MAINSTREAMING ADAPTATION TO CLIMATE CHANGE IN LEAST DEVELOPED COUNTRIES (LDCS)

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The International Institute for Environment and Development **CLIMATE CHANGE PROGRAMME** was established in 2001. The programme's goal is to enhance understanding of the linkages between sustainable development and climate change. Priority themes for the programme include: enhancing adaptation capacity in developing countries; climate change and sustainable livelihoods linkages in developing countries; capacity strengthening in developing countries; information dissemination; equity and; enhancing opportunities for developing countries to take advantage of opportunities offered for carbon trading (including CDM).

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Foreword

The Least Developed Countries (LDCs) represent the poorest and the weakest segment of the international community. As a result, these are also amongst the most vulnerable to the adverse impacts of human induced climate change in future. It is, therefore, essential for these countries to prepare themselves for coping with or, one can say, "adapting" to such adverse impacts and to ensure that such adaptation measures and policies are built-in to their existing national and sectoral development activities.

This publication put together jointly by the International Institute for Environment and Development (IIED), the Bangladesh Centre for Advanced Studies (BCAS) and Environmental Development in the Third World (ENDA) of Senegal is thus a very timely effort from these policy research institutes working on climate change issues in LDCs. It provides examples and ways forward on how the LDCs can mainstream the adaptation to climate change in their ongoing national development priorities. The publication is based on two country case studies in Bangladesh and Mali, which have already taken steps to do so. I believe there are important lessons to absorb for all other LDCs from this exercise.

This study, which was supported by the Shell Foundation, represents an important contribution of civil society based policy research institutes with support from the private sector to help the LDCs build their capacity to adapt to the potential adverse impacts of climate change. I would, therefore, commend the organisations involved for making this valuable contribution to the state of knowledge and recommend all policy makers in the LDCs to take account of the findings as presented in this report.

Anwarul K. Chowdhury
Under-Secretary-General
and High Representative

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ACRONYMS AND ABBREVIATIONS

APF	Adaptation Policy Framework
APQLI	Augmented Physical Quality of Life Index
BAU	Business-As-Usual
BCAS	Bangladesh Centre for Advanced Studies
BIDS	Bangladesh Institute of Development Studies
BMZ	German Federal Ministry for Economic Co-operation and Development
BUP	Bangladesh Unnayan Parishad
CCCM	Canadian Climate Change Model
CDM	Clean Development Mechanism
CEARS	Centre for Environmental and Resource Studies, New Zealand
CIDA	Canadian International Development Agency
COP	Conference of Parties
CRS	Creditor Reporting System
CRU	Climate Research Unit, University of East Anglia, UK
DAC	Development Assistance Committee
DfID	Department for International Development
DPHE	Department of Public Health Engineering, Bangladesh
DSSAT	Decision Support System for Agrotechnology Transfer
ESAF	Enhanced Structural Adjustment Facility
ENSO	El Niño Southern Oscillation
EVI	Economic Vulnerability Index
EWS	Early Warning System
FAO	Food and Agriculture Organisation
GCM	Global Climate Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gfd3	Geophysical fluid Dynamics
GFDL	Geophysical Fluid Dynamics Laboratory Model
GHG	Greenhouse Gas
GISS	Goddard Institute for Space Studies Model
GNP	Gross National Product
GTZ	German Agency for Technical Cooperation
HDO	High Development Option
ICRAF	International Centre for Research on Agriculture and Forestry
IDT	International Development Targets
IFRC	International Federation of Red Cross
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
LDC	Least Developed Country
LLDCs	Land Locked Developing Countries
LULUCF	Land Use, Land Use Change and Forestry
MDG	Millennium Development Goal
MEA	Multi-Lateral Environmental Agreements
NAPA	National Adaptation Programme of Action
NGO	Non-governmental organisation
NSSD	National Strategies for Sustainable Development
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development

POA	Plan of Action
PRSP	Poverty Reduction Strategy Paper
RA	Resource Analysis
SAARC	South Asian Association for Regional Cooperation
SAF	Structural Adjustment Facility
SIDS	Small Island Developing States
SMRC	SAARC Meteorological Research Centre
SNPA	Substantial New Programme of Action
TAR	Third Assessment Report
TWAS	Third World Academy of Sciences
UK89	United Kingdom Meteorological Office for 1989
UKMO	United Kingdom Meteorological Office
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
VARG	Vulnerability and Adaptation Resource Group
WB	World Bank
WMO	World Meteorological Organisation
WPGSP	Working Party on Global and Structural Policies
WSSD	World Summit on Sustainable Development

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"The United Nations family remains committed to helping the least developed countries overcome the formidable obstacles they face. I hope that all LDCs and their development partners, as well as civil society, the private sector and all other stakeholders, will forge partnerships that will make a difference between success and stagnation"

Statement by Kofi Annan, Secretary General of the United Nations
to the LDC ministerial meeting in Cotonou, Benin, 2002

SUMMARY

The Least Developed Countries (LDCs) are a group of 49 countries. They are considered to be the world's poorest countries as they have a per capita Gross Domestic Product (GDP) under $900 and they have very low levels of capital, human and technological development. These 49 countries have a combined population of 614 million, which is equivalent to just over 10% of the world's population, but their share of the world GDP is less than 1%. Between 1990 and 1998 the real GDP of the LDCs as a group grew by 3.2% per year, which represented a minor improvement over the economic performance in the 1980s. However, if Bangladesh is excluded then the real GDP growth rate is only 2.4%. The real GDP per capita in the LDCs grew at only 0.9% per year during that decade, and if Bangladesh is excluded, this figure becomes only 0.4% per year. For the other developing countries the real GDP per capita growth rates was 3.6% per year during the 1990s (four times higher than that of the LDCs). During the 1980s the real GDP per capita growth rates of the developing countries was only double that of the LDCs. This indicates that the gap in average per capita income between the LDCs and the other developing countries is growing.

In 1981, the first UN Conference on the LDCs was held in Paris by the UN General Assembly. At this conference the Substantial New Programme of Action (SNPA) for the 1980s for the LDCs was adopted. This contained guidelines for domestic action by LDCs that were to be complemented by international support measures. However, despite the many reforms preformed by the LDCs to carry out a structural transformation of their domestic economies, their economic situation did not improve during the 1980s. For this reason a second UN Conference on the LDCs was held in 1990 in Paris. This conference formulated national and international policies and measures to help accelerate LDC development processes for the 1990s. The outcome of the conference was the Paris Declaration and the Programme of Action for the LDCs for the 1990s. A mid-term review of the implementation of this programme showed that the LDCs continued to be marginalized, and so in 1997 the UN General Assembly decided to convene a 3rd UN Conference on the LDCs in 2001 in Brussels.

The LDCs have contributed the least to the emission of greenhouse gases but they are the most vulnerable countries to the effects of climate change and have the least capacity to adapt to these changes. They will suffer from a possible increase in natural disasters such as floods and droughts due to climate change. The LDCs lack the necessary institutional, economic and financial capacity to cope with climate change impacts and to rebuild the infrastructure damaged by natural disasters. When affected by a natural disaster, the LDCs are dependent on external aid, as they do not have the necessary funds available to deal with the problems themselves. The LDCs also have the least capacity to adapt to climate change, as they lack the resources and money both to carry out adaptation studies and to implement the strategies emerging from these studies. The IPCC (2001) describes the requirements that need to be met for a country to have a high adaptive capacity: a stable and prosperous economy, a high degree of access to technology at all levels, well delineated roles and responsibilities for implementation of adaptation strategies, systems in place for the national, regional and local dissemination of climate change and adaptation information, and an equitable distribution of access to resources. From the criteria used to determine LDCs, it is obvious that they do not meet these requirements, which explains their low adaptive capacity. The international community has recognised the vulnerability of LDCs to climate change and their low adaptation capacity. This is evident in the Marrakech Accords where a special LDC Fund has been created to help them adapt to climate change. The Programme of Action for the LDCs for the 2001-2010 decade has also been developed with the aim of eradicating poverty and promoting sustainable development in the LDCs.

In the Marrakech Accords a LDC Expert Group was established. This group consists of 12 experts who have the appropriate expertise and competence to assist in the development of the National Adaptation Programmes of Action (NAPAs). The objective of the LDC Expert Group

is “to advise on the preparation and implementation strategy for the NAPAs, which would meet the urgent and immediate adaptation needs of the LDCs”. The expert group can also advise the LDCs on their capacity-building needs for the preparation and implementation of the NAPAs. The guidelines for the preparation of the NAPAs were established ensuring that these will be integrated into the national sustainable development strategies.

Adaptation to climate change has become an important policy priority in the international negotiations on climate change in recent years. However, it has yet to become a major policy issue within the developing countries, especially amongst the LDCs (who will be amongst the most vulnerable to the adverse impacts of climate change). The experience cited in this report on two LDC countries, namely Bangladesh in Asia and Mali in Africa, shows that although much has been achieved in terms of describing and analysing vulnerability to climate change and identifying potential adaptation options, there remains much more to be done in terms of mainstreaming adaptation to climate change within the national policy making processes in those countries. This is a challenge that all the developing countries (particularly the LDCs) will have to face as they carry out their National Communications on climate change and especially the NAPAs.

Based on this study a number of key lessons can be identified for the LDCs to bear in mind as they prepare their respective NAPAs:

- Information on climate change impacts needs to be translated from the scientific research domain into language and time scales relevant for policy makers.
- Research on potential impacts of climate change needs to be supported in-country to enable information to be improved and passed on to policy makers.
- All relevant stakeholders need to be involved, but their needs for information may vary and thus information must be suited to the stakeholder group being engaged with.
- Sectoral level policy makers, planners and managers are relatively more likely to mainstream adaptation to climate change into their on-going and planned work (provided the information on impacts is given to them in a suitable form).
- High-level policy makers need to be especially targeted (with suitable material).
- National and international experts and researchers need to share their knowledge with people making decisions and plans on the ground more effectively.

The next few years will be an important period in the general climate change policy arena where the role of adaptation will play a crucial part (and in particular within the LDCs). A number of issues will need to be addressed at both the international as well as national levels within the LDCs.

The LDCs will need carry out their respective NAPAs over the coming few years while ensuring that:

- The relevant stakeholders from the most vulnerable sectors of the economy and regions within the country are involved.
- High-level policy makers are aware of the importance of the issue.
- The general public is made more aware about the issues.
- Special focus is given to the most vulnerable regions and populations within each country.
- All relevant institutions within the government as well as civil society need to be made aware of the problem and their respective roles in dealing with it.
- The focus needs to be on building long-term national adaptive capacity.
- Adaptation to climate change is effectively mainstreamed into national and sectoral development.

At the international level the LDCs also need to become much more effective both in their international negotiating capacity as well as sharing ideas amongst themselves on the results of their work on adaptation. These actions will include:

- Sharing results of NAPAs with other LDCs (firstly within their respective regions and then with others).
- Developing strategies for improving their own negotiating capacities.
- Ensuring their relative needs are well understood, especially for the various funding mechanisms for adaptation.
- Playing a more active role in the GEF (on funding issues).
- Improving dialogues with major bilateral funders to facilitate the inclusion of adaptation to climate change in development funding.

1. THE LEAST DEVELOPED COUNTRIES (LDCS)

1.1 General Background

The Least Developed Countries are a group of 49 countries (see figure 1 and table 1). They are considered to be the world's poorest countries as they have a per capita GDP under $900 and they have very low levels of capital, human and technological development (UNCTAD, 2001a). These 49 countries have a combined population of 614 million, which is equivalent to just over 10% of the world population, but their share of the world GDP is less than 1% (UNCTAD, 2001a). The economies of these 49 countries are very vulnerable to external shocks and natural disasters. Box 1.1 describes the three criteria used to determine which countries are LDCs.

Box 1.1. Criteria to determine the Least Developed Countries (UNCTAD, http://www.unctad.org/ldcs/)

Three criteria, developed by the Economic and Social Council of the United Nations, are used to determine which countries belong to the LDC group. The first one is the low-income criterion, which is based on a three-year average estimate of the GDP per capita. The GDP per capita must be under $900 to be included in the LDC group and above $1,035 to graduate from that group. The second criterion is the human resource weakness criterion, which involves the Augmented Physical Quality of Life Index (APQLI) based on nutrition, health, education and adult literacy indicators. The final criterion is the economic vulnerability criterion, which involves the Economic Vulnerability Index (EVI) based on indicators of: the instability of agricultural production, the instability of exports of goods and services, the economic importance of non-traditional activities (share of manufacturing and modern services in GDP), merchandise export concentration, and the handicap of economic smallness.

