in ICT/MIS activities should be properly trained for managing ICT and MIS in an efficient and meaningful way.

x. BARC should take lead for the establishment of MIS for helping decision makers, planners and development practitioners for improved management of agricultural research and development and to cater the information needs of other stakeholders.

xi. The library at each NARS institute should be automated and electronic journal system should be introduced.

# 8. Research Priority Setting

Bangladesh Agricultural Research Council is the Apex body of the NARS. The Council is entrusted with the task of preparing the vision document and the national agricultural research plan. These are the guide for planning and conducting research activities according to the national priorities. Based on these the research institutes draw their master plan. Priority setting is one of its mandated jobs and is being done at certain interval. For first time, efforts were made to incorporate grass-root views in priority setting. The priority of research agenda is dynamic as it changes with contextual and temporal changes. It changes with the needs and availability of resources. For funding of research, BARC needs priority research issues based on problem analysis. Also the government and donor agencies need research priority to fund/assist in agricultural research. Public and private sector follows priority research themes identified by BARC. Currently, the research components of the National Agricultural Technology Project – BARC and Krishi Gobeshona Foundation are using it for funding Sponsored Public Goods Research (SPGR) and Competitive Grants Programme respectively.

## Outcome of the Regional Stakeholders' Consultation Workshops

Based on the methodology stated in Section 2 of this report, only the portions related to ICT and disaster management have been compiled from the outcomes or identified problems emerged in the workshops and are presented in Table 10.