Figure 1: Map of the LDCs (UN, 2001a)

1.2 The Economic Situation of the LDCs during the 1990s

Between 1990 and 1998 the real GDP of the LDCs as a group grew by 3.2% per year, which represented a minor improvement over the economic performance in the 1980s. However, if Bangladesh is excluded then the real GDP growth rate is only of 2.4%. The real GDP per capita

Table 1: List of the LDCs. Data from the UNFCCC at http://r0.unctad.org/ldcs

Name	Population (million)	GNP per capita (US$)	% share of GNP in agriculture, forestry, fisheries	% share of GNP in industry	% share of GNP in services	Gross Domestic Investment	Main Exports (% of total exports)
Afghanistan	21.4	-	-	-	-	-	Dried fruits and nuts (51.3)
Angola	12.1	380	12.3	51.5	36.3	20.2	Petroleum (70.9)
Bangladesh	124.8	350	22.2	27.9	49.9	22.2	Garments (52.3)
Benin	5.8	380	38.6	13.5	47.9	17.1	Cotton yarn (38.9)
Bhutan	0.6	470	38.2	36.5	25.4	47.3	Electricity (24.9)
Burkina Faso	11.3	240	33.3	27.2	39.5	28.6	Raw Cotton (36)
Burundi	6.5	140	54.2	16.4	29.5	9.0	Coffee (73.4)
Cambodia	10.7	260	50.6	14.8	34.6	15.0	Saw Timber (25.3)
Cape Verde	0.4	1200	12.2	19.1	68.7	40.2	Air Transport Services (34.6)
Central African Republic	3.5	300	52.6	18.6	28.8	13.5	Diamonds (42.2)
Chad	7.3	230	39.8	14.3	45.9	15.0	Cotton Lint (48.9)
Comoros	0.7	370	38.7	12.8	48.5	19.8	Travel (51.7)
Democratic Republic of the Congo	49.1	110	58.0	16.9	25.3	8.1	Diamonds (17.2)
Djibouti	0.6	-	3.7	20.6	75.9	9.5	Gov Services to Expatriates (57.2)
Equatorial Guinea	0.4	1110	21.8	66.4	11.8	84.6	Petroleum Products (43.4)
Eritea	3.6	200	9.3	29.6	61.2	41.0	Port Services (76.5)
Ethiopia	59.7	100	49.8	6.7	43.5	18.2	Coffee (36.1)
Gambia	1.2	340	27.4	13.7	58.9	18.4	Travel (58.8)
Guinea	7.3	530	22.4	35.4	42.1	21.1	Bauxite and Alumina (51.6)
Gunea-Bissau	2.2	160	62.4	12.7	24.9	11.3	Cashew Nuts (74)
Haiti	8.0	410	30.4	20.1	49.6	10.7	Clothing (29.7)
Kiribati	0.9	1170	20.7	6.1	73.2	-	License fees/royalties (58.5)
Lao People's Democratic Republic	5.2	320	52.6	22.0	25.4	24.9	Wood Products (27.3)
Lesotho	2.1	570	11.5	42.0	46.5	48.6	Clothing (42.8)
Liberia	2.7	-	-	-	-	-	Iron ore (55.1)
Madagascar	15.1	260	30.6	13.6	55.8	13.3	Coffee (11.7)
Malawi	10.4	210	35.9	17.8	46.4	13.7	Tobacco (59.9)
Maldives	0.3	1130	16.4	-	-	-	Travel (71)
Mali	10.7	250	46.9	17.5	35.6	20.9	Cotton products (48.4)
Mauritania	2.5	410	24.8	29.5	45.7	21.0	Iron ore (47.8)
Mozambique	18.9	210	34.3	20.8	44.8	20.4	Business services (42.7)
Myanmar	44.5	-	53.2	9.0	37.8	11.7	Food and live animals (34.6)
Nepal	22.9	210	40.5	22.2	37.3	21.7	Basic Manufactures (38.9)
Niger	10.1	200	41.4	17.0	41.7	10.4	Uranium (39.4)
Rwanda	6.6	230	47.4	21.2	31.4	15.7	Coffee (43.2)
Samoa	0.2	1070	-	-	-	-	Travel (47.4)
Sao Tome and Principe	0.1	270	21.3	16.7	62.0	41.3	Cocoa (37.5)
Senegal	9.0	520	17.4	24.1	58.5	19.6	Fish (19.8)
Sierra Leone	4.6	140	44.2	23.9	32.0	8.1	Travel (45.3)
Solomon Islands	0.4	760	-	-	-	-	Timber products (42.7)
Somalia	9.2	-	-	-	-	-	Livestock (44.3)
Sudan	28.3	290	39.3	18.2	42.6	-	Sesame seeds (19.7)
Togo	4.4	330	42.1	21.1	36.8	14.2	Cotton products (30.9)
Tuvalu	11.0	-	-	-	-	-	Travel (29.5)
Uganda	20.6	310	44.6	17.6	37.8	15.1	Coffee (53.7)
United Republic of Tanzania	32.1	220	45.7	14.9	39.4	15.0	Travel (34.9)
Vanuatu	0.2	1260	24.7	12.2	63.2	-	Travel (33.9)
Yemen	16.9	280	17.6	48.8	33.7	21.5	Petroleum (83.7)
Zambia	8.8	330	17.3	26.4	56.3	14.3	Copper (70.6)

in the LDCs grew at only 0.9% per year during that decade, and if Bangladesh is excluded the figure becomes only 0.4% per year. For the other developing countries the real GDP per capita growth rates was 3.6% per year during the 1990s (four times higher than that of the LDCs). During the 1980s the real GDP per capita growth rates of the developing countries was only double that of the LDCs. This indicates that the gap in average per capita income between the LDCs and the other developing countries is growing (UNCTAD Secretary-General, 2000).

However, there are differences among the LDCs. There is a group of 15 LDCs, seven of which are from Asia, where the real GDP per capita growth exceeded 2% per year during the 1990s. However, there is another group of 22 LDCs whose economies have either been stagnating or in regress during the 1990s. For 11 of these countries, the real GDP per capita has been declining by over 3% per year (UNCTAD Secretary-General, 2000). Overall there are 32 LDCs that have either fallen behind the other developing countries in terms of per capita income or have experienced a dramatic deterioration in living standards during the 1990s.

To improve their economic situation 33 out of the 49 LDCs have undertaken policy reforms under the IMF-financed Structural Adjustment Facility (SAF) or Enhanced SAF (ESAF) programmes since 1988. LDCs have managed to keep up with the other developing countries in the process of structural reform in all areas except financial sector reform and public enterprise reform. Trade liberalisation has also proceeded further in the LDCs than in the other developing countries. However, economic growth is too slow to decrease the high rates of poverty prevalent in the LDCs. The overall progress in increasing real incomes, reducing poverty and achieving the international targets for human and social development has been disappointingly slow, except for a few of the LDCs. The rates of social progress in the LDCs are generally far behind those that are required to meet the international targets established at the international conferences during the 1990s (UNCTAD Secretary-General, 2000). The poorer LDCs are failing to catch up with the developed and developing countries and nearly a quarter of the LDCs are caught in a downward spiral of economic stagnation and regress, social stress and violent conflict.

If the LDCs do not improve in the future on their 1990-1998 average growth rate of real GDP per capita, then only one out of the 49 LDCs will reach the threshold of $900 GDP per capita (one of the criteria for graduation from the LDC group) by 2015 and only a further eight will reach it by 2050. Even the LDCs with a growing economy are not safe from external shocks, natural disasters or negative spill-over effects from neighbouring LDCs, as these could disrupt their economic activity and slow down or stop their economic growth (UNCTAD Secretary-General, 2000).

The LDCs are critically dependent on external finance. The development prospects for the LDCs depend critically on aid relationships and associated external debt dynamics. External rather than domestically generated resources dominate the central accumulation and budgetary processes. It is important for LDCs to break this dependence and to start generating domestic revenues and resources. International development cooperation should focus on approaches that allow LDCs to build up productive capacities and international competitiveness and to rely increasingly on domestic resource mobilisation and private capital inflows for their development finance needs (UNCTAD Secretary-General, 2000).

1.3 International Community Response to the LDC problems

In 1981, the first UN Conference on the LDCs was held in Paris by the UN General Assembly. At this conference the Substantial New Programme of Action (SNPA) for the 1980s for the LDCs was adopted. This contained guidelines for domestic action by LDCs that were to be complemented by international support measures. However, despite the many reforms preformed by the LDCs to carry out a structural transformation of their domestic economies their economic situation did not improve during the 1980s. For this reason a second UN Conference on the LDCs was held in 1990 in Paris. This conference formulated national and international policies and measures to help accelerate LDC development processes in the 1990s. The outcome of the conference was the Paris Declaration and the Programme of Action for the LDCs for the 1990s. A mid-term review of the implementation of this programme showed that the LDCs continued to be marginalized, and so in 1997 the UN General Assembly decided to convene a 3rd UN Conference on the LDCs in 2001 in Brussels (UNCTAD, 2001b).

1.3.1 Brussels Declaration from the 3rd UN conference on the LDCs

The governments participating in the 3rd UN Conference on the LDCs declare that they “are committed to the eradication of poverty and the improvement of the quality of lives of the people in LDCs” (UN, 2001b). They want to achieve this aim through “sustainable development based on nationally owned and people-centred poverty reduction strategies”, good governance at the national and international level, gender equality, investment in health, education and social infrastructure, strengthening productive capacities and institution building (UN, 2001a). The governments believe that “increased trade is essential for the growth and development of LDCs” and that “a transparent, non-discriminatory and rules-based multi-lateral trading system is essential for LDCs to reap the potential benefits of globalisation” (UN, 2001a). The governments affirmed that “official development assistance (ODA) has a critical role to play in support of LDC development” and they took the resolution to meet the targets of 0.15% or 0.20% of GNP as ODA to LDCs (UN, 2001a). They will also “undertake to improve aid effectiveness and to implement the OECD-DAC recommendation on untying ODA to LDCs” (UN, 2001a).

1.3.2 Programme of Action for the LDCs for the 2001-2010 decade

The main issues facing the LDCs and relating to their structural handicaps were discussed in the 3rd UN conference on the LDCs and are covered by the Programme of Action for the LDCs for the 2001-2010 decade. The overarching goal of this programme is to “make substantial progress toward halving the proportion of people living in extreme poverty and suffering from hunger by 2015 and promote sustainable development of the LDCs" (UN, 2001a). In this programme the LDCs and their development partners have agreed on seven commitments. These commitments relate to the following areas: fostering a people-centred policy framework, good governance at national and international levels, building human and institutional capacities, building productive capacities to make globalisation work for LDCs, enhancing the role of trade in development, reducing vulnerability and protecting the environment, and mobilising financial resources (UN, 2001a). This programme also emphasises the importance of international cooperation, which includes both North-South cooperation and South-South cooperation.

In the sixth commitment (reducing vulnerability and protecting the environment) there is recognition by all parties that the issue of long-term threats to the global environment should be addressed on the basis of the principle of common but differentiated responsibility. LDCs are extremely vulnerable to a variety of natural shocks and disasters and to the "adverse effects of climate change which, inter alia, exacerbates drought, desertification and sea level rise" (UN, 2001a). The parties recognise that the "LDCs are at present contributing the least to the emission of greenhouse gases, while they are the most vulnerable and have the least capacity to adapt to the adverse effects of climate change". These vulnerabilities considerably impair the development prospects of the LDCs and also tend to affect the poorest communities most. In this Programme of Action there is recognition of the importance of protecting the environment to achieve sustainable development. It recognises the threat of climate change to the LDCs and their need to develop strategies to adapt to future climate change (the Marrakech Accords also recognise the need to help LDCs adapt to climate change). One of the actions that the LDCs commit to is to identify "the special vulnerabilities and possible adaptation measures that need to be fully integrated into the country's development strategies, including development cooperation programmes" (UN, 2001a). The development partners commit to, among other things, providing assistance and support to the LDCs in "their efforts to integrate the environmental component into national development policies and strategies" (UN, 2001a). In this commitment, the parties also realise the importance of early warning systems, disaster preparedness and prevention, and of the creation of "innovative financial instruments, such as special insurance schemes, to facilitate post-disaster reconstruction" (UN, 2001a). Commitment seven recognises the importance of increasing domestic resource mobilisation through the development of appropriate financial systems and mechanisms such as micro-finance and micro-credit programmes "to help mobilise savings and deliver financial services to the poor" (UN, 2001a).

1.3.3 Creation of the UN High Representative for LDCs, LLDCs and SIDS

In early 2002, the United Nations Secretary General created the post of Under-Secretary General and High Representative for the LDCs, land locked developing countries, (LLDCs) and small island developing states (SIDS). Mr. Anwarul Karim Chowdhury was appointed to the post and tasked with reporting to the UN General Assembly on an annual basis on progress with respect to the implementation of the LDC Brussels Plan of Action (POA). Since then a number of UN agencies including UNDP, UNESCO, FAO and UNCTAD have developed special action plans for assisting the LDCs.

2. CLIMATE CHANGE AND THE LDCS

2.1 Emission of Greenhouse Gases from LDCs

The LDCs have contributed least to the emission of greenhouse gases, but they are the most vulnerable countries to the effects of climate change and they have the least capacity to adapt to these changes. They will suffer from a possible increase in natural disasters such as floods and droughts due to climate change. The LDCs lack the necessary institutional, economic and financial capacity to cope with climate change impacts and to rebuild the infrastructure damaged by natural disasters (Sokona and Denton, 2001). When affected by a natural disaster, the LDCs are dependent on external aid, as they do not have the necessary funds available to deal with the problems themselves. The LDCs also have the least capacity to adapt to climate change, as they lack the resources and money to both carry out adaptation studies and implement the strategies that would come out of these studies. The Intergovernmental Panel on Climate Change (IPCC, 2001) describes the requirements that need to be met for a country to have a high adaptive capacity: a stable and prosperous economy, a high degree of access to technology at all levels, well delineated roles and responsibilities for implementation of adaptation strategies, systems in place for the national, regional and local dissemination of climate change and adaptation information, and an equitable distribution of access to resources. From the criteria used to determine LDCs it is obvious that they do not meet these requirements, which explains their low adaptive capacity. The international community has recognised the vulnerability of LDCs to climate change and their low adaptation capacity. This is evident in the Marrakech Accords where a special LDC Fund has been created to help them adapt to climate change. The Programme of Action for the LDCs for the 2001-2010 decade has also been developed with the aim of eradicating poverty and promoting sustainable development in the LDCs.

2.2 Impacts of Climate Change on the LDCs

The impacts of climate change on the LDCs are mostly drawn from the third assessment report of the IPCC which provides information on impacts and vulnerability by the main regions in which the LDCs are located, namely, sub-Saharan Africa, Asia and the small island states. Additional information on vulnerability of individual LDCs is drawn from their respective National Communications to the United Nations Framework Convention on Climate Change (UNFCCC).

2.3 Climate Change Impacts on Sub-Saharan Africa

Africa is the most vulnerable region to climate change, as a result of the low adaptive capacity of the African population. This low capacity is due to the extreme poverty of many Africans, frequent natural disasters such as droughts and floods and an agriculture heavily dependent on rainfall. The main impacts of climate change will be on the water resources, food security and agriculture, natural resource management and biodiversity, and human health (Dieudonne, 2001).

2.3.1 Water Resources

The predictions for climate change in sub-Saharan Africa seem to show a trend of decreased precipitation in current semi-arid to arid parts of Africa. One of the main impacts of climate change will be a reduction in soil moisture in the sub-humid zones and a reduction in runoff. This could be a problem for the future water resources of these sub-humid regions. However, precipitation scenarios are not the same everywhere in Africa, as simulations seem to indicate a possible increase in precipitation in east Africa but a decrease in rainfall in southern Africa for the next 100 years. These changes in precipitation will affect the levels of water storage in lakes and reservoirs, as these respond to climate variability. This could cause major problems for lakes, such as lake Chad, which has already decreased in size by about 50% in the last 40 years. For the Niger River Basin there is a predicted possible 10% change in precipitation, potential evaporation and runoff. The Zambezi River, however, has the worst scenario of decreased rainfall (about 15%), increased potential evaporative losses (about 15–25%) and diminished runoff (about 30–40%). The Gambia River is also very sensitive to climate change. Climate change alone could cause a 50% change in runoff in the Gambia River catchment. A 1% change in rainfall can cause a 3% change in runoff for the Gambia River, and this could have serious impacts, such as increased salt-water intrusion (IPCC, 2001).

Sea level rise will also seriously affect a number of African countries. A one metre sea level rise is projected to cause the loss of 92 km^2 of land in The Gambia, to inundate and erode more than 6,000 km^2 of land, most of which is wetlands, in Senegal, and to inundate about 2,117 km^2 of land in Tanzania (although a one metre sea level rise is unlikely to happen in the next 50 years) (IPCC, 1998). An elevated seal level will also exacerbate the flood impacts of the large rivers, especially the Niger, which could have serious impacts in countries such as Mali and Niger (Magadza, 2000).

By 2050, the number of countries facing water stress will rise to 18, affecting 600 million people. This future water stress and scarcity will have serious impacts on the socio-economic development of the countries and will probably adversely affect their food production levels. This growing water scarcity combined with increasing population, degradation of shared freshwater ecosystems and competing demands for shrinking natural resources distributed across many countries has the potential to create bilateral and multi-lateral conflicts (IPCC, 2001).

2.3.2 Food Security

Over the last 30 years, food production in most of the sub-Saharan African countries has not kept pace with population increases. Many of these countries rely on food aid from the developed countries. If climate change adversely affects food production, then these countries will become increasingly dependent on external aid, food insecurity will increase and their development goals will be adversely affected.

It is likely that global warming will affect the production of certain crops, such as rice, wheat, corn, beans and potatoes, which are major food crops for many people in Africa (IPCC, 2001). Other crops, such as millet, are resistant to high temperatures and low levels of water, and so may be less affected by future climate change. An experiment in Zimbabwe showed that a 2° to 4°C increase in temperature caused a reduction of maize yield at all experimental sites. Changes in farming systems may compensate for some yield reductions although additional inputs such as fertilisers and increased irrigation may be needed, involving extra costs to the farmers. Food-importing countries will be at greater risk, although the impacts may have more to do with changes in world markets than with changes in the local climate and agricultural production (IPCC, 2001).

Global warming will also affect the fishing sector. In some cases, temperature increases will increase productivity. It is projected that a warming of 3° to 5°C will increase the productivity of the Gambia River by about 13–21%. However, some fish species might be more sensitive to temperatures, and increases of 3° to 4°C could negatively affect catfish and herring populations, whereas shrimp yields are estimated to increase significantly (IPCC, 2001).

A reduction in annual precipitation will affect range-fed livestock numbers in many African regions. Pastoral livelihoods in the semi-arid zones of Africa are likely to be adversely affected by climate change, as several Global Climate Models (GCMs) predict a decrease in mean annual precipitation of about 10–20%, and this will affect pastoralists' animal herds.

2.3.3 Natural Resource Management and Biodiversity

Climate change will impact the populations that are dependent on forest species for subsistence needs and on the fraction of the economy that is based on forest products. Climate change will affect the productivity of forest species, as it will alter the spatial and temporal patterns of temperature and rainfall. Fire intensity might increase with CO_2–induced climate change, and this might have serious effects on areas such as the Serengeti grasslands in east Africa or the miombo woodlands in southern Africa. Climatic changes in certain countries may affect the vegetation and natural resources of neighbouring countries. For example, a significant decline in precipitation or increase in evapo-transpiration in Angola would threaten the Okavango delta wetland in Botswana (IPCC, 2001).

Nature reserves will become less effective as the vegetation and animal species that they seek to protect will no longer be in their preferred bio-climatic region. The migration of animals will be constrained by ecosystem fragmentation and the potential hostility of certain landscapes (IPCC, 2001).

Locust outbreaks characterise the desert/semi-arid borders in southern African and the

Sahel. These outbreaks are linked to climate, as they typically occur when a dry period is followed by good rainfall, for instance following an El Niño episode. Changes in El Niño frequency would have an effect on the timing, location and extent of locust outbreaks in ways that are presently unpredictable (IPCC, 2001).

2.3.4 Human Health

Climate change will probably have an impact on vector-borne diseases. Small changes in temperature and precipitation may support malaria epidemics in the current transmission zones. Flooding would also facilitate the breeding of the malaria vectors and so would increase transmission in the arid zones. The Sahel, for example, could be at risk of epidemics if climate change increases flooding in that area. After the El Niño event in 1997-98, malaria, Rift Valley fever and cholera outbreaks were recorded in many east African countries. It is also possible that with global warming, cholera will increase in the lake regions. Increased precipitation may increase the risk of Rift Valley Fever in livestock and people. These risks could cause major economic and health problems for herding communities in Africa. Meningitis transmission appears to be affected by warming and reduced precipitation as meningitis infections and epidemics are prevalent in areas of low humidity. Regions where climate change will reduce rainfall levels could become at risk of a meningitis epidemic. Flooding could also cause the pollution of streams, wells and other water sources in rural areas, and this could introduce parasites such as giardia, amoeba and cryptosporidium into these sources (IPCC, 2001).

2.4 Climate Change Impacts in Asia

2.4.1 Water Resources

Water availability is expected to be highly vulnerable to future climate change. Significant changes in runoff regimes (increases in the high latitudes and near the equator, and decreases in the mid-latitudes) are predicted for Asia. In general most of the climate models project an enhanced hydrological cycle and an increase in annual mean rainfall over most of Asia. Over Asia, as a whole, the models predict an annual mean increase in precipitation of about 3% by 2020 and 7% by 2050. Over central Asia, an increase in winter precipitation and a decrease in summer precipitation is expected. However, as precipitation levels over this area are already low, some countries can expect severe water stress and droughts. Surface runoff is also predicted to decline in the arid and semi-arid zones of Asia and this would have a detrimental effect on the availability of water for irrigation. The average annual runoff in certain basins could decline by as much as 27% (projection for the Indus) by 2050 (IPCC, 2001).

The perennial rivers in the High Himalayas receive water from the melting of snow and glaciers. The melting season of snow occurs at the same time as the summer monsoon season, so any intensification of the monsoon would cause flood disasters in Himalayan catchments. Countries such as Nepal and Bangladesh would be at risk of increasing flood disasters in the wet season. The intensity of extreme events may be higher in a warmer climate, which would also increase the risk of flash floods in parts of Nepal and Bangladesh (IPCC, 2001).

Coastal zones and low lying delta areas in Asia, such as those in Bangladesh, Myanmar and Cambodia, are at risk from sea level rise and more frequent and severe storms due to climate change (IPCC, 1998; 2001). Deltas and estuaries will also increasingly suffer from saltwater intrusion, siltation and land loss. Sea level rise will threaten the rich biodiversity of wetlands, as it will decelerate wetland renewal. Mangroves will be affected by the rise in sea level as it will change the salinity distribution and productivity of those areas. Severe coral bleaching can be expected as a result of warmer seawater and higher incident solar radiation. The impact of global warming on fisheries will depend on how sea-level rise and changes in ocean currents affect the food chain. Increased frequency of El Niños could lead to a decline in plankton biomass and fish larvae abundance in the coastal waters of Asia, which would have a negative impact on fisheries (IPCC, 2001).

New water management strategies and increased investments will be required to help Asia cope with future water problems. The effects of climate change on the hydrological regimes and public water supply in the arid and semi-arid regions of Asia will require priority attention to avoid any inter-sectoral and international water conflicts and to secure sustainable development. Many of the watersheds in Asia are already stressed by intensive land use and unfavourable climates, so they will become highly vulnerable to climate change if no appropriate adaptation strategies are developed (IPCC, 2001).

2.4.2 Food security and agriculture

Climate change impacts on agriculture in Asia will be crucial, as agriculture plays a major role in the provision of food and fibre to the Asian population. If climate change negatively affects crop growth, this will have serious consequences on the level of food production and food security in Asia. Climate change may cause a decrease in the supply of water and soil moisture during the dry season, which would exacerbate stress on the available water supplies and increase the need for irrigation. Rice growing areas may be affected by climate change, and resultant declines in yield would have a significant effect on agricultural trade, economic growth and development goals of certain Asian countries. The level of vulnerability of Bangladesh is likely to increase as a result of severe land degradation, soil erosion, lack of appropriate technology and sea-level rise. Changes in precipitation and temperature caused by climate change will impair the efficiency of externally applied inputs, such as fertilisers, and this will have a negative impact on food production. The results from several studies made on the impact of climate change on agriculture in Asia seem to suggest that, in general, mid and high-latitude areas will experience an increase in crop yields, whereas the lower latitude areas will experience declining yields. It appears that climatic variability and change will seriously endanger sustained agricultural production in Asia in the next decades. Both the duration of the growing period of the crop and the agricultural calendar will be affected by climate change. The gap between the supply and demand of crops, which might arise in certain Asian countries due to climate change, will increase those countries' reliance on food imports (IPCC, 2001).

Climate change may alter the survival rate of pathogens. Temperature increases may result in higher pathogen survival rates and extend cropping areas thus providing more host plants for pathogens. Thus pathogen population numbers would increase. Damage from insects and pathogens may also be more serious as the heat-stress conditions will weaken the resistance of host plants (IPCC, 2001).

2.4.3 Ecosystems and Biodiversity

Climate change is likely to have an effect on the ecosystems and biodiversity of Asia. Climate change may accelerate damage to freshwater ecosystems such as lakes, marshes and rivers. More than 50,000 ha of coastal land has been damaged by floods in the past few years, and as precipitation is likely to increase with global warming, there may be increased flooding in the future, and this will increase the threat to coastal zones. The Sundarbans of Bangladesh, which supports a diversity of wildlife, are at risk from rising sea level. With a one metre sea-level rise, many of its species, such as Bengal tigers, Indian otters, estuarine crocodiles and mud crabs, will be at risk of extinction. Climate change will have a profound effect on the future distribution, productivity and health of forests in Asia, as it will affect the boundaries of forest types and areas, species population and migration, the occurrence of pests and diseases and forest regeneration. Forest fires may increase in number. In Nepal, forest fires in unseasonably high temperatures would threaten the extinction of species such as red pandas, leopards, monkeys and other wild animals (IPCC, 2001).

The majority of semi-arid lands in Asia are rangelands, composed mainly of grasses or scrubs. With an increase an increase in temperature of about 2°–3°C and a decrease in rainfall (future projections for the arid and semi-arid areas in Asia), grassland productivity will decline by 40—90%. Some rangelands, such as in Nepal, are already subject to degradation, so climate change will represent an unwelcome additional stress. Climate change will have a negative impact on desert vegetation, especially on the plants with surface root systems, which utilise precipitation moisture, and will therefore become more vulnerable due to reduced water availability. Climate change may also cause a shift in the dryland types in Asia, with semi-arid drylands becoming not only drier but also desertified (IPCC, 2001).

2.4.4 Human Health

Climate change will have a wide range of impacts on human health in Asia. With increased temperatures, an increase in the frequency and duration of heat waves can be expected. This will increase the risk of mortality in the older age groups and in Asia's urban poor population. An increase in respiratory and cardiovascular diseases in arid, semi-arid and tropical Asia can also be expected as a result of global warming (IPCC, 2001).

Global warming will alter the occurrence of vector-borne diseases, such as malaria and dengue fever. With an increase in temperatures and changes in rainfall patterns, the distribution of vectors, such as mosquitoes may change. It is possible that these temperature and rainfall changes will expand vector-borne disease ranges into temperate and arid Asia, which would have serious human health implications (IPCC, 2001).

Water-borne diseases, such as cholera and the diarrhoeal diseases caused by organisms such as giardia, salmonella and cryptosporidium, could become more prevalent in many south Asian countries as a result of global warming (IPCC, 2001).

2.5 Climate Change Impacts on the Small Island States

2.5.1 Water Resources and Water-Level Changes

Climate change will present water management challenges for the small island states. The most significant and immediate consequences will be related to changes in sea levels, rainfall regimes, soil moisture budgets and short-term variations in the regional and local patterns of wave action. Short-term variations are likely to be strengthened by the ENSO (El Niño Southern Oscillation) phenomenon. An increase in the frequency and magnitude of tropical cyclones would be a major threat to the small island states, as it would increase the risk of flooding, accelerate rates of beach and coastal erosion and cause displacements of settlements and infrastructure. Some small island states, such as Kiribati and the Maldives, are only three to four metres above mean sea level, so they are extremely vulnerable to higher sea levels. Sea-level rise will have disproportionately large effects on the economic and social development of many of the small island states, as it will disrupt the tourism industry through beach loss, inundation, coastal ecosystem degradation, saline intrusion, and damage to critical infrastructure. Many coastal areas are likely to experience annual or more frequent flooding. It is projected that by the 2080s the number of people on the small island states facing high flood risk from sea-level rise will be 200 times higher with climate change than without (IPCC, 2001).

If climate change leads to a reduction in rainfall and a rise in sea level, this would reduce the volume of potable water and the size of the narrow freshwater lens. Increased flood risks, impeded drainage and elevated water tables would pose engineering problems and would cause salinity intrusion into the freshwater lens. Higher salinity levels could be found not only in the coastal aquifers but also in the inland freshwater pumping plants (IPCC, 2001).

2.5.2 Agriculture and Food Security

Climate change will have impacts on both the agricultural and fisheries sectors. Changes in soil moisture and temperature, evapo-transpiration, rainfall and possible increases in heat stress will affect the growth of some subsistence root crops and vegetables. The agricultural sector in islands, which are already under some type of stress, such as water scarcity, will suffer even more from climate change. Floods or droughts, which could result from climate change, will also have a negative effect on agriculture. On the low islands, where agriculture is near the coast, sea-level rise will change the height of the water table and increase salinization. This will increase the stress on most crop varieties that have a low salt tolerance (IPCC, 2001).