**Table 10. Outcomes of Four Regional and National Workshops**

| **Problems/Issues** | **Research Title/ Key Words** | **Magnitude %** | **Extent of severity/ % of beneficiary** | **Priority Rank** |
|---|---|---|---|---|
| ***ICT in Land Management*** | | | | |
| GIS Map | GIS Mapping of suitable areas for wheat | 75 | 80 | High |
| Wheat | Mapping of thermal zones for wheat | | 80 | High |
| Land/soil | GIS Map updating nutrients & organic matter status of soils | 75 | 50 | Medium |
| Land/soil | Land/soil mineralogical studies (database) | 60 | 20 | Medium |
| Forestry | Assessment of climate change impact on forests using remote sensing and GIS | 80 | 80 | High |
| ***ICT in Agriculture:Livestock*** | | | | |
| Database Large Ruminants (Cattle and Buffalo) | Database Mapping of characterized and documented cattle genetic resources | 80 | 80 | High |
| GIS Map | Upazila-wise Mapping of nutrient status in feeds and livestock species | 60 | 60 | Medium |
| Livestock: Database | Develop data base on the | 90 | 90 | High |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Extent of severity/ % of beneficiary | Priority Rank |
|---|---|---|---|---|
| | chemical composition and nutritive value of feeds and fodder species at different seasons of the year under different cropping and production system | | | |
| Poultry | Dairy database Map of the country | 70 | 70 | Medium |
| Poultry | Development of database on composition of poultry feeds | 80 | 80 | High |
| ***Environmental Hazards and Climate Change: Salinity*** | | | | |
| Irrigation & Water Management Water management strategies for reduction of soil salinity and waterlogging | Water management for coastal saline soil; methods of reducing water logging in cultivable land. | 100 | 95 (of coastal people) | High |
| Pulses and Oilseeds Rapeseed is susceptible to salinity | Develop OP HYVs/ hybrids/even GM rapeseed for coastal belt | 80 | Farmers | Medium |
| Brassica, Sesame and Sunflower, Lentil, Mung gram, have not been extensively tested for cultivation under high salinity | Find out the varieties and genetic materials of Brassica, Sesame, Lentil, Mung, Gram, for increased production at coastal belt as Rabi crops | 80 | Farmers | High |
| | Production Increase in Crops and Vegetables<br>Salinity Rise in the Coastal Belt and Changes in the Cropping Practices and Household Income | 80 | 80 | High |
| Sugarcane:<br>Genetic resources | Evaluation against different stress to identify resistant genes | 100 | 65 | High |
| Sugarcane: Crop Improvement | Marker Assisted Selection (MAS) for development high yielding, high sugar, diseases and pest resistant varieties with tolerance to water-logging, drought and salinity stresses | 100 | 20 | High |
| Rice: Biotechnology and Plant Pathology | Introgression of salt tolerance and gene pyramiding for BB and BL in popular rice varieties (BBRI) | 100% Plant Breeder | 80 | High |
| Rice: | Mitigation of soil salinity developed in coastal area | 100 | 80 | High |
| Rice: | Amendment with divalent cations and other appropriate nutrient to mitigate salinity problems in crop production | 15 | 50 | Medium |
| Rice: | Study on salt balance and the natural factors affecting the salt regime to understand the process | 15 | 50 | Medium |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Extent of severity/ % of beneficiary | Priority Rank |
|---|---|---|---|---|
| | of salinization for developing preventive/ declamation measure | | | |
| Jute: Biotic and abiotic stress due to climate change | Development of transgenic jute, kenaf and mesta varieties for biotic stress | 60% jute growers | 40 | Medium |
| | Development of transgenic jute, kenaf and mesta varieties for abiotic stress | 50% jute growers | 30 | Low |
| | Molecular marker identification of jute, kenaf and mesta for marker assisted selection (MAS) | 100% plant breeders | 80 | High |
| | Varietal development through marker assisted selection(MAS) | 50% growers<br>100% for biotech | 40 | Low |
| Jute: Biotechnological research | Development of transgenic jute, kenaf and mesta varieties for biotic stress | 60% jute growers | 40 | Medium |
| | Development of transgenic jute, kenaf and mesta varieties for abiotic stress | 50% jute growers | 30 | Low |
| Jute: Saline water management for retting of jute and allied fibre plants | Screening of different varieties of jute and allied fibre crops in different levels of water salinity | 20% of jute grower | 70 | High |
| Saline intolerability | Development of salinity resistant or saline tolerant varieties of jute, kenaf and mesta | 10%<br>Farmers | 50 | Low |
| Highly susceptible to waterlogging condition (specially in tossa jute) | Development of abiotic/ physiological stress tolerant varieties of jute, kenaf and mesta. | 10%<br>Farmers | 50 | Low |
| Less availability of stress tolerant genotypes. | Screening for abiotic stress tolerant genotypes | Breeder-100% | 50 | High |
| Drought | | | | |
| Livestock | Development of salt, drought and flood tolerant forage crops | 90 | 90 | High |
| | Livestock Development of submergence tolerant fodder varieties | 80 | 80 | High |
| | Poultry<br>Development of tools and methods for combating stresses | 80 | 80 | High |
| Rice: Drought Management | Water Management to deal with drought, salinity and water saving. Drt. Area 1.39 mha (BRRI) | 100% of adopters | 80 | High |
| Cropping in Barind and South-West districts of Bangladesh is deficient | Study the water-use-efficiency of all varieties/PGR of pulses and oilseeds to further select the | Breeders and Farmers | 75 | Medium |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Extent of severity/ % of beneficiary | Priority Rank |
|---|---|---|---|---|
| in soil moisture during dry season | more efficient one with high yields under water stress environment | | | |
| Wheat Drought & saline tolerant varieties | Develop varieties for drought, water logging and saline areas. | 45 | 60 | High |
| Pulses and Oilseeds Breeding lines and wild relatives of variable genetic resources have not been identified & therefore, delays their use in breeding | Identify the saline and drought tolerant genes for use those in the breeding population using QTL and MAS for fast breeding | Pulses and Oilseeds Breeders | 80 | High |
| Pulses and Oilseeds Breeding lines and wild relatives of variable genetic resources have not been identified & therefore, delays their use in breeding | Identify some very promising materials having high root mass and late leaf senescence under water stress to be sued in drought & saline prone areas. | Pulses and Oilseeds Breeders | 80 | High |
| Maize | | | | |
| Maize Genetic resources and variety improvement | Collection of more inbred and hybrids, Characterization and documentation, Evaluation against different stresses to identify resistant genes, Utilizing new sources of gene in developing new inbred lines and hybrid varieties | 60 | 75 | High |
| Maize | Develop varieties for drought, water logging tolerant and for saline areas especially for kharif | 65 | 75 | High |