The impact of climate change on fisheries is complicated by the effect of anthropogenic and other non-climatic stresses such as overexploitation and habitat loss. Mangroves, coral reefs, seagrass beds and salt ponds, all breeding grounds for commercially important fish, are likely to be adversely affected by global warming. Higher temperatures and CO_2 levels will have unfavourable effects on coral reef development and will cause coral bleaching. Climate change is likely to cause significant changes in the abundance and distribution of local fish stocks (IPCC, 2001).

2.5.3 Biodiversity

Climate change will affect the biodiversity of the small island states. Increased temperatures and CO_2 levels will affect mangroves, seagrasses and coral reefs. High CO_2 levels will also affect the productivity of communities, which will have the effect of eliminating some species and introducing new species in their place. The impact of climate change on bird species will be linked to increased physiological stress in the birds and to the impacts on the forest ecosystems in which these birds live. Climate change may result in changes and loss in habitat, especially from fires and cyclones. In Samoa, flying foxes do nearly 100% of seed dispersal in the dry season. If climate change threatens or alters the flying foxes' habitats, this could result in the loss of many plant species (IPCC, 2001).

2.5.4 Human Health

Climate change will have important impacts on human health, especially via its effects on vector- and water-borne diseases. With higher temperatures and changes in the rainfall regime some vectors may be able to extend their range, which will increase transmission of the diseases carried by those vectors. Some interior upland areas of certain islands are currently virtually free of vectors that transmit malaria, dengue and other diseases. However, these areas could become favourable breeding sites in a changing climate. Increased frequency in outbreaks of dengue fever in the Pacific appears to be strongly correlated with the ENSO phenomenon. If these ENSO phenomenon increase in the future as a result of climate change then outbreaks of dengue fever will become even more frequent. Water-borne diseases such as shigella, cryptosporidium, giardia and amoebiasis may also increase as a result of disruption of sewage and water systems by flooding (IPCC, 2001).

3. ADAPTATION AND VULNERABILITY TO CLIMATE CHANGE

3.1 Definition of Adaptation

Many definitions of adaptation can be found in the literature (see box 3.1). Some of the simpler definitions describe adaptation as involving "changes in a system in response to some force or perturbation, in our case related to climate" (Smithers and Smit, 1997), or as referring "to adjustment in individual, group and institutional behaviour in order to reduce society's vulnerabilities to climate" (Pielke, 1998). The definition of adaptation taken here is that of Smit et al. (1999; 2000) and of the IPCC (2001): adaptation refers to the "adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts". The term adaptation refers to changes in "processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate" (IPCC, 2001). Adaptation involves adjustments to decrease the vulnerability of communities and regions to climate change and variability (IPCC, 2001). Adger (2001a) views adaptation as a dynamic social process and believes that the ability of a society to act collectively determines its ability to adapt.

Box 3.1. Different definitions of adaptation reviewed by Olmos (2001) and Smit *et al.* (1999; 2000).

Some definitions only refer to societal adaptation: Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides.

Other definitions distinguish between different types of adaptation: The term adaptation means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change.
Another definition given is very broad: Adaptation to climate change includes all adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system.

The definitions given here have much in common. They all refer to adjustments in a system in response to climatic stimuli. However there are differences in the scope, application and interpretation of the word adaptation. There are differences in how these definitions answer the question "adaptation to what?" and relate to the question "who or what adapts?" They also hint at the different forms or types of adaptation that can be found, and which explains the question "How does adaptation occur?" (See later section on the Frameworks for Adaptation for an explanation of these three questions).

The adaptive capacity of a system (region or community) is its potential or ability to adapt to the effects or impacts of climate change. Increasing the adaptive capacity of a system represents a way of coping with changes and uncertainties in climate. The enhancement of adaptive capacity is a way of reducing vulnerabilities and promoting sustainable development (IPCC, 2001).

3.2 Types and Forms of Adaptation

Common distinctions between adaptations are their purpose and timing. Autonomous or spontaneous adaptations occur as a reactive response to climatic stimuli, without the intervention of a public agency. Planned adaptations can be either reactive or anticipatory and are generally undertaken by governments on behalf of society. Some adaptations undertaken by individuals will be planned while others will be spontaneous or reactive to the changes related to resource use or to changing economic constraints or opportunities. Institutional and economic parameters determine the vulnerability and adaptive capacity of societies. There is therefore a clear role for public policy to create the right environment for appropriate adaptation to climate change (Adger, 2001b). Adaptations can also be short or long term and localised or widespread (IPCC, 2001). Table 2 summarises the different types and forms of adaptation.

Table 2: Bases for characterising and differentiating adaptation to climate change (Smit *et al.*, 1999).

General differentiating concept of attribute	Examples of terms used		
Purposefulness	Autonomous Spontaneous Automatic Natural Passive Strategic	Vs.	Planned Purposeful Intentional Policy Active
Timing	Anticipatory Proactive	Vs.	Responsive Reactive
Temporal Scope	Short Term Tactical Instantaneous	Vs.	Long term Strategic Cumulative
Spatial scope	Localised	Vs.	Widespread
Function/Effects	Retreat, accommodate, protect, prevent, tolerate, spread, change, restore.		
Form	Structural, legal, institutional, regulatory, financial, technological		
Performance	Cost, effectiveness, efficiency, implementability, equity		

3.3 Adaptation Strategies

It is generally agreed that effective adaptation strategies should reduce present vulnerability as well as future vulnerability to climate change. Adaptation measures can contribute to equitable and sustainable policies and to the present development decision framework by reducing present day risk from climate variability and by being relevant to immediate national development priorities (Downing et al., 1997; Adger, 2001b; Apuuli et al., 2000; Hulme et al., 2001). This strategy can be called a "no regrets" adaptation strategy. Reducing present vulnerability to climatic hazards should help to prepare for the potential future impacts of climate change. For the most vulnerable groups, adaptation strategies are vital, as failure to adapt to climate change could lead to "significant deprivation, social disruption and population displacement, and even morbidity and mortality" (Downing et al., 1997). The problem is in identifying those adaptations that favour the most vulnerable groups. Many adaptation strategies, such as large-scale agriculture, irrigation and hydroelectric development, will benefit large groups or the national interests but they may harm local, indigenous and poor populations (Kates, 2000). As Kates (2000) states, "one group's adaptation, is another group's hazard". Adaptation is not cost-free and does not yield the same benefits everywhere. Win-win solutions are unlikely with climate change, as there will always be winners and losers from extreme events (Adger, 2001b). The costs of adaptations need to include the secondary effects of the adaptations themselves, and the losses suffered by the groups bypassed or marginalized as a result of the adaptations (Kates, 2000).

3.4 Adaptation in the United Nations Framework Convention on Climate Change

The UNFCCC was accepted at the United Nations Conference on Environment and Development at Rio in 1992. Although the main aim of the UNFCCC is to "achieve…stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UN, 1992), a number of articles refer to the need for adaptation to climate change. Article 3.3, although it does not mention the word adaptation, still states that "The Parties should take precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects". With regard to the implementation of adaptation measures as part of a response strategy, the UNFCCC, through Article 4.1(b) commits parties to "formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change…and measures to facilitate adequate adaptation to climate change" (UN, 1992). Article 4.1(e) continues by saying that all parties should "cooperate in preparing for adaptation to the impacts of climate change" and it recognises the vulnerability of Africa as it commits parties to "develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods" (UN, 1992).

3.5 Adaptation in the Climate Change Negotiations

During the 1990s, most of the scientific research and most of the negotiations concentrated on mitigation. This resulted in the formulation of the Kyoto Protocol in 1997. There was a divergence between the priorities of the developed countries, which were to reduce greenhouse gas concentrations (also the main objective of the UNFCCC), and those of the LDCs, which were to reduce their vulnerabilities to climate change, which is primarily caused by the emission of greenhouse gases from the developed countries (Apuuli et al., 2000). However, in the last few years the scientific community has increasingly realised the importance of adaptation, especially for the developing countries and particularly the LDCs, which are most vulnerable countries to climate change. Even if emissions of all greenhouse gases stopped today, some degree of climate change would still occur and LDCs would suffer from the impacts. For this reason it is vital to emphasise the importance of adaptation. As Nordhaus observed, "mitigate we might; adapt we must" (Pielke, 1998). In 2001 the parties to the UNFCCC accepted the Marrakech Accords at the seventh Conference of the Parties (COP 7).

3.6 The Marrakech Accords

The Marrakech Accords looked at, amongst other things, the need for the LDCs to have more support from the international community regarding climate change, and the need to emphasise the importance of adaptation to climate change.

In the Marrakech Accords a LDC Expert Group was established (UN, 2001c). This group consists of 12 experts who have the appropriate expertise and competence to assist in the development of the National Adaptation Programmes of Action (NAPAs). The objective of the LDC Expert Group is "to advise on the preparation and implementation strategy for the NAPAs, which would meet the urgent and immediate adaptation needs of the LDCs" (UN, 2001c). The expert group can also advise the LDCs on their capacity-building needs for the preparation and implementation of the NAPAs. The guidelines for the preparation of the NAPAs were established ensuring that these will be integrated into the national sustainable development strategies (UN, 2001c).

The Marrakech Accords "expanded the scope of activities eligible for funding, including the areas of adaptation and capacity-building" (Adger et al., 2002). These accords also established two new funds under the UNFCCC (plus another, the adaptation fund, under the Kyoto Protocol), that will be managed by the Global Environment Facility (GEF): a Special Climate Change Fund and a LDC Fund (Adger et al., 2002; Konate, 2001). The Special Climate Change Fund will finance projects relating to capacity building, adaptation, technology transfer and climate change mitigation. It will also fund economic diversification for countries highly dependent on income from fossil fuels (Adger et al., 2002). The LDC Fund is there to specifically help the LDCs, with most of the focus so far being on helping the LDCs to develop NAPAs. The Kyoto Protocol Adaptation Fund is to receive a share of the proceeds from Clean Development Mechanism (CDM) project activities and will finance concrete adaptation projects and programmes (Abramovitz et al., 2002; Konate, 2001). The GEF is supporting work on adaptation to climate change in developing countries through a staged process. Stage I is to support studies and planning with an emphasis on impact studies to identify vulnerabilities, policy options and capacity-building (Adger et al., 2002; Apuuli et al., 2000). Stage II is to support detailed planning and capacity building, and Stage III is to support and facilitate actual adaptations, including insurance and other measures as described in articles 4.1(b) and 4.4 of the UNFCCC (Adger et al., 2002; Apuuli et al., 2000).

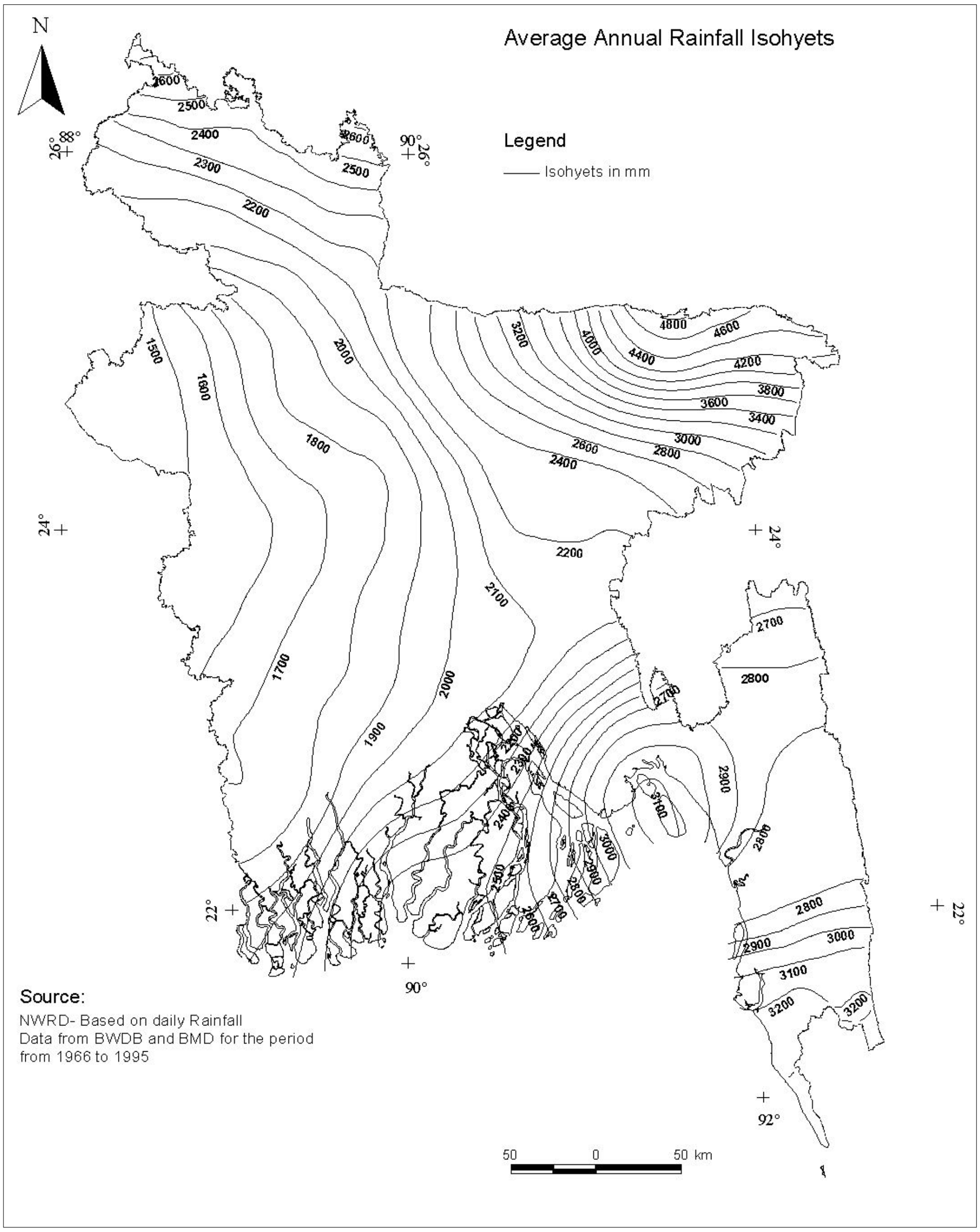
4. VULNERABILITY AND ADAPTATION IN BANGLADESH

Over the last decade a number of studies have been conducted on impacts, adaptation and vulnerability to climate change. The Government of Bangladesh, academic institutes, and research organizations carried out these studies and most of them were carried out collectively.

4.1 Earlier Studies on Impacts, Adaptation and Vulnerability

- *Effect of Climate Change and Sea Level Rise on Bangladesh*, by Dr Fasiuddin Mahtab, 1989, sponsored by Commonwealth Institute. The objective of the study was to assess the nature of climate change in Bangladesh and to assess the physical, economic, environmental and social impacts of the predicted climate change. The study assumes a scenario of a one metre change in sea level by the middle of the next century; it combines a 90 cm (average of 30 cm and 1.5 m) rise in sea level and about 10 cm local rise due to subsidence.
- *The Greenhouse Effect and Climate Change: An Assessment of the Effects on Bangladesh*, by Bangladesh Unnayan Parishad (BUP), Centre for Environmental and Resource Studies (CEARS), New Zealand, and Climate Research Unit (CRU), University of East Anglia, UK, 1993. The major emphasis of the study was to evaluate the implication of changes in climatic regimes and sea level on the natural systems of the country, its particular vulnerability to extreme weather events, the social implications and mitigation options and the overall socio-economic impacts of climate change on Bangladesh.
- *Country Study on Bangladesh under Regional Study of Global Environmental Issues* Project (Asian Development Bank, TA No. 5463), by Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh, 1994. A study on the impact of climate change in Bangladesh, the available options for adaptation and mitigation measures and response strategies.
- *Vulnerability of Bangladesh to Climate Change and Sea Level Rise*, by Bangladesh Centre for Advanced Studies (BCAS) /Resource Analysis (RA) /Approtech Ltd., 1994, with support from The Netherlands Government. The study report is published in a set of three documents: a summary report, a technical report (volume I and II) and an institutional report.
- *Climate Change Country Study Bangladesh* under U. S. Climate Change Study Programme, by BCAS/BIDS/BUP, 1996, with support from US Government. The study has four major components: a) greenhouse gas emission inventory, b) vulnerability and adaptation, c) mitigation options, and d) dissemination. The vulnerability and adaptation component focuses on climate change and sea level rise and its impacts on agriculture, water resources, forestry, fisheries and livestock. The study concludes that climate change and sea level rise will affect the whole country and not only the coastal areas. Main impact categories will be inundation, loss of crop production, etc. The study reveals that the southern part of Bangladesh would be most vulnerable in terms of inundation and salt-water intrusion. It thus recommends that salt-water intrusion should be studied based on model MIKE11-GIS as a function of changes in river discharges and sea levels for all seasons of the year.
- *Climate Change and Adaptation Study for Achieving Sustainable Development in Bangladesh*, jointly undertaken by RA, the Netherlands, BUP and BCAS, commissioned by the World Bank. This study deals with identification and preliminary analysis of a number of adaptation issues in five important sectors of the country. These are (a) agriculture, (b) coastal resources, (c) water resources, (d) bio-diversity and (e) human health. The study shows how major projects, especially the ones being undertaken by the World Bank and Asian Development Bank, responded to the need for adaptation to climate change and how issues of adaptation can be incorporated into the long-term planning framework of sustainable development of the country. The report highlights key risks to climate change and possible physical and institutional adaptation options.

Figure 2: Average annual rainfall isohyets



- *The Vulnerability Assessment of the SAARC Coastal Region to Sea Level Rise: Bangladesh Case*, undertaken by the SAARC Meteorological Research Centre (SMRC). The Theoretical Division of SMRC has analysed the existing Bangladesh coast tidal data and the findings are presented in this report. Results of the report provide a scientific basis for the sea level associated scenario for Bangladesh.

4.2 Major Ongoing Studies Related to Climate Change

- *Initial National Communication to the United Nations Framework Convention to Climate Change*, conducted by the Department of Environment with financial support from GEF. The draft report of the National Communication is under review process. It covers national impacts, adaptation and vulnerability, and mitigation potential.
- *Reduce Vulnerability to Climate Change in the six coastal districts*, conducted by CARE Bangladesh with financial support from the Canadian International Development Authority (CIDA). The project will work with 6,000 rural households to improve resilience and reduce vulnerability to climate change.

4.3 Climatic Situation

4.3.1 Climate

High temperatures, heavy rainfall, often-excessive humidity, and fairly marked seasonal variations characterize the climate of Bangladesh. Although more than half the country is north of the Tropics, the effects of the Himalayan mountain chain make the climate more or less tropical throughout the year. The climate is controlled primarily by summer and winter winds, and partly by pre-monsoon and post-monsoon circulation. The Southwest Monsoon originates over the Indian Ocean, and carries warm, moist, and unstable air. The easterly Trade Winds are also warm, but relatively drier. The Northeast Monsoon comes from the Siberian Desert, retaining most of its pristine cold, and blows over the country, usually in gusts, during dry winter months.

The country has an almost uniformly humid, warm, tropical climate, throughout. There are three main seasons: (1) a hot summer season, with high temperatures (five to 10 days with more than 40°C maximum in the west), highest rate of evaporation, and erratic but heavy rainfall from March to June; (2) a hot and humid monsoon season (temperatures ranging from 20° to 36°C), with heavy rainfall from June to October (about two-thirds of the mean annual rainfall); and (3) a relatively cooler and drier winter from November to March (temperatures ranging from 8° to 15°C), when minimum temperatures can fall below 5°C in the north, though frost is extremely rare.

The mean annual rainfall varies widely within the country according to geographical location, ranging from 1,200 mm in the extreme west to 5,800 mm in the east and northeast. There are three main periods of rainfall, with distinct sources of precipitation:

(1) The *western depression of winter rains*, mainly from 20th January to 25th February, when it rains from one to four centimetres.

(2) The *pre-monsoon thunderstorms*, known as the Nor'westers (North-westerlies), which begin about the 10th of March. The Nor'westers arise due to a variety of reasons, the main ones being the steady flow of cool dry air above 1,800 metres altitude from the northwest (Anti-Trades), a warm, moist current below 1,800 metres from the south, intense evapo-transpiration in the Bengal basin and Assam, and katabatic winds from the surrounding mountains.

(3) The *summer rains* known as the Monsoons. The main rainy period begins with the coming of the moisture-laden Southwest Trades, popularly known as the Monsoons, which are drawn to the Indian sub-continent by the intense heat, and consequent low pressure over Punjab (in Pakistan and India) and the Upper Ganges Valley. This gives rise to a "tropical cell", with convection currents of massive proportions. These winds blow across the North Indian Ocean, and reach the Malabar Coast of India two weeks before they come up the Bay of Bengal to Bangladesh. One arm of these vast trades moves up the Ganges valley, and brings in rains. It is the orogenic rains caused by the striking of this east-flowing air mass against the Arakan Yomas, Meghalaya Plateau, and the Himalayas that forms the major part of the rainfall of Bangladesh.

The Monsoon rains start from the end of May and continue till mid October. The total rainfall in these months varies in different parts of the country. It is 122 cm in the northwest, 149 cm in the centre, 338 cm in coastal areas, and over 500 cm in the northeast – across the borders from Cherapunji and Mawsyriem, two of the rainiest places in the world. Possible connections with El Niño have only now begun to attract attention as a major possible influence on climatic patterns in the Sub-continent.

4.4 Climate Change Projections

4.4.1 Trend of Temperature

There are two general approaches to determine future climate change: a) projection based on observed historical data, and b) using available climate models. Observed data reveals that temperature is generally increasing in the monsoon season (June, July and August). Average monsoon maximum and minimum temperatures show an annually increasing trend at the rate of 0.05° and 0.03°C respectively. On the other hand, average winter (December, January and February) maximum and minimum temperatures show annually decreasing and increasing trends at the rate of 0.001° and 0.016°C respectively. It is also revealed that the trend has regional variation. Figure 2 shows the trend of temperature from 1971 to 1998.

SMRC has studied surface climatological data on monthly and annual mean maximum and minimum temperature, and monthly and annual rainfall for the period of 1961-90. The study showed an increasing trend of mean maximum and minimum temperature in some seasons and a decreasing trend in others. The overall trend in annual mean maximum temperature has shown significant increases over the period of 1961-90.

The study has also projected climatic elements up to 2050 and 2100 using a five-year running average of the climatic elements, and actual values. Based on the five-year running average, the annual mean maximum temperature is likely to rise by 0.48°C and 0.88°C in 2050 and 2100 respectively. The annual mean minimum temperature is likely to decrease by 0.06°C and 0.11°C by 2050 and 2100 respectively. The overall annual mean temperature is likely to increase by 0.21°C and 0.39°C by 2050 and 2100 respectively.

The most important finding of the study is the seasonal variation in future trends in temperature and rainfall. In the pre-monsoon season the mean maximum temperature is likely to decrease by 0.44°C and 0.80°C by 2050 and 2100 respectively. Conversely in the southwest monsoon season the mean maximum temperature is likely to increase by 0.90°C and 1.65°C by 2050 and 2100 respectively, and the increasing trend is statistically significant.

4.4.2 Climate Change Scenarios

Climate change vulnerability studies have used different climate change scenarios to assess impacts, adaptation and vulnerability for different sectors. Climate Change Country Study, a comprehensive study on assessing impacts, adaptation and vulnerability, has used General Circulation Models to develop climate scenarios. Models were run to find correlation with the observed time-series data for 10 particular points distributed all over the country both for base and projection years. The model-estimated monthly average rate of change in temperature and precipitation for those locations were superimposed on the observed time-series monthly average data to obtain data for the projection years.

The results revealed that the average increase in temperature would be 1.3°C and 2.6°C for the years 2030 and 2070, respectively. It was found that there would be a seasonal variation in changed temperature: 1.4°C change in the winter and 0.7°C in the monsoon months in 2030. For 2070, the variation would be 2.1°C and 1.7°C for winter and monsoon, respectively. For precipitation it was found that the winter precipitation would decrease at a negligible rate in 2030, while in 2075 there would not be any appreciable rainfall in winter. On the other hand, monsoon precipitation would increase at a rate of 12% and 27% for the two projection years, respectively.

It was found that there would be excessive rainfall in the monsoon causing flooding and very little to no rainfall in the winter forcing drought. It was also found that there would be drastic changes in evaporation in both winter and monsoon seasons in the projection year 2075. It was inferred from the General Circulation Model output that moderate changes regarding climate parameters would take place for the projection year 2030, while for the projection year 2075 severe changes would occur.

The calibrated future temperature of Bangladesh shows that the average temperature increase would be 1.3°C and 2.6°C for the year 2030 and 2075, respectively. The results also show the seasonal temperature variation would be 1.3°C in the winter and 0.7°C in the monsoon for the year 2030. Similar temperature changes for the year 2070 would be 2.1°C and 1.7°C for the two seasons, respectively.

The results also reveal that there is a general increasing trend regarding temperature. In 2030, the increase is pronounced in winter months, although the maximum change is observed for post-winter months, i.e., April, May and June. However, in 2075, the increase in temperature during April and May is much higher; about 4.0°C.

The results show that precipitation in 2030 will increase slightly in winter and moderately in monsoon. However, in 2075, the change is pronounced in monsoon (about 112 mm/month), while there would not be any appreciable winter precipitation.

4.4.3 Sea Level Rise

SMRC carried out a study on recent relative Bangladesh coastal sea level rise. The study used 22 years of tidal data for three coastal stations. It revealed that the rate of sea level rise during the last 22 years is many times higher than the mean rate of global sea level rise over 100 years, which shows the important effects of regional tectonic subsidence. Variation between stations was also found.

4.5 Primary Physical Impacts of Climate Change

The impact of climate change has been assessed under different climate change scenarios for different sectors, and the following areas have been identified as critical for development policy makers to consider measures to combat the adverse impacts of climate change in a warmer Bangladesh.

4.5.1 Drainage Congestion

Drainage congestion will remain integral to climate change. The combined effect of higher sea levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood-protected areas will gradually increase waterlogging problems, and impede drainage. This effect will be particularly strong in the coastal zone, but will also be felt in riverine flood plains further upstream. The problem will be aggravated by the continuous development of infrastructure (e.g. roads) reducing further the limited natural drainage capacity of the delta and flood plains. Drainage congestion will increase the period of inundation and expand wetland areas. This may hamper agricultural productivity and threaten human health by increasing the potential for water borne diseases.

4.5.2 Reduced Freshwater Availability

Reduced freshwater availability will become a serious problem in the dry season due to low river flows and increased evapo-transpiration in the dry period. In the coastal zone, the additional effect of saline water intrusion in the estuaries and into the groundwater stimulated by low river flow and sea level rise will be significant. Pressure from growing populations and economic development will further reduce fresh water availability.

4.5.3 Disturbance of Morphological Processes

Disturbance of morphological processes will become a significant problem under climate change. Bangladesh's riverine and coastal morphological processes are extremely dynamic, partly because of the tidal and seasonal variations in river flows and run off. Climate change is expected to increase these variations, with two main (related) processes involved:

- Increased bank erosion and bed level changes of rivers and estuaries. There will be a substantial increase in morphological activity with increased river flow, implying that riverbank erosion might substantially increase in the future.
- Disturbance of the balance between river sediment transport and deposition in rivers, flood plains and coastal areas. This will result in higher bed levels of rivers and coastal areas, which in turn will lead to higher water levels.

4.5.4 Increased Intensity of Disasters

Increased intensity of disasters (extreme events) including cyclones/storm surges, floods and droughts will become evident with climate change. Though the country is relatively well equipped in one aspect of disaster management i.e. disaster response, there remains a serious lack of current data (especially in terms of lead time) in monitoring, and preparing for these events. Additionally, increased disaster intensity will lead to major constraints to the country's social and economic development. Bangladesh is particularly vulnerable to climate change in its coastal zone, covering about 30% of the country. Private sector investment in this area is likely to be affected by the increased risks of cyclones and flooding.