| Maize Crop Improvement | Development of stress (drought, water logged, flood and salinity ) tolerant varieties with high yield and high sugar potential | 40 | 50 | High |
| Crop Physiology & Sugar Chemistry Crop and Gur Production | Searching for flood, waterlog and drought tolerant varieties with higher yield potential using appropriate methods. | 40 | 60 | High |
| Horticultural Crops and Tubers | | | | |
| Horticultural Crops Poor yield and quality of vegetables due to water stress | Study on water requirement, irrigation technique and use of mulch in vegetable production | 50 | 80 | High |
| Poor yield and quality of fruits due to water stress | Study on water requirement, irrigation technique and use of mulch in fruit production | 90 | 90 | High |
| Roots and Tubers Spices Fruits Poor yield and quality due to water stress | Study on water requirement, irrigation and use of mulch in root and tuber crop production | 90 | 90 | High |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Extent of severity/ % of beneficiary | Priority Rank |
|---|---|---|---|---|
| Irrigation & Water Management Development and dissemination of water saving system/technologies | Study on crop-water demand; AWD technology; development of surface and sub-surface irrigation system; movable irrigation technology; improving irrigation efficiency | 90 | 90 | High |
| Irrigation & Water Management Ground and surface water pollution and its effects on food chain through irrigation | Assessment of arsenic pollution in ground water, technology for reduction of arsenic pollution in irrigation water; technology for reduction of iron content in irrigation water | 100 | 95 | Medium |
| Irrigation & Water Management Alternative energy use for STW & DTW | Use of CNG and solar energy | 60 | 60 | Medium |
| Irrigation & Water Management Use of rainwater & wastewater for irrigation | Reuse of domestic and industrial waste water; rain water for irrigation | 60 | 50 | Medium |
| Irrigation & Water Management Soil conservation and watershed management for sustainable development in hilly areas | Development of watershed, waterfalls (springs), rainwater storage facilities | 100 | 95 (Hill people) | High |
| Wheat. collection, conservation, documentation & evaluation of germplasm | Collection, characterization, documentation of more germplasm. Evaluation against biotic and abiotic stresses to identify resistant genes for utilizing in variety development | 60 | 75 | High |
| Late planting, heat tolerant varieties | Early maturing heat tolerant variety with high yield potential | 65 | 80 | High |
| | RCTs to manage heat, drought, salinity through straw retention and maintaining residual soil moisture. | 70 | 80 | High |
| Rice: Coastal Agriculture and crop Adaptation to climate change | Development of salt Tolerant var for Boro and Aus seasons (BRRI-BINA) | Area, Boro 0.Low56 mha and Aus 0.Low9Low9 mha (80%) | 80 | High |
| Rice: Coastal Agriculture and crop Adaptation to climate change | Development of submergence tolerant var in T.Aman season for tidal wetland and inland area (BRRI-BINA) | Area, tidal wet land and inland | 80 | High |
| Land/Soil: | CH4 & N2O emission from rice field | 80 | 50 | Medium |
| Land/Soil: | Leaching & gaseous N loss | 50 | | Medium |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Extent of severity/ % of beneficiary | Priority Rank |
|---|---|---|---|---|
| Jute: Appearance of new disease (s) | Monitoring of occurrence new disease pathotypes due to climate change. | 100% Pathologist & Farmers | 50 | High |
| Jute: Lack of sufficient data on yield loss due to different insects and mite attack. | Yield loss assessment of different varieties against different insect and mite. | 100 % Researchers | 80 | High |
| Jute: Forecasting system of jute insect and mite pest is not available. | Monitoring and forecasting of insect and mite pest of jute, kenaf and mesta due to climate change | 100% Farmers | 80 | High |
| Fisheries:<br>Over fishing marine fisheries<br>- unregulated access<br>- pollution | - hatchery development and breeding of commercially important species<br>- pilot/feasibility study | 80 | 80 | High |
| Global Climate Change | Mariculture (commercial species, sea weeds, mollusks, pearl, etc.)<br>- stock assessment, fishing protocol development<br>- development of value added products | 80 | 60 | Medium-Low |
| Fisheries<br>Climate change, global warming | - impact assessment, adaptation modeling study on aquaculture (mariculture) in extreme conditions | 100 | 100 | High |
| Forestry<br>Adverse effect of Climate change | Development of appropriate social forestry techniques for forest land | 80 | 80 | High |
| | Mitigation of impact of climate change on food security of forest dependent people | 80 | 80 | High |
| | Investigating possible impacts of climate change and sea level rise on different forest types with particular emphasis on the mangrove forests | 80 | 80 | High |
| Carbon Sequestration | Assessment of carbon stock in different forest land | 50 | 50 | Medium |
| Adverse effect of climate change productivity<br>of Livestock | Assessment of climate change effects on livestock production in different agro-ecological zones of the country and development of their mitigation technique | 100 | 10 | High |
| Climate Change | Assessment of climate change effects on health and disease problems of farm animals | 100 | 10 | High |
| Climate Change | Irrigation & Water Management Water management strategies for | 100 | 100 | High |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Extent of severity/ % of beneficiary | Priority Rank |
|---|---|---|---|---|
| | irrigated crops due to climate change | | | |
| Unavailability of updated bio-physical database | Updating of AEZ Database with land and climatic parameters | 80 | 80 | High |
| Lack of updated bio-physical database | Assessing Crop suitability for major crops of Bangladesh | 60 | 50 | Medium |
| Lack of crop suitability maps | Crop zoning for land use planning | 80 | 80 | High |
| Lack of web-enabled databases | Development of Web-based fertilizer recommendation | 60 | 70 | High |
| Unavailability of inventory of NARS scientists/researchers | Strengthening/updating of MIS of NARS institutes | 60 | 60 | High |
| Unavailability Laboratory inventory of NARS institutes | Development of Laboratory inventory of NARS institutes | 60 | 60 | High |
| Lack of appropriate climate change scenarios | Develop HR for generating climate change scenarios for simulation studies | 80 | 75 | High |
| Lack of appropriate modelling capability | Develop HR for assessing impact of climate change on crop, livestock and fisheries | 80 | 90 | High |
| M&E | Develop ICT based mechanism for monitoring and evaluation | 100 | 80 | Medium |
| Database of project | Development of database on completed and on-going projects | 100 | 100 | High |
| Expert Systems and Decision Support Systems | Develop Expert Systems and Decision Support Systems for hazard prediction and damage estimation | 60 | 80 | High |