4.6 Sectoral Analysis

4.6.1 Population at Risk

Poverty may increase under warmer climatic conditions. Low agricultural outputs due to drought, salinity and flooding may limit livelihood options and increase vulnerability. Proper adaptive measures should be considered immediately and integrated into the national development plan.

Under climate change scenarios, high percentages of the population will be affected by inundations, the maximum being 94% for both the Business-As-Usual (BAU) and High Development Option (HDO) under non-water sharing conditions. The following observations merit mention.

- For the HDO in Bangladesh and 100 cm sea level rise, 94% of the population will be affected if moderate or high levels of climate change occur. Without climate change, 55% of the population will already be affected by inundations under this scenario, so the additional effects of sea level rise are relatively small. However, under BAU conditions only 23% of the population is affected by inundations without climate change, thus making the increase to 94% under moderate or high levels of climate change much more significant.
- Under moderate or high levels of climate change, if the sea level rise is 30 cm, the percentage number of people affected by inundations is about one third of that predicted for a 100 cm rise.

About 8.5 million people lived in the severe and very severe drought prone areas in 1990. This number increases to about 25 million people under the high climate change scenario. For the rainy season under the low and high climate change scenarios, these numbers are 19 and 29 million people, respectively.

4.6.2 Human Health

The generally inadequate state of human health in Bangladesh is the result of inextricable linkages between overpopulation, poor nutritional status and inadequate potable water and sanitation provision. With a view to reducing malnutrition and improving quality of life, particularly for children, the creation of a healthy physical environment is of vital importance. The safe drinking water supply programme undertaken in the context of the government's commitment to universal coverage has resulted in unprecedented gains. Although only 1.17% of the GDP was spent on the health sector in 1996, 97% of the population had access to drinking water from a safe source (tubewell, ringwell or tap) by 1997. This comprised of 97% and 99% of those in rural and urban areas respectively, but only 68% in tribal areas. This achievement has already exceeded the goal of 80% coverage set for the year 2000. However, the success rate in use of safe water for all domestic purposes has lagged far behind at 56%. Surprisingly this rate was 98% in urban slums, despite the fact that slum dwellers spent more time (30 minutes to two hours) fetching the water. Others (5.6%) use water from ponds, marshes, rivers and springs. Use of water from unsafe sources for domestic purposes could potentially negate the benefits derived from safe drinking water particularly for malnourished children.

Improvements in sanitation or sanitary means of excreta disposal are lagging far behind improvements in the water supply. In 1996, 83% of the urban population had access to sanitation services compared to 38% of the rural population and 50% of those in tribal areas. The total percentage increased from 11% in 1990 to 44% in 1996 against a goal of 80% for the year 2000. Piped water supply systems and on-site sanitation facilities are operational in the four city corporations and 60 district towns. In Dhaka city, the percentage population covered by sewerage facilities grew from 25% in 1990 to only 35% in 1997. Only 25% of the population benefited from storm sewer facilities in 1995. Sanitation facilities in the fast growing urban slums and fringes are inadequate, while in the ever expanding new slum areas they are almost non-existent. This adds to environmental pollution and poses a threat to people's health. The process of installing pit latrines in pourashavas and some thana (the smallest administrative sub-region in Bangladesh) towns has started but numbers remain too inadequate to meet needs.

There are approximately 1.5 million public hand pumps or shallow tubewells operating in rural areas, at 106 persons per pump. These include the pumps installed by DPHE and NGOs. 1997 data shows that public tubewells constitute about 30% of all tubewells thus implying that there are an additional 3.5 million shallow tubewells installed privately by individual households. This extended coverage emanated directly from a 1988 policy change, which gave responsibility to NGOs and local communities for installation, maintenance and operation of pumps, on a cost sharing basis, for which they are provided with training by DPHE. More than 600 NGOs under the banner of the NGO Forum for Drinking Water and Sanitation are actively involved and have contributed to the promotion and provision of water supply and sanitation facilities.

Heavy extraction of water for irrigation and decreased recharge of the groundwater is causing a continuously falling water table. Seasonal variations add to the problem. Whilst only 12% of the country was within the suction zone of seven metres in 1986, this rose to 21% by 1994 and predictions sated that by the end of the year 2000 it would rise to as much as 50% of the country. In the dry season the water table falls sharply in some areas raising the pump to people ratio to 1:500, thereby making water shortages dangerously acute for people in such areas.

Existing literature does not provide an assessment of climate change impacts on human health in Bangladesh. Although there is a significant seasonal variation in temperature ranging from 10°C to 38°C, malnourished children and the elderly may face dehydration related problems, and heat stress mortality due to higher temperatures and humidity.

4.6.3 Infrastructure

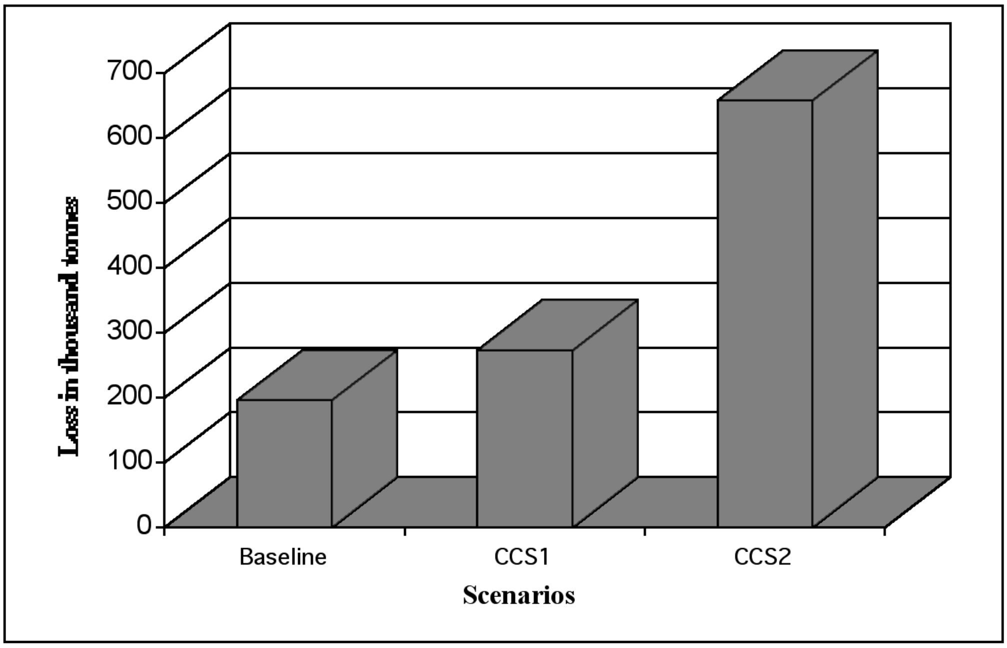
The country has about 2,858 kilometres of railroad, 15,053 kilometres of paved road and roughly 5,896 kilometres of perennial and seasonal waterways. Efforts are underway to develop the water transport system. In fact, rivers are the lifelines of the nation, and provide the cheapest means of transport, water for agriculture, and fish supplies. Steps have been taken to put more mechanized vessels into service and modernize existing boats.

Comparisons of GIS data infrastructure distribution and expected flood zones were conducted. Results reveal that the costs of losing immobile infrastructure due to inundation following a one metre sea level rise will be greater than US$5 billion, which is equivalent to 10% of country's GDP. Such infrastructure includes water works, housing and settlements, transport infrastructure, utilities, and industry.

4.6.4 Food Security and Crop Agriculture

The simulation study conducted under the Climate Change Country Study assessed the vulnerability of foodgrain production due to climate change in Bangladesh. Two General Circulation Models were used to develop climate scenarios. The experiments considered impact on three high yielding rice varieties and a high yielding wheat variety. Sensitivity to changes in temperature, moisture regime and CO_2 fertilization was analysed against the baseline climate condition. The GFDL model predicted about 17% decline in overall rice production and a decline as high as 61% in wheat production compared to the baseline situation. The highest impact would

Figure 3: Total loss in foodgrain production under climate change scenarios



be on wheat. The CCCM model predicted a significant, but much reduced shortfall in foodgrain production.

It was noticed that a 4°C increase in temperature would have severe impacts on foodgrain production, especially wheat. On the other hand, CO_2 fertilization would facilitate foodgrain production. A rise in temperature would reduce production of rice and wheat by 28% and 68% respectively. However, a doubling of atmospheric CO_2 levels in combination with temperature rises would result in an overall 20% rise in rice production and 31% decline in wheat production. It was found that Boro rice would enjoy a good harvest under severe climate change scenarios.

The apparent increase in yield of Boro and other crops might be constrained by moisture stress. 60% moisture stress on top of other effects might cause a decline as high as 32% in Boro yield, instead of having an overall 20% net increase. It is feared that moisture stress would be more intense during the dry season, which might force the Bangladeshi farmers to reduce the area for Boro cultivation. A shortfall in foodgrain production could therefore severely threaten national food security.

Drought and salinity intrusion have considerably higher impacts on crop production. They diminish the suitability of a number of seasonal crops that are usually preferred by farmers. Under a severe climate change scenario, the potential shortfall in rice production could exceed the trend by 30%, while that for wheat and potato could be as high as 50% and 70% respectively. Under a moderate climate change scenario, crop losses due to salinity intrusion could be about 0.2 Mt, which could reach up to 0.56 Mt under a severe climate change scenario (Habibullah et al., 1998). Salinity intrusion may therefore affect production more than floods. However, losses incurred by other sectors could be much higher due to floods. The effect of low-flow on agricultural vulnerability is thought to be much less intense compared to other effects.

Higher levels of temperature and precipitation would aggravate declining soil conditions. The organic matter content of the topsoil in most areas has already fallen below critical levels. The moderately affected areas would also suffer due to the impact of climate change. It is likely that a significant part of the moderately affected soils would become more vulnerable due to further declines in the organic matter content of topsoils. This would certainly have adverse impacts on foodgrain production.

Since climate change would cause significant changes in all these physical effects, it is obvious that the overall vulnerability of crop agriculture will be much higher than modelling results suggest. However, higher atmospheric CO_2 concentrations would also have some positive effects on the production, as revealed by the modelling exercise. Thus CO_2 fertilization would minimize some of the adverse effects.

The soil salinity of coastal areas would be increased due to climate change and consequential effects. Increased salinity would significantly reduce foodgrain production, especially under severe climate change scenarios. Reduction in foodgrain production would further threaten national food security.

4.6.5 Water Resources

The Vulnerability Assessment of the SAARC Coastal Region to Sea Level Rise project has carried out a rigorous analysis of water resources vulnerability to climate change and sea level rise. The analysis included changes in riverbeds due to sedimentation and subsequent impacts on water levels.

River water levels are affected by the sea level and upstream river discharges. Moreover, Bangladesh is located on a geotectonically active sedimentary basin and thus experiences subsidence over almost the entire delta. Subsidence of land (and consequently of river beds) will not affect the mean sea level, but it may result in water level changes over the surrounding lands and thus in levels of inundation.

Changes in river water levels may cause changes in bed levels as the sediment carrying capacity of rivers is affected. Decreased water level gradients due to higher downstream water levels at sea level result in lower flow velocities and consequently cause sedimentation of the riverbed. Rivers in Bangladesh are morphologically highly dynamic and are expected to adapt to such changes over time. Bed level changes will cause additional river level changes, which in effect will propagate the impact of sea level rise in an upstream direction. First assessments of this effect in a study for the Jamuna Bridge showed the importance of this feedback mechanism.

The discharge distribution at the tributaries of the Ganges and the Padma Rivers (Gorai and Arial Kahn Rivers) will change due to sedimentation. These changes might have important consequences for the course of the main river channels in Bangladesh.

4.6.6 Coastal Zone

Climate change is only one aspect of the vulnerability of those relying on coastal livelihoods. Vulnerability to climate change means that climate change adversely affects the capability of people to cope with other 'normal' vulnerabilities such as food and income security and safety of properties. Thus any analysis of vulnerability to climate change should start off with a full vulnerability analysis and then assess to what degree these vulnerabilities are affected by climate change.

Coastal zone vulnerability would be acute due to the combined effects of climate change, sea level rise, subsidence, changes in upstream river discharge, and cyclone and coastal embankments. The selection of the key primary physical effects of these 'agents of change' (comprising saltwater intrusion, drainage congestion, disasters (extreme events) and coastal morphology) is based on a full recognition of possible accumulative effects.

4.6.7 Forestry and Biodiversity

Bangladesh has a number of natural forest ecosystems including inland Sal forest, dipterocarp forest, savannah, bamboo bushes in the hilly regions and freshwater swamp forests. It also has littoral mangrove ecosystems. An attempt was made to qualitatively analyse the impact of climate change on forest resources of Bangladesh.

It was found that increased rainfall during monsoon would cause increased runoff on the forest floor instead of infiltration into the soil. As a result there would be enhanced forest floor soil erosion, particularly in dense hill forest areas. Prolonged floods would severely affect the growth of many timber species and cause high Artocarpus species mortality. Enhanced evapotranspiration in winter would cause increased moisture stress, especially in the Barind and Madhupur Tract areas, thus affecting the Sal forest ecosystem. Tea plantations in the northeast would also suffer due to moisture stress. The Sundarbans mangrove forest would be the worst victim of climate change due to a combination of high evapotranspiration and low flow in winter resulting in increasing soil salinity. The growth of freshwater-loving species would therefore be severely affected. Eventually non-woody shrubs and bushes would replace species offering dense canopy cover, while overall forest productivity would significantly decline. The degradation of forest quality might cause a gradual depletion of the rich diversity of the forest flora and fauna currently found in the Sundarbans ecosystem.