# 9. Priorities in ICT for Agricultural Research and Disaster Management

Based on the information provided by and gathered from different agencies on researchable problems at various levels were analyzed for setting the priorities in the field of ICT for agricultural research and disaster management. The following sources were considered:

i. Research Priorities of different ARIs
ii. Outcomes of discussions with researchers from BARC, ARIs and Universities
iii. Response from all extension agencies (DAE, DOF, DLS) who were requested to provide information on field problems
iv. Researchable problems extracted from Upazila Micro Extension Plan
v. Researchable issues on sub-sectoral commodities received from Hortex
vi. Outcomes of four regional workshops which provided valuable inputs on regional issues and
vii. Outcome of the National workshop on priority

Synthesis and finalization of the Research priorities in the field of ICT in agriculture and disaster management was done based on the following in the National Workshop held during 01-02 June 2010. The final outcome is presented in Table 11.

**Table 11. Research priorities in the field of ICT for agriculture and disaster management**

| **Problems/Issues** | **Research Title/ Key Words** | **Magnitude %** | **Priority Rank** |
|---|---|---|---|
| | | | |
| Unavailability of updated bio-physical database | Updating of AEZ database with land, soil, climate, hydrological parameter | 100 | High |
| Lack of updated crop suitability database | Assessing AEZ based suitability of major crops | 80 | High |
| Lack of crop zoning map | Crop zoning for land use planning | 80 | High |
| Lack of web-enabled databases | Development of web-based information systems | 60 | High |
| Unavailability of inventory of NARS scientists/researchers | Development of MIS of NARS institutes | 60 | High |
| Unavailability of equipments/Laboratory inventory of NARS institutes | Development of database of equipments/laboratory of NARS institutes | 60 | Medium |
| Lack of appropriate climate change scenarios | Develop HR for generating climate change scenarios for simulation studies | 80 | High |

| Problems/Issues | Research Title/<br>Key Words | Magnitude % | Priority Rank |
|---|---|---|---|
| | | | |
| Lack of appropriate modelling capability | Develop HR for assessing impact of climate change on crop, forestry, livestock and fisheries | 80 | High |
| Lack of research management information | Development of databases related to research management on completed and on-going projects<br>monitoring and evaluation<br>financial management | 100 | High |
| Lack of socio-economic database | Development of socio-economic database | 100 | High |
| Lack of Expert Systems and Decision Support Systems | Development of Expert Systems and Decision Support Systems for food security and disaster management | 60 | High |
| Lack of variety/agricultural technology database | Development of variety/agricultural technology database | 100 | High |
| Lack of irrigation and water management information | Development of GIS based information system on surface and groundwater resources | 80 | High |
| Lack of pest and disease information | Development of GIS based pest and disease information system | 80 | High |
| Lack of information on salinity, drought, flood, etc. | Development of GIS based information system for agro-ecologically constraint areas | 100 | High |
| Lack of early warning system and medium range weather advisory service | Development of early warning systems for<br>abiotic and biotic hazards (Flood, drought, rainfall, pests, diseases, etc. | 100 | High |
| Lack of PGR database | Development of GIS based information system on Plant Genetic Resources | 60 | High |
| Lack of crop area, production forecasting system | Development of Remote sensing & GIS based applications | 80 | High |
| Unavailability of information on forest coverage | Assessment of climate change impact on forests using remote sensing and GIS | 80 | High |
| Lack of fisheries information systems | Development of Remote sensing & GIS based applications for fisheries resources | 60 | Medium |
| Lack of livestock information systems | Development of spatial and non-spatial database/ applications for livestock resources | 60 | Medium |
| Lack of farmer information system | Development of farmer information system | 50 | Medium |

| Problems/Issues | Research Title/ Key Words | Magnitude % | Priority Rank |
|---|---|---|---|
| | | | |
| Lack of ICT personnel and ICT unit at NARS | Mainstreaming ICT at NARS Institutes | 100 | High |
| Lack of soil mineralogical information | Generation of mineralogical information on benchmark soils (database) | 40 | Medium |
| Lack of marketing information | Development of web-based agro-market intelligence systems | 80 | High |
| Lack of virtual knowledge centre | Development of virtual knowledge centre | 70 | Medium |

## 10. Conclusions

Research themes in ICT in Agriculture and Disaster Management are quite varied from those in case of commodity based sub-sectors. Since ICT is a tool for information generation and dissemination, its outputs is basically service-oriented in nature. However, computer based modeling research could be undertaken to solve problems. In one hand, in case of climate change related research simulation models could be used to predict the impacts on agriculture. On the other hand, ICT could become useful in developing early warning systems.

The studies may cover both short and long-term objectives including future projections or forecasts/predictions through development of Expert Systems (ES) and Decision Support Systems (DSS) for food security and disaster management. ICT should be used as a carrier of dissemination of technologies generated by the ARIs. The technology should be used as a tool for monitoring and evaluation. It could also be used to manage institutional human resources, resource inventories, database development (both spatial and textual).

Twenty-six researchable issues under six thematic areas have been identified. The thematic areas are as follows:

i. Development of MIS and Research Management Systems
ii. Development of Databases
iii. GIS and Remote Sensing
iv. Disaster Management
v. Human Resource Development

In order to address all the above mentioned problems and issues activities in ICT must be institutionalized in the NARS and other affiliated organizations. Enabling conditions must be created at the Institution and at National levels. This should be both in the context of infrastructure and trained and devoted human resources.

# 11. References


Abedin S.M.Z. (2009). Bangladesh Agriculture Sector adopts ICT for development http://www.e-agriculture.org/19.html?tx_ttnews[tt_news]=1858. Accessed on Friday, January 15, 2010

Ahmed, A.U. and M. Alam (1999). Development of Climate Change Scenarios with General Circulation Models. . In Vulnerability and Adaptation to Climate Change for Bangladesh. S. Huq, Z. Karim. M. Asaduzzaman and F. Mahtab (Eds.) pp 13-20. Kluwer Academic Publishers, The Netherlands

Ahmed, R. and Bernerd, A. (1989). Rice Price Fluctuation and an Approach to Price Stabilization in Bangladesh, Int. Food Policy Res. Inst IFPRI, 1989, pp 39-40

Ahmed, A.U., S. Huq, Z. Karim, M. Asaduzzaman, A.A. Rahman, M. Alam, M.Y. Ali, and R.A. Chouwdhury. (1996). Vulnerability and Adaptation Assessment for Bangladesh. In Vulnerability and Adaptation to Climate Change. J.B. Smith, S. Huq, S. Lenhart, L.J. Mata, I. Nemesova and S. Toure (Eds.). Kluwer Academic Publishers, The Netherlands

Ahmed, F. (2007) Climate Change: Bangladesh Takes Its Trauma to Bali. URL: http://ipsnews.net/

Ahsan, M. and Sattar, S.A. (2010). Coastal areas and Saline Soils of Bangladesh: Their Extent, Salinity Status, Management Practices and Future Research Needs. Presented at the National workshop on "Sustainable Land Management through Effective Fertilizer Use in Relation to Climate Change and Land Degradation" held during January 31-February 02, 2010, BARC, Dhaka

Agarwal, A. (2001). The Kyoto Compromise.Clime Asia. COP 7 Special Issue. Climate Action Network-South Asia (CANSA) Newsletter. BCAS, Dhaka.p 4-5

Amin, M.R. Saleheen, S., Kibria, R., and Karmakar, C.K. (2007). An Effective Approach for Implementing E-Agriculture in Bangladesh. Department of CSE, Shah Jalal University of Science & Technology. URL:http://i4donline.net/ATF/2007/fullpapers/MDRUHUL_ATF07ABS130.pdf. Accessed on January 20, 2010

Anonymous. (2003). Bangladesh. A National Strategy for Economic Growth, Poverty Reduction and Social Development. ERD, Ministry of Finance, Government of the Peoples Republic of Bangladesh

Ashrit, R.G., Douville, H. and Rupa Kumar, K. (2003). Response of the Indian monsoon and ENSO-monsoon teleconnection to enhanced greenhouse effect in the CNRM coupled model. J. Meteorol. Soc. Japan, 81, 779–803

Bazzaz, F.A. and Sombroek, W.G. (1996). Global climatic change and agricultural production: An assessment of current knowledge and critical gaps. Global climate change and agricultural production. Direct and indirect effects. Bazzaz, F.A. and Sombroek W.G. (Eds). Published by the Food and Agriculture Organization of the United Nations and John Wiley & Sons

BBS (Bangladesh Bureau of Statistics), (2008). Population Census, 2001. Bangladesh Bureau of Statistics. Planning Division, Ministry of Planning. Government of the Peoples Republic of Bangladesh

Brammer, H. (1987). Drought in Bangladesh: Lessons for Planners and Administrators, disaster, 11 (1)

Brammer, H. (1999). Agricultural Disaster Management in Bangladesh, University Press

BRRI (Bangladesh Rice Research Institute). (2009). Bangladesh Rice Knowledge Bank. URL:http://www.knowledgebank-brri.org/about_brkb.php. Accessed on 10 February 2010

BRTC-BUET, (2008). Preparation of Lookup table and generation of PRECIS Scenarios for Bangladesh: Validation and Parameterization. Workshop on Climate Impact Prediction Modelling and Economic Modelling, held in Dhaka on July 2008, organized by Climate change Cell, Department of Environment

BTRC (Bangladesh Telecommunication Regulatory Commission), (2010). http://www.btrc.gov.bd/newsandevents/mobile_phone_subscribers/mobile_phone_subscribers_january_2010.php

CEGIS (Centre for Environmental & Geographical Information Services) [2008]. URL:www.cegisbd.com/gis_div.htm

CEGIS (2009a). URL:http://www.cegisbd.com/software.htm

CEGIS (2009b). URL: http://www.cegisbd.com/aboutus.htm

CEGIS (2010). The Story Of CEGIS. URL: http://www.cegisbd.com/aboutus.htm#Story

Chanawongse, K. (2007). ICT for Disaster Management. United Nations Development Programme – Asia-Pacific Development Information Programme (UNDP-APDIP) and Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) – 2007

Chanuka, W. (2007). ICT for Disaster Management. United Nations Development Programme – Asia-Pacific Development Information Programme (UNDP-APDIP) and Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) – 2007

Cruz, R.V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., Honda, Y., Jafari, M., Li, C., Huu Ninh, N. (2007). Asia. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry ML, Canziani O.F, Palutikof J.P, van der Linden PJ, Hanson C.E., eds., Cambridge University Press, Cambridge, UK, 469-506

De Datta, S.K., Chang, T.T. and Yoshida, S. (1975). Drought tolerance in upland rice. In: Major Research in Upland Rice. IRRI, Los Banos, pp. 101-116

DoE and IUCN. (2005). National Action Program for Combating Desertification in Bangladesh. Dept. of Environment and International Union for Conservation of Nature and Natural Resources. Dhaka, Bangladesh