4.6.8 Fisheries

Fish and Fisheries have played a very significant role in the national nutrition, culture and economy from time immemorial. Currently about 80% of animal protein intake in the daily diet of people comes from fish. It is estimated that the fisheries sector contributes 3.5% of the national GDP. Three principal habitat forms exist from which fish are harvested. These are pure freshwater habitats in the rivers and their floodplains. These water bodies are inhabited by 260 species of fin fish, 25 species of prawn and 25 species of turtles. In addition, 11 exotic species of fin fish have been introduced for the purpose of aquaculture. Where freshwater rivers join the sea, for example in the Bay of Bengal, the water changes from fresh to saline with a wide range of salinity gradients both spatially and temporally. Many freshwater fish and prawn species visit these brackish estuarine habitats at different stages in their life cycles. Similarly, post-larval stages of many coastal and marine prawns come to these brackish habitats to feed and mature. In the Upper Bay of Bengal bordering Bangladesh, 475 species of fin fish are known to occur, of which about 65 are of commercial importance. The marine waters also contain about 38 species of marine prawn. In Bangladesh, very little or no work on the physiology and ecology of indigenous species of fin fish or prawn has been done. At this stage it is difficult to state or predict the likely effects of climate change on these populations and the fisheries based on them.

4.7 Mainstreaming Adaptation

Discussions with stakeholders (primarily sectoral planners and managers) in key sectors provided information on the likely sectoral impacts of climate change, and helped identify and prioritise (according to agreed criteria) suitable adaptations. Results are summarised, somewhat subjectively, below.

4.7.1 Coastal Resource Management

A major project on integrated costal zone management being planned (with World Bank support) allowed involved project managers to readily see the utility of incorporating climate change issues into their programme planning (which they have now decided to do). This was therefore quite a successful mainstreaming exercise into the coastal zone development community. Stakeholders involved with disaster mitigation (especially cyclones) were also quite receptive and have decided to incorporate climate change adaptation into their ongoing disaster preparedness plans.

4.7.2 Fresh Water Resource Management

Water sector planners were quickly able to see the importance of climate change impacts on their national water sector plans. They have agreed to incorporate climate change adaptation into the 25-year water sector plan under development.

4.7.3 Agriculture

Stakeholders involved in agricultural research were relatively quick to see the importance incorporating climate change considerations into their research programmes (especially for the development of drought and saline tolerant rice varieties). However, those involved in agricultural extension work did not recognise the importance of adaptation measures for their work.

4.7.4 Human Health

Success with stakeholders in this sector was reasonably high with respect to getting their attention, but not with affecting decision-making within the public health community. However, they did express desire to do more work on the issue.

4.7.5 Ecosystems and Biodiversity

Stakeholders involved in ecosystem conservation accepted that impacts on the Sundarbans forest were of major significance. They agreed to incorporate climate change impacts assessment into a major project being undertaken for the Sundarbans. With respect to the other ecosystems, success in engaging with the relevant stakeholders was not as good.

4.7.6 Cross-Cutting Issues and Research

Climate change and adaptation are relatively long term problems requiring research and an advancement of the knowledge base. It is important to enhance national research capacities to deal with the issue on an ongoing basis. Stakeholders representing the research community were quite willing to be involved in further work on the issue.

4.7.7 High-Level Policy Makers

Perhaps the area of least success was in engaging with, and getting the interest of high-level policy makers (for example those representing the Prime Minister's office, Finance and Planning ministries as well as legislators). This group seemed least concerned about the impacts of climate change on the overall economy of the country and need to be targeted more effectively in any future efforts to do more on adaptation to climate change in Bangladesh.

5. VULNERABILITY AND ADAPTATION IN MALI

Mali is a West African country with a surface area of 1,240,192 km^2 and which lies between the 10th and 25th latitude north, and between the 4th and the 12th longitude east. It is bordered to the north by Algeria, to the west by Mauritania and Senegal, to the east by Niger and to the south by Guinea, the Ivory Coast and Burkina Faso.

In terms of vegetation, Mali possesses a diverse ecology, contrasting forest formations with the shrub-covered savannah in the north and the drifts of forest to the west and south. In terms of climate, Mali typically has one rainy season per year with light rain throughout (between 200 mm and 1,200 mm). However, two large rivers (the Niger and the Senegal) and their effluents flow through it.

The population rose from 4.2 million in 1960 to 10 million in 2000. The population is on the whole rural despite a continuing rise in urbanisation, which has gone from 5% in 1960 to 25% in 2000. The growth rate is 3.2% per year. The greatest concentration is in the triangle Bamako-Mopti-Sikasso. The five main towns are Bamako (the capital), Ségou, Sikasso, Mopti and Koutiala.

The economy is dominated by the agricultural sector, which is based around cotton (the principal export) and livestock, but also gold. Wood production and fishing, which are considered to be the poor relations, exist alongside. The GNP rose from US$1.81 to 2.6 billion from 1994 to 1997. The country is classed as one of the least developed countries but has a healthy economic growth rate; the GDP has gone from 2.3% to 6.7% whilst the inflation rate has dropped from 23.2% to -1.2% for the same period. These trends are continuing favourably. The country uses its hydraulic potential but also, and overall, its ligneous energy for its energy consumption (0.2 billion tep per year). These energy needs are met by the country's on board thermal capacity, an important addition to the hydraulic potential mentioned above.

5.1 Mali's Vulnerability to Climate Change

The existing studies on vulnerability in Mali were conducted within the implementation framework of the UNFCCC and particularly the initial national communication. These studies cover the water resources and agricultural sectors. Such studies are justified, given the fact that the main occupation of the country's inhabitants is agro-sylvo-pastoral in nature. Indeed, 95% of Mali's population depends on the primary sector, which provides the basic raw materials required by the industrial sector and which thus contributes an important part of the GNP.

The study area is located in the upper valley of the Niger River, one of the main agricultural areas of the country. The objectives of the exercise were to (i) evaluate the eventual consequences of climate change on yields of millet and sorghum in the area, (ii) evaluate the socio-economic impact of climate change and (iii) propose strategies for adapting to any climate changes that may ensue.

The area covered by the study straddles two agro-climatic zones: a sahelo-Saharian zone (average rainfall less than 600 mm, a vegetation period ranging from 45 to 90 days, transhumant animal husbandry and dry crops, notably millet and flood recession crops), and a Sudano-Sahelian and Sudano-Guinean zone (average rainfall from 600 mm to 1,200 mm, vegetation period of 130 days, cash crops, dry crops and animal husbandry).

The area's rainfall ranges from 460 mm to 1,130 mm, alternating humid periods with dry ones. At the moment, average rainfall is consistently less than it was during the period 1961-1990. This causes fluctuations in the duration of the vegetation season which in turn leads to unsustainable agricultural production and degradation of the soil and vegetation.

The average surface area used each year for growing millet/sorghum was 51,000 ha between 1971-1995. The annual average variation in cultivated land is 30,000 ha and long-term trends indicate an increase in the amount of land worked. If there is no climate change, and provided current trends continue in the long term, there should be no structural shortages of food in the area.

The maximum temperature in the shade is between 34°C and 36°C and the minimum is 21°C or 22°C. The average rate of monthly sunlight is 232.2 to 266.2 hours. There has been an average rise of 0.4°C in the area's temperature between 1981 and 1995.

5.1.1 Agricultural Sector

Studies were carried out using General Circulation Models or GCMs and simulation models involving crop growth. They considered:
- 1995 as the reference year for all projections
- 1961-1990 as the normal climatological period
- 2025 as the temporal horizon

The GCMs were used to establish the possible climate scenarios, which were derived from reaction equilibrium experiments. The models were developed, using data which included the geographical coordinates of selected meteorological stations located in the study area, the average daily maximum temperature values for the period (1961-1990), the minimum insulation temperature and the daily precipitation figures for 1995. These calculations were made by assuming that the background level of CO_2 concentration to be equivalent to (2 x CO_2) until the simulated climate reaches a state of equilibrium. An indication of the climatic response when the CO_2 concentration in the atmosphere is doubled could be obtained from the difference between the climatic conditions at (2 x CO_2) and those at (1 x CO_2). Six GCMs were used:
- Canadian Climate Change Model (CCCM)
- United Kingdom Meteorological Office (UKMO)
- United Kingdom Meteorological Office for 1989 (UK89)
- Geophysical Fluid Dynamics Laboratory Model (GFDL)
- Goddard Institute for Space Studies Model (GISS)
- Geophysical fluid Dynamics (Gfd3)

In order to assess climate change impacts two Crop Growth Simulation Models were used. The first one is the MAIN model developed in collaboration with the Centre for Agro-biological Research in the Netherlands. This model was calibrated, using agro-meteorological data obtained from the study area. Scenarios involving temperature increases of one, two, three and four degrees centigrade were used to develop the simulation models.

The second one is the Decision Support System for Agrotechnology Transfer (DSSAT) model, which uses simplified functions to forecast crop growth, under the influence of certain factors which affect their yield, namely: genetic, climatic (sunlight, maximum and minimum temperatures, precipitation), soil properties and agricultural practices. This model is developed from data which includes: daily figures for sunlight intensity, maximum and minimum temperatures, and precipitation, as well as the necessary agronomical data such as: the sowing date, crop density, variety, the quantity of water from irrigation, with dates (where relevant).

The synthesis of results obtained from the General Circulation Models show that the best possible correlation is obtained between the Gfd3 model (at temperatures between 0.78 and 0.96 and rainfall between 0.92 and 0.98) and the CCCM model (for insulations of 0.51 and 0.67). By the year 2025, the average temperature rise will vary between 2.71°C and 4.51°C; while the decrease in rainfall and insulation will range between 8% and 10%, and 1% and 10% respectively. The impact that this will have on crops such as sorghum, can be summarised as follows:
- 16% decrease in yield for the Tiémantié variety, (for a temperature rise of 4°C); which will be equivalent to a food shortage affecting 12% of the region's population;
- 26% decrease in yield for the CSM388 variety, which is equivalent to the food ration for 44% of the region's population.

5.1.2 Water Resources Sector

This aspect was studied, using the analog method, in addition to expert judgment and simulation models. It considered:
- 1995 as the reference year
- 1961-1990 as the climatological normal
- 2025 as the temporal horizon
- The Niger basin at Mopti, as the study area

Two possible climate scenarios could be envisaged:
- A continuation of the present trend, which, by the year 2025 will culminate in a temperature rise of 0.4°C to 1.1°C and a decrease in rainfall of between 12% and 29%;
- A doubling of the CO_2 concentration, resulting in a 15% increase in rainfall in the year 2025.

5.2 Adaptation Strategies

The adaptation strategies cover the agricultural sector and water resource sector.

5.2.1 Agricultural Sector

Following the droughts experienced in the 1970s, the Malian Meteorological Department, with the assistance of the international community, developed a two–pronged approach to tackle the impact of drought on agriculture.

The first approach involves keeping the decision-makers and agricultural officials regularly informed about the state and evolution of agro-pastoral fields by means of a follow-up of relevant indicators (meteorological indicators, rainfall, water reports, hydrological indicators etc.), and their impacts on crops, pastures and well points. The second approach involves providing the rural community with the technical knowledge they need to enable them to plan and manage their agricultural activities more efficiently.

5.2.1.1 Agro-Hydro-Meteorological Follow-up Studies on Cultivation and Pastoral Lands

A multidisciplinary working group, GTP, consisting of representatives from rural sector technical services, as well as from the Hydrology Department and the National Radio and Television service, meets every ten days during the wet season. Their work is co-ordinated by the National Meteorological Department. This group analyses data received from meteorological and hydrological stations, as well as from satellites (maps indicating vegetation cover) and also data sent in by agricultural and livestock farming agents on farming, farming hazards, pastoral lands and well points. At the end of each meeting, an agro-hydro-meteorological information bulletin is prepared and distributed by mail, or over the national radio and television, to policy makers, agricultural officials and development partners. The bulletin provides up-to-date information on meteorological conditions, rainfall, water table levels and their impact on agriculture, in addition to information on pastoral lands, well points and detailed forecasts for the following ten days. These bulletins enable close monitoring of agricultural activities and detection of areas where conditions are critical. This information is used by the Early Warning System (EWS), in addition to other indicators, to evaluate the national nutritional, health and food situation, thus enabling decision-makers to take appropriate actions in time.

5.2.1.2 Agro-Hydro-Meteorological Assistance to Rural Communities

One of the consequences of the severe drought of the 1970s in Mali was the extinction of certain plant and animal species, as well as the disruption of their normal physiological behaviour. This caused the rural population to lose valuable reference indicators in their empirical cultural calendars.

Moreover, farming calendars, simplified for local farmers by agricultural training institutions, have undergone various modifications due to fluctuations in rainfall. It was in this particular context that an agro-meteorological assistance scheme was set up in 1982, through a participative, demonstrative, and multidisciplinary approach, with Suisse financial assistance and technical support from the World Meteorological Organisation (WMO). The objectives of this assistance scheme were:

- The sensitisation of rural communities, by directly involving them in various activities, through teamwork and a chain reaction network, involving extension workers, agricultural officials and policy makers. The sensitisation exercise will emphasize the importance of considering meteorological information in all agricultural decision-making processes, so as to minimise climatic risks and safeguard or even increase agricultural production.
- The provision of professional training for local farmers and their introduction to data collection and the practical use of meteorological and agro-meteorological information in all agricultural decision-making processes.
- The establishment of a functioning system of compilation and dissemination of agro-meteorological information and advice to rural communities.
- The preparation of forecasting tables to determine when to begin the main planting seasons.
- The establishment of a rural database to help with agro-meteorological work and operations.

5.2.2 Technical Assistance Methodology

GTP undertakes the implementation of the rural community assistance scheme. It gives rural communities agro-meteorological advice, which generally deals with the following:

- Agro-climatic reference tables, for planning agricultural activities (the appropriate time for preparing the field and the agricultural seeds).
- The right time to begin the planting season, with the help of planting forecast tables, daily rainfall figures, hydrological reports and daily weather forecasts.
- The appropriate time to undertake agricultural activities, such as mobilisation, field clearing, the use of different varieties of seeds and pesticides, etc., based on the hydrological report and daily weather forecasts.

• The outbreak of certain crop diseases, especially mildew (warning based on rainfall, temperature and humidity levels).

The farmers and instructors carry out data collection. This data reaches GTP through the sensitisation institutions. It is then treated and analysed by GTP during the group's fortnightly meetings, during which agro-meteorological opinions, warnings and advice are formulated and circulated by means of national radio and television to the local community (in French and local languages).

In general, as an outcome of those strategies, production has increased by an average of 42% for millet, 35% for sorghum and 68% for maize within the entire area covered by these activities. In addition, due to the use of calendars showing seed planting times, there has been a significant reduction in seed planting failure, which decreased from 40% to 5%, representing a significant decrease in seed loss.

On the basis of production figures obtained between 1990 and 1996, the cost/benefit ratio of the agro-meteorological assistance operations in rural areas was found to be 1/21. This means that for every franc invested, a profit of 21 francs was realised.

Besides the economic impact, agro-meteorological assistance has a positive influence on both society and the environment through:

• The consolidation of social cohesion, since regular information sharing helps to bring communities closer together;
• The transfer of technical competence and know-how to freshly trained members of the community (rainfall measurements, interpretation of meteorological information and a better mastery of agricultural activities, such as judicious use of seed planting calendars);
• The alleviation of women's domestic workload, resulting in better house keeping;
• The limitation of rural exodus;
• Better conservation of the environment due to:
  - Better mastery of landuse and the fallow system and better crop management.
  - Rational use of pesticides and chemical fertilizers (avoiding additional treatment against agricultural hazards and applying fertilizers under favourable conditions of humidity).

5.3 Adaptation Strategies Envisaged

On the basis of results obtained from agro-meteorological assistance efforts and impact studies of climate change on agriculture, the following strategies have been designed to minimise the effects of climate change on agriculture, and the following actions recommended:

• Genetic modification of certain species in order to produce varieties that are more tolerant to water shortages and elevated temperatures.
• Improvement of agricultural techniques and practices to permit better use of the water resources available.
• Reinforcement of agro-meteorological assistance to rural communities, through the improvement of the information system, by taking account of seasonal weather forecasts, rainfall estimation by satellite technology, vegetation cover indicators and the identification of agro-climatological risk zones.

In order to implement the above recommendations and to make a meaningful contribution towards food security, the reduction of poverty, and environmental protection through the use of agro-climatic information, an adaptation strategy project was developed. The objectives of the project were to:

• Develop viable climatic forecasts, for productive application, adapted to the needs of potential users.
• Develop crop varieties that are more adapted to climate change.
• Provide farmers with the best varieties.
• Promote efficient use of rainwater through adoption of the relevant agro-climatic recommendations and through use of appropriately adapted varieties.
• Provide farmers with a technological package, consisting of adapted varieties and agro-meteorological information.
• Convince farmers to use the technological packages, through a functional information system.

For the implementation, various activities have been identified, and these include:

• Regular maintenance of meteorological and hydrological stations.
• Collection and processing of rainfall, agro-climatic, hydrological and socio-economic data.
• Determination of meteorological and hydrological parameters.
• Phenological monitoring of crop cultivation.
• Continuation of studies on climate change and variability and their impact on socio-economic activity.
• Development of agro-climatic forecasting methods for crop yields in different agro-ecological

zones, in relation to the effects of climate change on crop production.

- Research and selection of varieties resistant to climate change for different agro-ecological zones.
- Preparation of a technological advice package on adaptation practices for farmers and rural agricultural instructors.
- Training and sensitisation of rural agricultural instructors and farmers.
- Sensitisation of decision-makers and potential users on the environmental and socio-economic implications of climate change.
- Specialisation of personnel in fields related to climate change.

The methodology consisted of the:

- Collection and processing of meteorological, hydrological, pedological and rainfall data.
- Enlargement of the genetic species base, and collection of data on: genetic variety, genetic crossing, genetic mutation and genetic transformation.
- Physio-morphological and enzymatic characterisation.
- Analysis and compilation of technical advice by a multi-disciplinary group.
- Dissemination of advice through national or local radio stations.
- Application of agro-meteorological advice by farmers and local communities.

It is expected that the exercise will provide the following:

- Farmers are provided with crop varieties adapted to climate change.
- Farmers effectively use such varieties.
- Forecast tables, indicating the beginning and end of the wet season are made available.
- Calendars indicating the start of crop planting are made available to producers.
- A functioning agricultural and pastoral lands monitoring system is established over the entire country, based on data from meteorological and hydrological observation networks, agricultural and pastoral land observatories and satellite reports.
- A well structured system of dissemination of information on climate and climate forecasting.
- Weather forecasts and agro-climatic information are made available for decision-making related to agricultural activities (with or without irrigation).
- Evaluation of the potential for fodder crops, to enable more rational management of pastoral lands.
- A modern management system of available environmental data, designed to help carry out the studies necessary for effective management and environmental protection.
- A department well equipped with the necessary telecommunication and data processing facilities.
- Decision-makers, key actors and users, who are well informed about the environmental and socio-economic implications of climate change.

5.3.1 Water Resources Sector

A study conducted in the Niger River basin, on the evolution of climatic parameters (temperature and rainfall), revealed the necessity for more effective water resources management. The strategies to be adopted will need to take account of the physical conditions of the terrain and the economic potential.

Confronted with the acute water shortages following drought years with very low rainfall, the Malian authorities adopted a number of strategies at the beginning of the 1980s in order to meet the demand for water:

- Development of the village and pastoral water supply system, through the construction of a number of wells, equipped with manual pumps.
- Development of urban water supply, through the construction of a supply system, fed either from surface waters or from high capacity borehole wells.
- Development of the agricultural water supply system, fed from surface water obtained from rivers in the region.

This policy has proved its worth, despite certain shortcomings observed in the 1991 Malian Water Resources Development Plan. Within the context of climate change, the above options could be implemented, while correcting the shortcomings. The following options could also be considered:

5.3.1.1 Construction of Water Supply Systems

- Construction of well points covering the entire needs of rural communities.
- Construction of a water supply system, covering the entire needs of urban communities.
- Deepening of 200 ponds and shallow wells for raising livestock.
- Construction of a number of small dams for agriculture and for recharging underground aquifers.
- Construction of discharge control dams on permanently flowing watercourses.

5.3.1.2 Combined Exploitation of Surface and Underground Water, for Meeting Water Demands

In urban areas located along permanent watercourses, water supplies are obtained only from nearby surface water. However, the exploitation of underground water resources could provide low cost water to surrounding suburban areas. This is a serious alternative to easily polluted surface waters.

On the agricultural front, the combined use of non-perennial surface waters and underground water resources is considered a very harmonious arrangement.

5.3.1.3 Protection Against Flooding

- Construction of embankments.
- Construction of drains to evacuate surface water flows from sensitive areas.
- Preparation of an evacuation plan for the entire area at risk.

5.3.1.4 Protection Against Pollution

- Constant monitoring of water quality.
- Implementation of programmes to combat silting of riverbeds, especially the river Niger.

5.3.1.5 Educational Research

Quantitative and qualitative evaluation of renewable resources, with the aim of upgrading information and knowledge on both surface and underground water resources.

5.3.2 The Energy Sector

In the energy sector it is necessary to assess the potential for energy saving and energy efficiency next to the aim of enhancing the development of locally produced energy saving technologies as well as the promotion of solar energy. These actions will help reduce the pressure on forest resources by reducing domestic wood consumption. A wide range of activities will be needed to implement these actions. These include:

- Determination of the efficiency of locally manufactured energy saving technologies (ovens, charcoal cookers and stoves, kerosene stoves).
- Determination of the efficiency of some locally manufactured appliances, which use alternative forms of energy to wood, such as briquettes, charcoal formed from agricultural wastes, and coal dust concentrates.
- Selection of the most efficient energy sources.
- Increased production of energy saving technologies (ovens, cookers and stoves using charcoal from agricultural wastes, kerosene stoves).
- Promotion and distribution of alternative technologies and combustion fuels.
- Promotion of photovoltaic solar equipment for household lighting.

The study will also enable the calorific values of forestry species used as wood fuel to be determined. This data constitutes a precious source of information used in the formulation of CO_2 emission limits and adaptation strategies in the energy sector.

The study area is located to the south and in the central part of the country, more precisely just south of the 13th parallel, since this is the area where the use of wood as energy, is very significant. Furthermore, the area falls within the limits of the green wall envisaged to check desert encroachment.

The following results are anticipated:

- Locally manufactured energy saving equipment.
- Combustion alternatives to wood are manufactured locally.
- Industrial units and small local enterprises manufacture energy saving technological equipment and energy alternatives to wood.
- Increasing use of energy saving technologies and combustion alternatives to wood.
- Decreasing pressure on forestry resources.
- Technicians and craftsmen are competent and could manufacture various equipment and energy alternatives.
- There is a well defined policy for selecting forest species to be used as fuel.
- Local GHG emission factors are available for forest species selected for energy use.

5.3.3 Biodiversity

A study initiated by the Ministry of the Environment is about to take off. It will be necessary to intensify it later on, by extending it to other parts of the country. Vast expanses of the arid region of Mali are undergoing serious degradation due to the combined effects of:

- Unfavourable climatic conditions, which have reduced productivity over the entire country.
- Local exploitation of pastoral lands, which has become uncontrollable and destructive.

- Extension of farming into more humid areas, thus reducing the reserve of fodder crops and the extent of pastoral lands.

As rainfall decreases, pastoral lands become increasingly degraded. Livestock farmers, whose flocks continue to graze on pastoral lands despite their low productivity, aggravate this situation.

The project's main objective is to preserve national biodiversity, while increasing CO_2 absorption capacity, through the development of an efficient arid land and natural resources management system. This should reverse the current degradation trends and establish sustainable livestock production, on a scale that is sufficient to meet the needs of a constantly growing population, which is becoming increasingly sedentary. The project will quantify the costs and benefits of increasing the productivity of Sahelian pastoral lands, within the context of an integrated management of local natural resources. It aims to help rural communities adopt more efficient alternative solutions, without leaving their local environment, based on their own life experiences and on ancient traditions and practices which are rapidly dying out. More specifically, the project will:

- Set up an integrated development demonstration programme, explaining the sustainable use of local resources (land, plants, water, energy, livestock resources, etc).
- Ensure the stability of the natural resources management system.
- Render traditional management systems more resistant to unfavourable climatic conditions.
- Select options which could be extended to similar arid zones.

The project will contribute to the preservation/rehabilitation of biodiversity in two ecosystems and will also include an evaluation of overcharges on additional carbon fixation.

5.4 Mainstreaming Adaptation

Efforts made to mainstream adaptation to climate change into national planning and activities in the different sectors have been relatively successful for the agricultural sector, which already has a long history of working on drought prone agriculture. In the area of energy it was moderately successful. However, in other sectors (such as water resources) and at the national policy making and planning levels, it has been less successful.

6. LESSONS LEARNED AND THE WAY FORWARD

Adaptation to climate change has become an important policy priority in international negotiations on climate change in recent years. However, it has yet to become a major policy issue within the developing countries, especially amongst the LDCs (who will be amongst the most vulnerable to the adverse impacts of climate change). The experience cited in this report on two LDC countries, namely Bangladesh in Asia and Mali in Africa, shows that although much has been achieved in terms of describing and analysing vulnerability to climate change and even regarding identifying potential adaptation options, there remains much more to be done in terms of mainstreaming adaptation to climate change within the national policy making. This is a challenge that all the developing countries (particularly the LDCs) will have to face as they carry out their national communications on climate change and especially their NAPAs.

6.1. Lesson Learned

Based on this study, a number of key lessons can be identified for the LDCs to bear in mind as they prepare their respective NAPAs:

- Information on climate change impacts needs to be translated from the scientific research domain into language and timescales relevant for policy makers.
- Research on the potential impacts of climate change needs in-country support to enable information to be improved and passed on to policy makers.
- All relevant stakeholders need to be involved, but their information needs may vary. Information must therefore be suited to the stakeholder group being engaged with.
- Sectoral level policy makers, planners and managers are more likely to mainstream adaptation to climate change into their on-going and planned work if the information on impacts is given to them in a suitable form.
- High-level policy makers need particular targeting (with suitable material).
- National and international experts and researchers need to share their knowledge with people making decisions and plans on the ground more effectively.

6.2. The Way Forward

The next few years will be an important period in the general climate change policy arena, where the role of adaptation will play a crucial part (and in particular within the LDCs). A number of issues will need to be addressed at both the national as well as international level within the LDCs.

6.2.1. National Level

The LDCs will need carry out their respective NAPAs over the coming few years, whilst ensuring:

- They involve the relevant stakeholders from the most vulnerable sectors of the economy and regions of the country.
- They also need to ensure that high-level policy makers are aware of the importance of the issue.
- The general public is made more aware about the issues.
- Special focus is given to the most vulnerable regions and populations within each country.
- All relevant institutions within the government as well as civil society need to be made aware of the problem and their respective roles in dealing with it.
- The focus is on building long-term national adaptive capacity.
- Adaptation to climate change is effectively mainstreamed into national and sectoral development.

6.2.2. International Level

At the international level, LDCs need to dramatically improve their international negotiating capacity and become more effective at sharing the results of their work on adaptation amongst themselves. Such actions will include:

- Sharing the results of NAPAs with other LDCs (firstly within their respective regions and then with others).
- Developing strategies for improving their own negotiating capacities.
- Ensure their relative needs are well understood, especially in relation to the various funding mechanisms in place for adaptation.
- Play a more active role in the GEF (on funding issues).
- Improve dialogues with major bilateral funding agencies to include adaptation to climate change in their development funding.

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The Least Developed Countries (LDCs) are a group of 49 of the world's poorest countries. They have contributed least to the emission of greenhouse gases but they are most vulnerable to the effects of climate change and have the least capacity to adapt to these changes. Adaptation to climate change has become an important policy priority in the international negotiations on climate change in recent years. However, it has yet to become a major policy issue within the developing countries, especially the LDCs. The experience cited in this report of two LDC countries, namely Bangladesh in Asia and Mali in Africa, shows that although much has been achieved in terms of describing and analysing vulnerability to climate change and identifying potential adaptation options, there remains much more to be done in terms of mainstreaming adaptation to climate change within the national policy making processes in those countries.

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