Doorenbos, J. and Pruitt, W.O. (1977). Crop Water Requirements. Irrigation and Drainage Paper No. 24, (rev.) FAO, Rome, Italy

Douville, H., et al. (2000). Impact of $CO_2$ doubling on the Asian summer monsoon: Robust versus model-dependent responses. J. Meteorol. Soc. Japan, 78, 421–439

Ericksen, N.J., Ahmad, Q.K. and Chowdhury, A. R. (1993). Socio-Economic Implications of Climate Change for Bangladesh, Dhaka: Bangladesh Unnayan Parishad (Briefing Document No. 4

FAO (Food And Agriculture Organization Of The United Nations). (2008). FAOSTAT. FAO Statistics Division. URL: http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567

Fajer, E.D. and Bazzaz, F.A. (1992). Is carbon dioxide a 'good' greenhouse gas? Effects of increasing carbon dioxide on ecological systems. Global Environmental Change: Human and Policy Dimensions 2: 301-310

FIPA (International Federation of Agricultural Producers) and WMO (World Meteorological Organization) [2009]. Climate Change: Impacts on Global Agriculture - Joint IFAP-WMO Issue Brief. URL:http://www.ifap.org/fileadmin/user_upload/ifap/items/climatechange_WMO_IFAP.pdf

Habibullah, M., Ahmed, A.U. and Karim,. Z. (1999). Assessment of foodgrain production loss due to climate induced enhanced soil salinity. In Vulnerability and Adaptation to Climate Change for Bangladesh. Huq, S., Karim, Z., Asaduzzaman, M. and Mahtab, F. (Eds.) pp 39-54 Kluwer Academic Publishers, The Netherlands

Hammer, G.L., Hansen, J.W. Phillips, J.G., Mjelde, J.W., Hill, H., Love, A. and Potgieter, A. (2001). Advances in application of climate prediction in agriculture. Agricultural Systems 70 (2001) 515–553

Hossain, M. (1990). Natural Calamities, Instability in Production and Food Policy in Bangladesh. The Bangladesh Development Studies. 18(1):33-54

Hossain, M., Islam, A.T.M.A. and Saha, S.K. (1987). Floods in Bangladesh. Recurrent Disaster and People's Survival. University Research Centre. Dhaka, Bangladesh. Pp 64-66

Hossain, M. M. (2010). Implementation of Online Fertilizer Recommendation System. Presented at the Review workshop 2009-2010 of Soil Resource Development Institute. Dhaka

Hudson, D.P. and White, J.W. (2003). GIS Tools: They're not just for Experts Anymore. Watson. D.J. (ed) International Conference an Impacts of Agricultural Research and Development: Why has Impact Assessment Research not Made More of a Difference? Proceeding of a conference organized by the Standing Panel on Impact Assessment (SPIA) of the Interim Science Council, Consultative Croup on International Agricultural Research (CGIAR), and the Economics Program, the International Maize and Wheat Improvement Center (CIMMYT). 4-7 February 2002, San Jose, Costa Rica. Mexico D.F.: CIMMYT

IPCC (Intergovernmental Panel on Climate Change). (2001). Climate Change 2001: Impacts, Adaptations, and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White K.S. (eds.)]. Cambridge University Press, Cambridge, UK

IPCC. (2007a). Summary for Policymakers. In: Climate Change (2007) The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.)

IPCC. (2007b). Climate Change 2007: The physical science basis. Summary for Policymakers. Intergovernmental Panel on Climate Change

Islam, M.T., Salam, M.A. and Kauser, M. (1994). Effect of Soil Water Stress at different growth stages of rice of yield components and yield. Progress. Argic, 5(20): 151-156

Johannsen, C. J. (1996). Advances in Remote Sensing for Agriculture. Presented on December 5, 1996 at Precision Decisions '96 Conference, Indianapolis, IN

Krishna Kumar, K.. et al., 2003: Future scenarios of extreme rainfall and temperature over India. Proceedings of the Workshop on Scenarios and Future Emissions, Indian Institute of Management (IIM), Ahmedabad, July 22, 2003. NATCOM Project Management Cell, Ministry of Environment and Forests, Government of India, New Delhi, pp. 56–68

Lal, M. and Harasawa, H. (2001). Future climate change scenarios for Asia as inferred from selected coupled atmosphere-ocean global climate models. J. Meteorol. Soc. Japan, 79, 219-227

Lal, M., et al., (2001). Future climate change: Implications for Indian summer monsoon and its variability. Cwr. Sci., 81, 1196-1207

May, W. (2004). Potential of future changes in the Indian summer monsoon due to greenhouse warming: analysis of mechanisms in a global time-slice experiment. Clim. Dyn., 22, 389–414

MoA (Ministry of Agriculture) (1999). National Agriculture Policy. Government of the People's Republic of Bangladesh p20

MoA (2006). Action plan for implementing the Actionable policy brief in Bangladesh Agriculture sector review (crop sub-sector). Government of the People's Republic of Bangladesh. Volume ii, p109

MoA (2009). Draft Agriculture Policy 2009. Government of the People's Republic of Bangladesh

MoEF (Ministry of Environment and Forest). [2009]. Bangladesh Climate Change Strategy and Action Plan-2009. Government of the People's Republic of Bangladesh.

MoFDM (Ministry of Food and Disaster Management). [2006]. National Food Policy 2006. Translated Version. Government of the People's Republic of Bangladesh

MoFL (Ministry of Fisheries and Livestock). [2007]. National Livestock Development Policy, Government of the People's Republic of Bangladesh

MoSICT (Ministry of Science and Information & Communication Technology). (2002). National Information and Communication Technology (ICT) Policy (October: 2002), Government of the People's Republic of Bangladesh. URL: http://www.most-bd.org/

MoSICT (2008). Bangladesh National ICT Policy – 2008. URL: http://www.mosict.gov.bd/index.php?option=com_docman&task=doc_download&gid=310&Itemid=390

MoWR (Ministry of Water Resources) (1999). National Water Policy. Government of the People's Republic of Bangladesh

MoWR (2005). Coastal Zone Policy 2005. Government of the People's Republic of Bangladesh

Nelson, G.C. (2003). What GIS Can (and Can't) Bring To Impact Assessment: Novel Data, Analysis, and Insights. Watson. D.J. (ed) International Conference an Impacts of Agricultural Research and Development: Why has Impact Assessment Research not Made More of a Difference? Proceeding of a conference organized by the Standing Panel on Impact Assessment (SPIA) of the Interim Science Council, Consultative Croup on International Agricultural Research (CGIAR), and the Economics Program, the International Maize and Wheat Improvement Center (CIMMYT). 4-7 February 2002, San Jose, Costa Rica. Mexico D.F.: C1MMYT.

O'Farrell, C. (2003). Global Trends and Major Issues of ICT Application in Agriculture Paper presented at APO seminar on Information and Communication Technology (ICT) for improved Agricultural Productivity and Competitiveness, held in Yogyakarta, Indonesia, during 8-12 September 2003.

Planning Commission. (2005). BANGLADESH: Unlocking the Potential: National Strategy for Accelerated Poverty Reduction. General Economics Division, Government of People's Republic of Bangladesh

Planning Commission (2008). Millennium Development Goals: Bangladesh Progress Report 2008. Government of the People's Republic of Bangladesh

Prime Minister's Office. (2009). Digital Bangladesh: Concept Note, Access to Information Programme. 5/11/2009

Reuters (2010). Disaster-prone Bangladesh trials cell phone alerts Source: URL:http://www.alertnet.org/thenews/newsdesk/SP256907.htm

Rahman, M. M. (2010). Feasibility Study for ICT at BARC & NARS Institutes (Final Report) National Consultant for Feasibility Study for ICT. National Agricultural Technology Project (NATP): Phase-1; Project Implementation Unit (PIU), Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka

Rai, A. (2010). Remote Sensing and GIS Applications in Agriculture, Indian Agricultural Statistics Research Institute, Library Avenue, New Delhi-110 012, anilraifaiasri.res.in. www.iasri.res.in/.../e.../4-Remote%20Sensing%20and%20GIS.pdf . Accessed on January 20, 2010.

Rashid, M.S. and Ali, M. M.. (1997). Status of GIS in Bangladesh : A Review. Oriental Geographer, 41(1) : 64-77.

RRDI (Rice Research and Development Institute). (1999). Netscape-Effect of Water Deficit Dept. Agric., Batalagoda, Ibbagamuwa, Srilanka.

Rupa Kumar, K., and R.G. Ashrit, (2001). Regional aspects of global climate change simulations: Validation and assessment of climate response over Indian monsoon region to transient increase of greenhouse gases and sulfate aerosols. Mausam, Special Issue on Climate Change,52, 229–244.

Rupa Kumar, K., et al. (2002). Climate change in India: Observations and model projections, In: Climate Change and India: Issues, Concerns and Opportunities [Shukla, P.R., et al., (eds.)]. Tata McGraw-Hill Publishing Co. Ltd., New Delhi, pp. 24–75.

Rupa Kumar, K., et al. (2003). Future climate scenarios. In: Future climate scenarios. Climate Change and India: Vulnerability Assessment and Adaptation [Shukla, P.R., et al. (eds.)]. Universities Press, Hyderabad, pp. 69–127.

Rupa Kumar, K., et al. (2006). High-resolution climate change scenarios for India for the 21st century. Curr India., 90, 334–345.

Ruttan, W. (ed.). (1994). Agriculture, Environment, Climate and Health: Sustainable Development in the 21st Century. University of Minnesota Press, Minneapolis.

Sajjan, A. K., Bhuiyan, M. A. and Dey, N. C. (2002). Impact of 1994-95 Drought in the Northwest Bangladesh through Questionnaire Survey, 2nd APM in the AE Division of the Institution of Engineers Bangladesh, 19p.

Singha, E. A. (2008). BIID and Zanala Bangladesh to deliver benefits of ICT to the Farmers. An effective approach for implementing E-agriculture in Bangladesh. URL:http://i4donline.net/ATF/2007/fullpapers/MDRUHUL_ATF07ABS130.pdf

SPARRSO (Space Research and Remote Sensing Organization). [2010]. URL:http://www.sparrso.gov.bd/

Swaminathan, M. S. (2008). Speech in the Inaugural Session. International Conference on Science – based Agricultural Transformation towards Alleviation of Hunger and Poverty in SAARC Countries held during 5-7 March 2008, New Delhi, India

UCS (Union of Concerned Scientists). (2007). Findings of the IPCC Fourth Assessment Report: Climate Change Science. Summary, drafted by Ekwurze, B. URL:http://www.ucsusa.org/global_warming /science/ipcc-highlights1.html

UNDP (2007). SOLARIS: The possible answer to "Fertilizer" problem of Bangladesh. Weekly e-Governance & Development Insights. Issue 2, Volume 1, 21 September 2007

UNDP, Bangladesh. (2008). MDGs and e-Development Cluster: Strategic Programme Framework 2008-2011. Version 1 February 2008 Page 1 of 23

UN/ISDR. (2004). Living with Risk: A Global Review of Disaster Risk Reduction Initiatives, Geneva: UN/ISDR. URL: http://www.unisdr.org

World Bank (2005). Revitalizing the Agricultural Technology System in Bangladesh. Bangladesh Development Series – paper no. 7.The World Bank Office, Dhaka

World Bank, World Development Indicators, Internet users: People with access to the Internet, URL: http://www.google.com/publicdata?ds=wb-di&met=it_net_user&idim= country: BD&dl=en&hl en&q=internet+users+in+bangladeshInternet users. Accessed on June 21, 2010.

Wood, S. and Chamberlin, J. (2003). Lost in Space: Enhancing the Role of Spatial Analysis In Strategic Impact Assessment. Watson. D.J. (ed) International Conference an Impacts of Agricultural Research and Development: Why has Impact Assessment Research not Made More of a Difference? Proceeding of a conference organized by the Standing Panel on Impact Assessment (SPIA) of the Interim Science Council, Consultative Croup on International Agricultural Research (CGIAR), and the Economics Program, the International Maize and Wheat Improvement Center (CIMMYT). 4-7 February 2002, San Jose, Costa Rica. Mexico D.F.: CIMMYT.

World Resources Institute. (2000). Coastal and Marine Ecosystems: Country Profiles. Coastal Statistics, 2000. URL:http://earthtrends.wri.org/pdf_library/country_profiles/. Accessed on January 24, 2010.

# Annex-1

## Terms of Reference (ToR) of the Group Leaders

Consultation and review of the documents related to agriculture and rural development. These are, but not limited to the followings. To accomplish the task the team may need to visit the concerned institutes.

Through collection and collation of the information as stated in Sl.-1, work out the countries situation/issues by the sub-sector/area (12 nos.) of agriculture. These are;

Sub-sectoral studies are expected to be in-depth and detailed in nature. This to cover all component's current trend in production, demand-supply and gap, opportunities, problems and constraints, required technological interventions and their analysis in the country's context. By the process determine the priority need of the concerned sector/area by the year 2030 and beyond.

Population dynamics, reduction in land resource base and degradation, issues pertaining to climate change and sea level rise (SLR), economics of commodity and non-commodity related activities, income growth rate etc. all these to be taken into account in formulating the research priority.

Undertake other related tasks as may be deemed necessary or evolved while performing this assignment

Draft report of the teams to be presented in the workshops to be organized by the Planning & Evaluation Division of BARC a at suitable date.

Draft final report incorporating the comments/opinion obtained from the workshops, different agencies/individuals to be submitted within 2 (Two) months from the date of assignment to the MD (P & E), Bangladesh Agriculture Research Council, Dhaka.

## Annex-2

## GROUP WORK OUTCOME

1. Research Area/sub-sector : .....

2. Research Agenda/Thematic Area(s): (Fill 2.1 to 2.5 or more)

Research Agenda/Thematic Area-1: ……..

| Problem/Constraints | Research Title/Key Words | % of beneficiary | Probability of success | Priority Ranking | Research Tenure | | |
|---|---|---|---|---|---|---|---|
| | | | | | Long | Med | Short |
| | | | | | | | |

2.2 Research Agenda/Thematic Area-2: ----------

| Problem/Constraints | Research Title/Key Words | % of beneficiary | Probability of success | Priority Ranking | Research Tenure | | |
|---|---|---|---|---|---|---|---|
| | | | | | Long | Med. | Short |
| | | | | | | | |

Research Agenda/Thematic Area-3: ----------

| Problem/Constraints | Research Title/Key Words | % of beneficiary | Probability of success | Priority Ranking | Research Tenure | | |
|---|---|---|---|---|---|---|---|
| | | | | | Long | Med. | Short |
| | | | | | | | |

Research Agenda/Thematic Area -4 : ----------

| Problem/Constraints | Research Title/Key Words | % of beneficiary | Probability of success | Priority Ranking | Research Tenure | | |
|---|---|---|---|---|---|---|---|
| | | | | | Long | Med. | Short |
| | | | | | | | |

2.5 Research Agenda/Thematic Area -5: ----------

| Problem/Constraints | Research Title/Key Words | % of beneficiary | Probability of success | Priority Ranking | Research Tenure | | |
|---|---|---|---|---|---|---|---|
| | | | | | Long | Med. | Short |
| | | | | | | | |

Signature:

(.....)
Name (Group Leader)

Date: