The NAPA Primer

by

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with contributions from
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CONTENTS

Preface

This primer is designed to introduce the National Adaptation Programme of Action (NAPA) and how it fits within the broader discussions of climate change and adaptation. Hopefully it will provide a good basis for countries to design and develop their adaptation program within the specific confines of the least developed country (LDC) NAPA programme. This primer is largely driven by the need to explain NAPAs, and the desire to see LDCs achieve the original *goals of the NAPAs – which are to identify and communicate, and then implement urgent and immediate needs for adaptation to climate variability, extremes and long-term climate change*.

Much has happened since the main NAPA decisions were adopted in November 2001 at COP 7, including regional workshops with LDCs conducted by the LDC Expert Group (LEG) with logistical support from UNITAR, to assist LDCs in their NAPA preparation. The feedback from these workshops brought forward misconceptions about the NAPA process. We hope that this primer will help to clarify issues and enable LDCs to arrive at their NAPAs quickly and expeditiously.

The UNFCCC established a special fund for adaptation to address adverse impacts of climate change on least developed countries (called the LDC Fund) at COP-7, which is intended to address urgent and immediate adaptation needs, while other adaptation funds in future would address longer-term adaptations. These urgent adaptation needs would be communicated through what is called a NAPA (a National Adaptation Programme of Action). The Conference of the Parties of the UNFCCC in Marrakech, Morocco (COP-7, October-November, 2001) cleared the way for NAPA preparation through the adoption of guidance for the LDC Fund, and guidelines for the preparation of NAPA documents and projects. The UNFCCC COP 9, in turn, adopted guidance for the LDC Fund to enable funding for the actual implementation of those urgent and immediate activities as identified in the NAPAs.

There are several key characteristics that set NAPAs apart from existing communication channels to the Convention and these appear to be understood differently by the various relevant players. As such, there is a need for a brief and yet concise elaboration of what NAPAs are about, what they aim to accomplish, and how they differ from other communication channels and programmes.

One of the main questions about NAPAs is the relationship with National Communications (NCs). Under the Convention, NCs are required for all countries, and are to be submitted by LDCs at their convenience. NCs are primarily a mechanism for countries to report their emission inventories to the convention, and other matters including a broad assessment of impacts and adaptation measures. However, they are not mandated to contain detailed descriptions of adaptation measures to allow project implementation. Most of the 48 LDCs that are parties to the UNFCCC have submitted their first national communication, but these vary in content, and in many cases, do not fully explore adaptation measures. The NAPAs are thus an effective and necessary complement to the NC process for the LDCs.

Recent adverse impacts of climate including climate variability, extreme events and other systematic changes in climate variables, have highlighted the need for developing countries especially LDCs to start responding and adapting to climate change. The concept of NAPAs arose as a mechanism for LDCs to communicate their urgent and immediate needs for adaptation, in a format that would lead to funding of adaptation activities and projects..

Three years after COP-7, not all the LDCs have received funding to prepare their NAPA, and to date, about five countries have yet to start the process of accessing funds for NAPA preparation. This slow progress in NAPA development highlights the obstacles LDCs are facing in implementing even the simplest of projects. It is belief that the implementing agencies and all institutional bodies involved in the preparation and implementation of NAPAs will see the urgency and immediacy of the NAPAs and provide the required resources in an expedited manner.

We sincerely hope that the methods for NAPA described in this Primer will assist LDCs in their work. We also hope the NAPA process will be a useful learning experience in planning for adaptation by other countries.

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Acknowledgements

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What does the future hold for these young girls, innocently collecting wood for cooking the evening meal in rural Salima, Malawi? How will climate change impact upon their ability to grow well and hopefully improve their life and livelihood?

UNFCCC official documents related to LDCs (see the following link for online copies of these documents and latest updates: http://unfccc.int/cooperation_and_support/ldc/items/2666.php).

COP 9 Decisions
- Further guidance for the operation of the LDC Fund (6/CP.9)
- Extension of the mandate of the LEG (7/CP.9)
- Review of the guidelines for the preparation of NAPAs (8/CP.9)

COP 8 Decisions
- Guidance for the operation of the LDC Fund
- Review of the guidelines for the preparation of national adaptation programmes of action

COP 7 Decisions
- Implementation of Article 4, paragraphs 8 and 9, of the Convention
- Guidance for the operation of the LDC Fund
- Guidelines for the preparation of national adaptation programmes of action
- Establishment of a least developed countries expert group
- SBI conclusions on LDCs
- Report of the LEG SBI 20
- Report of the LEG SBI 19
- Implementation of Article 4, Paragraphs 8 and 9, of the Convention, matters relating to the LDCs SBI 18
- Report of the LEG SBI 16
- SBI documents on LDCs
- Fifth meeting of the LEG, Maputo
- Fourth meeting of the LEG, Timphu (LEG first term)
- Third Meeting of the LEG, Apia
- Second Meeting of the LEG in Bonn and Workshop on Capacity-Building for NAPA, Preparation, Dhaka
- First Meeting of the Least Developed Countries Expert Group, Arusha
- Workshop to develop draft guidelines for the preparation of National Adaptation Programmes of Action (NAPAs), Kampala

LDC Expert Group (LEG)
- Composition
- Mandate
- LEG annotations to the NAPA guidelines
- Working Papers

Chapter 1

Climate Change and the UNFCCC

1. Some basic definitions

Human beings and the systems that support them have evolved in concert with weather and climate. Such systems as food production, shelter, ecosystems and health depend on a stable climate. Over the last one to two centuries, human activity has started to significantly modify the climate. This period, or the anthropocene, is generally assumed to have started around 1800 (Crutzen et al. 1999). Climate change has varied through out its history. However, the changes during the last 100 years are unprecedented.

The notions "weather" and "climate" can be defined. According to the IPCC (IPCC, 2001; Third Assessment Report or TAR), 'weather is the fluctuating state of the atmosphere around us, characterized by the temperature, wind, precipitation, clouds and other weather elements. This weather is the result of rapidly developing and decaying weather systems such as mid-latitude low and high pressure systems with their associated frontal zones, showers and tropical cyclones. Weather has only limited predictability. Mesoscale convective systems are predictable over a period of hours only; synoptic scale cyclones may be predictable over a period of several days to a week. Beyond a week or two, individual weather systems are unpredictable.'

Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate varies from place to place, depending on latitude, distance from the sea, vegetation, presence or absence of mountains or other geographical factors. Climate varies in time; from season to season, year to year, decade to decade or on much longer time-scales, such as the Ice Ages.

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

The United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines "climate change" as: "*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*". The UNFCCC thus makes a distinction between "climate change" attributable to human activities altering the atmospheric composition, and "climate variability" attributable to natural causes.

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

2. The Greenhouse effect

Greenhouse gases effectively absorb infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus greenhouse gases trap heat within the surface-troposphere system. This is called the *natural greenhouse effect.*

Atmospheric radiation is strongly coupled to the temperature of the level at which it is emitted. In the troposphere the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, -19°C, in balance with the net incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, +14°C.

An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere, and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing, an imbalance that can only be compensated for by an increase of the temperature of the surface-troposphere system. This is the *enhanced greenhouse effect* (see Figure 1.1).

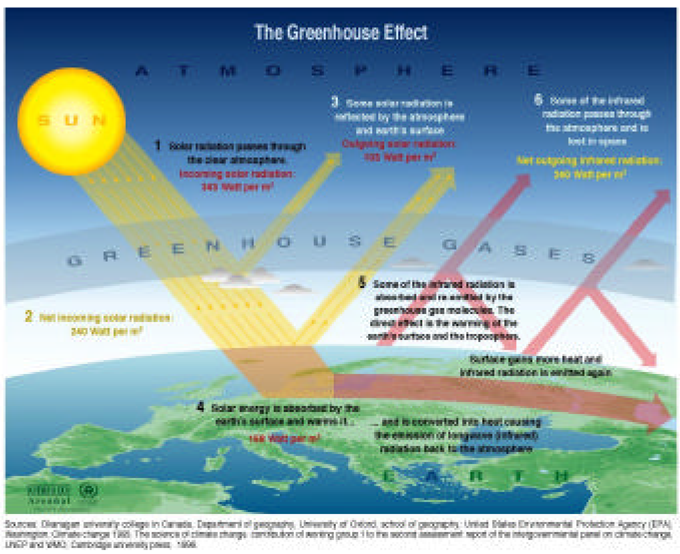


Figure 1.1. The Greenhouse Effect (from UNEP, 2002: Africa Vital Graphics of Climate Change, http://www.grida.no/climate/vitalafrica)

Global warming is caused by the enhanced greenhouse effect, which in turn is caused by emissions from industrial activities and energy use, with negligible contributions from LDCs. Figure 1.2 shows main sources of GHGs and regional averages. It is evident that LDCs suffer from a problem to which they contributed very little. The political implication of this fact is the obligation (morally and otherwise) of Annex II Parties to the convention to assist developing countries to adapt to climate change. Given that LDCs are exposed to the adverse impacts of climate change through climate extremes and other changes as well as their low economic status, they have little or no capacity to deal with climate change.

Although there may be a need for LDCs to participate in mitigation, it is clear that LDCs should be more concerned about adaptation to climate change. In addition, the concrete adverse effects are still largely unknown and dependent on what the developed world will do to curb GHG emissions. While LDCs have spent a lot of time compiling their national emission inventories and improving these estimates, they need to spend even more efforts on considering adaptation.

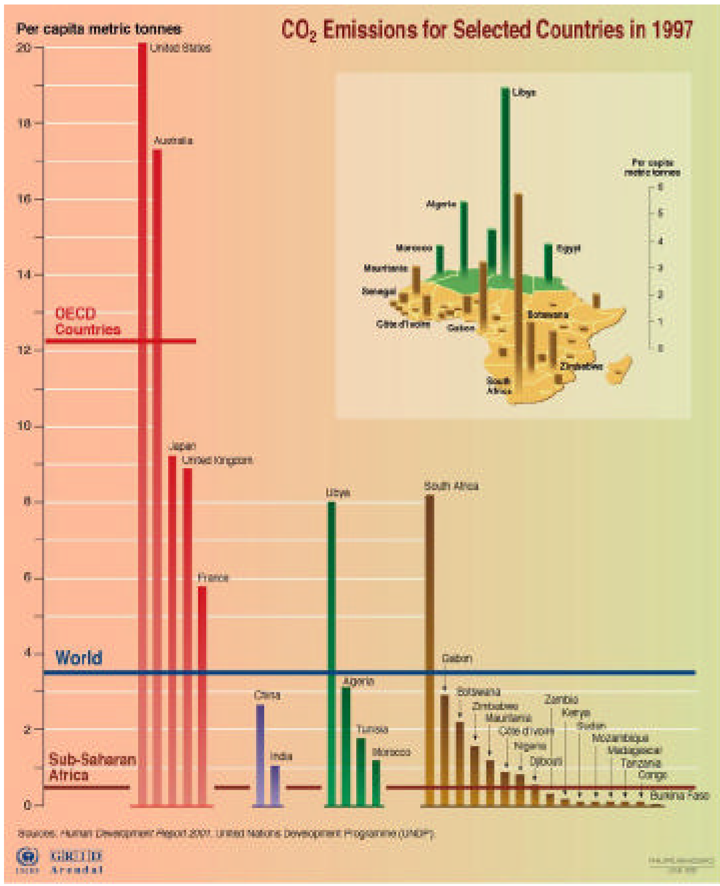


Figure 1.2. Carbon dioxide emissions by country (from UNEP, 2002: Africa Vital Graphics of Climate Change, http://www.grida.no/climate/vitalafrica)

We hope that the NAPA process will steer LDCs in this direction, and will offer them insight into how they could approach adaptation. Instead of conducting a new set of comprehensive assessments, LDCs should explore possible adaptation actions based on the following reasoning:

- there is enough knowledge about how climate is affecting and will affect critical human systems;
- we can implement some adaptation actions to address immediate and short-term needs to cope with adverse climate effects, without worrying about exact progression of climate change in the long run;

- many actions that countries can take to reduce impacts of climate change, such as adjusting cropping and managing water better, are all actions that have a fast turnover, and must continuously be revised;
- most actions will fall within a typical planning period of a few years to at most a few decades;
- practitioners in each sector have a lot to inform the adaptation process; and
- adapting to climate change will require new and additional financial resources.

Chapter 2

Least Developed Country Parties at a Glance

1. LDC Parties

In its latest triennial review of the list of Least Developed Countries in 2003, the Economic and Social Council of the United Nations used the following three criteria for the identification of the LDCs, as proposed by the Committee for Development Policy (CDP):

- a low-income criterion, based on a three-year average estimate of the gross domestic product per capita (under $750 for inclusion, above $900 for graduation);
- a human resource weakness criterion, involving a composite Augmented Physical Quality of Life Index (APQLI) based on indicators of: (a) nutrition; (b) health; (c) education; and (d) adult literacy; and
- an economic vulnerability criterion, involving a composite Economic Vulnerability Index (EVI) based on indicators of: (a) the instability of agricultural production; (b) the instability of exports of goods and services; (c) the economic importance of non-traditional activities (share of manufacturing and modern services in GDP); (d) merchandise export concentration; (e) the handicap of economic smallness (as measured through the population in logarithm); and, the percentage of population displaced by natural disasters.

To be added to the list, a country must satisfy all three criteria. To qualify for graduation, a country must meet the thresholds for two of the three criteria in two consecutive triennial reviews by the CDP. In addition, the fundamental meaning of the LDC category, i.e. the recognition of structural handicaps, excludes large economies, so a country’s population must not exceed 75 million for addition to the current list.

In the 2000 review, Senegal was included in the list of LDCs. Timor-Leste was added to the list in 2003, bringing the total number of LDCs to 50 (Figure 2.1). With regard to the 2003 triennial review of the list, the CDP concluded that Cape Verde and Maldives qualified for graduation and recommended that they be graduated from the LDC category. The CDP also concluded that Samoa was eligible for graduation in 2006. Based on the CDP report, the ECOSOC will make a recommendation to the General Assembly, which is responsible for the final decision on the list of LDCs. For updates to this information, please refer to http://www.un.org/special-rep/ohrlls/ldc/ldc%20criteria.htm.

The UNCTAD´s Least Developed Countries Report 2002 contains a statistical annex of basic data on the least developed countries, which includes 31 tables that synthesize recent data from international sources (it includes Somalia which is not a party to the UNFCCC, and does not include East Timor, which recently joined the list of LDCs). It is available online at www.unctad.org.

2. Information on LDCs: the UNCTAD Web Site

The United Nations Conference on Trade and Development (UNCTAD, www.unctad.org) has a special programme for Least Developed, Landlocked and Island Developing Countries. UNCTAD played a leading role in organizing the three United Nations Conferences on the Least Developed Countries (Paris, 1981 and 1990; Brussels, 2001).

UNCTAD promotes the socioeconomic development of LDCs through research, policy analysis and technical assistance, particularly capacity-building. It is guided by the objectives of the Programme of Action for the LDCs for the period 2001-2010 and by other intergovernmental decisions such as those of the General Assembly concerning these countries. UNCTAD serves as the main source of statistical information on the LDCs.

The UNCTAD Website provides online access to the following reports:

- LDCs Report Series
    - 2004 - Linking International Trade with Poverty Reduction
    - 2002 - Escaping the Poverty Trap
    - 2000 - Aid, Private Capital Flows and External Debt: The Challenge of financing Development in the LDCs
    - 1999 - Marginalization, Productive Capacities and the Least Developed Countries
    - 1998 - Trade, Investment and the Multilateral Trading System
    - 1997 - Agricultural Development and Policy Reforms in Least Developed Countries
    - 1996 - Selected Issues in the Context of Interdependence
- UNLDC III Conference *(Brussels, May 2001)* [includes online access to LDC National Action Plans for development for the 2000-2010 period]
- Joint Integrated Technical Assistance Programme
- Integrated Framework for Trade-related Technical Assistance

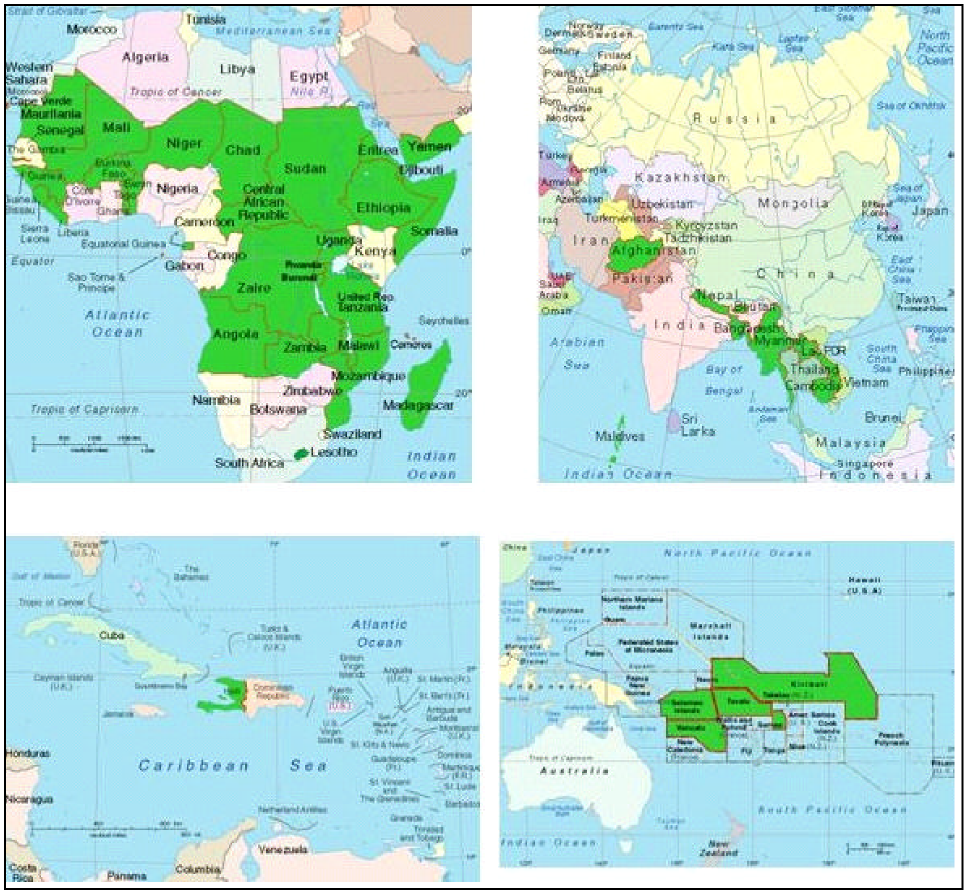


Figure 2.1. LDCs by Region

Chapter 3

The Emergence of the LDC Group Under the UNFCCC

A Brief History of the UNFCCC

In this section, we give a historical account of the emergence of the LDC group and the discussions that led to the NAPA idea. The evolution of the NAPA program is perhaps an indication of a gap that it has filled in addressing critical adaptation needs of LDCs.

Coordinated efforts to discuss and address climate change started with several world conferences. The First World Climate Conference (FWCC) was organized by the World Meteorological Organization (WMO) in collaboration with the United Nations Environment Programme (UNEP), and the International Council of Scientific Unions (ICSU; now the “International Council for Science”) in February 1979. It was attended by a wide cross-section of people. . It was clear at this time that the earth’s mean temperature was increasing. The FWCC agreed to assess the state of the global climate again in ten years. However, mounting evidence of global warming with possible serious impacts on socio-economic activities prompted the WMO and UNEP to set up the Intergovernmental Panel of Climate Change (IPCC) whose main function is to assess the state of the global climate, using available scientific research.

The Second World Climate Conference (SWCC) was held in Geneva, Switzerland in November 1990. The SWCC drew a much wider representation, including scientists (both physical and social scientists), planners and politicians. Heads of delegations to the conference were at the level of Heads of Governments and Ministers. The conference issued a ministerial declaration, which called upon the United Nations to establish a mechanism to negotiate an international treaty to combat global warming. The United Nations General Assembly responded by passing a resolution establishing the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC). The first meeting of the INC was held in February 1991 under the chairmanship of the late Monsieur Jean Ripert of France. The INC met 9 times to negotiate the United Nations Framework Convention on Climate Change (UNFCCC) and adopted it on May 9th, 1992. The Convention was opened for signature at the Earth Summit held in Rio de Janeiro, Brazil in June 1992. The Convention entered into force in 1994, and its First Conference of the Parties (COP) was held in April 1995 in Berlin, Germany. The COP meets annually to discuss progress and negotiate approaches to implement the convention. See Figure 3.1 for a timeline of the Convention process leading to the NAPAs.

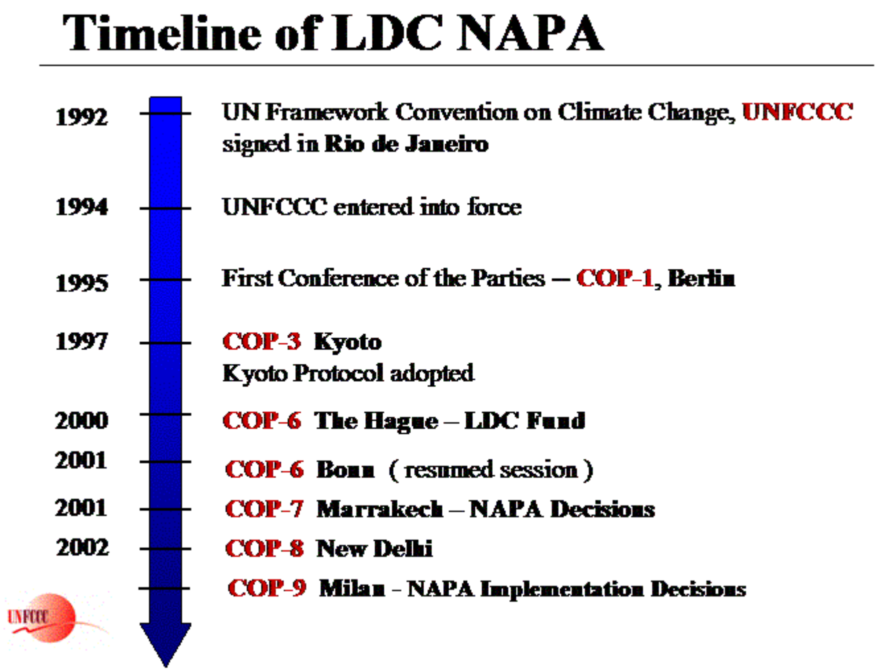


Figure 3.1. Timeline of LDC NAPA Decisions with reference to the UNFCCC

1. The Climate Change Negotiation Process

The negotiations of the UNFCCC are unique in that they include scientists and diplomats, which is due to the historical background of global warming. This was a serious disadvantage for developing countries in the early years, particularly those countries that were unable to send more than one delegate. Developing country negotiators have been requesting support for building their capacity and negotiating skills. Yet, the Group of 77 and China (G77 and China) have been achieving considerable success in furthering their interests under the process. In recent times, many negotiation training sessions have been conducted, including preparatory sessions for major topics such as the Clean Development Mechanism (CDM).

The G77 and China is a strong and well-established political negotiating group whose chairmanship rotates among its members in a predictable manner. The Chair of G77 and China chairs the group in any global negotiations irrespective of the subject and venue. The G77 and China has about 130 members. There are several regional sub groupings within the G77 and China, including: the African, the Asian, and the Latin American and the Caribbean Group. There are two other sub groupings whose members are united by circumstance: the Alliance of Small Island States (AOSIS) and the Least Developed Countries (LDCs). AOSIS has been a strong group since the initial negotiations of the UNFCCC.

The LDC group, under the climate change negotiations, operates under the ambit of the G77 and China. UNFCCC Articles of major importance to the LDCs include Article 4.8 and 4.9. Under Article 4.8 all Parties shall give full consideration including actions related to funding, insurance and transfer of technology to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and/or the impact of the implementation of response measures. Being particularly vulnerable to the adverse effects of climate change or of response measures is further specified based on physical and socio-economic characteristics in Article 4.8 and later in decision 5/CP.7 as it refers to:

a) Small island countries;
b) Countries with low-lying coastal areas;
c) Countries with arid and semi-arid areas, forested areas and areas liable to forest decay;
d) Countries with areas prone to natural disasters;
e) Countries with areas liable to drought and desertification;
f) Countries with areas of high urban atmospheric pollution;
g) Countries with areas with fragile ecosystems, including mountainous ecosystems.
h) Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products; and
i) Land-locked and transit countries.

In addition, LDCs are explicitly referenced in Article 4.9, which calls for meeting the needs of LDCs in actions regarding funding and technology transfer; and this has provided the opportunity for separate decisions concerning LDCs since COP 7.

The COP adopted the Kyoto Protocol in Kyoto, Japan in 1997. The primary objective of the Kyoto Protocol is to strengthen the commitments of developed countries, particularly the reduction of greenhouse gas emissions by an average of 5.2% below the 1990 level.

For more information about the Kyoto Protocol,
and on the latest developments under the CDM,
see http://www.unfccc.int/cdm

The Fourth Conference of the Parties (COP 4), held in Buenos Aires, Argentina in 1998, adopted the Buenos Aires Plan of Action (BAPA). The conference succeeded in defining issues and a timeframe in which unresolved issues would be addressed. The main elements of the BAPA were:-

- Financial mechanism (decision 2/CP.4 and 3/CP.4); [this notation indicates Conference of Parties (CP) decisions, where 2/CP.4 refers to decision number 2 at COP 4. All decisions and various documents about the UNFCCC can be found at http://www.unfccc.int . For those without reliable Internet access, the complete UNFCCC web sites are available on CD-ROMs, which are updated annually];
- Development and transfer of technology (decision 4/CP4);
- Implementation of Article 4.8 and 4.9 of the Convention and Articles 2.3 and 3.14 of the Kyoto Protocol (decision 5/CP4). These articles address the impacts of climate change and response measures on the economies of developing countries.
- Activities implemented jointly (AIJ) under the pilot phase (decision 6/CP4);
- The work programme on the Kyoto Protocol mechanisms (decision 7/CP4);
- Preparations for the first session of the Conference of the Parties serving as the Meeting of the Parties (COP/MOP) to the Kyoto Protocol (decision 8/CP4).

2. The LDCs and the Convention

There has been a tendency by developing country Parties to emphasize adaptation as their main concern. This may be misconstrued to imply that mitigation of greenhouse gas (GHG) emissions is less important. In fact, mitigation of GHG emissions is as important to developing country Parties, particularly to the LDCs and the small island developing states (SIDS) because of the high cost of future adaptation.

Article 4.1 commits all Parties to contribute to the stabilization of GHG concentrations in the atmosphere, in accordance with the principle of common but differentiated responsibility. This Article also commits Parties to adapt to the adverse effects of climate change. The Convention also recognizes historical contributions of developed countries to global warming and therefore urges them to play a leading role in combating climate change. The LDCs, which have contributed least to the concentration of greenhouse gases in the atmosphere, are the most vulnerable to the adverse effects of climate change because of their limited capacity to fund adaptation activities.

3. The Need for Urgent Actions

There are many adverse effects of climate change (in its broadest sense to include changes in trends, variability and extremes) that present particular challenges to LDCs. Climatic natural disasters, in particular, affect the pace of economic growth and destroy the assets of the poor segments of the population in affected areas, reducing them to a state of dependency, at least temporarily, on donations. Therefore, measures aimed at reducing these risks are of utmost importance (for example, the Mozambique Plan for the Reduction of Absolute Poverty). Since the mid-1970s, extreme weather events such as floods, landslides and droughts, as well as El Niño events have become frequent and intense, with serious consequences for socio-economic activities Figure 3.2 shows the increasing trend in droughts for Uganda. The trend for other countries is similar. In all these cases, the poor are affected the most, given their low capacities to deal with the unexpected.

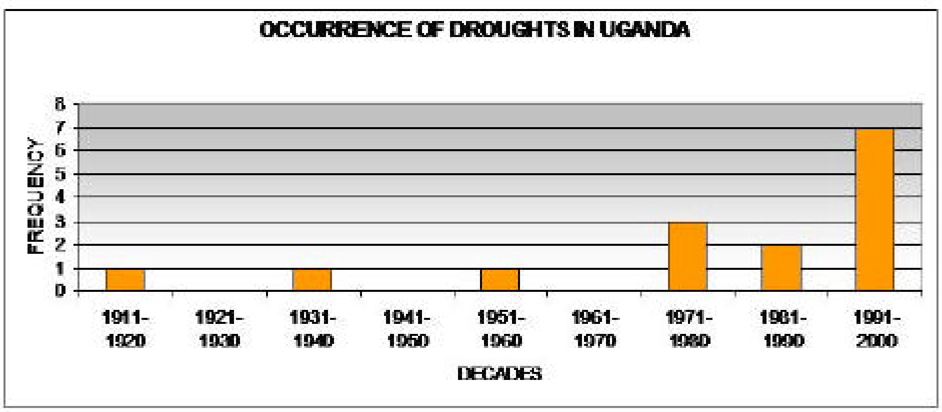


Figure 3.2. Occurrence of Droughts in Uganda (Source: Uganda Department of Meteorology)

While the physical effects are very obvious, there is also considerable personal and psychological trauma associated with climate disasters when family members and property are lost.

Most people in LDCs are inherently vulnerable because their survival is dependent on the environment and therefore their livelihoods are highly sensitive to sudden shocks and changes in physical conditions. Unpredictable weather patterns and climatic conditions, characterized by unusually heavy and erratic/unreliable rains, lead to crop and infrastructure damage, causing food insecurity in addition to loss of life For example, as a result of the hurricanes in September 2004 in the Atlantic Ocean/Caribbean Sea, there was a much higher loss of life in Haiti, compared to the other islands that were also affected (see Box 3.1).

Box 3.1. Update provided on September 20th, 2004 about the hurricanes in the Caribbean and the differential impacts on Haiti

The month of September 2004 saw several major storms and hurricanes in the Atlantic Ocean/Caribbean Sea. By Monday September 20th, more than 600 people had died in massive floods that raged across northern Haiti after Tropical Storm Jeanne hit this crushingly poor Caribbean nation, while 18 people were killed in other Caribbean islands, according to a report by Agence France-Presse on 20 Sept 2004 (http://www.reliefweb.int/w/rwb.nsf/UNID/9DB7C040AEB4967A49256F16000A0EF5?OpenDocument).

Prime Minister of Haiti Gerard Latortue, who declared three days of national mourning, flew over a flooded area by helicopter describing it as a "vast sea." "There is not one house in the city of Gonaives that is not flooded," Latortue said, adding that 80 percent of the population there, or 80,000 people, need food (see Figure 3.3 showing a remote sensing image of Gonaives, before and after the flooding). For several days, authorities were without news from the country's second largest island, La Tortue. MINUSTAH officials could not find the island of 26,000 people while flying over the region by helicopter on Sunday the 19th September.

In neighboring Dominican Republic, at least seven deaths were blamed on Jeanne. Storms in May 2004 left at least 1,500 dead when floods swept through the border area between the Haiti and the Dominican Republic. Jeanne also left nine dead in the Bahamas and two in Puerto Rico.

The final death tall in Haiti from tropical storm Jeanne in September 2004 was more than a thousand, and with another thousand missing, two thousand injured and about 300 thousand affected (www.reliefweb.int OCHA situation report no. 13, 28 September 2004). See Figure 3.4. After the four weeks of flooding and landslides, almost two thousand people lost their lives in Haiti.

A few weeks previously, Ivan first menaced the Caribbean island of Tobago on September 7 before pounding Grenada, Barbados, Venezuela, the Dominican Republic, Jamaica, Cuba, and the Cayman Islands, leaving 70 dead. Grenada alone suffered 37 deaths when Ivan pummeled it on September 8.

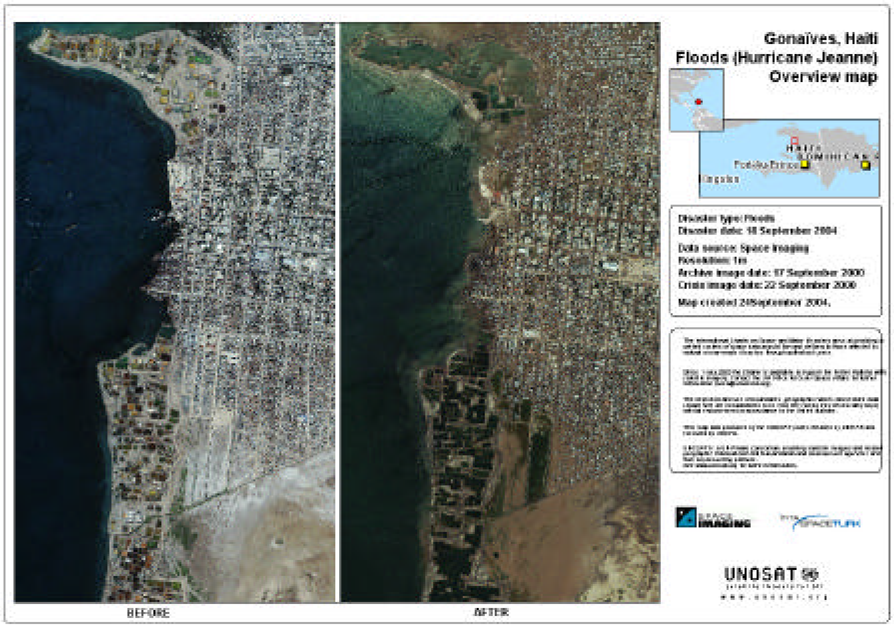


Figure 3.3. A remote sensing image of Gonaives, before and after (source: www.reliefweb.int)

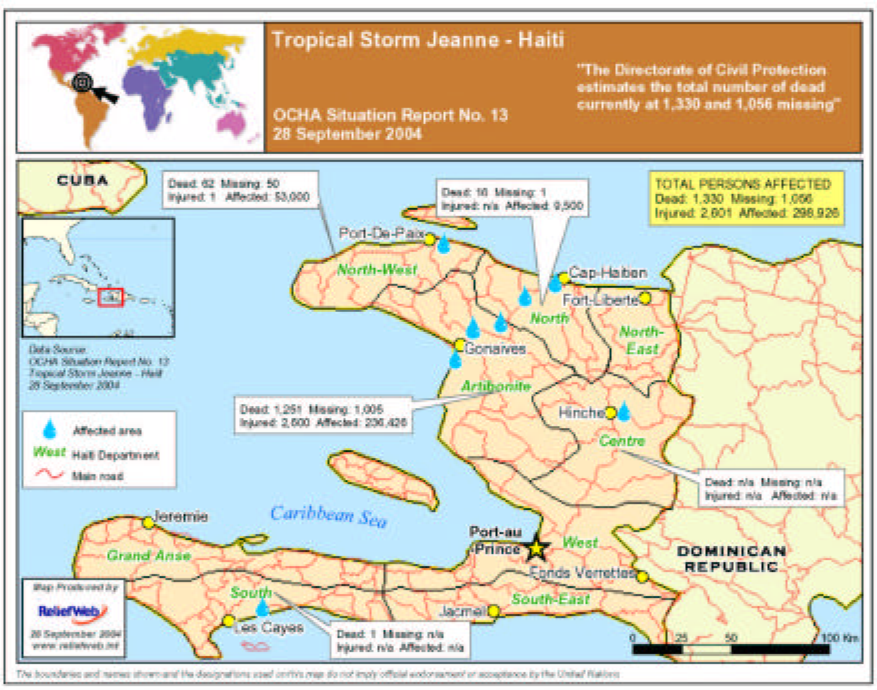


Figure 3.4. Tropical storm Jeanne – Haiti, September 2004

On September, 9th, the hurricane arrived at the US Gulf Coast, packing winds of up to 215 kilometers per hour (135 miles an hour), wrecking houses and buildings and causing widespread flooding. Ivan spawned tornadoes and left floods in its wake, killing at least 38 people across a massive swath of the United States from Louisiana on the Gulf Coast to Maryland, a small mid-Atlantic state adjacent to the US capital, to Connecticut, north of New York**.**

The LDCs have fragile ecosystems and economies as well as weak institutional frameworks and infrastructure. Their economies are dependent on exploitation of natural resources which are sensitive to climate variability and climate change. As a result, the LDCs are vulnerable to both economic and physical shocks. Such shocks destabilize their development programmes. Climate Change is a critical issue for LDCs, which threatens to disrupt and freeze their development efforts thus undermining efforts to eradicate poverty. It is in this context that the LDCs sought to operationalize Article 4.9 of the Convention.

4. The Emergence of the LDC Group

Article 4.9 of the Convention is the only article which makes explicit reference to LDCs. The LDCs have contributed least to global warming and yet available scientific information indicates that the LDCs will take a disproportionate toll of adverse effects of climate change. If the UNFCCC were to be rewritten now, there would probably be more articles on the LDCs given everything we now know about adaptive capacity and adverse effects of climate change. .

Article 4.9 calls upon all Parties to give special consideration to LDCs in their actions relating to funding and technology transfer. Hitherto accessing financial resources has been on equal basis with other developing countries. A cursory look at the distribution of funding and projects funded through the GEF clearly show the LDCs way behind in their ability to access funding. In June 2000 at the meeting of the Subsidiary Bodies, the LDCs proposed a separate decision to operationalize Article 4.9. Since the proposal was initially not supported by the G77 and China, the LDCs formed a group to promote their interests, and the concept of national adaptation programmes of action under the UNFCCC was initiated.. In other UN fora, the LDC group is well established and active.

The years 1999 and 2000 preceding COP 6 witnessed very intensive negotiations at both technical and high levels. The Presidents of COP 5 and the COP 6 President-Elect, worked tirelessly to accomplish the BAPA. Climate change negotiators and environmentalists saw COP6 as the climax for concluding the BAPA. The Subsidiary Bodies, which normally meet twice a year, had an extraordinary meeting in September 2000 in Lyons, France. A preparatory meeting of the African Group and G77 and China met in St. Etienne, France, preceding the Lyons meeting. It was hoped that the gaps among the negotiating groups would be narrowed prior to COP 6.

At a meeting of the African Group (within the G77 and China preparatory meeting), the LDCs tabled their proposal for a separate decision on the operationalization of Article 4.9. Although a large number of LDC Parties come from Africa, garnering support for the LDCs proposal was difficult.

At the Lyons meeting, the LDCs formed their regional group and elected Vanuatu as ChairThe LDC group did not have its proposal formulated in draft and legal text, and therefore requested the Subsidiary Body for Implementation (SBI) to authorize the organization of a workshop where the LDCs would formulate their position on implementation of Article 4.9. The SBI requested the secretariat to organize an LDC workshop in Geneva, Switzerland to enable the LDCs to formulate their position. The thrust of the LDC proposal was institutional capacity building as well as the preparation and implementation of national adaptation programmes of action (NAPAs). In general, many developed countries were supportive of the LDC views and willingly offered to fund the workshop.

Chapter 4

The Idea of NAPAs

1. Introduction

The normal channel for any country to communicate information to the Conference of Parties is through the national communication of a Party. National communications are elaborate time-intensive documents, presenting an inventory of greenhouse gases as well as other information regarding vulnerability and adaptation. They are therefore not designed for communicating urgent and immediate issues. The occurrences of extreme weather and climate events made it clear that climate change is a reality, particularly after the floods in Mozambique in 1999/2000. To facilitate rapid communication of their urgent needs, the LDCs developed a new mechanism, the National Adaptation Programme of Action (NAPA). The LDCs advanced the idea of NAPAs as the primary mechanism for operationalizing Article 4.9. The concept of NAPAs was subsequently developed through a series of meetings and workshops, and through the COP process as described in the following sections.

While NAPAs are limited to LDCs, their success has potential for other countries in the future, and so their preparation and implementation constitutes an important learning process for the UNFCCC process.

2. The LDC Geneva Workshop

A workshop was organized by the UNFCCC Secretariat in Geneva in October 2000. The main focus was to develop a textual proposal containing the LDC ideas tabled at the Subsidiary Bodies meeting in Lyons, France that year. Several LDCs and some developed countries attended the meeting, which focused on the following:

- Preparation and implementation of NAPAs;
- Institutional capacity building;
- Idea for an LDC Expert Group to advise on the preparation and implementation of NAPAs; and
- A proposal for an LDC fund to support the above activities.

The most difficult issue was the notion of establishing an LDC fund. Many developed countries argued that there was no need for a specific LDC fund, while the LDCs argued that there was a need for a separate basket for LDCs to meet their specific needs. The output of the workshop was legal text containing the LDC position, which was submitted to COP 6. This formed the basis of the negotiations for COP 6 and subsequent sessions.

Prior to COP 6, the President-Elect H.E. Jan Pronk convened a high level informal consultation in October 2000 at The Hague, the Netherlands. Although this meeting focused on the arrangements for COP 6, it discussed other key issues. The Chair of G77 and China, the Nigerian Minister of Environment, H.E. Mr. Mohammad Kabir SA'ID, called on other Parties to support the LDC position. He explained that the emergence of the LDC group was a clear manifestation that his group did not fully take into account their concerns. This political support from the Chair of G77 and China sent a strong message to the group.

3. The Sixth Conference of Parties in 2000

The Sixth Conference of the Parties held at The Hague, Netherlands in November 2000, was expected to make demonstrable progress in the implementation of the Bueno Aries Plan of Action (BAPA), and so, there were high expectations at COP 6. The structure of these negotiations was different. When the technical segment ended, the Ministers took over the negotiations of fairly complex and technical issues but could not make substantial progress. Ministers were designated by the President to chair negotiations on various issues. The LDC issues were chaired by the Danish Minister of Environment. Although he worked very hard to advance the negotiations, very little progress was made. By the last day of COP 6, there were still many differences in the various positions.

Unlike many negotiations where issues can be resolved individually, elements of the BAPA were to be concluded as a package deal. Despite the efforts invested in the negotiations by many ministers, it became quite clear that the negotiations of BAPA elements could not be concluded at The Hague. It was frustrating for a lot of people. The COP 6 was not able to complete its work, and it decided to suspend the session and requested the President of COP 6 to resume it in May/June 2001.

4. The Resumed COP 6

The resumed session of COP 6 (COP6-*bis*) was held from 16th to 27th July 2001 in Bonn, Germany. The lessons of COP 6 were still fresh and were therefore taken into account. It was quite clear that some of the issues required political solutions.

The resumed COP 6 did not strictly follow the normal pattern of technical sessions followed by a high-level segment. The first three and a half days were devoted to preparations for the high-level segment. Then the following three days were devoted to a high-level segment. The second week was again left for the technicians to complete the work. The issues under the negotiations were grouped into the following:

- Financial issues – this group included all issues which require financial inputs for their implementation;
- The Kyoto mechanisms;
    - Clean development mechanism;
    - Emissions trading; and
    - Joint implementation;
- Compliance with commitments of the Kyoto Protocol; and
- Land-use, land-use change and forestry.

The decisions on the Kyoto Protocol mechanisms and inclusion of land-use, land-use change and forestry (LULUCF) for complying with the Kyoto Protocol targets were viewed by developed country Parties as very important, necessary and key for promoting ratification of the Kyoto Protocol. The pulling out of the United Sates from the Kyoto Protocol led to additional demands by developed country Parties for the relaxation of rules on the use of the Kyoto Protocol mechanisms and LULUCF.

The high-level segment focused on the political issues. The ministers debated these issues in plenary and then further consultations were carried out by groups of ministers designated by the President of the COP. Then the President of the COP developed a political agreement based on the output of the consultations carried out by the smaller groups of ministers and reactions of ministers in the plenary. This text provided the basis for the political negotiation. Unlike in COP 6 at The Hague, where the issues of the LDCs were under a specific chair, COP 6-*bis* discussed them under financial issues. The LDC ministers of environment sought audience with the President and discussed the LDC issues. The President requested a short text on the key issues for his consideration. This was done, and the LDC issues appeared in the political agreement of COP 6-*bis*.

The political agreement covered issues of interest to both developing and developed country Parties. It formed the basis for completing the BAPA negotiations. This achievement was largely due to the political agreement at the resumed session of COP 6. Negotiations at both the resumed COP 6 and the Seventh Conference of the Parties (COP 7) were confined within the integrity of the Bonn political agreement. The following elements of the BAPA were concluded at the resumed session:

- Capacity building for both developing countries and countries with economies in transition;
- Development and transfer of technology;
- Impacts of adverse effects of climate change and impacts of response measures by developed countries on economies of developing countries;
- Guidance to the financial mechanism of the Convention (the Global Environment Facility); and
- Joint implementation – a mechanism of the Kyoto Protocol.

Negotiations on the following issues could not be completed:

- Land-use, land-use change and forestry;
- Clean development mechanism and emissions trading;
- Reporting under Articles 5,7 and 8 of the Kyoto Protocol;
- Actions to support urgent adaptation activities in LDCs; and
- Compliance with provisions of the Kyoto Protocol.

The establishments of three funds (Special Climate Change Fund, Least Developed Countries Fund, and the Adaptation Fund) were part of the political agreement. Even at this point in time, the NAPAs were not concluded as yet although the principle was accepted. They were further negotiated at COP 7.

5. The Least Developed Countries Fund (LDCF)

The LDCF is a special fund to meet special concerns and needs of the LDCs. The LDCs recognized the need to develop an integrated approach to addressing the adverse effects of climate change. The LDCs conceived the national adaptation programmes of action (NAPAs) as a strategy to mitigate their urgent needs arising from the impacts of climate change in an integrated manner. The LDCF was proposed to cover a work programme for LDCs, which includes the following main activities:

- Preparation and implementation of NAPAs;
- Strengthening climate change secretariats and focal points;
- Training in negotiating skills and language;
- Promotion of public awareness;
- Developing and transfer of technology.

Chapter 5

Development of the LDC NAPA

1. Introduction

The technical design of NAPAs begun during a workshop organized by the UNFCCC secretariat in April 2001 in Kampala, Uganda. A subsequent meeting in the Maldives in September refined proposals for the NAPA process, and these were used as the basis for negotiation at COP-7 in Marrakech, Morocco during November-December 2001. These and other critical steps in the development of the NAPAs as a programme under the UNFCCC are discussed below.

2. The Kampala LDC Workshop

In order to prepare for discussions of Article 4.9 at COP 7, the UNFCCC Secretariat convened a workshop in April, 2001 in Kampala, Uganda, to design the elements of the NAPA. A consultant paper was prepared as input to this workshop (Desanker, 2001). The workshop was attended by experts from LDCs and non-LDC developing countries as well as from Annex II countries. Other invited papers were presented to broaden the experience to Small Island Developing States (SIDS) and related issues from the Convention to Combat Desertification (CCD). The workshop was very successful in formulating core elements of the NAPA guidelines.

This was the year after the 2000 floods in Mozambique (See Box 5.1). The impacts of this flood on Mozambique's economy, development plans and on the rural poor were still very vivid to many workshop participants. A sample NAPA presented at the Kampala workshop demonstrated a possible final structure for a NAPA using Mozambique as an example (see Box 5.2). The full background paper and presentation is available at http://www.NAPAPrimer.org/kampala. The results of the Kampala workshop were presented at the SB meetings in June of 2001 (FCCC/SBI/2001/7). A few months later, a meeting was convened in Male, the Maldives to further refine the LDC proposals to serve as a basis for negotiation at COP.

Box 5.1: Impact of the 2000 and 2001 floods in Mozambique

During the early months of 2000 and 2001, Mozambique experienced severe floods that threatened its successful economic growth. The floods were caused by a combination of heavy rains in the water catchments areas of the major rivers (Limpopo, Save, Pungue, etc), combined with storm surges from the Indian ocean onto the coastal areas.

Mozambique and its neighbours experienced heavy rainfall in December 1999 and February 2000 that raised water levels in rivers to unprecedented levels. When Cyclone Eline hit the region in late February, the most severe flooding in 100 years was experienced in three of Mozambique's river basins. In April 2000, Cyclone Hudah also hit Mozambique's coastal areas of Nampula and Zambesia. The 2000 floods caused significant damage to the southern and central regions of Mozambique. Two million Mozambicans (about 12% of the population) were affected by the storm, including about 700 who lost their lives and almost 250,000 who lost their homes. Over 20,000 cattle disappeared and about 11% of the country's cultivated and grazing lands were destroyed, causing over 113,000 small farm households to lose their livelihoods. Ninety per cent of Mozambique's functioning infrastructure and irrigation systems were damaged. Many bridges and secondary and tertiary roads were washed away, and all of the railroads in southern Mozambique were badly damaged.

The following year, heavy seasonal rains again caused widespread flooding in central and northern Mozambique in mid-February 2001. The resulting floodwaters covered twice the land surface of the 2000 floods, affected more than 540,000 people, and caused over 50 deaths. The 2000 floods significantly reduced Mozambique's real GDP growth—to 2.1% in 2000 compared to 7.5% in 1999 and 12.1% in 1998. International financial assistance of $471 million combined with the limited impact of the floods on the country's business sector and on investor confidence enabled Mozambique to recover in 2001 and experience economic growth rates of about 10%. Although Mozambique's economy has recovered from the floods of 2000 and 2001, hundreds of thousands of people, particularly in the rural areas, continue to rebuild their livelihoods and communities. This task was made difficult by droughts affecting the southern Africa region.

Sources:
Australian Department of Foreign Affairs and Trade. www.dfat.gov.au/geo/fs/moza.pdf
United Nations Development Programme.
www.undp.org/upa/frontpagearchive/2001/july/20july01/
AFROL.com. http://www.afrol.com/News/moz003_flood_economy.htm
KPMG. www.kpmg.co.mz/articles-engl/floods.htm
United Nations Children's Fund. http://www.unicef.org/emerg/Mozambique22Jun01.PDF

Box 5.2. Sample NAPA activities proposed for Mozambique as presented at the Kampala Workshop, Uganda in April 2001

The following urgent needs and activities were suggested during the Kampala workshop in 2001 to demonstrate the type of activities that a NAPA might contain.

(a) Flood risk mitigation in the lower Zambezi delta

Support would be requested to implement a number of activities that would help adapt to future floods (and other climate related disasters) such as:

- improvements in food storage and distribution, including seed
- provision of emergency facilities such as health and water supplies
- installation of alternate power sources for critical facilities such as hospitals and schools
- securing of storage of national cultural icons, as well as develop an inventory of those icons that can not be moved to safer ground.

It was estimated that some of these activities would reduce number killed by more than half, and would reduce costs of recovery, as well as safeguard national and cultural resources.

(b) Emergency Action Plan for the Zambezi River Basin in southern Africa in relation to Lower Zambezi

Analysis showed significant threats from flooding due to heavy rains in a number of areas outside of Mozambique combined with dam operations to release water in Zambia, Zimbabwe and Malawi through the Lake Kariba, Lower Shire in Malawi and Cahora Bassa dams in Tete, Mozambique. There were currently no plans in place to communicate dangers to the inhabitants of lower Zambezi (some warnings would possibly be sent to Maputo (the capital of Mozambique in the southern tip of the country), but there was no mechanism to communication directly with those actually exposed to the risks in the flood plain).

Experiences in the Limpopo River basin during 2000, showed significance of local perceptions and reactions to government pronouncements – news of impeding disaster was not enough by itself to make people evacuate. This necessitates response plans to be developed jointly with local communities.

Funding would be requested to call meetings and to develop an emergency action plan that would be jointly owned and operated by the operators of the Lake Kariba, Cahora Bassa Dam and Lower Shire management along with the inhabitants of lower Zambezi.

(c) Early Warning System for Extreme Weather Events: Weather radar and communication network along the Mozambique coast and around the capital, Maputo.

There was limited capacity to track adverse weather. Request would be made to install a weather radar system and a communications network between the Meteorological Services and the communities at risk (all people in flood plains and along coastal areas).

Update:

Although the above activities were purely hypothetical at the time, these ideas were in fact implemented by bilateral donor programmes to address these major adaptation needs for an early warning system and a monitoring system for floods along the major rivers such as the Limpopo, flowing into Mozambique.

3. The Seventh Conference of Parties (COP 7)

The agenda of COP 7 focused on the remaining elements of the BAPA and also on completion of the LDCs issues. The details of the NAPA including the guidelines for the preparation of NAPA, the LDC fund and the LDC expert group (LEG) were negotiated and completed at COP7. The contents of the political agreement brokered at COP6-*bis* were preserved. This facilitated the conclusion of the BAPA and hence the results of COP7, the Marrakech Accords. Decision 5/CP.7 established a work programme for implementation of Article 4.9 of the Convention, including the preparation of NAPAs (see Box 5.3).

Box 5.3. The LDC Work Programme

The LDC work programme includes the following, as specified in Decision 5/CP.7 (**http://unfccc.int/resource/docs/cop7/13a01.pdf#page=32**):

(a) Strengthening existing and, where needed, establishing, national climate change secretariats and/or focal points to enable the effective implementation of the Convention and the Kyoto Protocol, in the least developed country Parties;

(b) Providing training, on an ongoing basis, in negotiating skills and language, where needed, to develop the capacity of negotiators from the least developed countries to participate effectively in the climate change process;

(c) Supporting the preparation of national adaptation programmes of action (NAPA);

(d) Establishment of a least developed country group of experts to support preparation and implementation of NAPA;

(e) Capacity building; and

(f) Technology transfer.

[END BOX]

4. Future Challenges for the LDCs

While the emergence of the LDC group has been well received by many people involved in the climate change process, enormous efforts are required to translate the decisions into tangible benefits to justify the expenditure (efforts and financial). At the Lyon, France meeting of the Subsidiary Bodies, Michael Zammit Cutajar (first executive-secretary of the UNFCCC) said that the formation of the LDC group was overdue. The emergence of the LDC group has also reinvigorated the zeal and determination of LDC negotiators to put more efforts into the process. There is need to capitalize on this momentum and spirit for subsequent negotiations.

The biggest challenge now is how to translate the LDC and other COP decisions into actions on the ground to directly influence the people in LDCs. There is likely to be inertia to continue planning and modifying policies, but it is important that concrete actions are taken to contribute to poverty alleviation and economic development, now rather than later.

There are many barriers to the successful implementation of NAPAs, including paucity of climate and hydrological information. Despite repeated appeals for improvements in observing systems, very little, if anything, has changed on the ground. This is likely to impede successful identification of adverse effects and subsequent adaptations. Almost every COP and IPCC report includes references to the need for improvements in observational systems. Little has been done to improve the situation, in spite of the fact that the cost for automated weather stations is in the order of a few thousand dollars if not less.

Implementation of the Convention at the country level will require different actors because climate variability and climate change will affect programmes of many sectors including the financial sector. Many of these sectors may argue they have very little to do with climate. Convincing policy-makers and legislators in LDCs to see the potential threat of climate change is seen as an important step, although most countries appear to have gone beyond these first stages of awareness.

Another challenge will be to overcome logistical problems of accessing funds for the preparation of NAPAs in a timely fashion. Many countries are involved in several enabling activities, which require a lot of human resources and time to complete. Given the urgency of implementing NAPA projects, it is hoped that NAPAs would not fall into the same bureaucratic trappings of other projects.

There is no doubt that the NAPAs have led to significant advances in how we look at adaptation, including recognizing local coping strategies, the role of indigenous knowledge and technology systems, as well as the need to address transient effects of climate variability versus climate change. The LDC fund, however, does not have access to large financial resources, and is likely to need supplementation from other sources of funding, particularly for large infrastructure projects that may be defined in NAPAs.

Given the delays in NAPAs preparation, it should be assessed how far NAPAs as adaptation plans should cover a full portfolio of adaptation needs versus concentrating on urgent and immediate needs only. It is important that LDCs address all their needs to adapt, given the seriousness of some of the adverse effects they have already started to suffer.

Chapter 6

Adverse Effects of Climate Change

1. Introduction

The climate change community is grappling with large uncertainties in climate change projections, which are derived from general circulation models (GCMs) and variants thereof at smaller scales, and with the need to plan adaptation activities. While there may appear to be an increasing frequency of climatic extreme events, it is not yet possible (and probably not in the near future) to attribute many of these events to a changing climate beyond random events or climate variability. This is an area of active research, and improvements in modeling and in analyzing past observed data will likely improve our ability to attribute events to climate change in the future. In the meantime, learning to deal with climate variability is a generally accepted strategy to build capacity to adapt to long-term climate change. We will discuss later how this can be accomplished, while ensuring that implemented measures are not counterproductive in the long run.

2. Observed Impacts

The IPCC (IPCC Third Assessment Report, IPCC 2001; hereafter the TAR) has concluded with high confidence, that climate will and is already changing, and that there are already some observable indicators , . These include the "shrinkage of glaciers (see Figure 6.1); thawing of permafrost; shifts in ice freeze and break-up dates on rivers and lakes; increases in rainfall and rainfall intensity in most mid- and high latitudes of the Northern Hemisphere; lengthening of growing seasons; and earlier flowering dates of trees, emergence of insects, and egg-laying in birds" (IPCC TAR WGII TS, Section 7.1).

The attribution of any observed impact is also severely confounded by other factors such as land use change, pollution, land degradation, socio-economic factors, etc. At a broader scale, the IPCC was unable to compile similar lines of evidence for impacts associated with altered precipitation patterns, because it is difficult to model precipitation changes under global warming. Climate models cannot reproduce climatic patterns at the sub-regional level especially in terms of patterns of climate variability – GCMs in fact tend to underestimate decadal variability in rainfall for Africa (Hulme, et al. 2001)

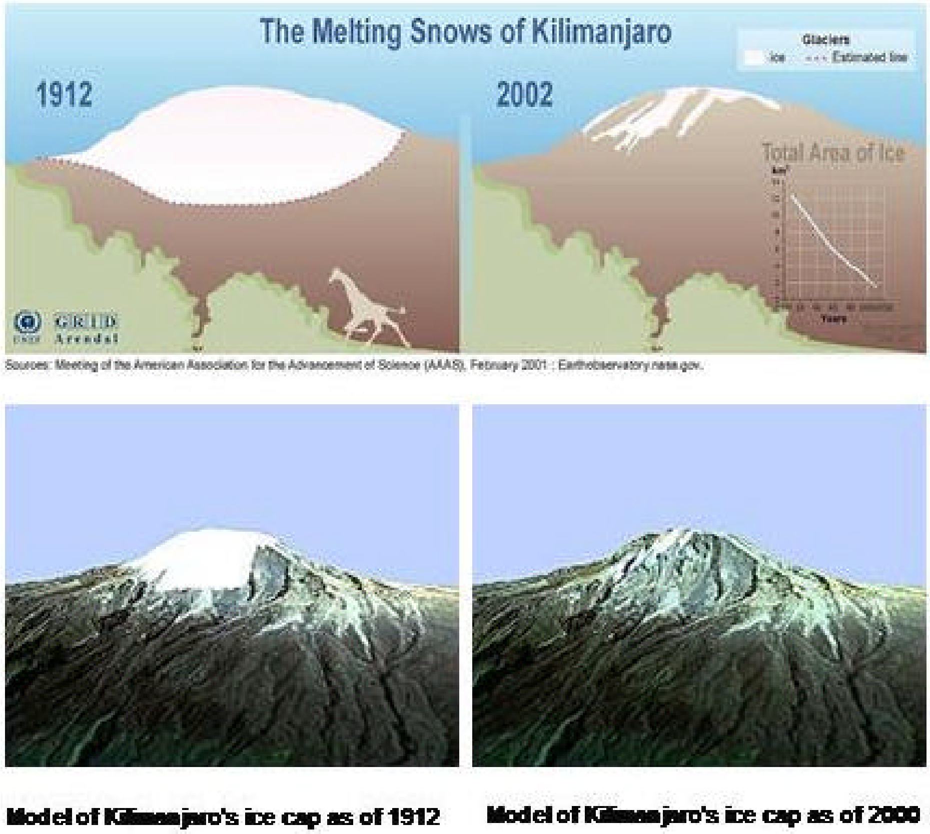


Figure 6.1. The melting snows of Kilimanjaro

Source:
- the top artist impression of the snows of Kilimanjaro are based on data from the Meeting of the American Association for the Advancement of Science (AAAS), February 2001; http://earthobservatory.nasa.gov).
- 1912: Fritz Klute, "Karte der Hochregion des Kilimandscharo-Gerbiges" (scale 1/50,000)
- 2000: Landsat ETM image taken on 29 January 2000 and aerial survey done on August- September 2001

The DEM by Janet Akinyi based on all the contour lines digitized from topomaps at scale 1/50,000
- The draped image is true colour composition (bands 3,2,1) of the Landsat image.

(Courtesy: Christian Lambrecht, UNEP); available as part of the Africa Vital Climate Change Graphic by UNEP at http://www.grida.no/climate/vitalafrica/english/03p.htm

While the IPCC TAR lines of evidence cover all continents, for Africa they only include the shrinking glaciers in East Africa (see Figure 6.1), which can be linked to increasing temperatures associated with global climate change. This is due to a lack of long-term observations in Africa (and other developing countries for that matter) that would satisfy the scientific rigor required to attribute an observation to climate change. It has been emphasized many times that the lack of climate observational systems in developing countries is hindering progress in climate change research. The IPCC also concluded that "signals of regional climate change impacts are expected to be clearer in physical and biotic systems than in social and economic systems, which are simultaneously undergoing many complex non-climate-related stresses, such as population growth and urbanization" (IPCC TAR WGII TS, Section 7.1). Observations are also missing for social and economic systems, where data on costs and (benefits) is very limited.

3. Climate Change and Extreme Events

The IPCC was able to make general statements on how climate variability and climatic extremes may change in the future, and how in general conditions might deteriorate (see IPCC Table TS-2, reproduced below as Tables 6.1 to 6.6. See also Figures 6.2-6.8 for examples of observed effects of climatic change).

Table 6.1. From IPCC Table TS-2: Examples of impacts resulting from projected changes in extreme climate events.

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts**[b] *(all high confidence of occurrence in some areas*[c]*)*
Simple Extremes	
Higher maximum temperatures; more hot days and heat waves[d] over nearly all land areas (Very Likely[a])	• Increased incidence of death and serious illness in older age groups and urban poor • Increased heat stress in livestock and wildlife • Shift in tourist destinations • Increased risk of damage to a number of crops • Increased electric cooling demand and reduced energy supply reliability
[a] Likelihood refers to judgmental estimates of confidence used by TAR WGI: very likely (90-99% chance); likely (66-90% chance). Unless otherwise stated, information on climate phenomena is taken from the Summary for Policymakers, TAR WGI. b These impacts can be lessened by appropriate response measures. c Based on information from chapters in this report; high confidence refers to probabilities between 67 and 95% as described in Footnote 6 of TAR WGII, Summary for Policymakers. d Information from TAR WGI, Technical Summary, Section F.5.[e] Changes in regional distribution of tropical cyclones are possible but have not been established.	

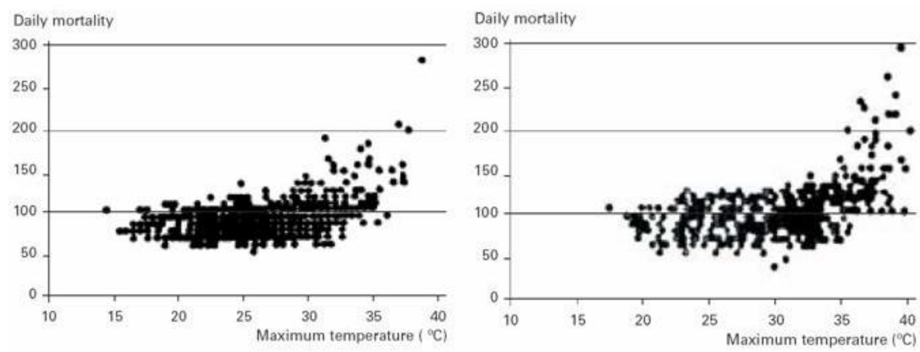
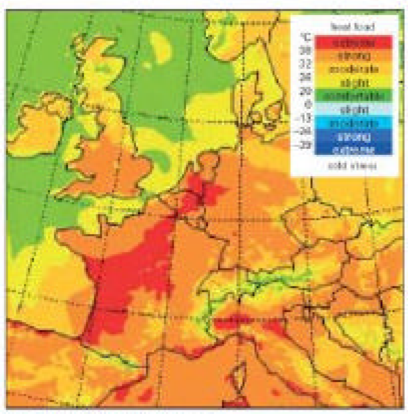


Figure 6.2. Number of fatalities as a function of the maximum temperature. The number of deaths increases enormously at elevated temperatures. Source: McMichael et al., 1996. Clmate Change and Human Health, WHO/WMO/UNEP (source: TOPICSgeo, 2004).

Map of perceived temperatures in Europe on 8 August 2003



Service: German Weather Service

Victims of the hot summer of 2003 in Europe

	Fatalities
France	14,800
Spain	2,000
Portugal	1,300
Italy	4,000
Germany	3,500
United Kingdom	900
Netherlands	500

Snapshot of perceived temperatures in Europe on 8 August at the peak load time (1 p.m.). Paris was in the extreme zone for days and recorded by far the largest number of victims. The figures published on numbers of victims varied widely from country to country and were not always easy to verify. The figures quoted in the table reflect the best estimates of ministries and state statistical offices at the end of the year.

35

Figure 6.3. Perceived temperature in Europe on 8 August at the peak load time (1 p.m.). Paris was in the extreme zone for days and recorded the largest number of heat wave victims (Source: TOPICSgeo, 2004; based on Muniche Re, 2004)

Although the above figures show the tragic effects of heat waves on human life in non-LDCs, they highlight the potential for disastrous effects even in developed countries that presumably have a much higher capacity to cope with climatic events like this.

Table 6.2. From IPCC Table TS-2: Examples of impacts resulting from projected changes in extreme climate events

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts**[b] *(all high confidence of occurrence in some areas*[c]*)*
Simple Extremes	
Higher (increasing) minimum temperatures; fewer cold days, frost days, and cold waves[d] over nearly all land areas (Very Likely[a])	• Decreased cold-related human morbidity and mortality • Decreased risk of damage to a number of crops, and increased risk to others • Extended range and activity of some pest and disease vectors • Reduced heating energy demand
(see Table 6.1 for footnotes)	

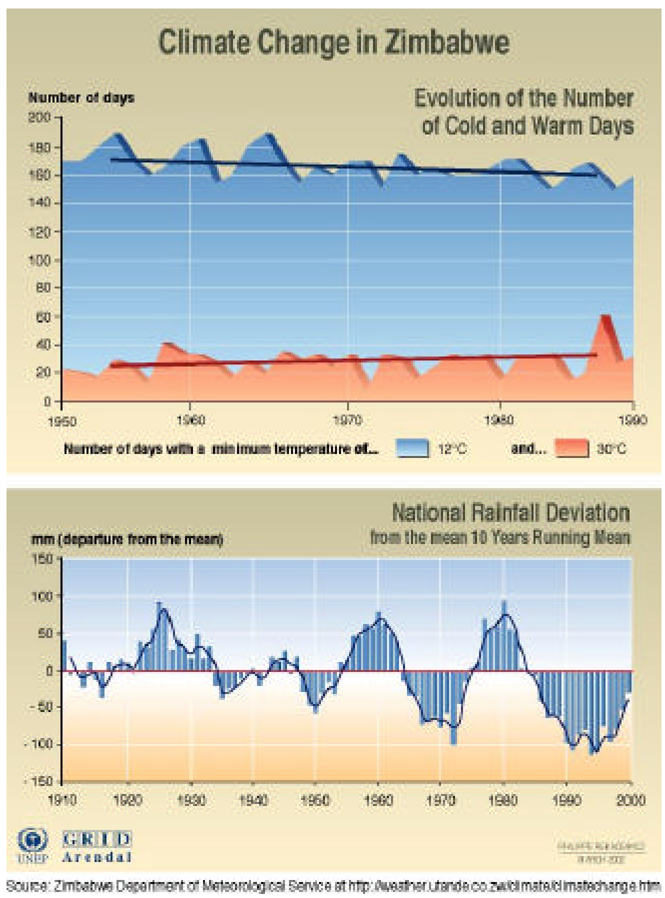


Figure 6.4 Climate change in Zimbabwe showing evolution of number of cold and warm days (source: Africa Vital Climate Graphics, www.grida.no/climate).

Table 6.3. From IPCC Table TS-2: Examples of impacts resulting from projected changes in extreme climate events

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts**[b] *(all high confidence of occurrence in some areas*[c]*)*
Simple Extremes	
More intense precipitation events (Very Likely[a] over many areas)	• Increased flood, landslide, avalanche, and mudslide damage • Increased soil erosion • Increased flood runoff could increase recharge of some floodplain aquifers • Increased pressure on government and private flood insurance systems and disaster relief
(see Table 6.1 for footnotes)	

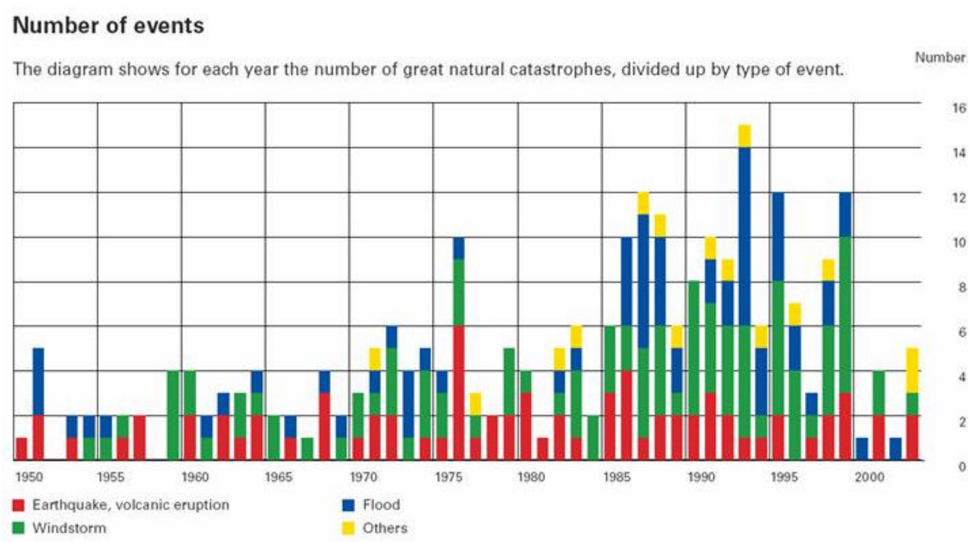


Figure 6.4. Number of great catastrophes by type and by year (source: Muniche Re, 2004).

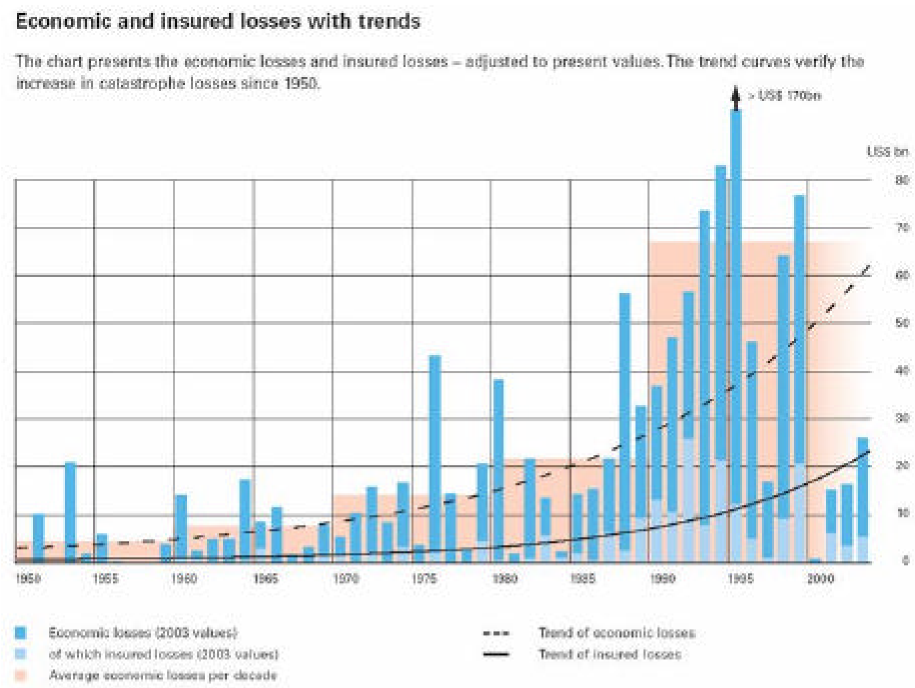
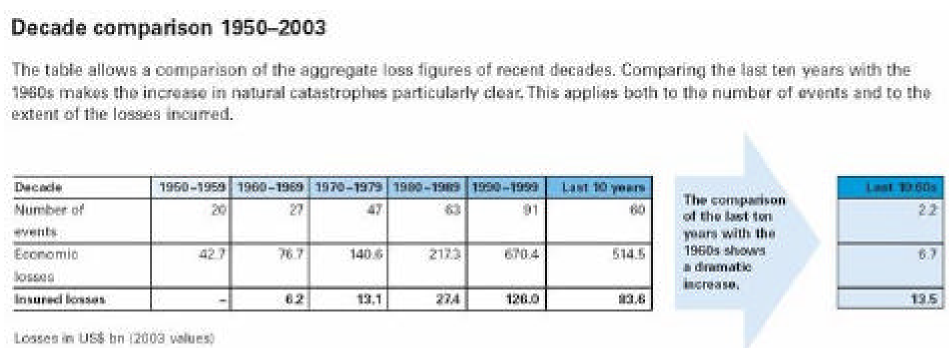


Figure 6.5. Trend in economic and insured losses (source: Muniche Re, 2004).



Decade comparison 1950–2003

The table allows a comparison of the aggregate loss figures of recent decades. Comparing the last ten years with the 1960s makes the increase in natural catastrophes particularly clear. This applies both to the number of events and to the extent of the losses incurred.

Decade	1950–1959	1960–1969	1970–1979	1980–1989	1990–1999	Last 10 years
Number of events	20	27	47	63	91	60
Economic losses	42.7	76.7	140.6	217.3	670.4	514.5
Insured losses	–	6.2	13.1	27.4	126.0	83.6

The comparison of the last ten years with the 1960s shows a dramatic increase.

Last: 1960s
2.2
6.7
13.5

Losses in US$ bn (2003 values)

Figure 3. Decadal comparison of economic and insured losses (source: Munich Re, 2004)

Table 6.4. From IPCC Table TS-2: Examples of impacts resulting from projected changes in extreme climate events

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts[b]**
Complex Extremes	
Increased summer drying over most mid-latitude continental interiors and associated risk of drought (Likely[a])	

Table 6.5. From IPCC Table TS-2: Examples of impacts resulting from projected changes in extreme climate events

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts[b]** *(all high confidence of occurrence in some areas[c])*
Complex Extremes	
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities (Likely[a] over some areas)[e]	• Decreased crop yields • Increased damage to building foundations caused by ground shrinkage • Decreased water resource quantity and quality • Increased risk of forest fire
(see Table 6.1 for footnotes)	

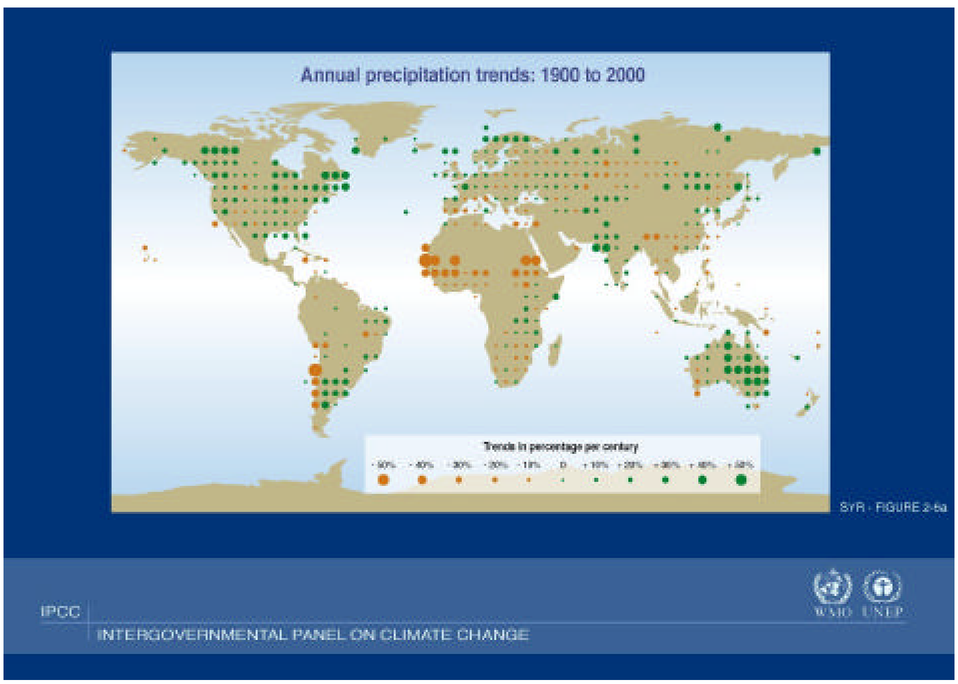


Figure 6.6. Annual precipitation trends 1900 to 2000 (Source: IPCC TAR, 2001).

Table 6.6. From IPCC Table TS-2: Examples of impacts resulting from projected changes in extreme climate events

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts**[b] *(all high confidence of occurrence in some areas*[c]*)*
Complex Extremes	
Higher maximum temperatures; more hot days and heat waves[d] over nearly all land areas (Very Likely[a])	• Increased incidence of death and serious illness in older age groups and urban poor • Increased heat stress in livestock and wildlife • Shift in tourist destinations • Increased risk of damage to a number of crops • Increased electric cooling demand and reduced energy supply reliability
Intensified droughts and floods associated with El Niño events in many different regions (Likely[a]) (see also under droughts and intense precipitation events)	• Decreased agricultural and rangeland productivity in drought- and flood-prone regions • Decreased hydro-power potential in drought-prone regions
Increased Asian summer monsoon precipitation variability (Likely[a])	• Increased flood and drought magnitude and damages in temperate and tropical Asia
Increased intensity of mid-latitude storms (little agreement between current models)[d]	• Increased risks to human life and health • Increased property and infrastructure losses • Increased damage to coastal ecosystems
(see Table 6.1 for footnotes)	

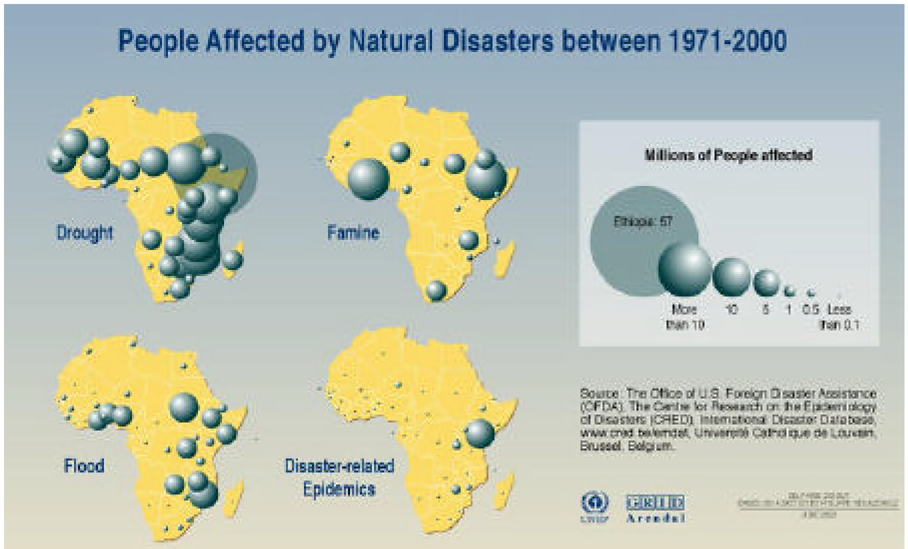


Figure 6.7 People affected by natural disasters between 1971-2000 in Africa (source: Vital Climate Graphics for Africa, www.grida.no/climate).

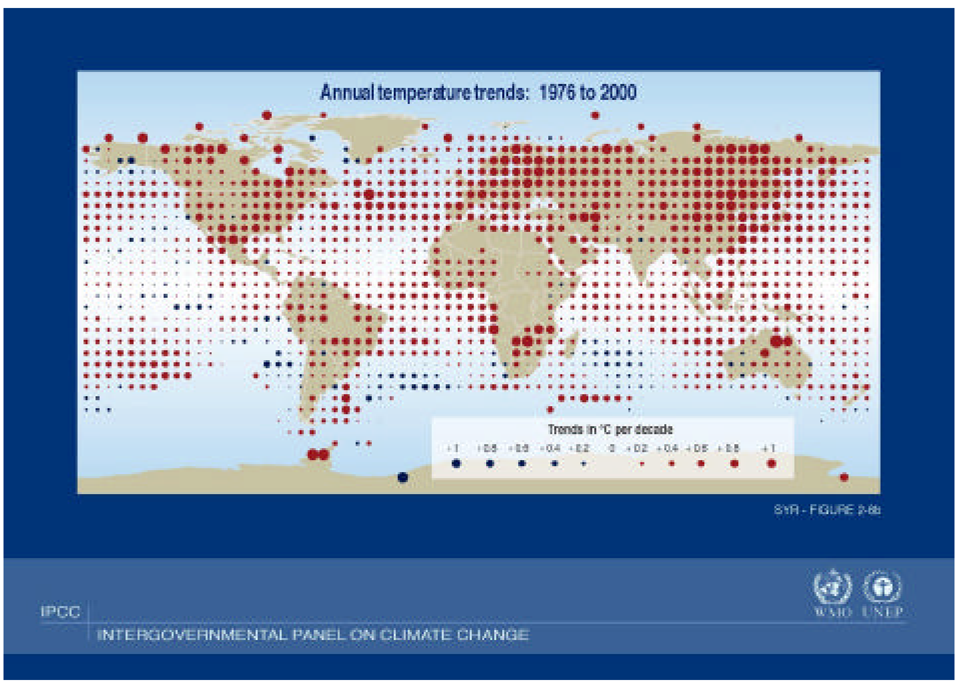


Figure 6.8. Trends in annual temperature from 1976 to 1999 (Source: IPCC TAR, 2001)

4. Global Warming: Early Warning Signs - Fingerprints and Harbingers of Global Warming

Early warning signs of global warming are tracked at a web site at www.climatehotmap.org which distinguishes between two basic kinds of hotspots:

- The *fingerprints* of global warming, such as heat waves, rising seas, and the melting of polar ice and mountain glaciers are indicators of the global, long-term warming trend observed in the historical record. Fingerprints are what researchers seek to detect and then to confirm that climate change is indeed underway.

- By contrast, *harbingers* such as exceptional droughts, fires, and downpours, the spread of disease-bearing insects or other carriers, and widespread bleaching of coral reefs may be directly or partly due to the warmer climate, but it is impossible to say for sure. Harbingers are events that are consistent, given our current scientific theories and models, with the kinds of impacts projected to occur as global climate change proceeds.

AFRICA

Although the data on these hotspots is skewed towards northern latitudes where there is a longer observational record and more research being carried out, there are still some examples over Africa.

Signs of a changing climate in Africa have already emerged: spreading disease and melting glaciers in the mountains, warming temperatures in drought-prone areas, and sea-level rise and coral bleaching along the coastlines (http://www.climatehotmap.org/africa.html). References to published details about each incident are given at http://www.climatehotmap.org/references.html (accessed 11 November 2004).

Fingerprints over Africa (the numbers refer to points on the map in Figure 18)

3. Cairo, Egypt -- Warmest August on record, 1998. Temperatures reached 105.8°F (41°C) on August 6, 1998.
5. Southern Africa -- Warmest and driest decade on record, 1985-1995. Average temperature increased almost 1°F (0.56°C) over the past century.
41. Senegal -- Sea-level rise; Sea-level rise is causing the loss of coastal land at Rufisque, on the South Coast of Senegal.
61. Kenya -- Mt. Kenya's largest glacier disappearing. 92 percent of the Lewis Glacier has melted in the past 100 years.
121. World Ocean - Warming water. The world ocean has experienced a net warming of 0.11°F (0.06°C) from the sea surface to a depth of 10,000 feet (3000 m) over the past 35-45 years. More than half of the increase in heat content has occurred in the upper 1000 feet (300 m), which has warmed by 0.56°F (0.31°C). Warming is occurring in all ocean basins and at much deeper depths than previously thought. These findings lend support to the hypothesis that the oceans are taking up excess heat as the atmosphere warms, and would account for the apparent discrepancy in the magnitude of the observed atmospheric warming as compared to climate model predictions.
133. Mount Kilmanjaro, Tanzania - Ice projected to disappear by 2020. 82% of Kilimanjaro’s ice has disappeared since 1912, with about one-third melting in just the last dozen years. At this rate, all of the ice will be gone in about 15 years. Scientists hypothesize that less

snow on the mountain during the rainy season decreases the surface reflectiveness, leading to higher rates of absorption of heat and increased ice melt.

134. Rwenzori Mountains, Uganda - Disappearing glaciers. Since the 1990s, glacier area has decreased by about 75%. The continent of Africa warmed by 0.9^o F (0.5^{o}C) during the past century, and the five warmest years in Africa have all occurred since 1988.

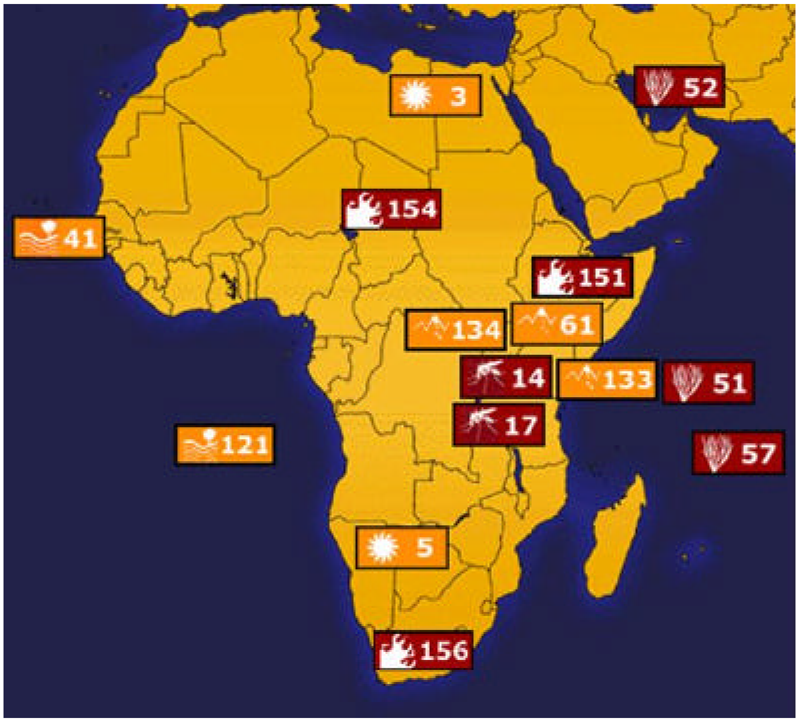


Figure 6.9. Map of Africa showing fingerprints (yellow) and harbingers (red) of global warming (www.climatehotmap.org/africa.html, accessed on 26 October 2004)

Harbingers over Africa (Figure 18):

14. Kenya -- Deadly malaria outbreak, summer, 1997. Hundreds of people died from malaria in the Kenyan highlands where the population had previously been unexposed.

17. Tanzania -- Malaria expands in mountains. Higher annual temperatures in the Usamabara Mountains have been linked to expanding malaria transmission.

51. Indian Ocean -- Coral Reef Bleaching (includes Seychelles; Kenya; Reunion; Mauritius; Somalia; Madagascar; Maldives; Indonesia; Sri Lanka; Gulf of Thailand [Siam]; Andaman Islands; Malaysia; Oman; India; and Cambodia).

52. Persian Gulf -- Coral reef bleaching.

57. Seychelles Islands -- Coral reef bleaching.

151. Kenya - Worst drought in 60 years, 2001. Over four million people were affected by a severely reduced harvest, weakened livestock, and poor sanitary conditions.

154. Lake Chad - Disappearing Lake. The surface area of the lake has decreased from 9,650 square miles (25,000 km^2) in 1963 to 521 (1,350 km^2) today. Modeling studies indicate the severe reduction results from a combination of reduced rainfall and increased demand for water for agricultural irrigation and other human needs.

156. South Africa - Burning shores, January 2000. One of the driest Decembers on record and temperatures over 104^{o}F (40^{o}C) fueled extensive fires along the coast in the Western Cape Province. The intensity of the fires was exacerbated by the presence of invasive vegetation species, some of which give off 300% more heat when burned compared to natural vegetation.

ASIA

For Asia, refer to Figure 19, and the list that follows. References to published details about each incident are given at http://www.climatehotmap.org/references.html (accessed 11 November 2004).

Fingerprints

1. Llasa, Tibet -- Warmest June on record, 1998. Temperatures hovered above 77^{o}F for 23 days.

59. Garhwal Himalayas, India -- Glacial retreat at record pace. The Dokriani Barnak Glacier retreated 66 ft (20.1 m) in 1998 despite a severe winter. The Gangorti Glacier is retreating 98 ft (30 m) per year. At this rate scientists predict the loss of all central and eastern Himalayan glaciers by 2035.

62. Tien Shan Mountains, China -- Glacial ice reduced by one quarter in the past 40 years.

90. Southern India - Heat wave, May 2002. In the state of Andhra Pradesh temperatures rose to 120^{o}F, resulting in the highest one-week death toll on record. This heat wave came in the context of a long-term warming trend in Asia in general. India, including southern India, has experienced a warming trend at a rate of 1^{o}F (0.6^{o}C) per century.

91. Nepal - High rate of temperature rise. Since the mid-1970s the average air temperature measured at 49 stations has risen by 1.8^{o}F (1^{o}C), with high elevation sites warming the most. This is twice as fast as the 1^{o}F (0.6^{o}C) average warming for the mid-latitudinal Northern Hemisphere (24 to 40^{o}N) over the same time period, and illustrates the high sensitivity of mountain regions to climate change.

93. Taiwan - Average temperature increase. The average temperature for the island has risen 1.8-2.5^{o}F (1-1.4^{o}C) in the last 100 years. The average temperature for 2000 was the warmest on record.

94. Afghanistan - 2001 - Warmest winter on record. Arid Central Asia, which includes Afghanistan, experienced a warming of 0.8-3.6^{o}F (1-2^{o}C) during the 20th century.

95. Tibet - Warmest decade in 1,000 years. Ice core records from the Dasuopu Glacier indicate that the last decade and last 50 years have been the warmest in 1,000 years. Meteorological records for the Tibetan Plateau show that annual temperatures increased 0.4^{o}F (0.16^{o}C) per decade and winter temperatures increased 0.6^{o}F (0.32^{o}C) per decade from 1955 to 1996.

96. Mongolia - Warmest century of the past millennium. A 1,738-year tree-ring record from remote alpine forests in the Tarvagatay Mountains indicates that 20th century temperatures in this region are the warmest of the last millennium. Tree growth during 1980-1999 was the highest of any 20-year period on record, and 8 of the 10 highest growth years occurred since 1950. The 20th century warming has been observed in tree-ring reconstructions of temperature from widespread regions of Eurasia, including sites in the Polar Urals, Yakutia, and the Taymir Peninsula, Russia. The average annual temperature in Mongolia has increased by about 1.3^{o}F (0.7^{o}C) over the past 50 years.

119. Chokoria Sundarbans, Bangladesh - Flooded mangroves. Rising ocean levels have flooded about 18,500 acres (7,500 hectares) of mangrove forest during the past three decades. Global sea-level rise is aggravated by substantial deltaic subsidence in the area with rates as high as 5.5 mm/year.

120. China - Rising waters and temperature. The average rate of sea-level rise was 0.09 +/- 0.04 inches (2.3 +/- 0.9 mm) per year over the last 30 years. Global sea-level rise was aggravated locally by subsidence of up to 2 inches (5 cm) per year for some regions due to earthquakes and groundwater withdrawal. Also, ocean temperatures off the China coast have risen in the last 100 years, especially since the 1960s.

126. Bhutan - Melting glaciers swelling lakes. As Himalayan glaciers melt glacial lakes are swelling and in danger of catastrophic flooding. Average glacial retreat in Bhutan is 100-130 feet (30-40 m) per year. Temperatures in the high Himalayas have risen 1.8^{o}F (1^{o}C) since the mid 1970s.

127. India - Himalayan glaciers retreating. Glaciers in the Himalayas are retreating at an average rate of 50 feet (15 m) per year, consistent with the rapid warming recorded at Himalayan climate stations since the 1970s. Winter stream flow for the Baspa glacier basin has increased 75% since 1966 and local winter temperatures have warmed, suggesting increased glacier melting in winter.

130. Mt. Everest - Retreating glacier. The Khumbu Glacier, popular climbing route to the summit of Mt. Everest, has retreated over 3 miles (5 km) since 1953. The Himalayan region overall has warmed by about 1.8^{o}F (1^{o}C) since the 1970s.

131. Kyrgyzstan - Disappearing glaciers. During 1959-1988, 1,081 glaciers in the Pamir-Altai disappeared. Temperatures in the mountains of Kyrgyztan have increased by 0.9-2.7^{o} F (0.5-1.5^{o}C) since the 1950s.

142. Siberia - Melting permafrost. Large expanses of tundra permafrost are melting. In some regions the rate of thawing of the upper ground is nearly 8 inches (20 cm) per year. Thawing permafrost has already damaged 300 buildings in the cities of Norilsk and Yakutsk. In Yakutsk, the average temperature of the permanently frozen ground has warmed by 2.7 ^{o}F (1.5^{o}C) during the past 30 years.

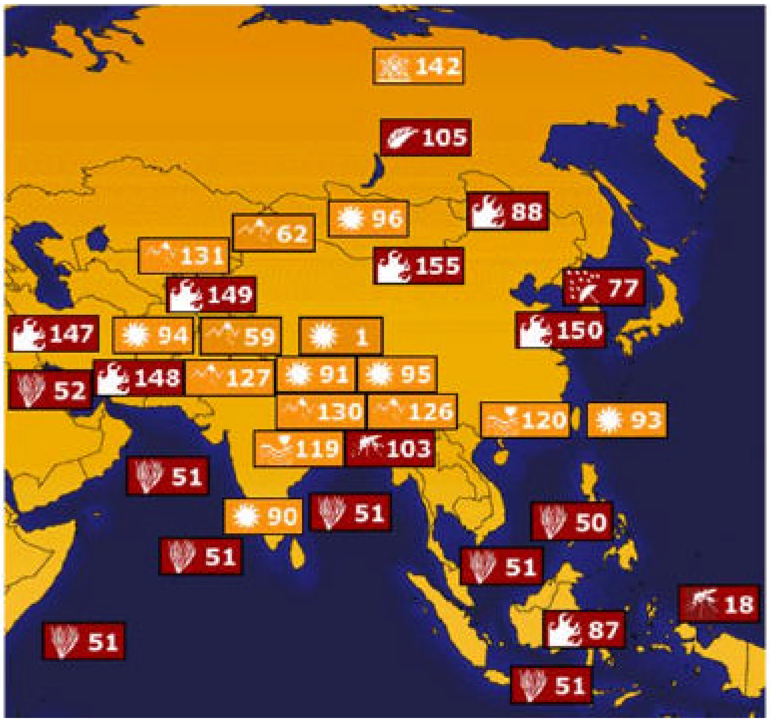


Figure 6.10. Map of Asia region showing fingerprints (yellow) and harbingers (red) of global warming (www.climatehotmap.org/asia.html, accessed on 11 November 2004)

Harbingers

18. Indonesia -- **Malaria spreads to high elevations**. Malaria was detected for the first time as high as 6,900 feet (2103 m) in the highlands of Irian Jaya in 1997.

50. Philippines -- Coral reef bleaching.

51. Indian Ocean -- Coral reef bleaching (inclues Seychelles; Kenya; Reunion; Mauritius; Somalia; Madagascar; Maldives; Indonesia; Sri Lanka; Gulf of Thailand [Siam]; Andaman Islands; Malaysia; Oman; India; and Cambodia).

52. Persian Gulf -- Coral reef bleaching.

77. Korea -- Heavy rains and flooding. Severe flooding struck during July and August, 1998, with daily rainfall totals exceeding 10 inches (25.4 cm).

87. Indonesia -- **Burning rainforest, 1998**. Fires burned up to 2 million acres (809,371 hectares) of land, including almost 250,000 acres (101,172 hectares) of primary forest and parts of the already severely reduced habitat of the Kalimantan orangutan.

88. Khabarovsk, Russia -- Wildfires threaten tiger habitat, 1998. Drought and high winds fueled fires that destroyed 3.7 million acres (1,497,337 hectares) of taiga and threatened two important nature reserves that are habitat for the only remaining Amur tigers.

103. Bangladesh - Link between stronger El Nino events and cholera prevalence. Researchers found a robust relationship between progressively stronger El Nino events and cholera prevalence, spanning a 70-year period from 1893-1940 and 1980-2001. There has been a marked intensification of the El Nino/Southern Oscillation phenomenon since the 1980s, which is not fully explained by the known shifts in the Pacific basin temperature regime that began in the mid-1970s. Findings by Rodo et al.,(2002: PNAS 99(20):12901-12906) are consistent with model projections of El Nino intensification under global warming conditions. The authors make a strong case for the climate-health link by providing evidence for biological sensitivity to climate, meteorological evidence of climate change, and evidence of epidemiological change with global warming. The study likely represents the first piece of evidence that warming trends over the last century are affecting human disease.

105. Lake Baikal, Russia - Shorter freezing period. Winter freezing is about 11 days later and spring ice breakup is about 5 days earlier compared to a century ago. Some regions of Siberia have warmed by as much as 2.5^{o}F (1.4^{o}C) in just 25 years.

147. Iran - Desiccated wetlands, 2001 Ninety percent of wetlands have dried up after 2 years of extreme drought. Much of South West Asia has experienced a prolonged three-year drought that is unusual in its magnitude. Out of 102 years of record, 1999, 2000, and 2001 rank as the fifth, third, and seventh driest on record. 1999-2000 was the driest winter on record.

148. Pakistan - Longest drought on record, 1999-2001. The prolonged three-year drought, which covers much of South West Asia, has affected 2.2 million people and 16 million livestock in Pakistan.

149. Tajikistan - Lowest rainfall in 75 years, 2001. 2001 marked the third consecutive year of drought, which has destroyed half the wheat crop.

150. Korea - Worst drought in 100 years of record, 2001. It coincided with an average annual temperature increase in Asia's temperate region, which includes Korea, by more than 1.8^{o}F (1^{o}C) over the past century. The warming has been most pronounced since 1970.

155. China - Disappearing Lakes, 2001. More than half of the 4,000 lakes in the Qinghai province are disappearing due to drought. The severity of the impact is exacerbated by overpumping of aquifers. Annual average temperature in China has increased during the past century, with pronounced warming since 1980. Most of the warming has been in northern areas, including Qinghai Province, and in the winter.

OCEANIA

Refer to Figure 20 for Oceania, and the list that follows. References to published details about each incident are given at http://www.climatehotmap.org/references.html (accessed 11 November 2004).

Figure 6.11. Map of Asia region showing fingerprints (yellow) and harbingers (red) of global warming (www.climatehotmap.org/asia.html, accessed on 11 November 2004

Fingerprints (refer to Figure 20)

2. Christchurch, New Zealand -- Warmest February on record, 1998. Daily temperatures averaged near 67°F (19.4°C).

43. Fiji -- Sea-level rise. Reports from local inhabitants at 16 sites indicate that the island's average shoreline has been receding half a foot (0.15 m) per year over at least the past 90 years.

44. American and Western Samoa -- Land loss. Western Samoa has experienced shore recession of about 1.5 feet (0.46 m) per year for at least the past 90 years.

67. New Zealand -- Retreating glaciers. The average elevation for glaciers in the Southern Alps has shifted upslope by more than 300 feet (91.4 m) over the past century.

129. Heard Island (Australia) - Rising temperatures; retreating glaciers. Since 1947 the island's 34 glaciers have decreased by 11% in area and 12% in volume, with half the loss occurring in the 1980s. Air temperature has risen 1.3°F (0.7°C) between 1947 and 2001.

Harbingers (refer to Figure 20)

18. Indonesia -- Malaria spreads to high elevations. Malaria was detected for the first time as high as 6,900 feet (2,103 m) in the highlands of Irian Jaya in 1997.

48. American Samoa -- Coral reef bleaching.

49. Papua New Guinea -- Coral reef bleaching.

50. Philippines -- Coral reef bleaching.

51. Indian Ocean -- Coral reef bleaching (includes Seychelles; Kenya; Reunion; Mauritius; Somalia; Madagascar; Maldives; Indonesia; Sri Lanka; Gulf of Thailand [Siam]; Andaman Islands; Malaysia; Oman; India; and Cambodia).

56. Australia, Great Barrier Reef -- Coral reef bleaching.

75. New South Wales, Australia -- Wettest August on records, 1998. On August 15-17, a storm dumped nearly 12 inches (30.5 cm) of rain on Sydney, over 8 inches (20.3 cm) more than what normally falls during that entire month.

87. Indonesia -- Burning rainforest, 1998. Fires burned up to 2 million acres (809,371 hectares) of land, including almost 250,000 acres of primary forest and parts of the already severely reduced habitat of the Kalimantan orangutan.

100. Australia - 2002 - Warmest April on record. This occurred in the context of an average annual temperature increase of 0.9-1.8^{o}F (0.5-1.0^{o}C) per decade over the past century. There has also been an increase in warm days and a decrease in cold winter days.

123. **New Zealand - Ocean warming**. The oceans around New Zealand have been warming over the past decade at a rate not seen since the 1930s. Over the last century the average ocean temperatures around New Zealand increased by about 1.8^{o}F (1^{o}C), slightly more than the global average. Despite 20 years of cooling from the 1970s through the early 1990s - due to longer and stronger El Nino events affecting the regional ocean temperatures - New Zealand’s ocean temperature increase over the 20th century is consistent with the global average upward trend. Sea level along the country’s shoreline has been rising accordingly by an average of 0.04-0.08 inches (1-2 mm) per year.

124. Fiji - Coral reef bleaching, 2000. A new wave of coral bleaching events has been observed during the southern summer in Fiji and on many other South Pacific atolls. Satellite measurements by the National Oceanic and Atmospheric Association documented unusually high temperatures across much of the Pacific. The 1990s has seen several major bleaching events. Repeated and prolonged bleaching episodes - expected as tropical water temperatures warm with climate change - eventually kill corals and cause a decline in associated marine species.

Why is Climate Change important for LDCs?

Climate change poses considerable risks to LDCs, and is a major obstacle to development efforts.

Any change in climate whether through increased variability, extremes or average conditions is likely to have profound impacts on development in LDCs. Most people in LDCs live in rural areas and rely on rain-fed agriculture for food and income generation. Changes in climate variability and seasonal patterns are threatening subsistence food production leading to severe food shortages and sometimes famine. Extreme events such as cyclones, floods, storm surges and droughts are very costly to recover from; especially for LDCs given their low economic resources (see Table 6.7). These disruptions of the development process can easily derail any chances for positive economic growth and development. Table 6.8 shows linkages between the Millennium Development Goals and climate change.

Table 6.7. Selected Indicators for LDCs

Indicator	Year	LDCs	Other developing countries
Share of labor in agriculture	1990	75%	32%
Share of agriculture in GDP	1997	34%	17%
Per capita consumption of coal, oil, gas and electricity	1996	69 kg coal eq	898 kg coal eq
Per capita consumption of fuelwood and charcoal	1996	210 kg coal eq	135 kg coal eq
Hospital beds per 1000 population	1990	1.1	4.8
Physicians per 1000 population	1990	0.1	1.6
Adult literacy rate (age 15 and above)	1995	48.9	81.4

Source: UNCTAD: The Least Developed Countries 2000 Report

Table 6.8. Potential Impacts of Climate Change on the Millennium Development Goals (VARG 2003)

Millennium Development Goals: Climate Change as a Cross-Cutting Issue	
Millennium Development Goal	Examples of Links with Climate Change
Eradicate extreme poverty and hunger (Goal 1)	• Climate change is projected to reduce poor people's livelihood assets, for example, health, access to water, homes, and infrastructure. • Climate change is expected to alter the path and rate of economic growth due to changes in natural systems and resources, infrastructure, and labor productivity. A reduction in economic growth directly impacts poverty through induced income opportunities. • Climate change is projected to alter regional food security. In particular in Africa, food security is expected to worsen.
Health related goals: ? Combat major diseases ? Reduce infant mortality ? Improve maternal health (Goals 4, 5 & 6)	• Direct effects of climate change include increases in heat-related mortality and illness associated with heat waves (which may be balanced by less winter cold related deaths in some regions). • Climate change may increase the prevalence of some vector-borne diseases (for example malaria and dengue fever), and vulnerability to water, food, or person-to-person borne diseases (for example cholera and dysentery). • Children and pregnant women are particularly susceptible to vector and waterborne diseases. Anemia – resulting from malaria – is responsible for a quarter of maternal mortality. • Climate change will likely result in declining quantity and quality of drinking water, which is a prerequisite for good health, and exacerbate malnutrition – an important source of ill health among children – by reducing natural resource productivity and threatening food security, particularly in Sub-Saharan Africa.
Achieve universal primary education (Goal 2)	• Links to climate change are less direct, but loss of livelihood assets (social, natural, physical, human, and financial capital) may reduce opportunities for full-time education in numerous ways. Natural disasters and drought reduce children's available time (which may be diverted to household tasks), while displacement and migration can reduce access to education opportunities.
Promote gender equality and empower women (Goal 3)	• Climate change is expected to exacerbate current gender inequalities. Depletion of natural resources and decreasing agricultural productivity may place additional burdens on women's health and reduce time available to participate in decision making processes and income generating activities. • Climate related disasters have been found to impact more severely on female-headed households, particularly where they have fewer assets to start with.
Ensure environmental sustainability (Goal 7)	• Climate change will alter the quality and productivity of natural resources and ecosystems, some of which may be irreversibly damaged, and these changes may also decrease biological diversity and compound existing environmental degradation
Global partnerships	• Global climate change is a global issue and response requires global cooperation, especially to help developing countries to adapt to the adverse impacts of climate change.

Chapter 7

Vulnerability and Adaptation to Climate Change in LDCs and the NAPAs

1. Definitions: Adaptation and Vulnerability

Adaptation in the context of climate change is an adjustment in a system in response to actual or expected climatic changes and its impacts. It includes changes and adjustments designed to moderate, offset potential damages or to capitalize on the changes in climate. In turn, *adaptive capacity* is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change (IPCC TAR).

The central goal of NAPAs is the enhancement of adaptive capacity, since it promotes learning in dealing with climate change through coping with climate variability and extreme events

Learning to cope with existing climate provides a basis for planning for potential future changes, with an understanding that some future conditions may be unlike those experienced previously, especially when it comes to extreme events. Still, in such cases, there is usually information from elsewhere that provides an idea on the likely impacts. For natural systems, responses to new climatic conditions are more difficult to predict.

Systems (both natural and human) have adapted to spatial and temporal characteristics of climate. For example, human communities have developed cropping systems based on long-term average climatic conditions for their region, with a tolerable number of extremes. Outside the average margins (and associated acceptable variability), the crops would not perform well. The favorable range is called the coping range for the cropping system. This coping range varies by region and by system under consideration, and can change over time if the system is able to adjust (adapt) to changing external factors. Adaptive capacity then, includes both the ability inherent in the coping range and the ability to move or expand the coping range with new or modified adaptations (IPCC TAR, see Figure 7.1 for a depiction of coping range, with the time domain indicated for NAPAs).

The IPCC TAR chapter 18 on Adaptation gives a comprehensive overview on adaptation. The reader is referred to it for further details.

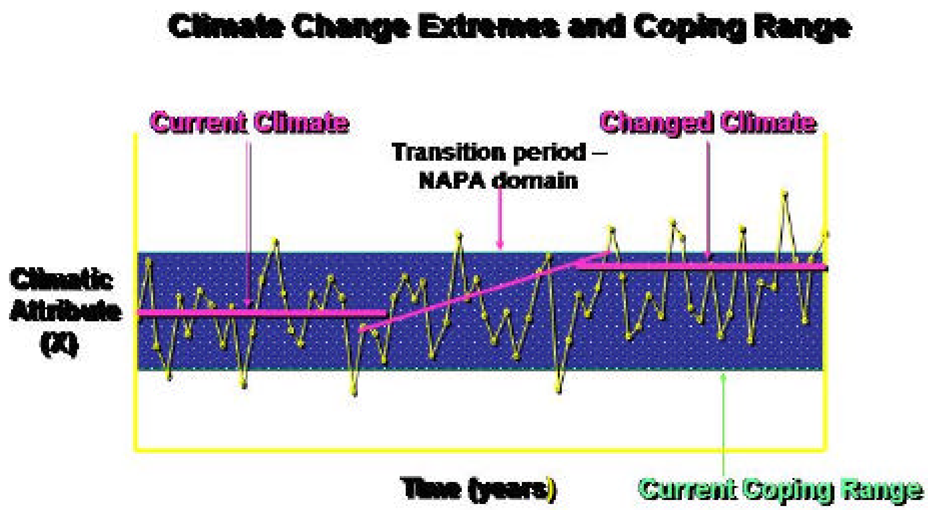


Figure 4. Climate change and extremes and coping range showing NAPA domain along the transition period

One can develop a comprehensive typology of cases requiring adaptation within the depiction of coping range. In the NAPAs, we will assume that different types and forms of adaptation are possible, regardless of motivation or basis (whether based on experience, observation, speculation or intuition about what might work).

Various indicators and systems of indicators have been developed to describe vulnerability and adaptive capacity of systems including communities, regions and countries. No single set of indices or indicators is universally applicable , although this is an active area of research.

Adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector (IPCC TAR WGII, Chapter 18). This complex mix of conditions determines the capacity of systems to adapt. The main features of communities or regions that seem to determine their adaptive capacity are: economic wealth, technology, information and skills, infrastructure, institutions, and equity. These factors combine to contribute to the very low adaptive capacities of LDCs. Within a given country, determinants of this capacity cascade down on nested spatial and economic scales.

Exposure to climate change: Climatic hazards

There is a considerable body of research on climatic hazards, impacts and response actions, both within the climate change literature, but more importantly, within the disaster preparedness arena and social sciences. The following is a list of common climatic hazards that may be considered in a NAPA assessment (it is neither complete nor are the elements mutually exclusive):

A. Extremes in temperature (warm spells, cold spells, frost, changes in diurnal range)
B. Extremes in rainfall rates and amounts
C. Drought: seasonal (dry spells), multi-year drought
D. Floods: riverine, coastal inundation, flash floods
E. Storms: Tropical Storms/Storm Surges, wind storms, hailstorm

F. Changes in Seasonal Cycles (change in start, length, quality of the growing season, dry spells, excessive wet spells, etc)
G. Complex hazards e.g. mud/landslides

Establishing trends in many of these hazards for a given locale is not easy, mainly because of data constraints. Usually, each hazard can be described in terms of intensity, frequency and duration; extent of impact, trend, spatial extent and so on. In general, these descriptors can be ranked along an exponential scale from low to high. For example, frequency can be mapped against the extent of damage as in Figure 7.2.

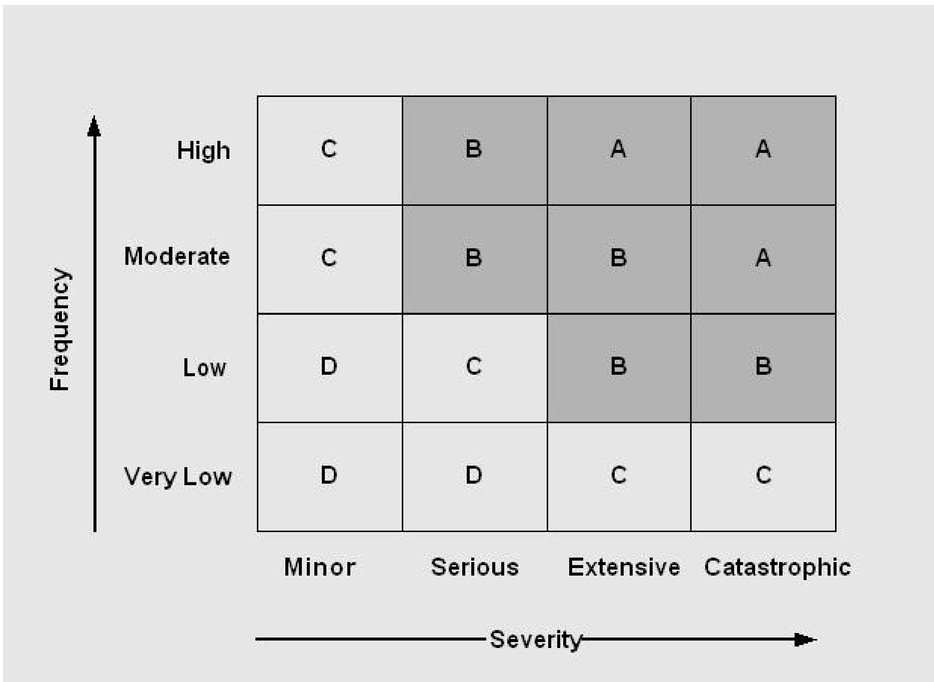


Figure 5. Graph of probability of occurrence versus extent of damage following an exponential scale.

National level data on natural disasters is available from the Center for Research on the Epidemiology of Disasters (http://www.cred.be). See Box 7.1 for an example of data on Malawi. Munich Re also produces aggregate summaries of hazards by country (such as the 'Global hazards Map').

Box 7.1: Malawi Profile of Natural Disasters

The information on natural disasters presented here is taken from EM-DAT: The OFDA/CRED International Disaster Database. In order for a disaster to be entered into the database at least one of the following criteria has to be fulfilled:

- 10 or more people reported killed
- 100 people reported affected
- a call for international assistance
- declaration of a state of emergency

Top 10 Natural Disasters in Malawi sorted by numbers of people killed and affected

Disaster	**Date**	**Killed**
Epidemic	28-Oct-2001	502
Drought	Feb-2002	500
Flood	10-Mar-1991	472
Epidemic	Feb-2002	175
Epidemic	Jan-2000	83
Flood	Jan-2001	59
Epidemic	Jan-2002	42
Epidemic	Oct-1989	35
Epidemic	1-May-2002	24
Epidemic	Mar-2001	20

Disaster	**Date**	**Affected**
Drought	1993	7,000,000
Drought	30-Apr-1992	5,700,000
Drought	Feb-1994	3,000,000
Drought	Feb-2002	2,829,435
Drought	Feb-1990	2,800,000
Famine	1987	1,429,267
Famine	1988	878,000
Flood	Jan-2001	500,000
Flood	18-Feb-1997	400,000
Flood	10-Mar-1991	268,000

Created on: Nov-16-2004. - Data version: v09.04
Source:"EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net - Université catholique de Louvain - Brussels - Belgium"

For some natural disasters (particularly floods and droughts) there is no exact day or month for the event, and for other disasters (particularly pre-1974) the available record of the disaster does not provide an exact day or month.

Summarized Table of natural Disasters in Malawi from 1967 to 2003

	# of Events	Killed	Injured	Homeless	Affected	Total Affected	DamageUS (000's)
Drought	6	500	0	0	21,329,435	21,329,435	0
ave. per event		83	0	0	3,554,906	3,554,906	0
Earthquake	1	9	100	50,000	0	50,100	28,000
ave. per event		9	100	50,000	0	50,100	28,000

Epidemic	10	891	0	0	26,009	26,009	0
ave. per event		89	0	0	2,601	2,601	0
Famine	2	0	0	0	2,307,267	2,307,267	0
ave. per event		0	0	0	1,153,634	1,153,634	0
Flood	18	570	0	132,300	1,745,090	1,877,390	700
ave. per event		32	0	7,350	96,949	104,299	39

Created on: Nov-16-2004. - Data version: v09.04
Source:"EM-DAT: The OFDA/CRED International Disaster Database,
www.em-dat.net - Université catholique de Louvain - Brussels - Belgium"
**Events recorded in the CRED EM-DAT. First Event: Mar/1967, Last Entry: Apr/2003.*
**Epidemics inluded: Meningitis, Diarrhoeal/Enteric, Plague, Diarrhoeal/Enteric(Cholera), Diarrhoeal/Enteric(Acute watery diarrhoeal syndrome)*

Conceptualizing Vulnerability

Vulnerability is commonly defined as the degree to which human and environmental systems are likely to experience harm due to a perturbation or stress (IPCC TAR 2001; Kasperson et al., 2003; Turner et al., 2003; and many others). Vulnerability is commonly described to be a function of three main characteristics: exposure (to climatic hazards), sensitivity (to climate), and adaptive capacity (IPCC TAR, 2001; Chapter 18). In the case of coupled human-environment-economic systems, vulnerability is integrate across these components, and encompasses multiple spatial and temporal scales at which these systems interact.

Conceptually, we can imagine a complex model of sustainable development that includes interlinked components in the social, environmental and economic domains. We can analyze the dynamics of such an integrated model by taking partial differentials of the system to examine how the system of development would be affected by a particular driver or stressor, in this case, a climatic hazard.

In a simple case, we can evaluate our ‘integrated model’ against one variable, that is, one climatic hazard at a time. But it is entirely reasonable to expect multiple climatic hazards to co-drive our system of development, in which case, this will result in complex dynamics. Future work will explore this further. For now, we will be satisfied with a qualitative analysis of this framework, where we will look at each climatic hazard in turn, and evaluate vulnerability independent of other stress factors.

We can approximate this vulnerability model by a number of formulations, including:

- the basic IPCC model:

$$V = f(\text{exposure, sensitivity, adaptive capacity})$$

- the sustainable likelihoods approach (DFID, 1999) or

- reformulations of the IPCC model such as the one by Turner et al., (2003: PNAS 100(4):8074-8079).

In most of these cases, it is not intuitively obvious how one goes from vulnerability to adaptation. For the NAPAs, we have developed a working model as shown in Figure 7.3 based on the standard IPCC one. Steps are shown that correspond with operational steps in modeling or framing inputs in order to establish metrics for hazard risk (probabilistic or qualitative), impact potential (to include any sensitivity analysis of a climate-sector model, and coping range), and adaptive capacity or resilience.

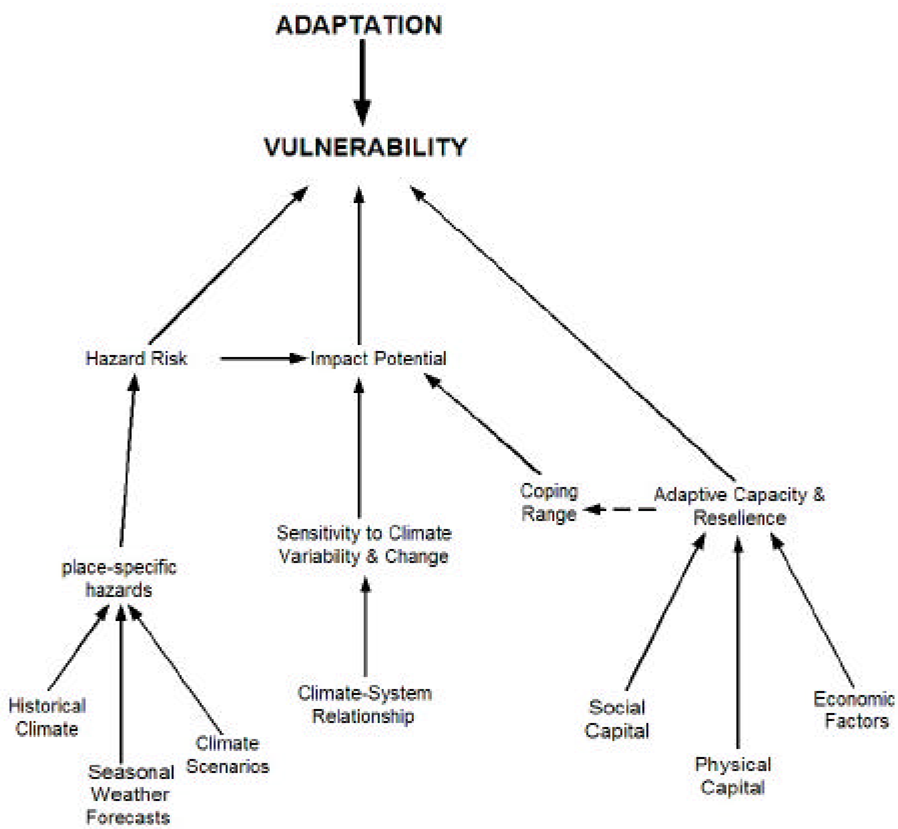


Figure 7.3. Vulnerability and adaptation in NAPA (based on PRIVA, Desanker, 2004)

Adaptation is then defined as follows:

Adaptation = minimize Vulnerability to zero

This minimization of vulnerability can be achieved in multiple ways, including through:

- Reducing the risk of hazards by manipulating components of risk, for example engineering designs to mitigate against flooding including dams and levees; (removing/reducing hazards through mitigation of global warming is outside the domain of analysis for the LDCs given their negligible contributions to global GHG emissions)

- Reducing the impact potential through manipulation of the system-dependence on climate (for example cropping manipulations through irrigation and crop breeding to minimize sensitivity to climate variability), increasing coping range through micromanagement of constraints such as water, and modification of sensitivity to climate through genetic manipulation); or

- Increasing adaptive capacity components including human coping abilities (e.g. addressing key determinants such as poverty, access to financial resources, etc.), increasing resilience, enhancement of human capital through capacity building, or policy measures to remove any barriers to adaptation.

Based on this rather simple characterization of vulnerability and adaptation, we can fit any activity in this framework. Next, let us examine what the key climate driven vulnerabilities are in an integrated system of development.

Key Vulnerabilities – Case Study of Key Sectors

In order to understand key vulnerabilities, it may be useful to group LDCs into broad categories of:

- Landlocked, regular, e.g. Malawi, Zambia;
- Landlocked, high altitude, e.g Bhutan;
- Mainland but with low-lying coastal area/delta system, e.g. Bangladesh, the Gambia;
- Small island state (atoll – type), e.g. the Maldives; and
- Small island state (volcanic origin: not all flat), e.g. Samoa

Each of these will be affected differently by climate change, depending on the types of climatic hazards. The following are examples of impacts/effects of different climatic hazards and corresponding adaptation options.

Water (Gambia case study, Table 7.1)

Table 7.1. Climate change impacts on water resources status and management functions and corresponding adaptation measures (Gambia 1NC).

Expected impacts	**Adaptation measures**
1. inundation of flood-plain areas	(a) construction of embankments/dykes (b) relocation of threatened activities (c) construction of flood-proof housing (d) Institutional Reforms
2. saline intrusion into aquifers	(e) relocation of abstraction points (f) changes in pumping policies of fully penetrating/deep wells/boreholes
3. increased saline intrusion length	(g) flow regulation (h) licensing and permits for withdrawal of river water for irrigation;
4. changes in river salinity regime	(i) flow regulation
5. decrease in	(j) increase water column in wells

groundwater recharge	

- **Agriculture**

The main problem for agriculture in rain-fed systems is the increasing erratic nature of rainfall, especially since the particular system characterized by the choice of crops – type, cultivar, etc.; timing of planting, and manipulations of the crop – when to fertilize, supplement with water, when to harvest, storage, etc., has been developed in response to local knowledge of past ‘normal’ or average conditions of climate.

Responding to erratic rain fall, local communities have adopted staggered planting (e.g. in southern Africa, Miombo AIACC project), but this does not appear to be cost effective, although it is most likely the best approach with incomplete information, assuming that availability of seed and land are not a major constraint.

Erratic rainfall causes the following impacts:

- reduced yields
- crop failures
- local food insecurity
- national food shortages
- extreme shortages leading to famine and subsequently health problems, even death
- increased local poverty because of reduced income flows from subsistence agriculture
- national economic shocks when main cash crops are impacted
- loss of livelihood for farmers and, in some extremes, loss of life through suicide
- land degradation as a result of exposure to damaging heavy rains at times when the soil is exposed
- depletion and loss of seed banks for indigenous varieties

Potential adaptation measures

a) Breed crop varieties that are more resilient to drought, pests, disease, salinity etc while being high yielding.
b) Develop or enhance seed storage facilities for indigenous varieties and other newly developed cultivars. [Preserve genetic material].
c) Conduct common sense activities to maintain and improve soil fertility, and improve water use efficiency,
d) In cases where growing seasons are changing (whether start date, length, or quality), adjust planting dates and choice of crop varieties. Shorter duration varieties are likely to be more successful than those requiring a longer growing season.
e) Improve water management in irrigation systems to get maximum returns and to reduce waste.
f) Improve efficiency in agricultural production through improved techniques and technologies.
g) Develop or improve early warning systems and, in particular, develop effective networks of providers and users of early warning information and products.
h) Introduce, promote and encourage the adoption and diffusion of improved post harvest technologies that will reduce post-harvest losses in the field and in storage

Chapter 8

Introduction to NAPA Preparation

1. Overview

This section of the book describes the steps for NAPA preparation based on the COP guidelines, with simplifications intended to facilitate the process. It takes into account the experiences gained from LEG regional workshops on NAPAs.

Different countries will have different levels of information about their vulnerability to climate change from previous studies. The approach presented here is designed to capture the main steps needed for a comprehensive and effective NAPA. It builds on information that is typically available in LDCs, while leaving the details and final components of the assessment to the countries themselves.

Keeping in mind that there is adequate information and understanding of climate change issues in LDCs, NAPAs were designed to identify urgent and immediate needs for adaptation, especially those that could enhance coping abilities and build capacity to adapt to further and future climate change. The concept of NAPAs recognizes that countries will still need to design their long-term adaptation strategy through a comprehensive assessment that is likely to take several years to develop. The COP guidelines characterize urgent and immediate projects as being those whose further delay could lead to an increase in vulnerability or costs.

The NAPA process is different from conventional impact and vulnerability assessments to climate change, since NAPAs also internalize changes in climate variability, extremes and long-term climate change. Uncertainties about future climate change notwithstanding, NAPAs are intended to approach adaptation by emphasizing activities designed to enhance adaptive capacity and community- to local-level coping strategies. They are informed by current understanding of how climate is likely to change, without the need for a detailed climate change scenario analysis.

The NAPA design is meant to be bottom-up, country-driven and carried out using a participatory approach, leading to specification of actions designed to respond to urgent adaptation needs that address broad stakeholders, especially those that have the least resources, such as the rural poor. Given the complexity of causal factors of vulnerability, NAPAs will implicitly support sustainable development goals and activities, especially those addressing poverty or other development priorities, since it is inconceivable that any actions taken to reduce vulnerability of the poor would be inconsistent with development. However, the full integration of climate change in national development is most likely part of a longer-term process; and one that is bound to be very resource-intensive, and as such belongs beyond the NAPA context.

Although NAPAs are an optional opportunity for those LDCs that wish to prepare them, it is very likely that all LDCs will prepare one, given the value placed on the NAPAs, and the opportunity for immediate adaptation action. Among the LDCs, there are some countries that for one reason or another will experience more challenges than others, and it is hoped that this primer will be especially useful for them.

2. Introduction

One of the main conclusions of the IPCC Third Assessment Report (TAR) is that there are several established impacts of climate change from direct observation across many parts of the world. Although such lines of evidence are presented on impacts only related to temperature increases, it is likely that impacts related to changes in rainfall and extremes are even more widespread and more serious, but difficult to prove. Developing countries especially the least developed among them have the least capacity to adapt for obvious fiscal constraints, as well as many complicating stresses including poverty, health, dependence on rain-fed agriculture, and so on. Given the poor state of observational systems for weather/climate factors and their impacts in LDCs, it is unlikely that LDCs will be able to demonstrate many directly-observed impacts of climate change any time soon

An apparent increase in extreme events and changes in climate variability such as changes in growing season conditions has raised the stakes for many LDCs to address adaptation needs sooner than later. The LDC group under the UNFCCC has proposed and designed the NAPAs as a mechanism for them to address their urgent and immediate adaptation needs without compromising the need for careful planning of longer-term needs. . Many of the activities envisioned under the NAPAs would directly contribute to sustainable development programming and so, NAPAs are seen as supporting national development planning.

3. Available Guidelines for Napa Preparation

There are several guidelines and resources to help countries prepare their NAPAs.

Most important are the NAPA guidelines adopted by the UNFCCC Conference of Parties (COP-7). These detailed guidelines, commonly referred to as the 'NAPA Guidelines', outline the process and format for NAPAs. To help countries develop their NAPA, the COP created a group of experts on LDC issues. This group, called the LDC Expert Group or LEG in short, is mandated to assist in explaining and interpreting the NAPA guidelines as well as in developing strategies for implementing the NAPA projects. The LEG has annotated the NAPA Guidelines to assist countries, and these are available through the UNFCCC LDC Web site (http://www.unfccc.int/ldc).

Second, the GEF has produced oeprational guidelines for funding the preparation of NAPAs (available at http://www.gefweb.org/climate), which specify the procedures and format for proposals, and require countries to clearly define their information sources and procedures to be used. NAPA preparation is classified as an 'enabling activity' in accordance with Article 12 of the UNFCCC so that funding is granted on an agreed full cost basis. It is expected that the NAPA proposals are written by country teams in a truly country-driven and bottom-up approach. The preparation of proposals requires a substantial effort to address all the information needed and the elaboration of linkages with related enabling activities or other assessments. If done properly, information collated and reviewed at the proposal stage would form a substantial input into the NAPA preparation process.

The LDC Expert Group with support from the GEF (through UNDP as implementing agency and UNITAR as executing agency) conducted four regional workshops on NAPA preparation. A team of three people represented each country from their NAPA team. The workshops introduced the NAPA process and worked through examples of critical issues particular to each region. The materials from these workshops including commissioned regional case studies, are available at several websites (http://www.africaclimatechange.org; http://www.unitar.org/climate; and http://www.unfccc.int/ldc).

4. NAPA Development

The following sections present a streamlined set of steps for developing a NAPA, building upon the NAPA guidelines. Three levels of effort are presented based on the amount of available information on vulnerability and adaptation. Proposed methods are carefully chosen to reflect data inputs and methods that are readily available to most LDCs. Countries are encouraged to study these steps carefully and to customize them to suit their local conditions. The discussion of NAPA steps in the following chapters is based on the flow of activities shown in Figure 8.1. There is no particular significance to the numbering of the steps; in fact, some of the steps have been further separated in comparison to the list of steps in the original NAPA guidelines as approved by COP-7, and used in the LEG regional workshops. The reader is asked to pay attention to the name of the steps rather than the numbering. Table 8.1 shows a summary of these steps as they will be described in this NAPA Primer.

Table 8.1. NAPA Steps

1. Build Multidisciplinary NAPA teams
2. Define Society - Environment - Development Integrated Framework
3. Define Goals and Objectives, Review Policies, Mainstream National Development Goals in NAPA Goals
4. Synthesize Available Vulnerability Assessments
5. Conduct Participatory Rapid Integrated Vulnerability Assessment
    a. Select Key Climatic Hazards and their Risks
    b. Choose Vulnerability Framework
    c. Assess Vulnerability
        i. Define Climate-System Linkages
        ii. Collate Available Climate Data & Other Information
        iii. Analyze Climatic Trends and Define Hazard Risks
        iv. Define impact potential and Threshold Excedance
        v. Characterize Adaptive Capacity and Coping Ability of System
        vi. Characterize Vulnerability
    d. Select Highly Vulnerable Sectors, Systems and Sub-regions [Rank Adaptation Needs]
6. Identify Adaptation Options
7. Rank Projects and Activities to Address Priority Adaptation Needs [Rank Adaptation Options]
8. Identify Urgent Adaptation Needs and Projects [Rank for Urgency]
9. Develop Implementation Strategy for NAPA
    a. Develop Project Profiles for Urgent Priority Activities
    b. Define Coordination of Implementation of Specific Activities
    c. Plan Outreach of NAPA and Promotion of Synergies
10. Submit NAPA to the GEF, UNFCCC and Potential Donors

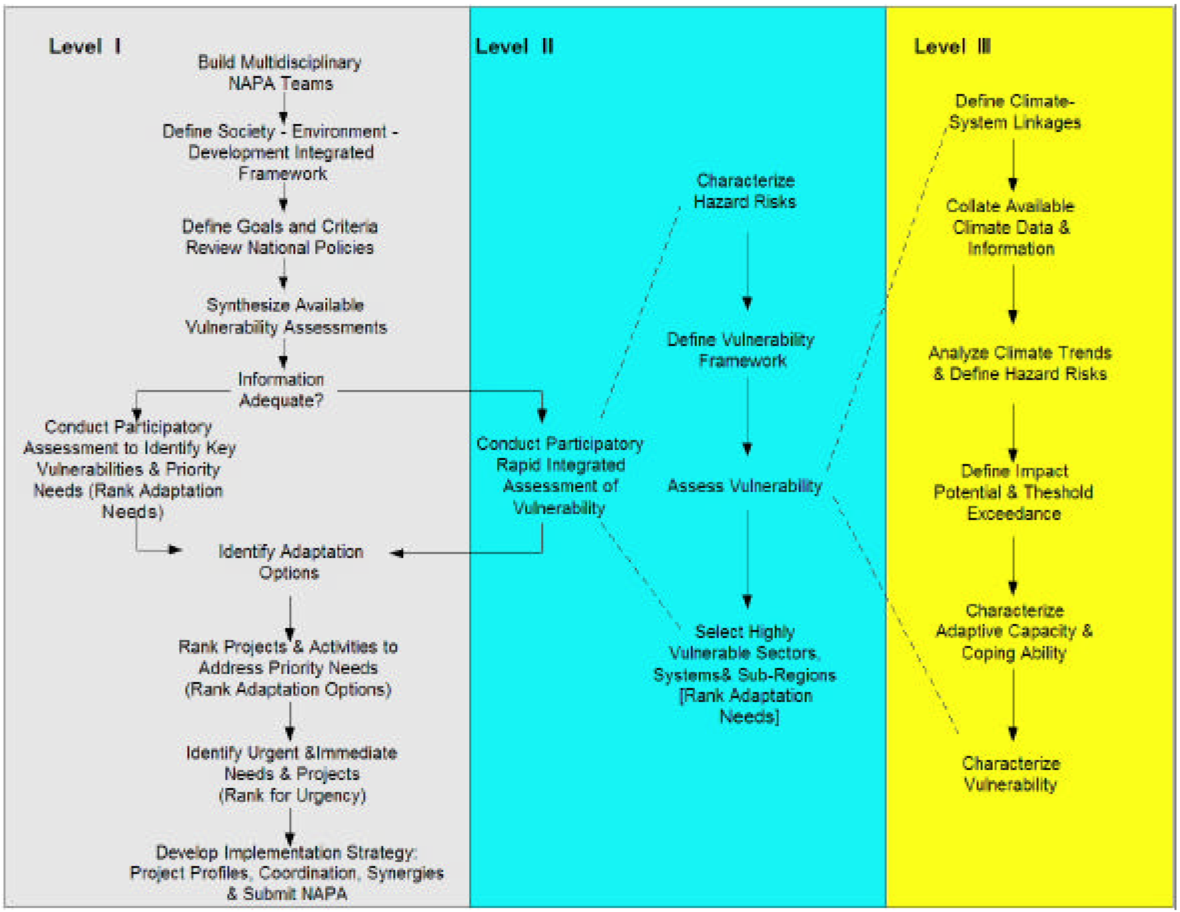


Figure 8.1. Main steps in a participatory process of developing National Adaptation Programmes of Action (NAPA). Where adequate information exists to complete a NAPA, the country would use the steps under Level I, otherwise they would conduct synthesis or even limited data analysis by including Levels II and III in their approach

Chapter 9

Build Teams and Define Development Framework

1. Build Multidisciplinary NAPA teams

The Climate Change Focal Point is responsible for initiating the NAPA process in a country. The following are key teams that may be assembled:

a) Proposal Writing Team

The writing team for the GEF proposal for NAPA preparation, at a minimum would include members of key sectors (economic planning, environment, physical planning, economically important sectors, as well as members from the private sector and non-government organizations). The writing team would include representatives of implementing agencies to ensure that proposals address all necessary requirements for successful approval by the GEF.

b) NAPA Preparation Committee or National NAPA Team

The writing team would normally transition into the *National NAPA (preparation) Team*, although more members would be added to coordinate the preparation process after funding has been secured from the GEF. It is expected that the NAPA preparation team would comprise about 10 people with members from the groups identified in the writing team above, and could be co-chaired by the Climate Change Focal Point and someone from the economic-planning or finance department, or another appropriate person. The advantage of someone from the planning department is that NAPA activities can then be fully integrated into national planning, a desirable principle for NAPAs. Some countries may appoint a full-time NAPA Project Director who would work closely with the coordinating ministries.

While a country maintains its autonomy in setting up their NAPA teams, it is important that these teams are multidisciplinary, include government as well as non-governmental members, as well as members of the public and private sectors, in order to maximize the effectiveness of the NAPA process. Another way of looking at the composition of the NAPA team is through the required skills needed to complete a NAPA. These include:

- Knowledge of the climate change process (UNFCCC, GEF) and related multilateral environmental agreements;
- Knowledge of key sectors and systems that are especially vulnerable to climate change;
- Experience in development planning at the national level;
- Technical expertise in project development and priority setting;
- Experience in dealing with major problems associated with climate, such as floods, food insecurity, drought management and health especially at the rural community level, in particular, members of NGO's and the private sector;
- Experience in participatory rural appraisal; and
- Knowledge of climate and impact assessment.

It is expected that the NAPA team will provide overall guidance and leadership in the NAPA preparation especially in ensuring a bottom-up and participatory approach. In cases where specialized expertise is needed, the NAPA team should identify and enlist help from a broader team, which we will call the *NAPA integrated assessment team.*

c) NAPA Integrated Assessment Team

The Integrated Assessment Team could include consultants, technical experts, and representatives of major stakeholder groups. They would participate in the rapid assessment of vulnerability and identification of adaptation activities, providing a much wider base and input into the NAPA preparation process. It is critical that such a team be assembled to include members from outside the immediate climate change team, to provide a broader perspective for the NAPA. The NAPA Team would act as a moderator of the rapid assessment by the integrated assessment team.

The size of the teams will likely depend on the size of the country and the nature of the issues to be addressed. There are some LDCs that are very big and extend over terrain that is inaccessible for a number of reasons – in such cases, the NAPA Team should make some strategic decisions about their approach to the NAPA. For instance, a country may choose to approach their NAPA preparation along one of the following lines:

- Cover the whole country in a comprehensive way to include all communities and all sectors in the assessment;
- Select the highest priority sector(s) (e.g. food, water, health, etc);
- Select a vulnerable region or group of communities (e.g. coastal areas, flood plains, rural communities); and
- Develop the NAPA to deal with one or several key climate hazards (e.g. drought, floods, storm, seasonal changes, diurnal changes, etc).

These decisions would be informed by what the country wishes to achieve with the NAPA and would be based on recent experiences with adverse impacts of climate change (variability, extremes, etc), or some major scientific result highlighting major climate threats for the country. Countries should resist conducting comprehensive analyses for all sectors and for the whole country if there is no justification for doing so as indicated by emerging urgent needs.

2. Define Society – Environment – Development Integrated Framework

Although the NAPA is not an opportunity to conduct a comprehensive development-environment assessment for the country, it is useful to examine the underlying core drivers of environmental change and how these interlink with impacts on society and development.

There are many conceptual frameworks for sustainable development that integrate social, economic and environmental concerns. We propose the framework shown in Figure 9.1 to guide further discussion on the components of development. Specific integrative frameworks for the national level that take into account sectors, major drivers and economics are under development (Desanker et al., 2004; Africa and Climate Change, edited by Pak Sum Low, Cambridge University Press, *in press*).

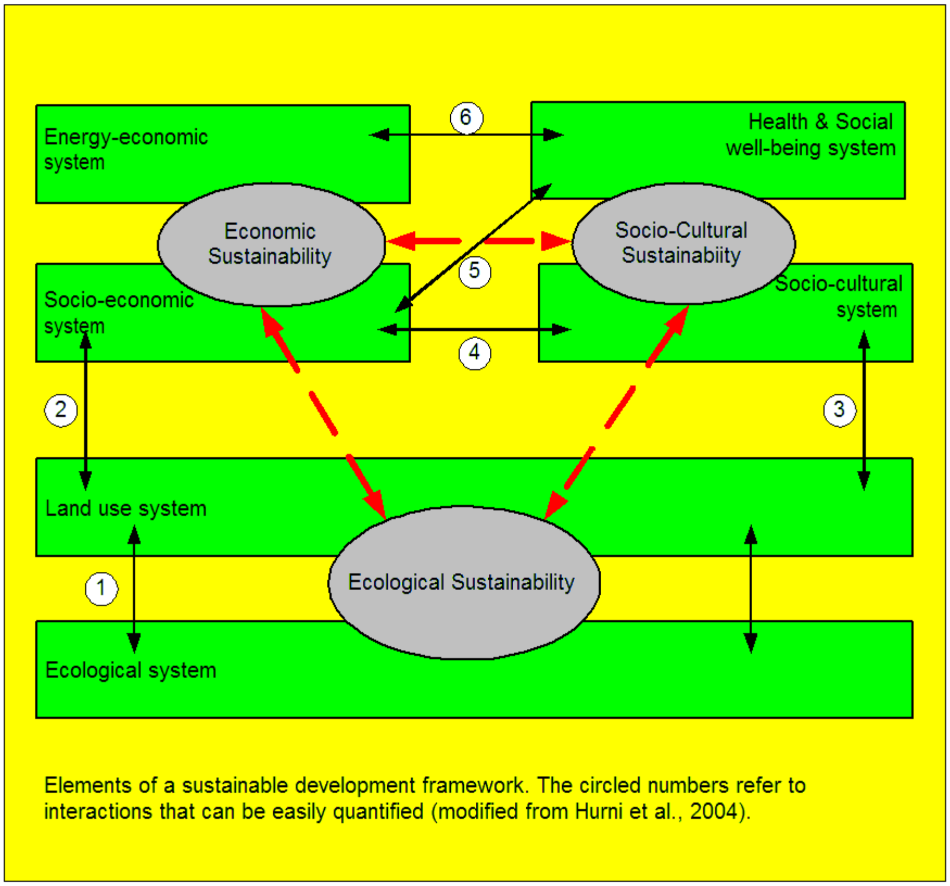


Figure 9.1. Elements of a sustainable development framework showing interactions that can be easily quantified (based on Hurni et al., 2004)

A more detailed framework based on what is called *syndromes of global change*, developed by the German Advisory Council on Global Change (WGBU, 1996), provides an integrating framework for looking at broad environmental changes. A comprehensive list of what are called syndromes of global change can be drawn in a diagram overlaying major spheres as shown in Figure 9.2. Lines can be drawn to connect the symptoms with each other for a given situation and/or location. Particular strong sets of relationships define what is called a *Syndrome*. Further analysis of a syndrome and its core relationships, can lead to fundamental understanding of development situations. For example, analysis of overcultivation of marginal lands in what is called the *Sahel Syndrome*, reveals a vicious circle of poverty, overcultivation of marginal lands that feeds further degradation and so reduced productivity, and leads to increased poverty. Such analysis can lead to improved understanding of causal factors, and inform development of solutions. A total of 16 syndromes have been described to encompass global changes worldwide (see Table 9.1). Once a syndrome has been identified, solutions become obvious based on the study of past cases.

The syndrome approach allows us to put the environmental change issues in context, and by examining the succession of syndromes over time (from one type to another in a progression triggered by events or more intense driving forces, we can assess where we are in terms of a trajectory of sustainable development. While we will not take the syndrome analysis any further, the conceptualization of the relationships between sectors including processes of society and development, is a useful one and helps us to identify major drivers and symptoms of environmental change, and how these may reinforce each other to result in typical outcomes. Most environmental change problems begin with overexploitation (Figure 9.3), with further development triggering the overcultivation of marginal lands (Sahel syndrome, Figure 9.4 and 9.5), then the dust bowl syndrome (non-sustainable agro-industrial use of soils and water) or the green revolution (environmental degradation and development problems through use of inappropriate farming methods, Figure 9.6).

Syndrome diagrams enable further analysis of core mechanisms of environmental problems for a region, and can lead to further insights on how to intervene. For example, analysis of overcultivation of marginal lands in the *Sahel Syndrome*, reveals a vicious circle of poverty: poverty leads to overdependence on subsistence agricultural activities, these degrade the soil, thereby increasing poverty as yield decrease. This further increases the overcultivation rates, thereby intensifying the circle (Figure 9.6).

A variant of the PRIVA Tool is under development to enable the syndromes to be evaluated using quantitative (and qualitative) data for an LDC, and will provide assistance in exploring solutions to core problems. Other integrated assessment frameworks that help contextualize society – environment – development include the Pressure – State – Driver –Impact – Policy framework. See Figure 9.7.

Table 9.1. Syndromes of global environmental change as described by the German Advisory Council on Global Change (WGBU, 1996-1999)

A total of 16 syndromes have been described, and these are:

Utilization syndromes

1. Overcultivation of marginal land: *Sahel Syndrome*
2. Overexploitation of natural ecosystems: *Overexploitation Syndrome*
3. Environmental degradation through abandonment of traditional agricultural practices: *Rural Exodus Syndrome*
4. Non-sustainable agro-industrial use of soils and water: *Dust Bowl Syndrome*
5. Environmental degradation through depletion of non-renewable resources: *Katanga Syndrome*
6. Development and destruction of nature for recreational ends: *Mass Tourism Syndrome*
7. Environmental destruction through war and military action: *Scorched Earth Syndrome*

Development syndromes

8. Environmental damage of natural landscapes as a result of large-scale projects: *Aral Sea Syndrome*
9. Environmental degradation and development problems through the adoption of inappropriate farming methods: *Green Revolution Syndrome*
10. Disregard for environmental standards in the context of rapid economic growth: *Asian Tigers Syndrome*
11. Environmental degradation through uncontrolled urban growth: *Favela Syndrome*
12. Destruction of landscapes through planned expansion of urban infrastructures: *Urban Sprawl Syndrome*
13. Singular anthropogenic environmental disasters with long-term impacts: *Disaster Syndrome*

Sink syndromes

14. Environmental degradation through large-scale dispersion of emissions: *High Smokestack Syndrome*
15. Environmental degradation through controlled and uncontrolled waste disposal: *Waste Dumping Syndrome*
16. Local contamination of environmental assets at industrial locations: *Contaminated Site Syndrome*

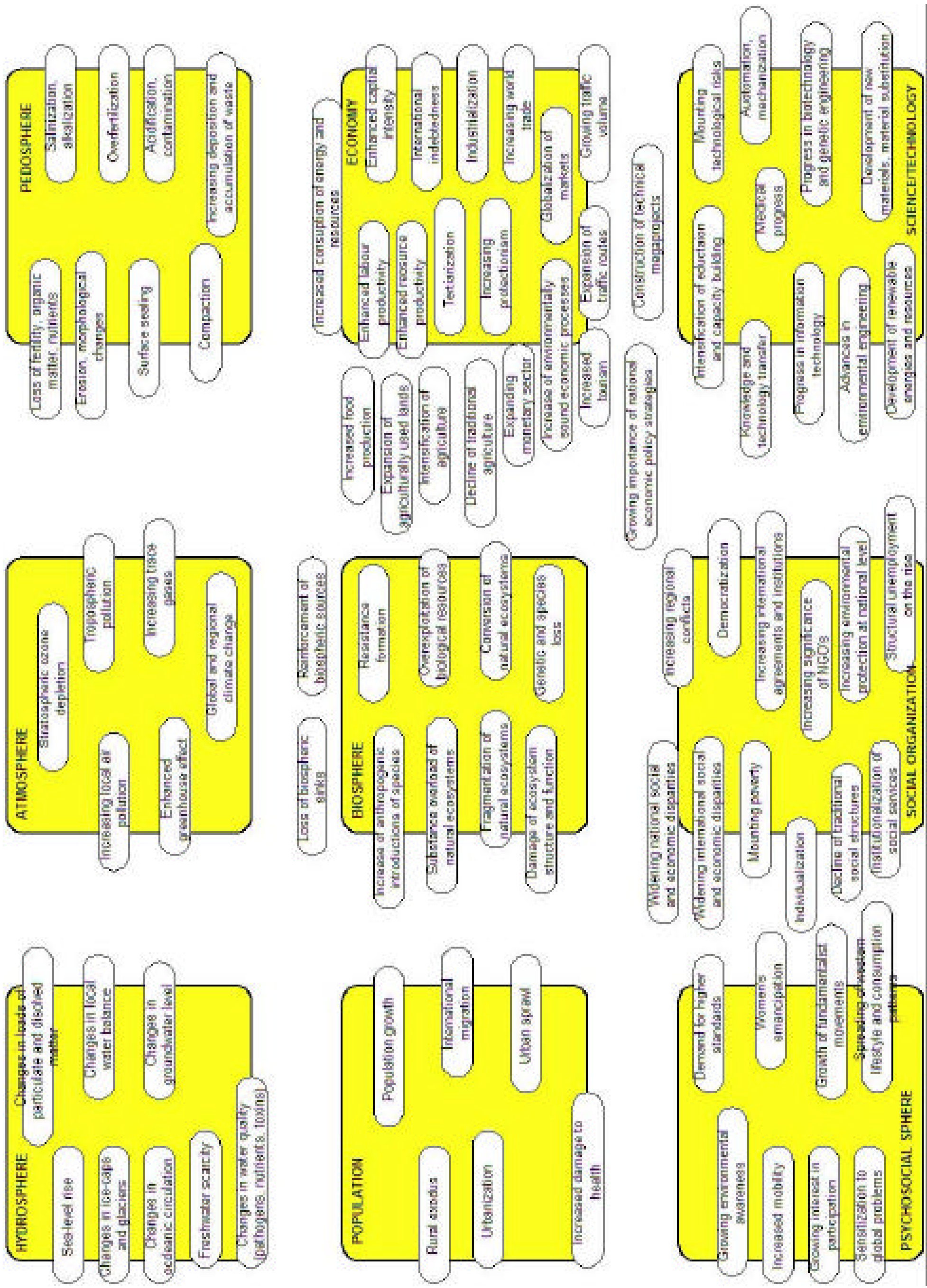


Figure 9.2. Syndromes diagram showing spheres or sectors and main symptoms

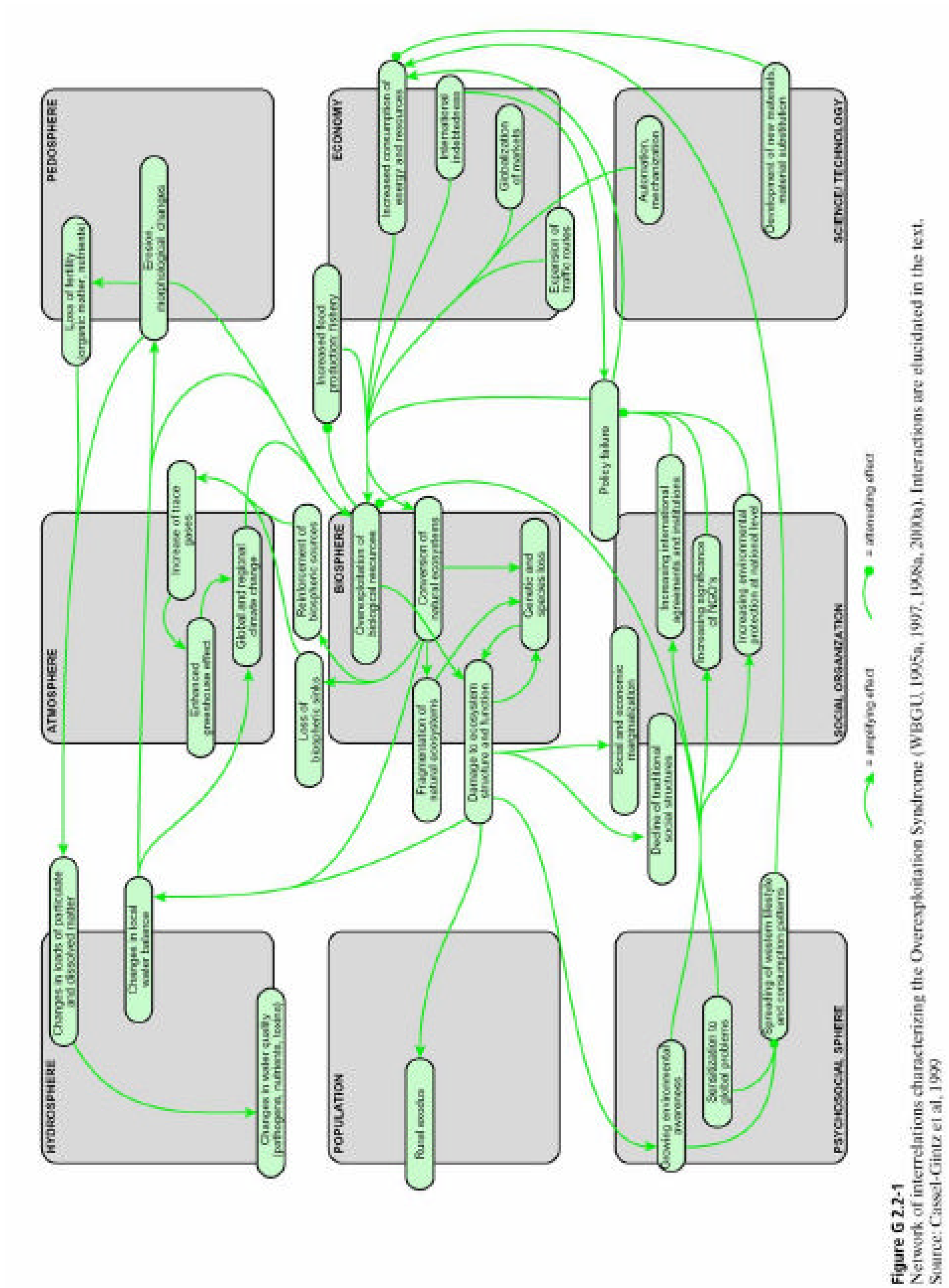


Figure 9.3. Network of interrelations characterizing the Overexploitation Syndrome (WBGU 1995-2000; Cassel-Gintz et al., 1999)

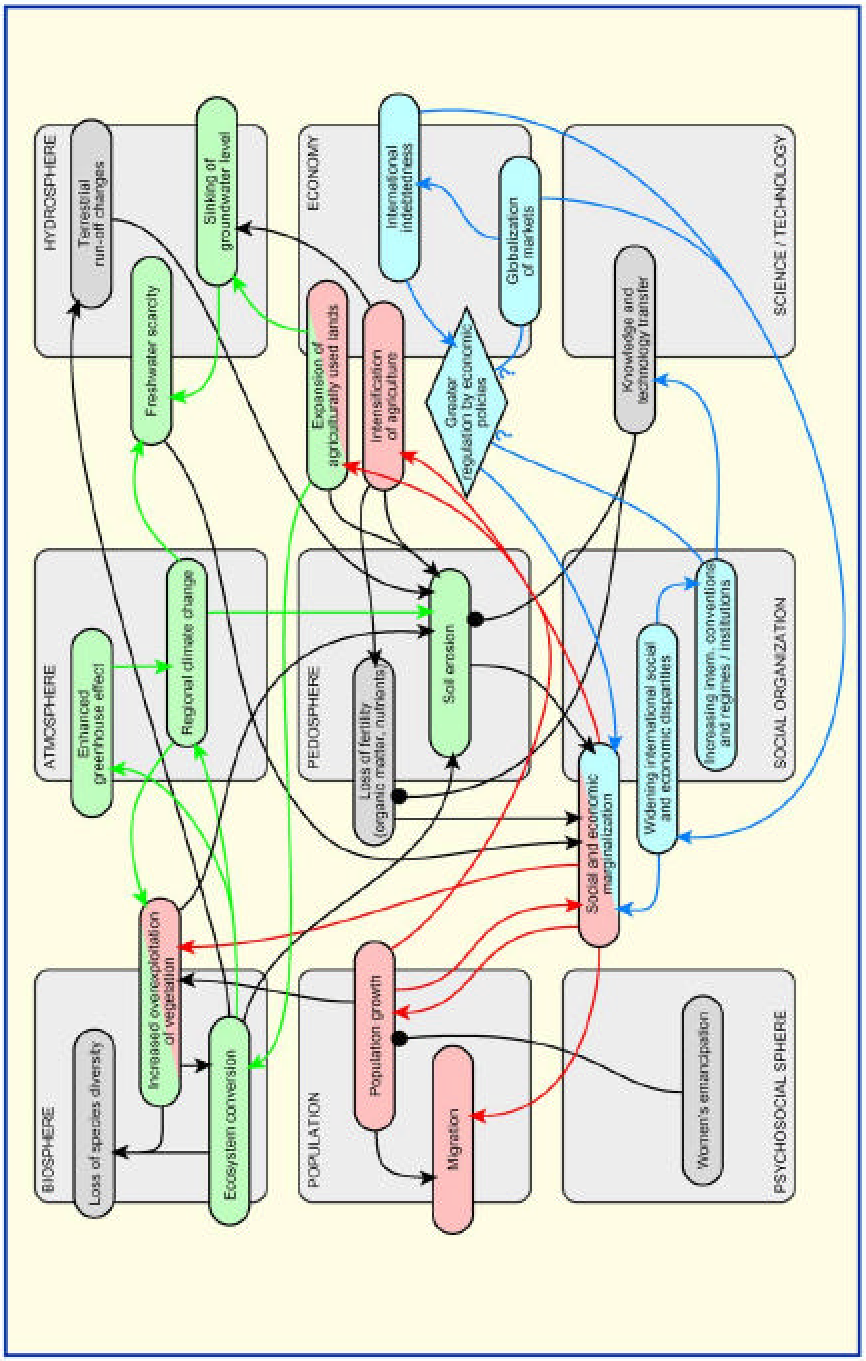


Figure 8
Syndrome-specific network of interrelations of the *Sahel Syndrome*. The three sub-networks from which the complexes of issues are derived are marked red, green and blue.
Source: WBGU

Figure 9.4. Syndrome-specific network of interrelationships of the Sahel Syndrome. The three sub-networks represent sources of complexity in major issues of this syndrome. See also Figures 4

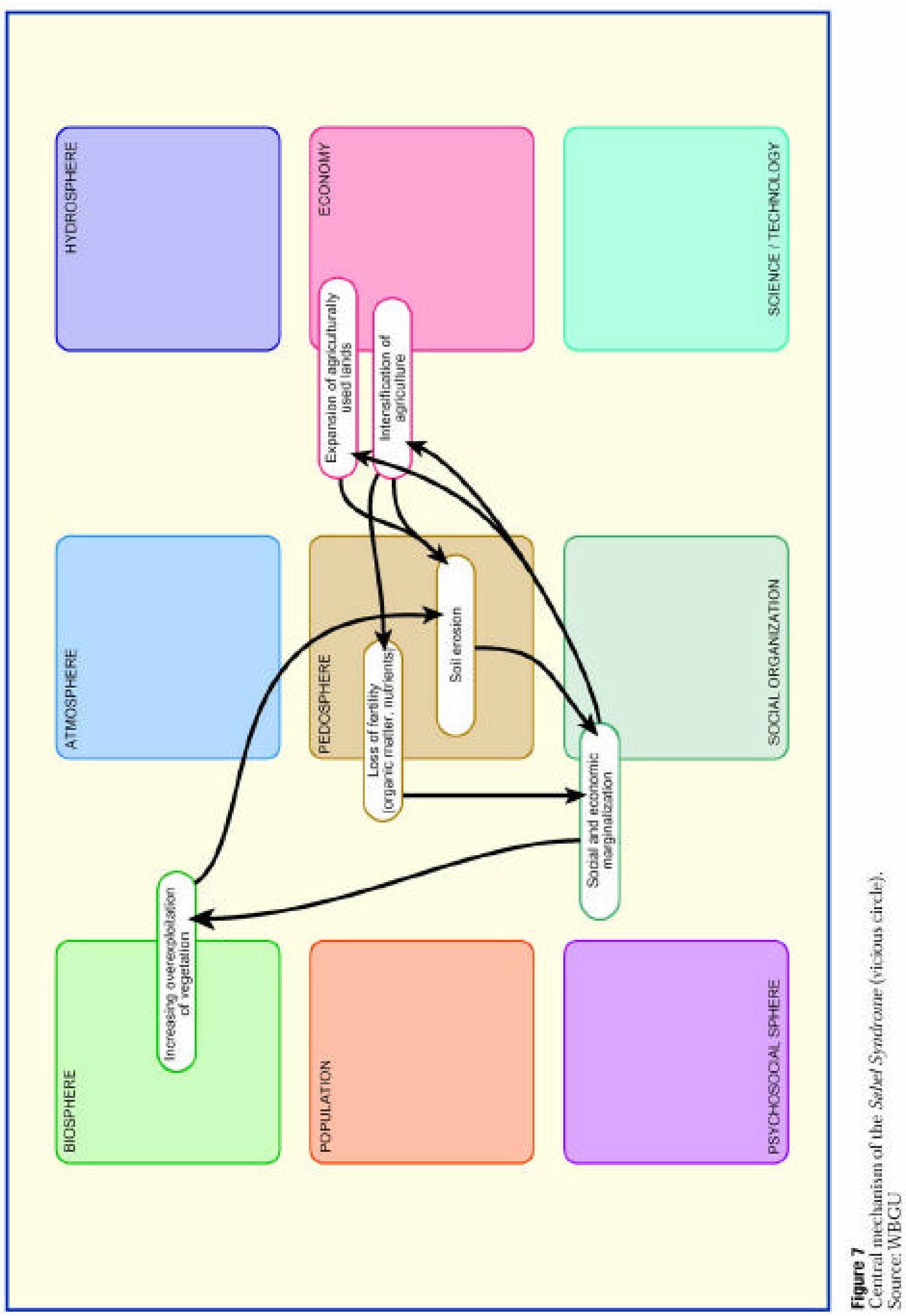


Figure 9.5. Central mechanism of the Sahel Syndrome (vicious circle; Source WBGU)

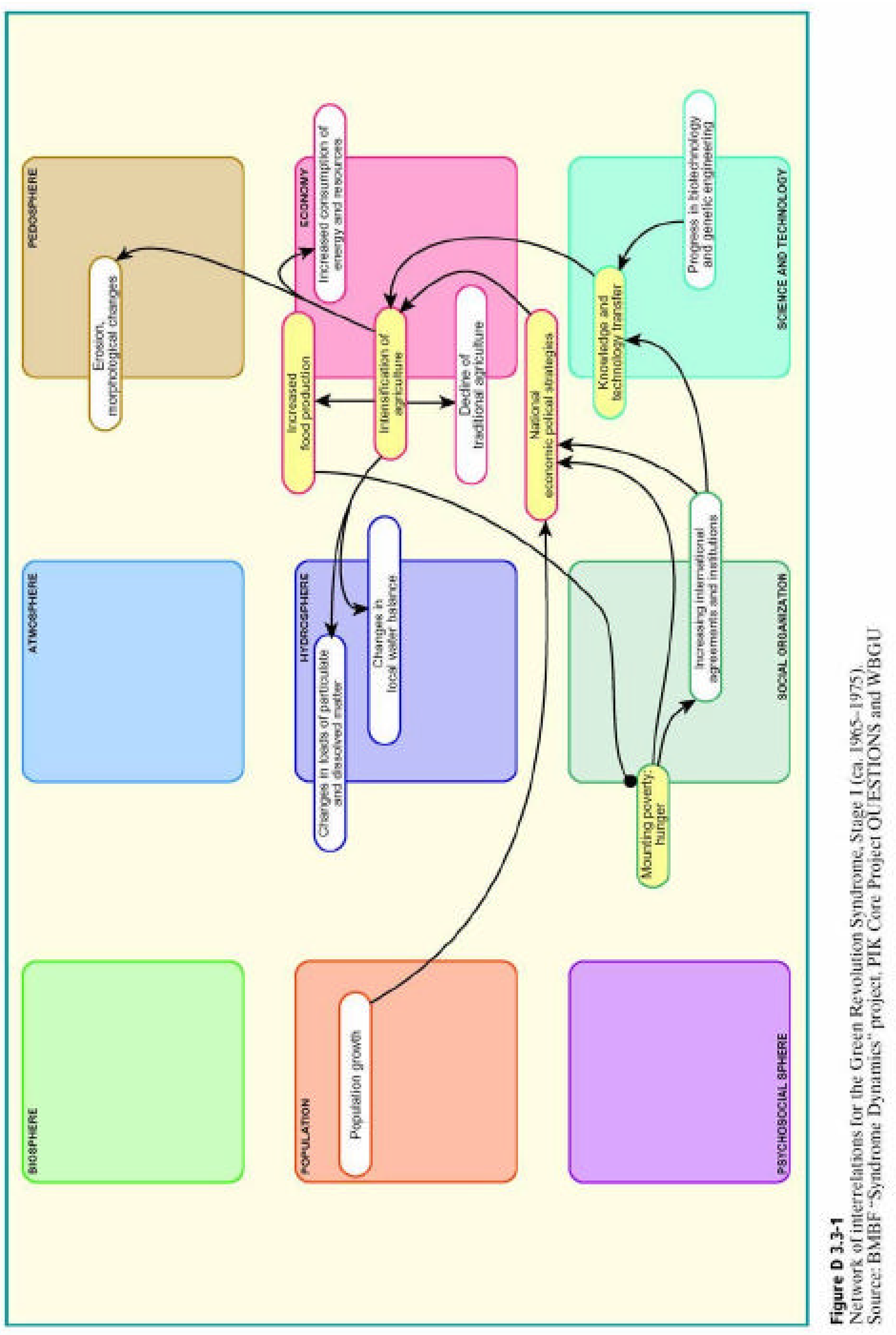
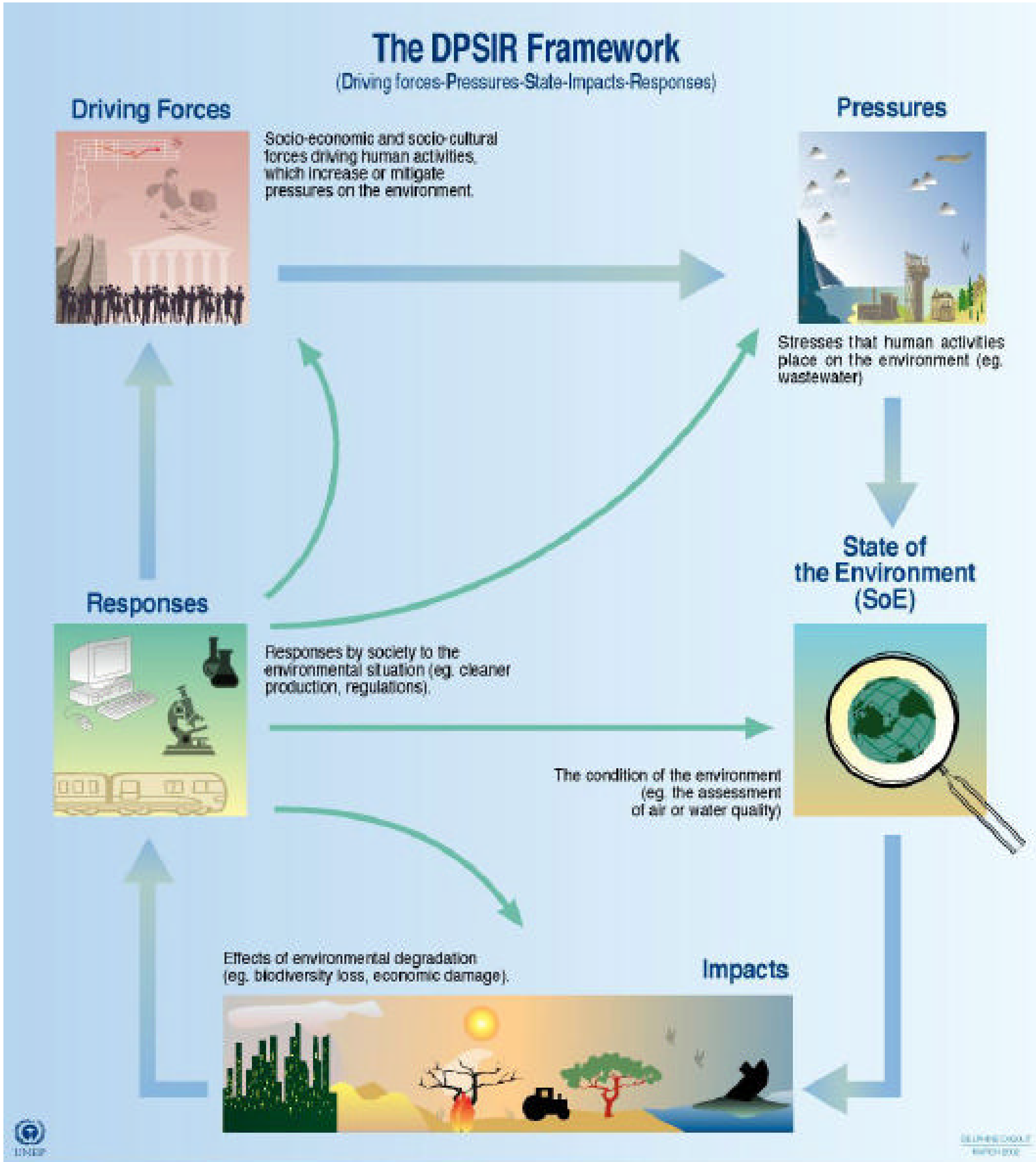


Figure 9.6. Network of interrelationships for early stages of the Green Revolution Syndrome (WGBU)



Source : Global International Water Assessment (GIWA), 2001; European Environment Agency (EEA), Copenhagen.

Figure 9.7. The DPSIR Framework

3. Review Development Policies and Define NAPA Goals and Objectives of NAPA and Criteria

The National NAPA Team is expected to understand the guiding principles of NAPA and how NAPAs fit within other national action plans and activities.

The NAPA team should review various development policies (economic development, social policies, etc.), and in particular, the Poverty Reduction Strategy Papers and identify those important development policies, goals and objectives that NAPA activities will strive to enhance and help implement. Directly linking the NAPA to development priorities will ensure that NAPAs are fully supported by the national planning process. As an example, a country may wish to start with the Millennium Development Goals, then connect these to national priorities and policies especially those designed to fight poverty and diseases, and those that foster the social development of women and children. In other cases where a country developed Vision 2020 documents, these could also be useful targets which NAPA activities could complement.

The following documents are available online for most countries, and provide a useful starting point for NAPA development:

- Poverty Reduction Strategy Papers (PRSP); [http://www.imf.org/external/np/prsp/prsp.asp];
- National Action Plans for Development for the 2001-2010 period (NAP) presented to the Third UN Conference on the LDCs, Brussels, 20 May 2001 [http://www.unctad.org/conference/doclist/ldc3_npa.en.htm];
- National Environmental Action Plans (NEAP); and
- Millennium Development Goals (MDGs).

The goal should be to identify clear development goals, objectives and strategies from these government policy documents that could be seriously constrained by climate change, and use these to inform the selection of priority adaptation needs and activities under the NAPA.

This mainstreaming of NAPA preparation in the context of national development has been cited as essential in ensuring that outcomes of NAPAs fit well within national development activities. The explicit consideration of a guiding development goal and priority in NAPA sets it apart from other activities that would require mainstreaming after they would have been completed.

As an example, the overall goal of the Malawi Poverty Reduction Strategy (MPRS; April 2002, available online at http://www.imf.org/External/NP/prsp) is to achieve “sustainable poverty reduction through empowerment of the poor”. Rather than regarding the poor as helpless victims of poverty in need of hand-outs and passive recipients of trickle-down growth, the MPRS sees them as active participants in economic development. The MPRS also emphasizes prioritization and action. The MPRS is built around four pillars. These pillars are the main strategic components grouping the various activities and policies into a coherent framework for poverty reduction:

- The first pillar promotes rapid sustainable pro-poor economic growth and structural transformation;
- The second pillar enhances human capital development;
- The third pillar improves the quality of life of the most vulnerable;

- The fourth pillar promotes good governance.

The isolation of a concise development goal/objective/policy to guide NAPA preparation is important in guiding further steps in the process. While the prevailing internationally driven development paradigm is of poverty reduction/poverty alleviation, it is important for countries to take a fresh look at what is most reasonable in the context of NAPAs. NAPAs are not an instrument for restructuring development and coordinating the breadth of activities that a country may be implementing. Integration of development ideas in NAPAs is simply to ensure that there is neither duplication nor inconsistency, and that activities build on previous thinking and analysis. It also helps to identify opportunities for co-funding at present or in the future.

Some countries are stressing growth in their economies as a priority, as opposed to reducing poverty alone. Figure 9.8 shows two contrasting development plans – one driven by the World Bank's poverty reduction emphasis, while the other strives to achieve equitable economic and social growth. The NAPA team may wish to work with their planning department to articulate a local and specific development plan. Other appropriate frameworks include sustainable development and sustainable livelihood frameworks.

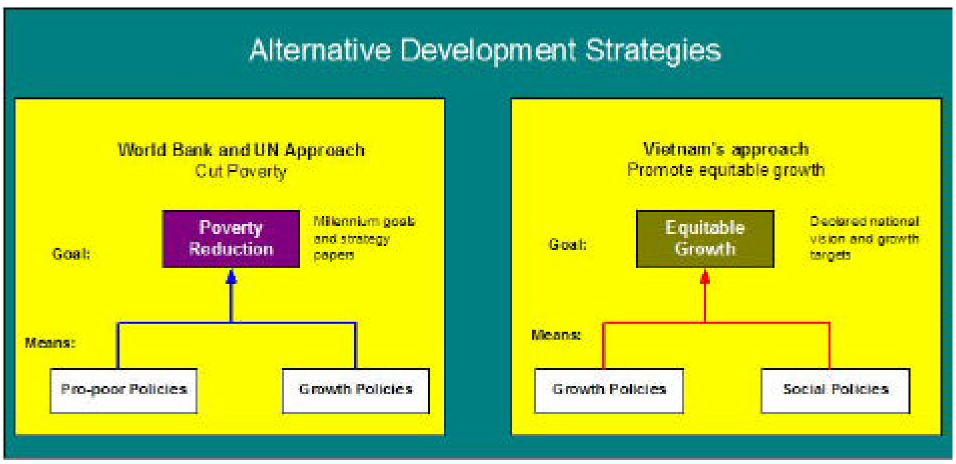


Figure 9.8. Alternative development plans showing the conventional World Bank approach that emphasizes poverty reduction versus an alternative that strives for equitable economic and social growth (adapted from Ohno, K. 2002. For diversity in development strategies. OECD Observer No. 233, August 2002; www.oecdobserver.org)

To further guide NAPA preparation, it is important to define a goal and to set up objectives for the NAPA, as well as criteria to guide the selection of priorities and urgent needs, which would be subject to revision and improvement as the assessment progresses. In general, most NAPA preparations could have the following goal:

To communicate a short list of urgent needs for activities to address adverse impacts of climate change, including climate variability and extreme events. Activities proposed will be those that must be addressed in the immediate term to avoid further loss of life if left unattended, as well as protect critical livelihoods, key infrastructure, and other activities that help a country implement its priority development goals and objectives. The NAPA will be designed to address the needs of the most vulnerable systems, groups and regions of the country, using criteria agreed upon by representatives of major stakeholders in the country.

Specific objectives might include the following:

- To reduce losses (of life, property, land and livelihood) due to increased incidence of floods and other climate related natural disasters;
- To reduce further loss (of life, property, land, and livelihood) due to increasing incidences of drought;
- To enhance adaptive capacity to climate change by reducing poverty in areas particularly exposed to changing climate, including as areas along the coast or in flood plains; and
- To increase early warning capability of adverse weather in order to improve disaster response; and to improve seasonal forecasts to safeguard agricultural production.

Criteria

The goals and objectives suggest criteria that could be useful in ranking activities. In cases where activities are drawn from PRSPs, criteria for evaluation might already have beendeveloped, and may include specific targets whichdevelopment plans would strive to achieve during the next 10 years for example. Other criteria that a country may choose might include the following (based on the NAPA guidelines):

(a) Loss of life;
(b) Loss of property or land;
(c) Loss or serious disruption of livelihoods;
(d) Protection of human health;
(e) Enhancement of food security and agriculture;
(f) Water availability, quality and accessibility;
(g) Preservation of essential infrastructure;
(h) Security of cultural heritage;
(i) Conservation of biological diversity;
(j) Protection of land use management and forestry;
(k) Protection of key environmental amenities;
(l) Reduction of impacts on coastal zones, and associated loss of land.

Whichever criteria are chosen, it is important to document every step and include adequate details in the project profiles to help support selected activities. While the final NAPA document will be very brief as we will see later, it is important for the country to keep detailed records for future use and revision of the priorities as situations change. The National NAPA Team may wish to create a NAPA website where this information would be archived. It is likely that the information gathered during the NAPA process would be useful in subsequent National Communications.

It is also important that a country strive to produce its NAPA without delays that may be caused by a perceived need for lengthy consultancy reports for the many steps along the way. The complete NAPA is ideally a very brief document with appropriate backing information and certainly not a collection of hundreds of pages of reports and supporting documents.

Climate change is but one important environmental problem that any country is likely to be addressing at a given point in time. Most countries will be working on their national biodiversity strategy and action plan, their national capacity self assessment, or their national communication. It is important that synergies between these activities as well as common threads are identified.

The NAPA team is likely to include people that are actively involved in the other assessments, and this will help in building ties between the different environmental issues. These synergies are best explored at the implementation level – whether at project level or for the targeted communities or regions instead of at a higher level.

Chapter 10

Synthesize Past Vulnerability Assessments and Available Information

1. Introduction

The synthesis of past studies and other available information is a necessary step in the development of NAPAs. While some vulnerability assessments may exist, most studies do not give the required levels of detail to enable adaptation actions to be specified. It is also unlikely that many existing assessments would have developed or applied a clear adaptation framework in the context of a major development goal such as those articulated in Poverty Reduction Strategy Papers (PRSPs) for example. The ideas presented here are designed to guide a national team towards amassing data and information that would then be used to guide the identification of adaptation needs, including through a rapid assessment of vulnerability.

A NAPA is intended to be a brief document, arrived at using a streamlined approach that recognizes the many limitations of LDCs in terms of capacity to conduct comprehensive assessments. Data are also in short supply. Usually, enough is known within the confines of a country about what constitutes urgent and immediate needs in terms of adaptation or of what is required to enhance coping ability or adaptive capacity, *in the short term.* (Longer term needs for adaptation would be considered outside the NAPA process and through a more comprehensive assessment process). It is thus assumed that a participatory process of assessment among stakeholders and others would result in a list of adaptation activities. Once they are ranked using mutually acceptable metrics, a prioritized list of urgent adaptation needs and activities can be identified for the NAPA.

It is important to rely on previous assessments as much as possible, or on data and information that may be available in regions of similar vulnerabilities. The IPCC reports are also important sources of reliable but general information regarding potential effects of climate change, such as expected trends in extremes, which are difficult to assert in an LDC setting.

The synthesis activity should address the following questions:

(a) What was the stated *development framework* most relevant for the NAPA identified in the previous step (see last chapter)?
(b) What is an overview *framework of vulnerability* for the country?
(c) What is known about the adverse effects of climate change from *previous assessments*, including the national communication if completed, natural disaster preparedness plans, and other past consultations?
(d) What are *major climate hazards* and *associated risks* from *past experience* for the region or country of interest?
(e) What are place-, time- and situation-specific *coping strategies* to given climatic hazards?

(f) What are *trends* in climate parameters and indices? What are useful *thresholds or trigger points*?
(g) What are *regional factors* that influence adverse impacts in the country of study?

2. Synthesize Past Assessment Studies at Multiple Levels

A diagram summarizing major symptoms of climate change and how these would affect critical sectors and systems for the country of study is useful in guiding the NAPA assessment. This can be constructed through a participatory process of identifying what drivers of change and sectors are important. For exanple, the Bangladesh NAPA team has developed an overview of vulnerability for their country that provides a useful panorama of the issues (Figure 10.1).

2.1 Past National and Sub-national Assessments

It is likely that some assessments of impacts exist for many LDCs as a result of work in developing national communications. Most of these would be in the form of modeling studies that may have addressed various sectors and systems in the context of a series of climate change scenarios. In some cases, response options would have been suggested that could be considered adaptation options. Some recent NCs would have explicitly listed proposed projects and activities that are grouped under adaptation options. These specific activities, if well justified, would constitute an initial input into the pool of potential activities and projects to be considered by the consultative process of the NAPA.

A sample summary of the vulnerability assessment for the Maldives used in their submitted First National Communication, along with suggested adaptation activities is given in Appendix I. As can be seen, the results are comprehensive enough so that the NAPA preparation process could advance in exploring priorities and urgent needs through an appropriate multiple stakeholder consultative process.

In some cases, there are sub-national assessments carried out as part of other activities, such as the development of national action plans to address land degradation issues that could constitute a viable input and valuable source of information.

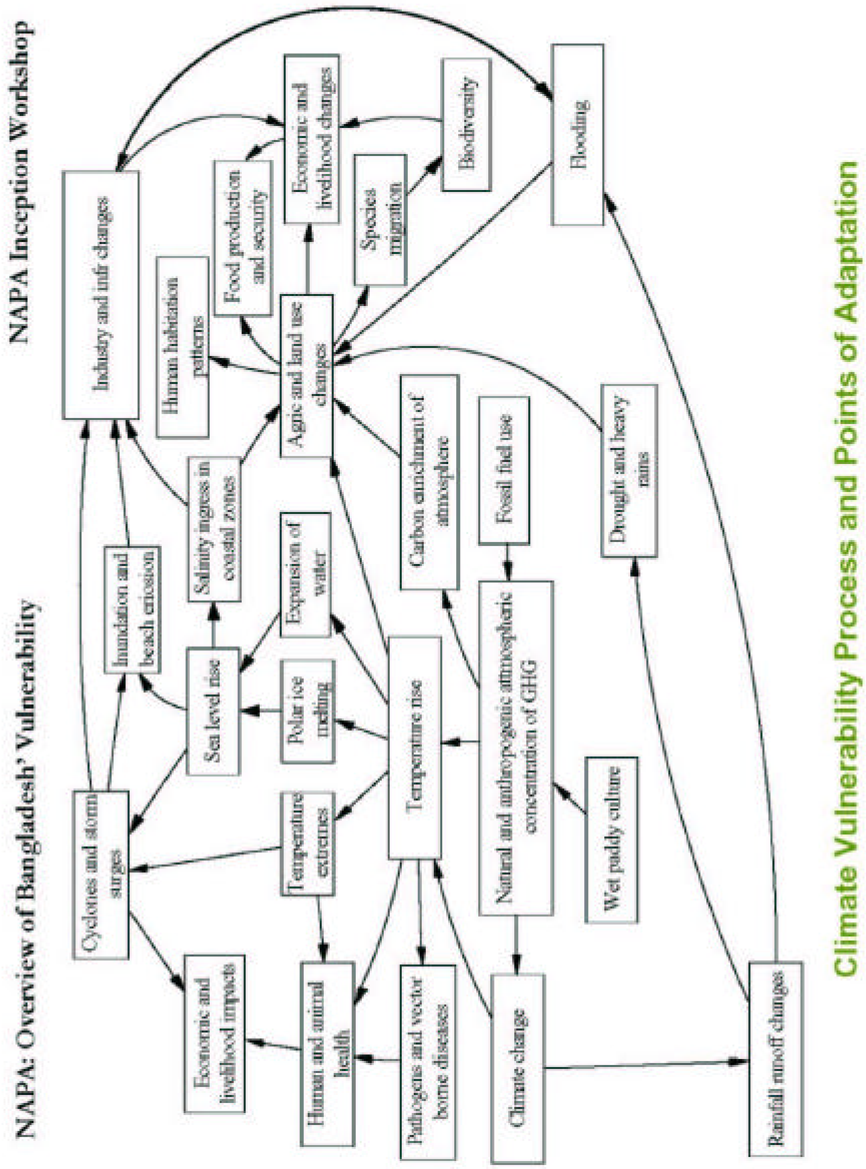


Figure 10.1. Overview of vulnerability to climate change for Bangladesh (source: Bangladesh NAPA Team, available online at http://www.sdnpbd.org/sdi/issues/climate_change/napa/index.htm, accessed November 13, 2004)

Not all past assessments can directly inform adaptation planning, such as, for example, modeling studies of crop production that would have explored yield changes under different climatic drivers from various climate change scenarios. Since the projected yield outputs were dependent on the GCM and scenario used, no concrete adaptation actions can be identified. In cases where yields drop, one can suggest increased inputs to compensate yields, or suggest drought resistant crops. While the latter activity would be reasonable under a climate change scenario, no methods exist to select one scenario over another due to model uncertainties. In many cases, scenarios will provide contrasting outputs, making such modeling studies of limited value in planning specific adaptation activities. In addition, many scenarios are centered on long-term climate impacts in such a way that would limit their utility in the identification of urgent and immediate adaptation needs.

It seems very useful then to carefully understand recent trends and patterns in climatic variables and indices in relation to important processes in major sectors, and use this information to make some guided suggestions about response options. One important variable is the properties and trends of the growing season – in terms of the beginning, quality, length and ending of the crop growing season. Climate data are usually available for the recent past to indicate increasing variability or shifts in important dates for agriculture. In parts of Southern Africa, for example, farmers are able to point out with certainty how the beginning of the growing season has shifted by 3 to 4 weeks, which can be confirmed by specific data. Farmers can also indicate whether the growing seasons are shorter or in some cases have shifted forward. In such cases, documenting specific instances of a shift and associated farmer responses would be an invaluable contribution to the preparation of the NAPA. We discuss this point later on when we look at local coping strategies.

2.2 Past Regional Assessments

In many parts of the world, various regional assessments have been carried by sector or in an integrated manner, and may provide information that would guide the selection of vulnerabilities. In some cases, these regions include non-LDCs. These assessments are valuable sources of information and ideas about trends and possible actions. For the SIDS, for example, a number of assessments have been carried out to analyze patterns and trends in natural disasters, and these provide a useful source of information for NAPAs (for example, see Charvériat, 2000 for an analysis of natural disasters in Latin America and the Caribbean).

In mainland countries, there are usually many assessments carried out to coincide with shared major river basins, or regional economic groups such as ECOWAS, SADCC, etc. Such assessments often point to sources of contributing factors of vulnerability that operate at the regional, multi-national level, often involving non-LDCs. In the case of Mozambique for instance, heavy rains in several areas of the Zambezi Basin lead to excessive runoff in the Zambezi River and invariably lead to severe flooding in the lower Zambezi region that is in Mozambique. Dams and man-made lakes also contribute to flood dangers in downstream communities when flood gates are opened to avoid catastrophic dam failures, often with little or no warning facilities for rural communities in downstream flood plains. Figure 10.2 shows a map of the Zambezi basin with circles highlighting areas where heavy rains would lead to flooding in the lower Zambezi.

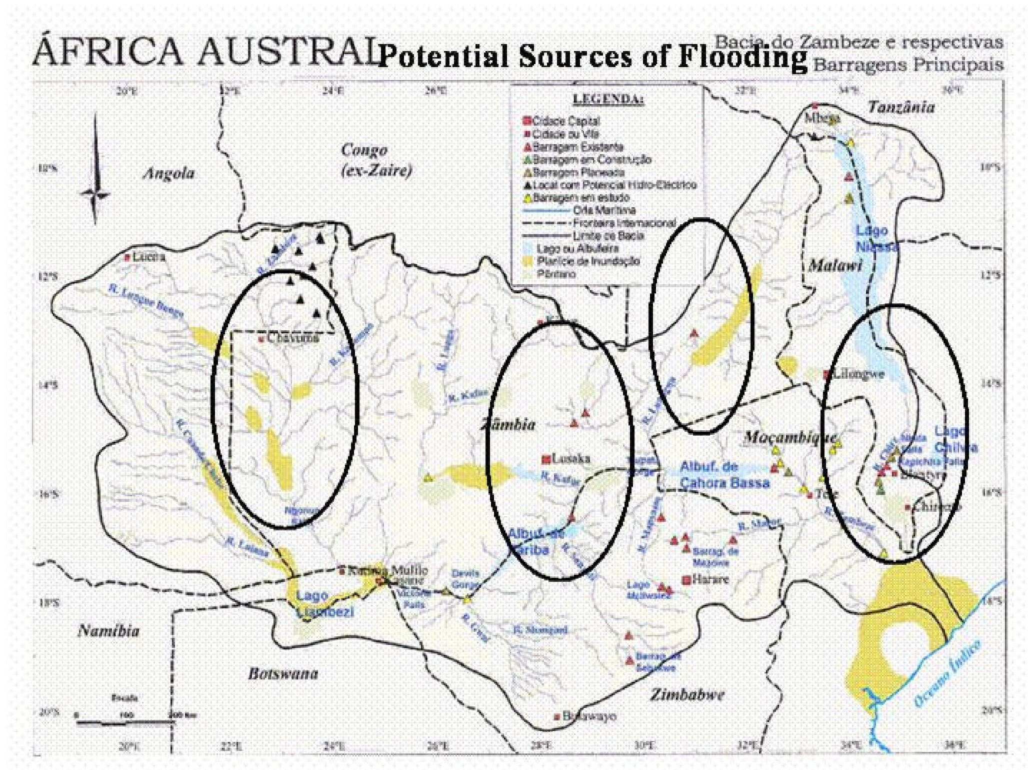


Figure 10.2. The Zambezi River Basin in Southern Africa showing parts of Angola, Zambia, Zimbabwe, Botswana and Tanzania. The balloons indicate areas where heavy rains would lead to flooding risk along lower parts of the Zambezi River

Assessments of food security are perhaps another common source for data and information at the regional level. The Famine Early Warning Systems network (FEWS NET) conducts periodic assessments of the food situation. While these assessments cover a season over at most one year, they do point to vulnerable areas that would be further compromised by flooding, droughts or other climatic extreme. Their latest reports are given at www.fews.net. Similar assessments can be found at the World Food Programme website (www.wfp.org).

2.3 Past Global Assessments

Perhaps the most relevant large scale assessments are the results of the IPCC assessments (IPCC TAR, 2001, available online at http://www.ipcc.ch). The conclusions drawn by the IPCC provide the most reliable assessment of projected trends in climate change along with their evaluation of the level of confidence associated with each conclusion. Table 1 shows the main conclusions related to extreme events. In the absence of local studies for each of these climatic hazards, the IPCC conclusions should guide further thinking about likely changes in intensity and frequency of extreme events, as well as the likely impacts. Preparation of NAPAs should bear in mind that LDCs are fully recognized as having very limited research in areas of climate change, and so, NAPAs should make the best of available information without conducting new assessments. It should suffice to refer to the IPCC for likely changes in extremes and other variables.

Besides the projected trends in extremes, there are several important results from the IPCC worth noting (see Figures 10.3 to 10.5), including:

- Maintaining emissions at a fixed level such as that of 1990 or 2000 will not lead to a stabilization of the CO2 concentration in the atmosphere – in fact it would lead to a linear increase in concentration and a temperature increase. Stabilizing future CO2 concentration and so future temperatures would require emission reductions, and even with the most conservative emission reductions, temperatures are expected to increase at least over the next 100 years (Figure 10.3).
- Emission reductions as suggested under the Kyoto Protocol would only be a minor start in the reductions that would be required to stabilize future carbon dioxide concentrations, and will have absolutely no effect on the urgent adaptation needs of LDCs. Stabilization scenarios for CO2 assessed by the IPCC range from 450 to 1000 ppm. The strictest of these, the 450 ppm, would only lead to a stable climate after 100-200 years from now assuming the drastic cuts in emissions were possible. The implication of this is that climate will continue to change for the next 50 years or so, making the short to medium term nature of NAPA absolutely necessary, and invariant to any future emission reductions.
- Temperature increases expected over next 100 years range from a minimum of 2^oC to 6^oC depending on the future stable CO2 concentration sought – the lowest levels of 450 ppm would result in a 2^oC temperature increase (Figure 10.4 and 10.5).
- The upper end of rapid change in global warming expected for the next 100 years is in fact the same that would have occurred over thousands of years since the last glacial period (it was about 6^oC cooler during the last ice age 18 thousand years ago). Species were able to evolve and adapt to these long-term but slow changes. In contrast, the rapid changes expected over the next century or two, would probably be too fast for many ecosystems to adapt to and evolve.

The IPCC has indicated difficulties in attributing particular climatic events such as extreme events to climate change versus climate variability. This important observation implies that it will not be possible for LDCs to apportion cause and effect for given climatic events. This makes the idea of enhancing coping capacity under NAPA a reasonable approach to adaptation.

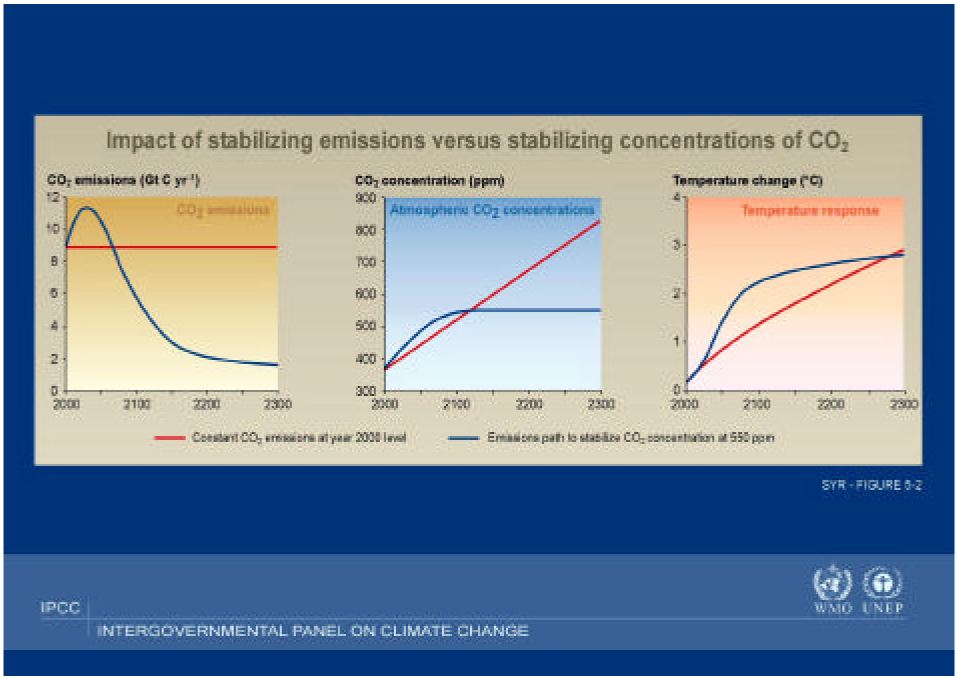


Figure 34. Impact of stabilizing emissions versus stabilizing concentrations of CO2 (IPCC TAR, 2001)

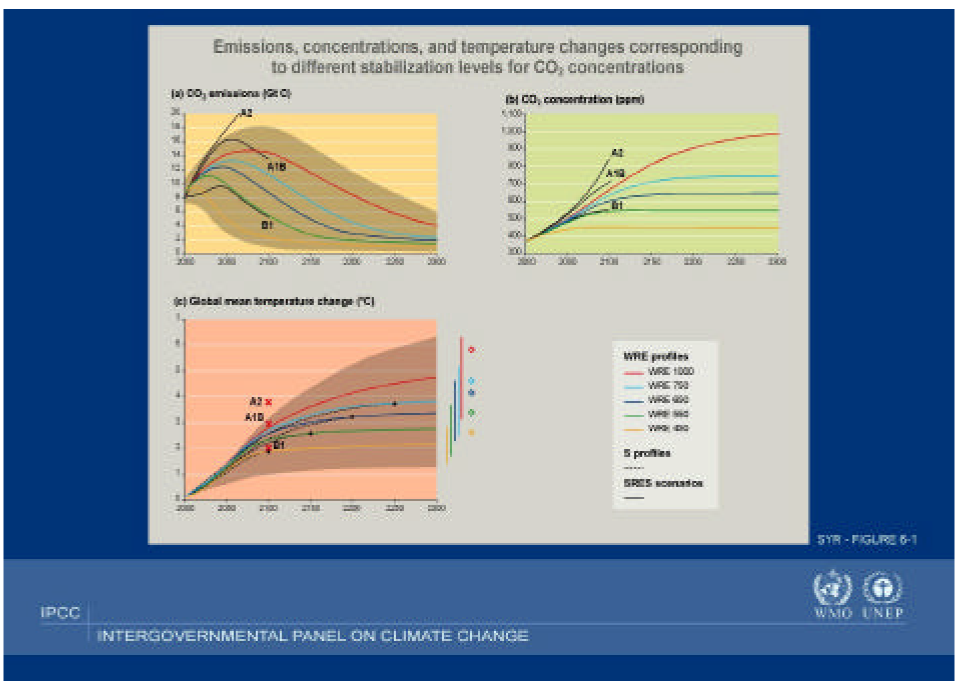


Figure 35. Emissions, concentrations, and temperature changes correpsonding to different stabilization levels for CO2 concentratios (IPCC TAR, 2001)

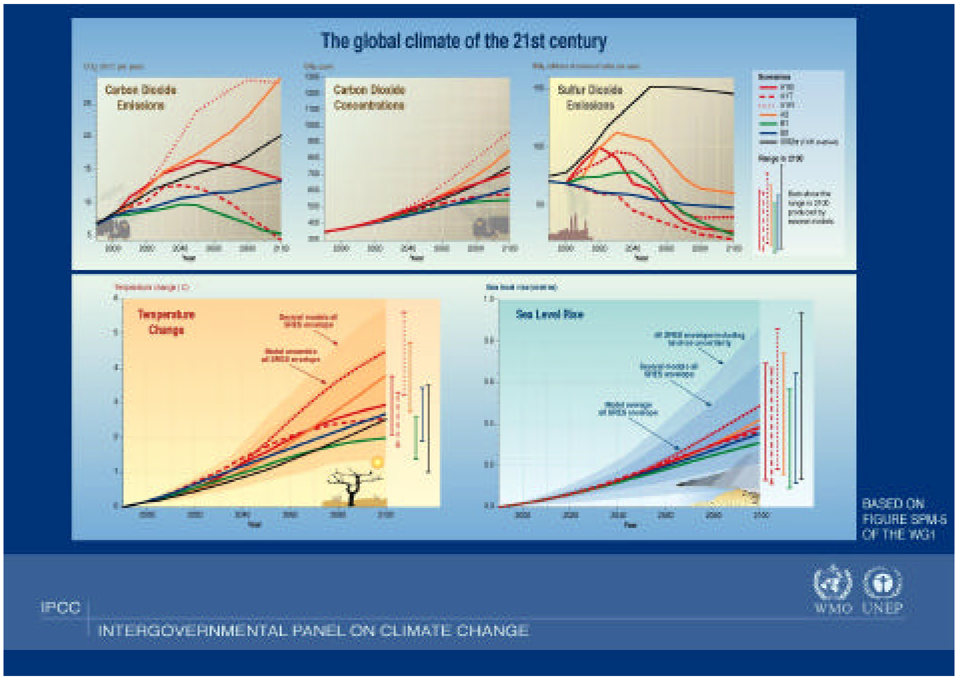


Figure 36. The global climate of the 21st century (IPCC TAR, 2001)

3. Identify major climate hazards and associated risks for the region or country of interest

A good way to organize adverse impacts is to identify major climatic hazards for the country or region of study, then to look at what sectors and systems would be vulnerable, versus evaluating vulnerability of all possible sectors in order to identify critical areas. At the national level, it is often obvious which major climatic hazards are of concern and where – that is, whether they are floods, droughts, storms, or erratic growing season conditions, and in which districts. Past climatic records sometimes indicate past trends and help to define risks, where risk is defined as the likelihood for the climatic event or hazard to occur.

Past records serve as inputs into this analysis. Future conditions are likely to change, and will bring new and sometimes additional hazards. It is important that all possible hazards are included in this analysis to avoid solutions that would result in unintended vulnerabilities.

Once a short list of hazards has been identified, a whole suite of solutions open up from experiences from other regions undergoing similar exposures.

4. Document Coping Strategies

4.1 Place, time and situation-specific coping strategies to given climatic hazards

For the climatic hazards identified above, it would be helpful to document coping strategies at the local community level as well as other higher level responses, including some assessment of effectiveness.

In many cases, there will be effective local coping strategies, some of them based on indigenous technologies that may have been in use for generations. These ‘adaptations’ will be useful in designing new activities, especially in areas where new hazards manifest themselves. For example, experiences in areas that are subject to chronic floods will provide solutions that may work for areas that are now becoming flood-prone.

The documentation of these local coping strategies can also be enhanced through local consultations at the community or project level, including:

- Consultations to prepare profiles of major installations that are especially vulnerable to climatic events such as hydroelectric power stations; major dams; water sources for major urban areas; major industries in drought-flood prone areas
- Interviews of communities at risk from droughts and floods to establish their views and experiences of past events (coping strategies, thresholds and limits to what they could do to avoid future hazards)
- Profiles of major groups dealing with main sectors that are dependent on climate to establish current programs and strategies used to address climate variability and disasters (food – FEWS Network; World Food Program; national agricultural organizations; water; power; health – malaria projects; etc
- Status of warning systems for storms and weather (radar installations)
- Characterization of the country’s population into sectors that can be addressed jointly, e.g. urban residents (they share water and energy sources), rural subsistence farmers that use a lower circuit economy; commercial farmers, industrialists, etc. While all major groups cannot be represented, it will be useful to identify the most vulnerable
- Case studies of impacts of El Nino.

4.2 Results from Other Countries and Regions for Similar Vulnerabilities

Climate change is introducing new climatic hazards to vulnerable communities, such as major flooding or severe droughts in regions that were previously not exposed, at least not with the same intensity and frequency. In such cases, it is beneficial to learn how people from other regions have adapted to particular climatic hazards.

In the case of flooding, there is a wealth of experience and lessons from countries in South East Asia where communities have adapted their housing and way of life to floods. In contrast, areas in Southern Africa that are now beginning to experience repeated and severe flooding, do not have the housing and farming techniques designed to withstand flooding. The opportunity exists for a lateral transfer of experiences and technologies. Building elevated houses, which are common in SE Asia, is not intuitively obvious for other regions facing increased flood risks.

In arid and semi-arid regions of the world, many techniques have been mastered for water harvesting and water management. Whether such techniques and experiences may indeed contribute to better adaptation will eventually depend on the specific socio-economic and cultural context. The respective communities must be in a position to accommodate them into their livelihoods. As we gain practical experience with adaptation, it will be useful to document inputs and outputs (costs and benefits), including lessons learned in ‘adopting’ solutions from other areas.

Table 10.1. Estimates of confidence in observed and projected changes in extreme weather and climate events (available online at http://www.grida.no/climate/ipcc_tar/vol4/english/078.htm)

Confidence in observed changes (latter half of the 20th century)	Changes in Phenomenon	Confidence in projected changes (during the 21st century)
Likely	**Higher maximum temperatures and more hot days over nearly all land areas**	Very likely
Very likely	**Higher minimum temperatures, fewer cold days and frost days over nearly all land areas**	Very likely
Very likely	**Reduced diurnal temperature range over most land areas**	Very likely
Likely, over many areas	**Increase of heat index over land areas**	Very likely, over most areas
Likely, over many Northern Hemisphere mid- to high latitude land areas	**More intense precipitation events** [b]	Very likely, over most areas
Likely, in a few areas	**Increased summer continental drying and associated risk of drought**	Likely, over most mid-latitude continental interiors. (Lack of consistent projections in other areas)
Not observed in the few analyses available	**Increase in tropical cyclone peak wind intensities** [c]	Likely, over some areas
Insufficient data for assessment	**Increase in tropical cyclone mean and peak precipitation intensities** [c]	Likely, over some areas

[a] For more details see Chapter 2 (observations) and Chapter 9, 10 (projections) of the IPCC TAR WGI Report (IPCC 2001b)
[b] For other areas, there are either insufficient data or conflicting analyses.
[c] Past and future changes in tropical cyclone location and frequency are uncertain.

5. Elaborate trends in climate parameters and indices including thresholds and trigger points

Recent trends in climatic parameters and indices are probably useful indicators of potential trends over the short to medium term. In cases where climatic records are not available, there are global datasets that provide monthly summaries over a half-degree grid of the land surface, available through the IPCC Data Distribution Center (www.ipcc.ch), based on the monthly climate data from the University of East Anglia, UK. An Internet-based graphic tool draws a profile of these data for land based locations. More information on methods for analyzing climate data can be found in the chapter on Rapid Integrated Assessment.

For many important sectors, there is knowledge of critical thresholds and trigger points. For example, in the case of food, there is knowledge on the required growing season duration, the recommended calorie intake, etc. For agricultural studies and in particular assessments of impacts on food security, profiles of growing season parameters such as crop calendars for major crops (growing, maturation and harvest), and statistics from observed data (beginning and end of growing season) are useful indicators. Remotely sensed data may be available to show the extent of the problem as shown in Figure 10.6 for the Northern parts of Tanzania (and Kenya). The figure also shows the number of events that will be regional and will involve non-LDCs. This presents opportunities for regional coordination and mutual learning.

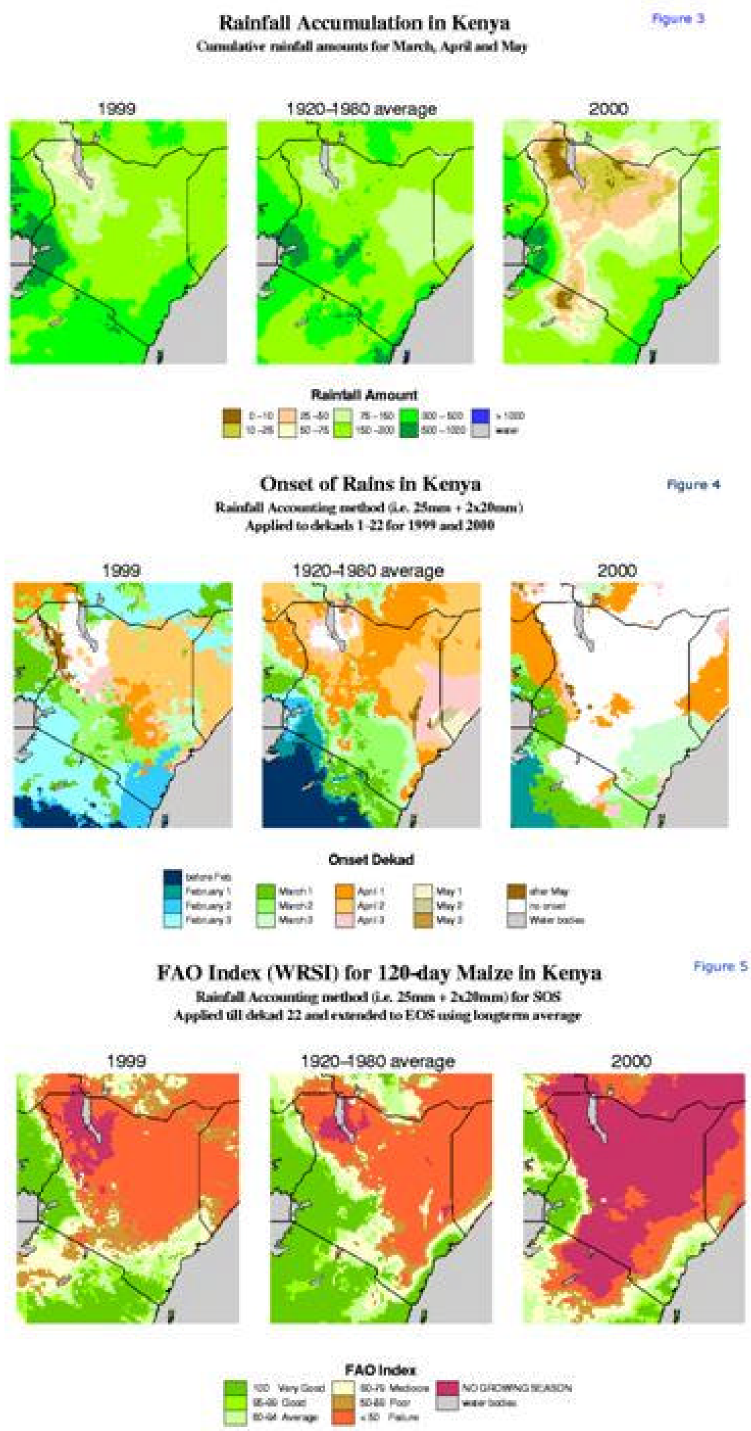


Figure 10.6. Example of use of remote sensing to evaluate seasonal rainfall patterns that demonstrate rainfall failure and major seasonal differences which ultimately lead to major food shortages

6. Identify regional factors that influence adverse impacts including response actions in the country of study

There are several factors at the regional level (regional in the sense to mean a group of countries in close geographic proximity or within a regional economic group). As discussed above under (b), countries connected by large shared river basins often share risks associated with flooding. In such cases, specific needs may include plans for early warning for communities especially those in rural areas that may be exposed to serious floods that would be triggered by events well outside the national boundaries. Such a communication system would need to be linked to major dam activities to enable a rapid relay of warnings. This becomes challenging with different languages used across borders, and the lack of explicit international legislation to require investments in these issues. After the 1999-2000 floods in Mozambique, communication was identified as one of the priorities for immediate improvement. A system of solar radios was installed in rural communities to improve early warning in cases of flooding.

Regarding droughts, one has to account for possible wildlife migrations – the presence of physical barriers to migration would be an important consideration in planning response actions.

From an economic point of view, the presence of regional economic cooperation is an important consideration when looking at short-term responses to such impacts as food shortages. The status of communication lines that deliver critical fuel, foods and supplies across borders would be very important to appraise. In many cases, one main road with possibly several bridges constitutes the main access route, which is problematic in times of flooding. When bridges are disabled, delivery routes are cut off, with severe consequences. The same can apply in cases where access is provided by rail lines, in which case damages can lead to expensive repairs and lengthy delays in the delivery of critical supplies.

7. Spatially characterize the country to create visual summaries that would be useful in participatory discussions

An important step in the NAPA process is that of seeking multiple stakeholder inputs in decisions about adaptation solutions and priorities. This requires the effective communication of information to non-expert audiences to facilitate discussions. The use of maps and other visual displays would greatly enhance this process. We propose using geographic information systems (GIS) to create maps showing districts, river systems, communications, population distributions, etc., to assist in identifying the most vulnerable regions and communities. Most LDCs have some capability in using GIS, and there are numerous resources available on public online databases to make its incorporation in the NAPA preparations relatively easy. . Useful reference and data resources include:

- Down to Earth: Geographical Information for Sustainable Development in Africa (2002), Board on Earth Sciences and Resources (BESR), National Academy Press, 2002. (Available online at http://www.nap.edu/books/0309084784/html).
- Basic country level data (administrative and basin boundaries, land cover, population etc) as well as satellite images for 1990 and 2000 based on Landsat 5 and 7 data (see www.napaprimer.org for links to online sources).
- A useful GIS tool that is very affordable is called AWhere (www.mudsprings.com). It is built using Arc View (www.esri.com), standard GIS software for PCs. The AWhere software includes data bundles for many African countries, and includes tools for easy

spatial characterization of weather and related analyses for agricultural planning and so on. A bundle of data was assembled for Samoa and Malawi and used during the regional workshops, and is available at http://www.napaprimer.org.

8. Collection of information on Costs and Benefits of specific project activities

An important set of data that may be collected, if available, is that on costs and benefits of specific activities for possible use in ranking them later in the NAPA process. Sometimes, economic analyses exist that have compared different development options to address major problems such as food security, water or energy. These would be useful in informing the process of selecting cost effective solutions. It is important to note that since data on costs and benefits is likely to be scarce, NAPA preparation should not require explicit consideration of costs and benefits where such data does not exist. Inventing data on costs and benefits would invariably lead to wrong solutions when quantitative tools are applied such as cost-benefit analysis (CBA) and similar methods.

9. Presentation of Synthesis Results

It is important to design the synthesis of available information in such a way that it informs the later steps in the NAPA process effectively. It is likely that the synthesis will be carried out by consultants, probably presenting their results in a lengthy report. We believe that it would be most beneficial if the results are presented in the form of data sheets (spreadsheets), graphs, figures and maps rather than in descriptive reports. The main purpose of this information is to inform the identification of possible adaptation activities, be it policy reform activities, or concrete actions in specific regions or sectors. A profile for such proposed activities is most useful showing past adverse impacts, trends in climatic hazards, and coping strategies of communities in similar situations in other regions.

Chapter 11

Conduct Participatory Rapid Integrated Vulnerability and Adaptation Assessment (PRIVA)

Identify Key Vulnerabilities and Major Adaptation Needs

During the early stages of the NAPA preparation, goals and objectives of the whole NAPA would have been defined, including the definition of the *systems* to be included in the assessment, such as specific sectors, regions or issues that integrate across sectors. Examples of these systems can include food security, water security, sustainable energy, the conservation of critical biodiversity; or even sectors such as agriculture or water resources. A region of interest may be defined as a coastal area, or a particularly important river basin that would in turn, include sub-systems of its own.

An important aspect of NAPA preparation is the involvement of stakeholders in identifying priorities needs that must be addressed, either to minimize vulnerability to climate change or to safeguard critical development activities that are sensitive to climate change. In cases where there is adequate information about potential impacts and vulnerability, the NAPA preparation process can proceed to the Selection of Priority Needs. Likewise, in situations where a vulnerability assessment was undertaken, for example as part of a National Communication, there may be enough information to identify priority needs. In that case, the NAPA preparation can skip the rapid assessment and jump to the selection of priority needs.

In most cases, however, even though a National Communication may exist, there is inadequate information about vulnerability and potential interventions that some kind of additional vulnerability assessment will be required. This chapter provides a possible approach for a rapid assessment based on commonly available data.

We foresee at least three different scenarios for the assessment:

- Case 1: Previous vulnerability assessments provide a good basis for stakeholder consultations on urgent needs. Assessment to proceed with discussion of urgent needs. (see Chapter 8 Figure 8.1 Level I)

- Case 2: Some assessments exist, but do not indicate vulnerability or do not cover all major sectors. In this case, assessment to use information on hazards and associated risks to evaluate vulnerability and identify priority needs for adaptation (See Figure 8.1 Level II).

- Case 3: Lack of reliable information on vulnerability. Country to conduct a full rapid assessment of vulnerability, based on available climate data and information on how climate influences specific sectors. The selection of key climatic hazards to involve participation of stakeholders especially those in rural communities (See Figure 8.1 Level III).

The above typology of situations is meant as a guide only, and a country can constrain the analysis based on local needs and priorities, including emphasis on one sector only as their basis for their NAPA.

The steps in the rapid vulnerability assessment can be summarized as shown in Table 11.1.

Table 11.1. Steps in Rapid Vulnerability Assessment, extracted from the full list of NAPA steps in Table 8.1

a. Select Key Climatic Hazards and their Risks
b. Choose Vulnerability Framework
c. Assess Vulnerability
    i. Define Climate-System Linkages
    ii. Collate Available Climate Data & Other Information
    iii. Analyze Climatic Trends and Define Hazard Risks
    iv. Define impact potential of climate hazards on systems
    v. Characterize Adaptive Capacity and Coping Ability of System
    vi. Characterize Vulnerability
d. Select Highly Vulnerable Sectors, Systems and Sub-regions [Rank Adaptation Needs]

a. Select Key Climatic Hazards and their Risks

For any given geographic region (country) and social-economic-environmental setting, specific climatic hazards are important to consider. Past experiences as well as studies that have examined future climatic scenarios can guide the identification of critical climatic hazards and associated risks. It is expected that the majority of LDCs will be most concerned with such hazards as droughts, floods, changes in growing season condition, storms and sea level rise. This list can never be complete, as each local situation is unique, and many of these hazards are also interconnected. Where enough information exists on the likelihood of particular events, it can be used to define the risk of particular hazards. In the absence of data however, qualitative assessments of the likelihood of occurrence would be adequate.

b. Choose Vulnerability Framework

There are several vulnerability frameworks that can be used to conduct the assessment. For NAPAs, we have developed a new framework that is explained in Desanker (2004). Basically, vulnerability is defined in terms of hazard risk (likelihood of hazards occurring), impact potential (further dependent on how a system is dependent on climate, system sensitivity to climate variability, and coping range), and adaptive capacity (a function of social capital, physical capital, resilience and economic capital). See Figure 11.1.

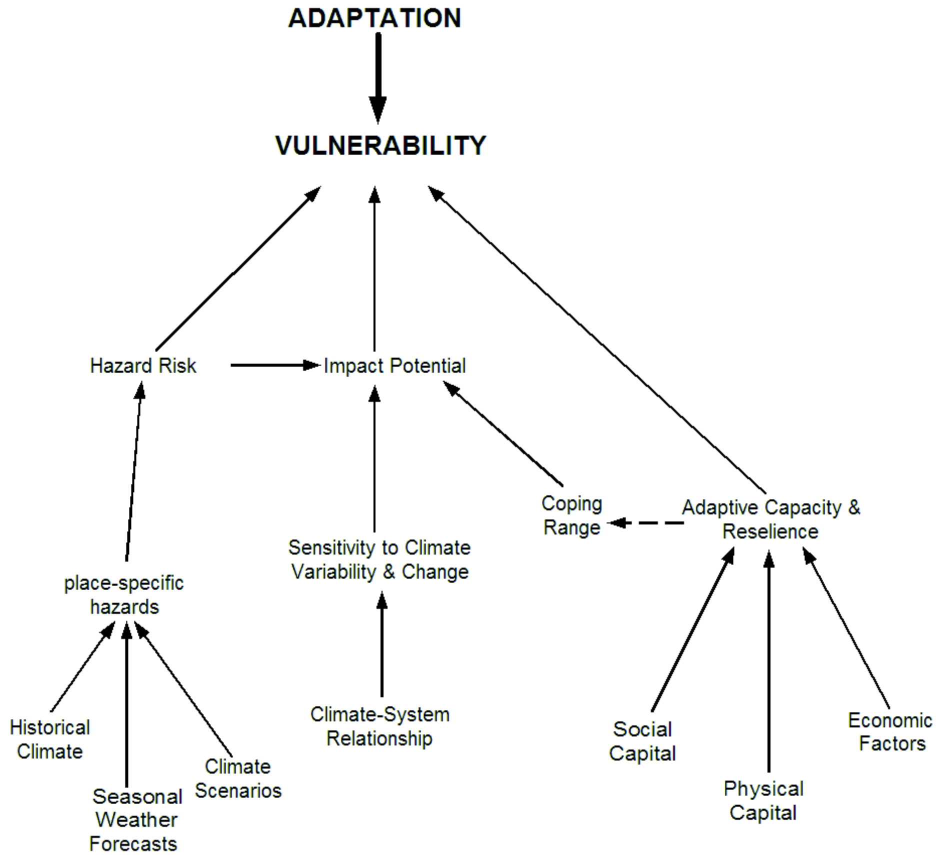


Figure 11.1. Vulnerability and adaptation in NPA (based on PRIVA, Desanker, 2004)

A tool called PRIVA (Participatory Rapid Integrated Vulnerability Assessment) is being developed to assist countries in conducting their assessments using the framework laid out in Figure 11.1 (Desanker et al., 2004 – Miombo AIACC Project, www.aiaccproject.org; see Box 11.1). This Figure is repeated here for ease of reading – it appeared as Figure 7.3 previoulsy.

Box 11.1. PRIVA – A Tool for NAPA Development

PRIVA is a method that is being designed to assist adaptation planning in least developed countries. It combines a synthesis of the past with a guided view of the future in order to design activities that would address urgent and immediate needs for adaptation to climate change. The time frame is therefore, short to medium term.

PRIVA attempts a semi-formal description of vulnerability and adaptation. Vulnerability is defined as a function that integrates (i) risk of climatic hazards or climatic threats; (ii) impact potential, which is a function of sensitivity to a given hazard and coping range of the system; and (iii) coping ability, as a function of various determinants for given climatic hazards. Adaptation is framed as actions to minimize vulnerability through any of the following: by reducing the risk associated with hazards by manipulating components of the risk (could include mitigation of climate change); reducing impact potential through manipulation of the system dependence on climate; or by increasing coping ability such as by addressing key determinants such as access to technology, financial resources, poverty, etc.

PRIVA, as a tool, is a collection of GIS routines (and basic data for African LDCs), that allows overlays of different data inputs to create maps of vulnerability. Users can then select regions for further consideration depending on a number of rules. Then they can generate summaries for those areas such as potential numbers of people that may be affected by a climatic event. The ability to display maps as well as to easily combine different data inputs is amenable to public inputs where multiple stakeholders can provide their weights about what is important. The PRIVA approach emphasizes multiple stakeholder participation to ensure a good balance in proposed activities to include adequate representation of the poor and distant communities.

PRIVA is flexible enough that it can be applied at any spatial scale, from a community, to a national level, or even regional such as for the southern Africa region comprising several countries within a major shared river basin such as the Zambezi, as long as it is possible to isolate key dependencies. At the regional shared basin level such as the Zambezi, heavy rains in parts of the basin all contribute to increased risk of flooding in the lower basin, combined with dam management at the regional level. And so, it is possible to isolate critical interventions that would lower vulnerability.

A major finding from this work is that although the analysis can be nested across multiple spatial scales, the results cannot. Optimal or so-called urgent adaptation needs at one scale often do not translate well to other scales, where priorities change, or determinants change, as happens often when one crosses national boundaries and general levels of poverty and coping ability change dramatically.

Source: Desanker, P.V. (2004). PRIVA: Participatory Rapid Integrated Assessment of Vulnerability and Adaptation - A Tool for NAPA Development, Paper presented at the AIACC Regional Workshop, Dakar, Senegal, March 2004, Penn State University/Miombo Network; AIACC Project AF38, desanker@psu.edu

c. Assess Vulnerability [over domain of NAPA – by sector, region or hazard]

In cases where past impact assessments were conducted in different sectors, or where general studies about climate sensitivity of different systems and sectors exist, the information about potential hazards from above can be used to evaluate vulnerability by sector or region. This can be done using stakeholder participation to identify specific vulnerable groups (regions, communities, etc). Tools such as GIS, web diagrams and other graphic methods can be used with public input to rank regions and issues that deserve further attention in designing interventions.

In cases where vulnerability assessment is not possible without more explicit analysis of climatic data, the following five steps can be used to conduct further analysis. *[It must be noted that for most LDCs, there is likely to be adequate information on vulnerability to enable them to complete their NAPAs without going through the following detailed steps].*

(1) Define Climate-System Linkages

Given the selection of systems under consideration, the first step in the rapid assessment would be to describe the linkages of important aspects of the system to climate, or aspects that are linked to reducing vulnerability to climate. For now, we restrict ourselves to how the system is driven or constrained by climate. In the following step, we will look at the full question of vulnerability and other components.

Given that the literature on food security and on agricultural production is enormous (including crop simulation models - see a recent book by Rosenzweig and Hillel (2002)), we use food security as an example to demonstrate the methodology. Food security can be sub-divided into (i) food production, and (ii) issues related to food access (income, distribution, etc). For the sake of illustration, let us assume that it is the production aspects only that are directly influenced by climate. We can thus develop a conceptual model of agricultural production – climate, and explore how production would respond to different climates, and then we can explore thresholds, coping ranges and potential bottlenecks in trying to achieve food security.

Climatic aspects of agricultural production can be broken down into the following components:

- *Site suitability* of a particular geographic area to specific crops defined by climatic indices such as water availability, length of growing season, average temperature, and extreme climatic variables that particular crops will tolerate, linked to frost damage, dry spells and requirements for particular plant physiological processes (such as maturation, triggers for phenological stages etc). A climatic envelope model can easily be calibrated to predict areas suitable for given crops under any climatic regime, at present or in future. Useful tools include the FAO/IIASA Agroecological zone toolkit (available from IIASA or FAO, see www.iiasa.ac.at/Research/LUC for more details), and the AWhere GIS software available from Mud Springs Geographers (www.mudsprings.com) including data bundles for many African developing countries.

- *Yield* as a function of climatic variables. Yield depends on climatic variables along with other factors such as inputs (fertilizers, pesticides, labor in terms of weed control, and water management such as through irrigation). Simulation crop models are available to assess the yield response to different climatic conditions, includingthe DSSAT/CERES models for maize and numerous other crops. See Rosenzweig and Hillel (2002) for a comprehensive list. In the absence of results from these models, a simple rule-based model can be constructed to assist in assessing levels of impact of different climatic conditions (scenarios). For example, reductions (or enhancements) in yield can be defined for particular climatic hazards. In the case of maize, a reduction factor can be applied to reduce yield based on the quality of the growing season in terms of total rainfall, normality of rainfall pattern, etc. Later, when the changes in risks of climatic hazards are defined, the simple models of yield can be used to project likely impacts on total production.

  In countries where these crop models are already applied, it would be useful to conduct sensitivity analyses of yields to different scenarios of climatic conditions, and response surface developed for yield against input climate. This information would be useful in later evaluating the impact potential..

Regarding water resources, similar approaches can be applied to define water availability as a function of climatic indices, aspects of water quality and access. In both cases, one has to define how the variables of interest respond to climatic conditions in a continuous fashion, rather than reporting on, for example, yields under particular climatic scenarios.

Coping Range and System Limits

For most systems, such as agricultural production based on certain crops such as maize, it is possible to identify critical thresholds and limits in terms of what climatic conditions are suitable or acceptable. For example crop cultivars will have minimum requirements for their growing season (length, quality). Livestock requires a minimum amount of water; it can tolerate heat up to a certain point, etc. For hydro-energy production, it is possible to define a minimum water flow required to produce electricity. These limits should be defined as concisely as possible to guide the vulnerability assessment. In many cases, these limits will not be absolute; but can rather be defined in terms of a range (or coping range for the system).

Human Coping Range and Thresholds

Coping ranges can be defined at multiple levels. In the food security example, limits can be defined for the crop production processes themselves, as well as in terms of the amount of food needed to satisfy the needs of the population. Thus, it would be necessary to define thresholds for food security which would then be a function of population, production, and other factors. In some cases, thresholds can be translated into minimum requirements for production per capita, so as to satisfy a minimum daily calorific intake.

Potential Bottlenecks

In some cases, it will be possible to define what we are calling bottlenecks, which will be conditions that must be met before subsequent steps can be allowed to happen; for example, leaving enough time to replant after a natural disaster wiped out a young crop, which requires an adequate amount of seed. Likewise, maintaining critical infrastructure is paramount so that food aid can reach regions suffering from severe crop failures and food shortage as a result of prolonged flooding. Such potential obstacles to success must be explored and borne in mind.

(2) *Collate Available Climate Data & Other Information*

The most important data are the daily records of weather variables collected over as much of the country as possible; the longer the temporal coverage, the better. In the absence of good local data, there are global databases such as the CRU monthly time series for temperature and rainfall from 1901-2000 that can be used as a surrogate. The United Nations Relief Web is also a very useful source of information on impacts or recent natural disasters.

Other information that can be useful includes data on water availability and use, agricultural production, energy use, population, etc., at the finest possible spatial resolution. This is often at the district level, but can be gridded at around 1km for population data.

(3) *Analyze Climatic Trends and Define Hazard Risks*

Common climatic hazards include drought, floods, storms, extreme heat or cold conditions, and wind. Analysis of past climate is a useful indication of the likelihood of these hazards for particular regions, and in some cases, recent climate can indicate possible shifts in ‘normal’ conditions. While future changes in hazards are impossible to predict at a local scale, the IPCC TAR is clear about the general worsening of various hazards (see earlier table). Climate data from weather stations is a useful data source for understanding local conditions. Suggested indices for analyzing climate data are given in the following Table 11.1, and can be computed using software that is available for download at http://cccma.seos.uvic.ca/ETCCDMI/software.html (accessed October 28, 2004) using the ClimDex and RClimDex packages.

Table 11.1. List of ETCCDMI core Climate Indices (from X. Zhang and F. Yang (2000), RClimDex 1.0 User Manual, available at http://cccma.seos.uvic.ca/ETCCDMI/RClimDex/RClimDexUserManual.doc)

ID	Indicator name	Definitions	Units
FD0	Frost days	Annual count when TN(daily minimum)<0ºC	Days
SU25	Summer days	Annual count when TX(daily maximum)>25ºC	Days
ID0	Ice days	Annual count when TX(daily maximum)<0ºC	Days
TR20	Tropical nights	Annual count when TN(daily minimum)>20ºC	Days
GSL	Growing season Length	Annual (1st Jan to 31^{st} Dec in NH, 1^{st} July to 30^{th} June in SH) count between first span of at least 6 days with TG>5ºC and first span after July 1 (January 1 in SH) of 6 days with TG<5ºC	Days
TXx	Max Tmax	Monthly maximum value of daily maximum temp	ºC
TNx	Max Tmin	Monthly maximum value of daily minimum temp	ºC
TXn	Min Tmax	Monthly minimum value of daily maximum temp	ºC
TNn	Min Tmin	Monthly minimum value of daily minimum temp	ºC
TN10p	Cool nights	Percentage of days when TN<10th percentile	Days
TX10p	Cool days	Percentage of days when TX<10th percentile	Days
TN90p	Warm nights	Percentage of days when TN>90th percentile	Days
TX90p	Warm days	Percentage of days when TX>90th percentile	Days
WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX>90th percentile	Days
CSDI	Cold spell duration indicator	Annual count of days with at least 6 consecutive days when TN<10th percentile	Days
DTR	Diurnal temperature range	Monthly mean difference between TX and TN	ºC
RX1day	Max 1-day precipitation amount	Monthly maximum 1-day precipitation	Mm
Rx5day	Max 5-day precipitation amount	Monthly maximum consecutive 5-day precipitation	Mm
SDII	Simple daily intensity index	Annual total precipitation divided by the number of wet days (defined as PRCP>=1.0mm) in the year	Mm/day
R10	Number of heavy precipitation days	Annual count of days when PRCP>=10mm	Days
R20	Number of very heavy precipitation days	Annual count of days when PRCP>=20mm	Days

Rnn	Number of days above nn mm	Annual count of days when PRCP>=nn mm, nn is user defined threshold	Days
CDD	Consecutive dry days	Maximum number of consecutive days with RR<1mm	Days
CWD	Consecutive wet days	Maximum number of consecutive days with RR>=1mm	Days
R95p	Very wet days	Annual total PRCP when RR>95th percentile	Mm
R99p	Extremely wet days	Annual total PRCP when RR>99th percentile	mm
PRCPTOT	Annual total wet-day precipitation	Annual total PRCP in wet days (RR>=1mm)	mm

For Europe, the European Climate Assessment & Dataset project ECA&D maintains a website (http://eca.knmi.nl) of indices of climate extremes for analyzing and monitoring climate change for European and Mediterranean member countries. It is an excellent resource for tools and publications on these topics.

Statistical methods for probability of extremes are well developed, and some computer packages exist to enable estimation of risk. For the most part, general scales of risk would suffice for the elaboration of NAPA. From local knowledge, hazards can be described in qualitative terms in terms of probability of occurrence and extent of damage or severity. Another useful index that is used widely in early warning systems (for food security) is that of the water requirement satisfaction index (WRSI; USGS and FEWS NET). For more information, see Box 2.

Box 2. Water requirement satisfaction index (WRSI)

Originally developed by FAO, the WRSI has been applied widely by the Famine Early Warning System Network (FEWS NET) to monitor growing season conditions and assess potential yields. The following description is adapted from http://igskmncnwb015.cr.usgs.gov/adds/readme.php?symbol=ws last updated: July 2003).

The spatially explicit water requirement satisfaction index, WRSI, is an indicator of crop performance based on the availability of water to the crop during a growing season. FAO studies have shown that WRSI can be related to crop production using a linear yield-reduction function specific to a crop (FAO, 1977; FAO, 1979; FAO, 1986). More recently, Verdin and Klaver (2002) and Senay and Verdin (2001) demonstrated a regional implementation of WRSI in a grid cell based modeling environment.

WRSI for a season is based on the water supply and demand a crop experiences during a growing season. It is calculated as the ratio of seasonal actual evapotranspiration (AET) to the seasonal crop water requirement (WR):

$$WRSI = \frac{AET}{WR} * 100$$

WR is calculated from the Penman-Monteith potential evapotranspiration (PET) using the crop coefficient (Kc) to adjust for the growth stage of the crop.

$$WR = PET * KC$$

AET represents the actual (as opposed to the potential) amount of water withdrawn from the soil water reservoir ("bucket"). Whenever the soil water content is above the maximum allowable depletion (MAD) level (based on crop type), the AET will remain the same as WR, i.e., no water stress. But when the soil water level is below the MAD level, the AET will be lower than WR in proportion to the remaining soil water content (Senay and Verdin, 2003).

The soil water content is obtained through a simple mass balance equation where the level of soil water is monitored in a bucket defined by the water holding capacity (WHC) of the soil and the crop root depth, i.e.,

$$SW_i = SW_{i-1} + PPT_i - AET_i$$

where SW is soil water content, PPT is precipitation, and i is the time step index.

The most important inputs to the model are precipitation and potential evapotranspiration (PET). FEWS NET at the USGS calculates daily PET values for Africa at 1.0-degree resolution from 6-hourly numerical meteorological model output using the Penman-Monteith equation (Shuttleworth, 1992; Verdin and Klaver, 2002). Blended satellite-gauge rainfall estimate (RFE) images for the African continent are obtained from NOAA at 0.1-degree (~10 km) spatial resolution. Rainfall images are produced using an interpolation method that combines data from Meteosat cold cloud duration (CCD), the Special Sensor Microwave/Imager (SSM/I) of the Defense Meteorological Satellite Program, the Advanced Microwave Sounding Unit (AMSU) on board the NOAA-15 polar orbiter, and reporting rain gauge data from Global Telecommunication System (GTS) (Xie and Arkin, 1997). In addition, the WRSI model uses relevant soil information from the FAO (1988) digital soils map and topographical parameters from Digital Elevation Model (DEM) derived data (HYDRO-1K, Gesch et al. (1999)).

WRSI calculation requires a start-of-season (SOS, see Figure 11.2 for southern Africa) and end-of-season time (EOS) for each modeling grid-cell. Maps of these two variables are particularly useful in defining the spatial variation of the timing of the growing season and, consequently, the crop coefficient function, which defines the crop water use pattern of crops. The model determines the SOS using onset-of-rains based on simple precipitation accounting. The onset-of-rains is determined using a threshold amount and distribution of rainfall received in three consecutive dekads. SOS is established when there is at least 25 mm of rainfall in one dekad followed by a total of at least 20 mm of rainfall in the next two consecutive decades. The length of growing period (LGP) for each pixel is determined by the persistence, on average, above a threshold value of a climatological ratio between rainfall and potential evapotranspiration. Thus, EOS was obtained by adding LGP to the SOS dekad for each grid cell. The WRSI model is capable of simulating different crop types whose seasonal water use pattern has been published in the form of a crop coefficient. Such crops include maize (corn), sorghum, millet, wheat, etc.

At the end of the crop growth cycle, or up to a certain dekad in the cycle, the sum of total AET and total WR are used to calculate WRSI in a Geographic Information System (GIS) environment at 0.1 degree (about 10 km) spatial resolution. A case of "no deficit" will result in a WRSI value of 100, which corresponds to the absence of yield reduction related to water deficit. A seasonal WRSI value less than 50 is regarded as a crop failure condition (Smith, 1992).

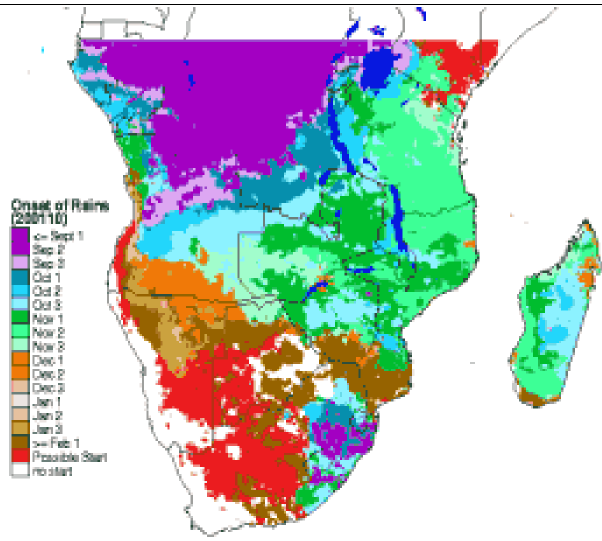


Figure 11.2. Onset of rains for Africa

Yield reduction estimates based on WRSI contribute to food security preparedness and planning. As a monitoring tool, the crop performance indicator can be assessed at the end of every 10-day period during the growing season. As an early warning tool, end-of-season crop performance can be estimated using long-term average meteorological data. Due to the difference in the growing season, WRSI maps are generated and distributed on a region-by-region basis (e.g., the Sahel, Southern Africa, Greater Horn of Africa regions). At the end of every dekad, two image products associated with the WRSI are produced and disseminated for the FEWS NET activity. The following paragraphs provide a brief description of these products. See Figure

Brief Description of the Two Image Products:

1. *Current WRSI*

This map portrays WRSI values for a particular crop from the start of the growing season until this time period. It is based on the actual estimates of meteorological data to-date. For example, if the cumulative crop water requirement up to this period was 200 mm and only 180 mm was supplied in the form of rainfall, the crop experienced a deficit of 20 mm during the period and thus the WRSI value will be ((180 / 200) * 100 = 90 %). This approach is slightly different from the traditional FAO update where the cumulative supply-to-date is compared to the seasonal crop water requirement, instead of the requirement up to the current period. Note that, unlike the FAO update, the current WRSI can increase in value in the later part of the growing season if the demand (crop water requirement) and supply (rainfall) relationship becomes favorable. However, both the FAO and this approach are mathematically equivalent when the end-of-season dekad becomes the current dekad.

2. *Extended WRSI*

This is a forecast estimate of WRSI at the end of the growing season. Long-term average climatological data are used to calculate WRSI for the period between the current dekad and the end-of-season. The calculation principles are the same as the "Current WRSI". This is also a deficit-based estimate of WRSI.

The long-term average PET and rainfall is extracted from FAO's (1961-1990) long-term average monthly data. Note that at the end of the growing season, only current-year PET and PPT are used as input.

Application of WRSI Model for Kenya (refer to Figures 11.3 – 11.4)

In a typical year, the East African country of Kenya has two rainy seasons: the long rains, occurring during the months of March-April-May, and the short rains occurring during the months of October-November. The long rains are especially important for the production of maize and bean staples, and thus they have a significant effect on food security. In 2000, exceptionally low rainfall was observed over the entire northern half of the country, with severe drought extending southward through the Rift Valley and well into Tanzania. Few areas within Kenya received adequate rainfall to cultivate staple crops. FEWS NET staff monitored the effect of this drought on Kenya's food production using SOS and WRSI analyses.

The first step in measuring the quality of Kenya's growing season was to determine SOS. This figure shows that in 1999 the onset of rains generally followed the pattern of the long-term average. In 2000, however, the full extent of the disaster was striking. For roughly three-quarters of the country, the SOS criteria (see above) were never met.

Undoubtedly, the failed SOS affected crop production throughout Kenya. These WRSI maps were produced to illustrate the consequences of these rainfall patterns during the 120-day maize growing season. The WRSI map for the long-term average conditions shows that this type of maize will usually fare well in central-western parts of the country, and along the coast. In 1999, poor growing conditions prevailed to the immediate north, west and south of Nairobi. For 2000, crop failure was mapped throughout most of Kenya. These patterns are consistent with assessments of the Government of Kenya, which projected a 35% shortfall in long-rains maize production for 2000, relative to the average production for the period 1991-1998.

The United States Geological Survey (USGS) FEWS NET web has results for many parts of the world, including Haiti, Afghanistan and greater horn and southern Africa at http://edcintl.cr.usgs.gov/fewsnet.html.

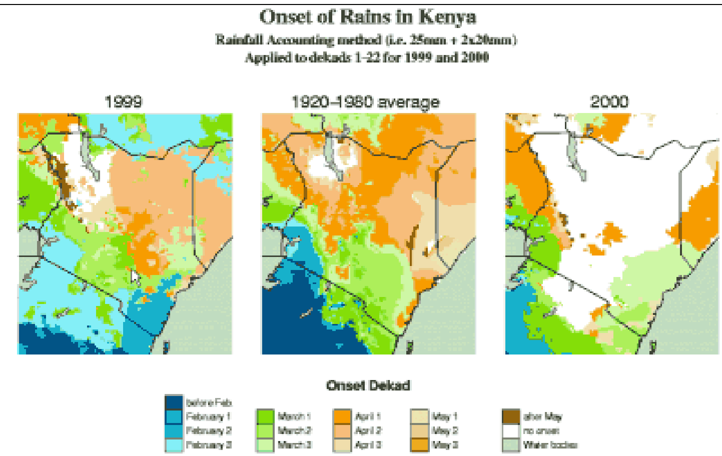


Figure 11.3. Onset of rains for Kenya

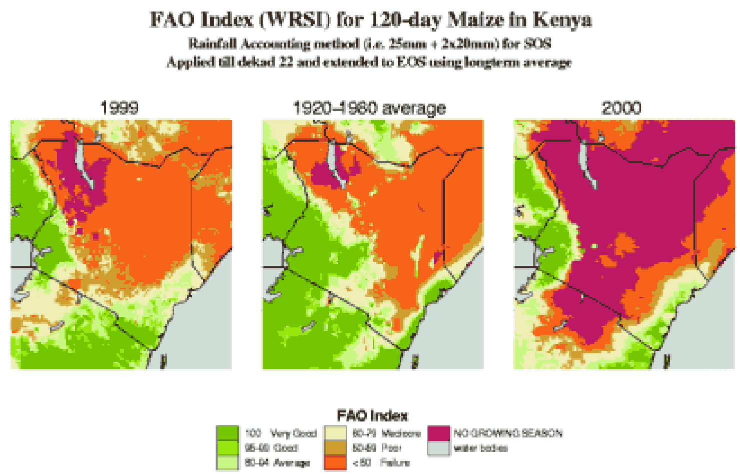


Figure 11.4. Water requirement satisfaction index for Kenya

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(4) *Define impact potential of climate hazards on systems*

From the previous step of climate-system linkage definition (c(1) above), the identified potential impact of critical hazards for the region of study can now be evaluated. For example, if seasonal droughts are expected to worsen, the agricultural production model can be used to project how yields will be impacted. The magnitude of this impact will be a key contribution to the assessment of vulnerability.

(5) *Characterize Adaptive Capacity and Coping Ability of System*

In most cases NAPAs will be dealing with human systems, and so, adaptive capacity will be in terms of socio-economic factors such as community cohesion, wealth indices, etc. In the case of ecosystems (such as in assessing biodiversity concerns), adaptive capacity may be defined differently, for instance in terms of resilience and other characteristics that define the ability to cope with climate variability, and may be determined by such factors as landscape metrics (availability of habitat, degree of fragmentation, minimum size requirements for communities to thrive, etc).

(6) *Characterize Vulnerability*

Vulnerability would then be defined as a function of the hazard risk, impact potential and adaptive capacity/coping ability. This can be carried out over districts or other suitable disaggregation units of the country. A display using GIS can be a useful communication tool when conducting further stakeholder interactions.

Use of Vulnerability Indices

There are several systems of indicators being developed that could be useful in framing vulnerability. Many of these methods have been developed for multi-country application because of the availability of national-level statistics. Some of these can be scaled down and applied within a country if adequate data exist at the district level. Food security analyses are perhaps the most advanced in using indicators based on district level data, which are routinely collected by every country. Figure 11.5 shows a system developed by Moss (2002).

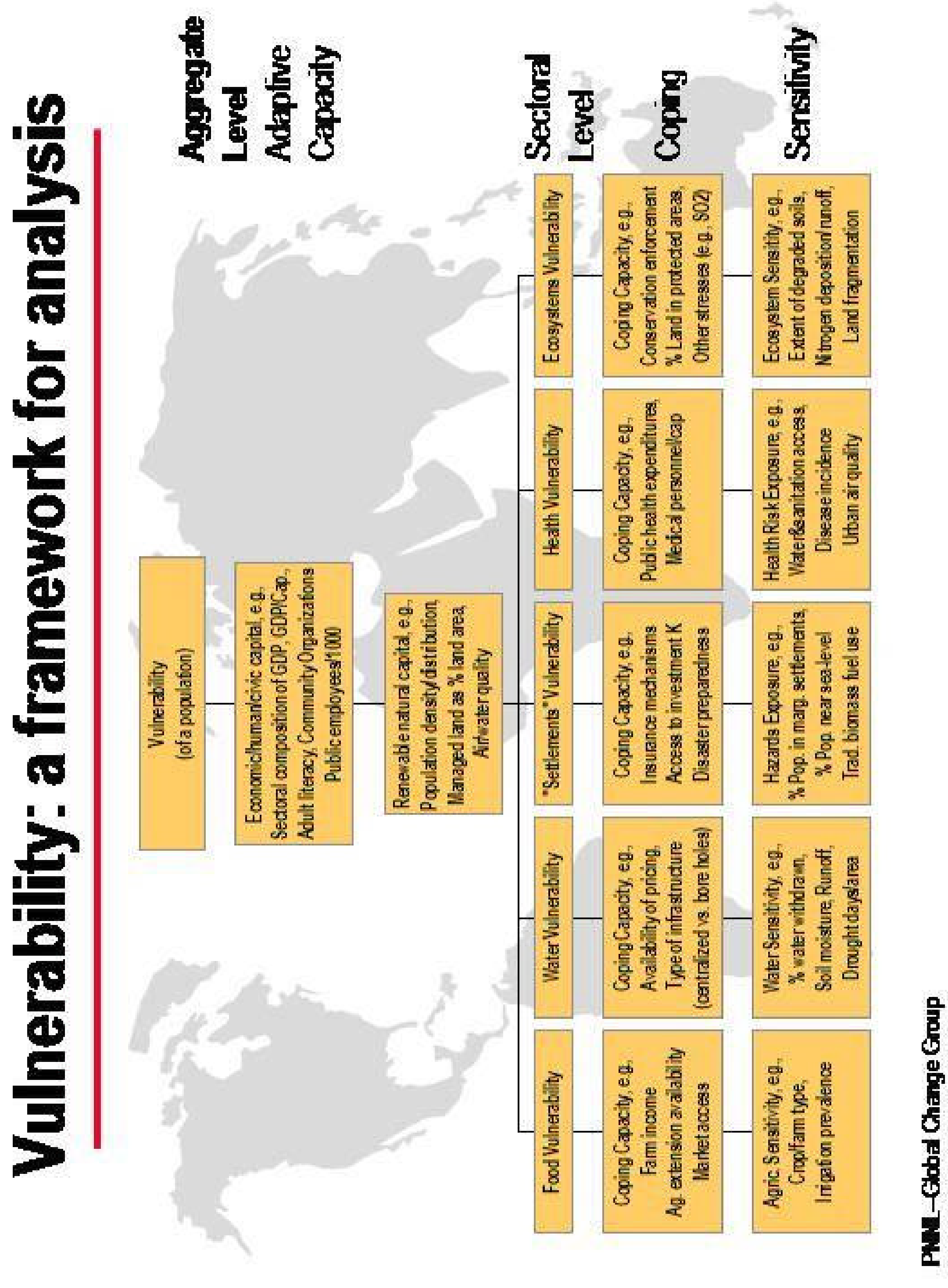

Figure 11.5. A framework for vulnerability based on Moss (2002)

d. Select Highly Vulnerable Sectors, Systems and Sub-regions as Priorities for Adaptation [Rank Needs]

Based on the vulnerability analysis above, stakeholders can define thresholds of acceptable vulnerability. In an ideal situation with unlimited financial resources, every sector, system or region will have important needs that must be addressed to reduce their vulnerability. However, resources for NAPAs are likely to be small, so the number of vulnerable sectors that are further analyzed is restricted. For example, all coastal areas will be vulnerable to sea level rise and coastal erosion, but it will be impractical to intervene everywhere. So a choice may need to be made based on a trade-off between cost and proportions of valuable property/land to be protected.

Criteria for selecting the highly vulnerable areas have been defined in earlier stages of the NAPA, and may include potential numbers of lives lost, potential loss of livelihoods, areas of critical coastal land, and potential loss of foreign income, etc.

It is unlikely that a region’s vulnerability will be defined by the most vulnerable of the systems/sectors alone, but rather by some combination of factors. This has been the case in many areas where floods have been severe during the rainy season, and droughts have also occurred in these same areas during the dry season. These multiple exposures to adverse effects of climate change make adaptation to singular events or hazards particularly risky.

Chapter 12

Identify Priority Needs Based on Participatory Assessment

Rank Priority Adaptation Needs

1. Introduction to Ranking Under NAPA

The ranking in a NAPA will be done in several stages:

- First, priority needs for adaptation are selected, which are defined broadly as areas of development that will be impacted the most by climate changes and which would jeopardize the process of development the most. [We call this **Ranking Priority Adaptation Needs**].
- Once the priority needs have been selected, a second ranking process is conducted to identify options for specific adaptation activities to address each need. [We call this step **Ranking Adaptation Options**].
- Third, a final ranking of needs and activities will be conducted based on urgency; that is, based on an assessment of when the adaptation actions should be carried out – either immediately or in the medium or long term. [We call this **Ranking for Urgency**].

The core of the NAPA preparation process is a rapid integrated assessment that involves communities and all important stakeholders to arrive at priority actions to address adverse effects of climate change. The requirement to engage local communities is important in NAPAs to ensure that the results have broad support from all stakeholders. Results of the integrated assessment are then used as inputs into a process that identifies major needs for adaptation. In cases where there is adequate information about major climatic effects and impacts, the rapid assessments should be streamlined to just a synthesis of available knowledge that can then act as inputs for the stakeholder assessment of priority needs. Major questions to be addressed include:

- What are major climatic and climatic change threats for the country?
- What key components of development have been identified and how are these compromised by climate change?
- Which are priority areas based on a set of criteria already identified in earlier phases?

2. Ranking Priority Adaptation Needs

The assessment of impacts reveals critical impacts and systems (regions, communities, sectors) that are most vulnerable, for example food security; access to adequate water for agriculture, etc. It can also show the need for scientific and other capacities to develop appropriate management responses and for the removal of policy obstacles to dealing with climate change. The assessments may also frame results in terms of critical climatic threats and hazards, such as in terms of increased climate variability, intensity or frequency of extreme events, or long term changes and irreversible effects of climate change.

For example, a low-lying deltaic country such as Bangladesh may select major needs to be addressed as indicated in Figure 12.1.

Impacted sectors and key issues	Are anticipatory measures needed because of:	
	Long term changes and irreversible effects	Increased intensity of extreme events
Coastal resources		
Drainage congestion	Y	
Saline water intrusion	Y	
Coastal morphology	Y	Y
Storm surges		Y
Water resources		
Flooding		Y
Drainage congestion	Y	
Droughts and low river flows	Y	Y
Sedimentation of flood plains	Y	
Erosion and sedimentation	Y	Y
Water balance	Y	
Agriculture		
	Y	
Public health		
	Y	Y
Ecosystems / biodiversity		
	Y	

Figure 12.1. Bangladesh sectoral needs for adaptation (adapted from World Bank report on Bangladesh, Chapter 3: Climate Change and Adaptation in Bangladesh, date unknown)

The study that identified the major needs in Figure 12.1 based its findings on the critical impacts of climate change as summarized in Box 1. The ranking of needs produces a short list of priorities that would be the basis for the identification of specific adaptation activities and projects in subsequent steps. Appropriate methods include the use of multiple criteria analysis (see LEG, 2004 – selected examples from NAPA regional workshops; and the LEG Annotated Guidelines for NAPA Preparation – www.unfccc.int/ldc); or through consensus building. Box 12.1 describes the process of consensus building, which is used widely in decision-making in Samoa.

Box 12.1. Critical impacts of climate change in Bangladesh

(source: World Bank report on Bangalesh, Chapter 3: Climate Change and Adaptation in Bangladesh, available online at: http://wbln1018.worldbank.org/sar/sa.nsf/Attachments/ch3/$File/ch3.pdf; accessed November 11, 2004)

Drainage congestion problem will be a major impact of climate change**.** The combined effect of higher sea water levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood protected areas will gradually increase drainage and water logging 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 in the delta and the flood plains. One of the key effects of drainage congestion is that it will increase the period of inundation, and will expand wetland areas. This may hamper agricultural productivity, and also threaten human health by increasing the potential for water borne diseases and holding back food production. Drainage congestion will thus affect several sectors including agriculture, and human health.

Reduced fresh water availability will become a serious constraint to development due to growing demands stimulated by climate changes (through increased evapo-transpiration), population growth and economic development**.** Low river flows and increased evapo-transpiration in the dry period will reduce the availability of fresh water. In the coastal zone, the additional effect of saline water intrusion in estuaries and into the groundwater stimulated by low river flow and sea level rise will be significant. Pressure of the growing population and economic development will result in over-abstraction and salinization of groundwater aquifers, and further reduce fresh water availability.

Disturbance of morphological processes will also 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:
(i) *Increased bank erosion and bed level changes of rivers and estuaries*. Theory suggests an exponential increase in morphological activity with increased river flow, implying that bank erosion might substantially increase in the future. Experience with the latest severe floods in Bangladesh support this prediction. Yearly erosion of river and coastal banks incurs the loss of valuable land and homesteads of hundreds of thousands of people, which is not fully compensated by the accretion of new land.
(ii) *Disturbance of the balance between river sediment transport and deposition in rivers, flood plains and coastal areas*. Disturbance of the sedimentation balance will result in higher bed levels of rivers and coastal areas, which in turn will lead to higher water levels. Continuous protection of rural areas against inundation will further reduce the sedimentation in the flood plains, which might increase both the river bank erosion and the drainage congestion / risks for flooding.

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 real time data (especially in terms of lead time) in monitoring and preparing (through proper dissemination) for these events. Additionally, increased intensity of the disasters imply major constraints to the country's social and economic development. The study shows that Bangladesh is particularly vulnerable to climate change in its coastal zone, covering about 30 percent of the country. Private investment in this area is likely to be affected by the risks of cyclones and increased flooding.

Box 12.2. Using consensus to rank activities: a case study of Samoa.

Methods for Achieving Consensus

A method that is used widely in many countries and communities to arrive at group decisions and to prioritize is consensus-building. Community participation and stakeholder consultation has enabled consensus-building on a number of national and community development initiatives in Samoa. Samoa's Statement for Development Strategy provides for the development of national programmes enhancing the growth of the country and the sustainable management of its natural environmental resources. Government and private sector partnerships are guiding this process. .

The partnership encourages a process of interactive dialogue between public and private sector agencies which have a stake in the particular set of adopted development strategies and in their anticipated outcomes. The goal is to reach a consensus on these strategies and priorities, so that a maximum of support can be achieved. This process of review, debate and consensus is also expected to strengthen the public/private sector partnership.

The *faaSamoa* (Samoan way of decision making) formal decision making procedures, which feature community consultations, participation and consensus decision making is prevalent in effecting agreement on many issues at all levels of the planning process including the national, sectoral, as well as district and village levels.

The complementary and Multidisciplinary Approach

The nature of the institutional set-up for the development of a national plan is important for its successful development. The NAPA process calls for the establishment of a multidisciplinary team to coordinate activities pertaining to the NAPA development as well as its implementation.

The NAPA team ensures that the main stakeholders at the national level share the same understanding and perception of objectives and goals of the process. Support from ministries who may initially see their functions or roles being taken over by the climate change focal point would be forthcoming as they become more aware of the needed strengthening of their existing roles. Private sector and community representatives will also find and understand where they would best contribute to the work of the team and the overall NAPA development process.

A clear understanding of all issues and responsibilities will make negotiation of issues within the national team faster and less cumbersome. In addition, allowing the members of the team to be personally involved, for example through collating information during the synthesis of existing information, or the participatory vulnerability assessment, would bring in a wide range of expertise that would help in responding to a diversity of questions and issues raised by consulted stakeholders and interested parties.

In Samoa, the multidisciplinary team is involved in all the activities and stages of the NAPA process, and its members are paid a honorary allowance for their efforts. At the community level, it is ensured that all groups of the community (regardless of age, sex, cultural standing, and interest) are involved and that their concerns are properly taken into account in project decisions, implementation and evaluation.

The process of National and Interest group consultation

In Samoa, community consultation and participation play an integral part in achieving goals of fostering the government-community partnerships, including community responsibility for design, development and implementation of adaptation activities.

The process is initiated through informal discussions between the main anticipated players in the consultation, including government agencies, private-sector entities and non-governmental organizations. . .

Consultations at the national level and across government and private sector institutions are conducted separately from the community consultations. Reasons for the separation include: flexibility in the use of both English and local languages, and the presumed level of understanding of the issues. In order to reach an agreement at the end of the consultations, it is important that sufficient information is presented in a user friendly way (through proper packaging and common language).

Reaching consensus at the district level is at most times difficult but not unachievable. Sometimes it takes more than a day or even months to reach agreement on many issues, and the delays are mostly caused by a lack of understanding of the issues and a lack of visible tangible outputs.

Community consultation

Community consultations taking place at either the district or village levels require the involvement of key government ministries, particularly the coordinating or national executing agency. Dialogue with village councils and other village focus groups, for example women committees; have to be arranged through the Ministry of Women, community development and village welfare to avoid complications.

The willingness of communities to be consulted and participate is encouraged by going through the proper official as well as cultural protocols. Each village in Samoa has a *Pulenuu* or village mayor. These village representatives meet monthly under the auspices of a Ministry of Women, Community and Social Development, and it is during these gatherings that a summary or brief of the proposed plan or program will be made known. Consultations within districts and villages are arranged through this gathering, although direct contact can also be made for each village through their Pulenuu. These could even be arranged to cover the whole country.

Once the dates and venues for the consultations are confirmed, consultations start in the villages, which take place in three main stages.

The first involves an awareness raising and educational workshop on the objectives of the programme, its rationale and expected roles of government and communities. A brief is prepared in both English and Samoan for ease of reference for all participants. Having these meeting arranged through the Pulenuu ensures that they are well attended. The second meeting is with the policy makers of the village or the chief council. In addition, a walk through the village is organized during which the consultation team has the opportunity to consult those who were busy with daily activities. At the same time, the team can take note of existing vulnerabilities and coping strategies. Other members of the village such as the untitled men and women may also attend but will not be in a position to make their views known out of respect for the chiefs who will be doing all the talking. That is why a third meeting is arranged mainly with the women groups in the village so that their views are also gauged. The consultation team presents the group consultation views to the chief council where consensus is reached after all chiefs have spoken on the matters under discussion. It is important that the facilitator of the consultation from the government's side (which is the NAPA Team in the NAPA process) is also a chief and respected orator.

Increased involvement of the village and district representation is encouraged, for example through committees, once the process advances to the district or regional level.

Further sessions at the district level are held with a smaller district representation group. Encouraged to participate are three to four members from each village including the Pulenuu, a representative of each village's women committee and two others. Negotiations will then resume on the programme components including activities to be undertaken by the government as well as by those falling under the responsibility of the villages and district, to achieve the objectives of the programme. Village representatives relate discussions and outcomes of the meetings to their village councils for feedback into the process, and by the third meeting of this group consensus would be achieved and formalized by the signatures of all those involved from the villages. Where resources allow, agreement from all 43 districts of Samoa can be sought, otherwise a representative sample of about 40% would suffice with a balanced representation of all four inhabited islands.

The approach for the principle of greater local management authority emphasizes the importance of local responsibility for the successful implementation of NAPAs. The issue of village and district managers having sufficient information for decision making raises the importance of the partnership approach between government and local authorities and the role of the government in providing information and guidance for sound resource management.

Chapter 13

Identify Adaptation Options

1. Reflections on Adaptation

A comprehensive review of the adaptation literature and of results from National Communications (NCs) reveals main adaptation responses to various climatic hazards and risks. Based on these sources, several observations can be made, including:

- There is little consistency in the amount of detail given about proposed adaptations in NCs and other documents. Information about costs and potential benefits as well as potential complications, is particularly missing.

- Some proposed adaptations are no more than regular activities within a given sector carried out to improve production/productivity. They are often suggested without a clear decision process or time frame for incorporation into planning.

- Many adaptation responses are given by sector, and reflect sectors involved in the impact assessments leading to the National Communication. There is often little analysis of complex effects involving multiple climatic threats, or explicit links to economic factors and metrics used in decision making.

- Earlier studies that assessed impacts often led to statements of vulnerability and adaptation without a clear connection between the two stages of analysis (impacts versus adaptation), which is particularly the case where few climate change scenarios are used to analyze potential impacts, While many adaptations are local, there is a great commonality in the suggested approaches . See Table 13.1 from FCCC/SBI/2003/13, page 40 based on 16 national communications. Many of these activities are linked to sustainable development goals and practices.

- Many national communications emphasize mitigation activities, although it can be argued that adaptation is most important for developing nations given the immediate impacts climate change has on development, especially for the small LDCs that have marginal total emissions.

Table 13.1. Adaptation options in agriculture, water resources and coastal zones and marine ecosystems sectors for 16 countries as indicated in their National Communications (from FCCC/SBI/2003/13, Table 9)

Option/sector	**Albania**	**Bangladesh**	**Belize**	**Benin**	**Cambodia**	**Djibouti**	**Eritrea**	**Guinea**	**Iran**	**Kenya**	**Kyrgyzstan**	**Mauritania**	**Namibia**	**Tajikistan**	**The former Yugoslav Republic of**	**Uganda**
Agriculture																
Educational and outreach activities to change management practices to those suited to climate change		√	√	√			√		√	√			√	√		√
Switch to different cultivars	√	√								√	√		√		√	√
Improve and conserve soils	√	√	√		√				√	√	√		√		√	
Enhance irrigation efficiency and/or expand irrigation	√	√	√		√				√	√						√
Agriculture research and transfer of technology		√	√	√					√	√	√				√	√
Establish seed banks									√							
Develop new crops		√	√		√				√	√	√		√			√
Develop and introduce policy measures, including taxes, subsidies, facilitation of free market	√						√		√							
Develop early warning system and disaster preparedness	√	√	√	√			√							√		
Improve pest and disease forecast and control	√	√	√	√						√	√					√
Water resources																
Increase water supply, e.g by using groundwater, building water storage reservoirs, improving or stabilizing watershed management, desalination		√	√	√		√	√		√	√	√			√		√
Decrease water demand, e.g. by increasing efficiency, reducing water losses, water recycling, changing irrigation practices		√	√	√					√		√		√	√		√
Develop and introduce flood and drought monitoring and control system.	√	√	√				√		√				√			
Reduce water pollution	√								√	√			√			
Improve or develop water management	√	√	√	√			√		√	√	√					
Alter system operating rules, e.g. pricing policies, legislation	√								√	√	√					

Coastal zones and marine ecosystems																
Develop integrated coastal zone management	√				√		√									
Develop planning/new investment requirements		√	√		√		√						√			
Protect, including building sea walls, and beach nourishment		√	√	√	√		√					√				
Retreat																
Research/monitor the coastal ecosystems		√	√				√						√			

The above reflections lead to the following questions:

- Can we define common impacts of climate change on given sectors and systems?
- Can we define common solutions, notwithstanding the need to customize local implementation (localizing the solutions)?
- Can we constrain detailed vulnerability assessments for every country, and instead, develop screening methods that would identify the most appropriate solutions for any given locality and situation?
- Do detailed vulnerability assessments result in any surprises or unique solutions for a given locale?
- How can the NAPA process address the above questions?

2. Defining Adaptation

Consider the Vulnerability Framework being developed in PRIVA (Desanker, 2004) as discussed in the rapid assessment chapter earlier, where

V = f(risk of hazard, impact potential (coping range,
system sensitivity to climate, system-climate linkage), adaptive capacity)

Adaptation can be defined as those steps taken to minimize vulnerability through any of the following:

- Reduction of the risk of hazards by manipulating components of risk (removing/reducing hazard through mitigation of global warming is outside the domain of analysis for the LDCs given their negligible contributions to global GHG emissions). There may be cases where local risks can be manipulated, such as through improved water managed to reduce flooding risk.

- Reduction of impact potential through manipulation of the system-dependence on climate (cropping manipulations for instance through irrigation and crop breeding to minimize sensitivity to climate variability), increasing coping range through micromanagement of constraints such as water, and modification of sensitivity to climate through genetic manipulation).

- Increase in adaptive capacity components including human coping abilities (e.g. addressing key determinants such as poverty and access to financial resources)

A comprehensive review of the literature revealed common adaptations to key vulnerabilities as shown in Table 13.2. At this stage in the NAPA, potential adaptation activities can be identified and could form the basis for the "**ranking of adaptation options**'.

Table 1. A preliminary indicative list of climatic hazards, impacts and adaptation strategies including indigenous knowledge systems.

Top level - Hazards

1. Extremes in temperature and rainfall
2. Drought
3. Floods
4. Tropical Storms/Storm Surges, wind storms
5. Hailstorms
6. Diurnal Temperature Changes (decrease or increase resulting in changes in frost conditions)
7. Changes in Seasonal Cycles (change in start, length, quality of the growing season, dry spells, excessive wet spells, etc)
8. Complex hazards e.g. mud/landslides

Second level - Impacts

- Water shortage
- Contaminated water
- Decline of crop production
- Loss of a whole year's crop
- Coastal inundation/erosion/salinization
- Hunger/malnutrition
- Increased incidence of diarrhea
- Destruction of human settlements
- Decline of climate-sensitive primary industries (agriculture, forestry, fisheries)
- Destruction of sites of high cultural value
- Destruction of public utilities and infrastructure (bridges, railways, roads)
- Destruction of livestock

Third level - Adaptation strategy

- Water Harvesting
- Shoreline protection structures
- Population evacuation/relocation
- Amending agricultural practices
- Improving health awareness
- Economic diversification
- Risk distribution schemes
-
- Removal of policy barriers
- Shelters
- Early warning systems
- Zoning
- Staggered planting of rain-fed crops
- Amending crop types or cultivars
- Mitigating frost damage

Fourth level - Indigenous actions and technologies

- Water catchments
- Bunds
- Artificial lakes
- Furrows

- Migration
- Readjusting planting dates
- Intensifying local agricultural practices (shifting cultivation, slash & burn)
- Conducting health awareness campaigns

Fifth Level - actors

- Individuals/families
- Community
- Sub-national body
- Nation
- Regional organization
- Global

Sixth - Modes of Delivery

- Insurance Schemes, including micro-finance and micro-insurance
-
- Policy review, new policies
- Research to improve information and knowledge base
- Monitoring and early warning systems
- Outreach
- Community action
- Projects
- Mainstreaming
-

Chapter 14

Rank Adaptation Projects and Activities to Address Priority Needs

Rank Adaptation Options

1. Introduction

Given a list of priority needs and specific activities from the previous steps, the next step is ranking specific activities. Methods such as Multiple Criteria Analysis can be used, and may include finding solutions that are combinations of different approaches. For example, a solution may include irrigation, increased use of fertilizers and food imports in order to achieve food security.

The quantitative and semi-quantitative methods are only applicable if there is adequate information on costs and benefits for proposed activities. Such methods include multiple criteria analysis (MCA), cost-benefit analysis (CBA), and optimization, and have been suggested and illustrated in the LEG annotations of the NAPA guidelines. The consensus approach described in the previous chapter can also be used to explore the tradeoffs between activities that would address a need. This is particularly useful in the absence of reliable data on costs and benefits.

Criteria for the ranking could be established through stakeholder consultations. For example, criteria identified by the Samoan team are shown in Table 14.1. Table 14.2 shows a ranked list of criteria based on a stakeholder consultation and a percentage of views for each.

Table 14.1. Criteria used by the Samoa NAPA team

Criteria for Choosing Adaptation Activities

1. Level or degree of adverse effects of climate change
2. Poverty reduction to enhance adaptive capacity
3. Synergy with other multilateral environmental agreements
4. Cost-effectiveness
5. Addressing vulnerabilities of communities and sectors
6. Strengthened existing coping strategies and methods

Broad list of criteria for prioritisation of activities

1. Loss of life and livelihood
2. Human health
3. Food security and Agriculture
4. Water availability, quality and accessibility
5. Essential Infrastructure
6. Cultural heritage
7. Biological Diversity
8. Land-use management and forestry
9. Costal zones and associated loss of land
10. Other environmental amenities

Table 14.2. An ordered list of criteria to be used in selecting NAPA activities

PRIORITY	CRITERIA ELEMENT	VIEWS (%)
1	Essential Infrastructure	82
1=	Land-use management & Forestry	82
2	Water accessibility, quality & availability	78
3	Health	77
4	Education	55
5	Cultural Heritage	48
6	Loss of livelihood	38
6=	Other environmental amenities	38
7	Loss of Life	28
8	Food Security & Agriculture	27
9	Biological Diversity	22
9=	Coastal Zones & associated loss of land	22

Chapter 15

Rank Needs And Activities For Urgency

To address the urgent and immediate needs in the NAPA preparation process, the following criteria can be useful:

- Costs, including in terms of human impact (and loss of life) that would increase if key vulnerability not addressed immediately;
- Likelihood of irreversible change and damage;
- Imminence of threat on critical components of development and livelihood;
- Activities that have particular positive tradeoffs for sustainable development e.g. through removal of triggers for environmental, social and economic deterioration and degradation;
- Activities that are beneficial or significantly facilitate effective implementation of other adaptation activities;
- Viability of immediate implementation; and
- Enhancement of system properties (such as coping ability) to improve resilience.

The LEG recommends this extra step to rank for urgency, for countries that have not submitted their NAPA as yet, to facilitate targeting of funds towards those activities that must be addressed first. The LEG feels very strongly that well articulated NAPAs will in the end, help the NAPA programme achieve its goals and objectives, and will facilitate successful implementation.

Eligibility Criteria

The criteria suggested above for dealing with the issue of urgency can be further expanded to define eligibility criteria for NAPA projects. NAPA projects should:

(a) Reduce vulnerability, enhance adaptive capacity, increase coping range, reduce threats due to climate change;
(b) Be urgent and immediate relative to the country's needs; and;
(c) Reduce vulnerability of most vulnerable communities as a priority.

Effective ranking of urgency requires a good characterization of the system in order to understand its future dynamics. For instance, while addressing issues of food, it is important to understand the underlying causes, determinants and driving forces, including critical junctures in the evolution of food insecurity.

In the absence of comprehensive system models to facilitate analysis, stakeholders can be involved in a consensus building exercise to arrive at a ranking of urgency in the adaptation activities identified.

Chapter 16

Develop Implementation Strategy for NAPA and Submission

Elements for Further Annotations to the NAPA Guidelines

1. Annotated NAPA Guidelines

The LEG has produced annotations to the NAPA guidelines that have been in circulation for a number of years. These annotations include extended procedures for mainstreaming, ranking using Multiple Criteria Analysis (MCA), and for building synergies with other multilateral environmental agreements. The LEG will consider further annotations, as the need arises, particularly in the areas of project profiling; mainstreaming and links between adaptation and development frameworks, including poverty reduction strategies; regional synergies (in design of implementation); and, local coping and indigenous strategies and technologies. For now, we discuss an implementation strategy for NAPAs, to include project profiling, national coordination of implementation and regional synergies.

2. National Implementation Strategy for Addressing Climate Change

These annotations are intended to provide further guidance to countries in the presentation of their NAPA to facilitate its implementation. It is proposed that countries include in their NAPA document elements of a National Implementation Strategy. This will build on the information developed under the project profiles. We start with further annotations of the project profile section.

a) Project Profile

- Expand and include ideas from log-frame analysis; simplify as needed. Emphasize Inputs/Outcomes and metrics to evaluate progress. Include definition of institution to take primary charge of implementation/execution.

b) Coordination of implementation

Each country could produce a table showing main outcomes of NAPA/main needs/goals and information in the following areas:

- Goal/NAPA Priority Needs
- Objectives/Specific Activities
- Degree of urgency
- (National/Local) Executing Agency
- Timing: whether immediate, short-term, medium or long-term

c) Regional Synergies

There is much to be learned from experiences and approaches taken by different communities and countries to address similar climatic hazards. For example, there are regions that have adapted themselves to persistent droughts or flood conditions, and have developed local coping strategies and technologies unique to their situation. Under climate change, there are now many areas beginning to experience new hazards, or more severe hazards than previously encountered, including an increased frequency and intensity of floods or droughts in many parts of the world. While it is not clear whether severe conditions will persist in the future or get worse, there are coping mechanisms that can be readily adopted in the immediate term based on methods from other regions.

A recent UNFCCC workshop on local coping strategies and indigenous technologies in New Delhi, India (November, 2003), explored experiences from different regions of the world. Differences were observed in the ability of communities to cope with flooding events. For example, in Bangladesh where floods are very common, communities have developed mechanisms for living on water, and for moving around in inundated conditions using boats. In Mozambique, however, the severe floods during the 1999-2002 wet seasons took large numbers of people by surprise and most had no means to cope or even to escape. It is entirely possible that such floods might become common place in southern Africa, in which case communities would have to develop mechanisms for living with floods. The approaches used in Bangladesh or India can be useful in designing new strategies.

Another opportunity for synergies is in regions where several countries share large basins, have similar environmental conditions, or depend on each other for critical resources such as food or trade. For example, in Southern Africa, the countries of Zambia, Zimbabwe, Malawi and Mozambique share the Zambezi River basin. They also trade with each other in food and other major commodities. Flooding in the Zambezi can be triggered by one or many events in any part of the basin, and has critical impacts on other neighboring countries. For example, heavy rains in central Zambia, northern Zimbabwe or southern Malawi would lead to excessive runoff into the lower Zambezi and lead to major flooding.

Likewise, droughts that cause major reductions in food production in Zimbabwe, for example, can have negative impacts on countries that typically import maize from Zimbabwe. It is thus important for any project or activity that aims to address food security in any of the LDCs in this region to take any regional initiatives and implications into account.

The implementation strategy for NAPAs can include discussions on whether joint implementation of adaptation activities across nations would be beneficial. In cases where the other countries are not LDCs, special attention would be needed to address financing arrangements from sources other than the LDC Fund.

It is likely that the need for regional synergies will become clearer after countries in a region finalize their NAPA activities and projects. The LEG can assist in identifying any regional synergies that may be worth pursuing.

3. Global Coordination of NAPA Activities and Funding

Each LDC that has produced a NAPA could have, on average, five or more urgent priority activities, and when all LDCs are taken into consideration, there will be a sizeable number of proposed activities, all expecting funding from the LDC Fund and other sources.

For the LDCs, their identified urgent priorities are those that must be funded in the immediate term in order to address the adverse impacts of climate change. Given resource constraints of the LDC fund, the GEF and other sources of support will need to undertake a selection and/or prioritization process for the proposed NAPA projects.

Criteria that the GEF and/or other funding entities may consider could include:

3.1 Eligibility Criteria

- *Must reduce vulnerability, enhances adaptive capacity, increase coping range, reduce threats due to climate change.*

- *Must be urgent and immediate*: NAPAs are built around the idea of addressing urgent needs for adaptation, and in particular those that must be addressed immediately. It is likely that there will be some urgent needs that may not need to be addressed immediately, such as those that require comprehensive analysis and planning.

3.2 Possible Criteria for cross-country ranking

- *Urgency relative to the country*: activities are only urgent relative to the specific situation of a country. The same activity might not be seen as urgent under a collective assessment of all proposed urgent activities included in the totality of the LDC NAPAs.

- *Vulnerability reduction* of the most vulnerable communities (MVCs): there must be some indication of expected positive results after the activity is implemented;

- *Contribution to enhancing adaptive capacity:* activities must demonstrate how they would enhance adaptive capacity, for example through poverty reduction. Activities need to show a long-term impact on reducing poverty, and more specifically, how they would increase adaptive capacity to deal with future climate threats.

3.3 Guiding elements

NAPAs by design are guided by the elements specified in the NAPA guidelines, including:

- A participatory process involving stakeholders, particularly local communities;
- A multidisciplinary approach;
- A complementary approach; building upon existing plans and programmes, including plans under MEAs; and national sectoral policies
- Sustainable development;
- Gender equality;
- Country drivenness
- Sound environmental management;
- Cost effectiveness
- Simplicity;
- Flexible procedures base don individual country circumstances.

This list is not exhaustive, and not intended to serve as a screening mechanism for projects. Projects must apply these principles in the context of the specific vulnerabilities and activities under consideration. It is proposed that during the selection of activities for funding from the LDCF and other available sources, the following principles are also taken into account:

- Consideration of NAPA activities for funding soon after NAPA completion to avoid delays in addressing the urgent needs specified by countries;
- Considerations of issues with respect to the proportion and size of the country and its population that is vulnerable to climate change in the immediate term;
- Considerations of equitable access to the LDC Fund regardless of the timing of completion of the NAPA; as well as
- Equity in access to funds regardless of the size of the LDC Fund.

4. The Issue of Mainstreaming

4.1 Defining Mainstreaming

Mainstream is commonly defined as '*the prevailing current of thought, influence, or activity*' (Common English Dictionary, see www.dictionary.com). The transitive verb, mainstreaming, 'refers to the *process of integrating or incorporating [something] into an existing or prevailing group*. Within the climate change community, mainstreaming is used with careless abandon, and needless to say, with different and specific meanings in mind, adding to a lot of confusion in trying to make progress with the LDC issues. We have reviewed the literature (there is not much that directly discusses this issue), and the various contexts in which mainstreaming is used under the UNFCCC.

In order to facilitate meaningful dialogue and programming under the UNFCCC, the LEG proposes that mainstreaming be qualified appropriately when it is referenced. We feel that continued use and abuse of the concept of mainstreaming is not helpful, and a common understanding is required to facilitate future dialogue. We propose the following contexts for mainstreaming, and how they relate to the NAPA process and broader development ideas.

4.2 Contexts for Mainstreaming

Mainstreaming in the Context of NAPA

Mainstreaming in NAPA is understood to mean the process of integrating national development priorities and goals into the NAPA preparation process. This is achieved through careful review of existing national development goals and programmes during the design of the NAPA, with appropriate actions taken to ensure that the NAPA complements existing development activities and priorities. The NAPA is prepared through a consultative process involving diverse stakeholders, with appropriate public input in identifying key vulnerabilities, adaptation responses and in the ranking of priorities and identification of urgent needs. At the end, the NAPA is formally approved and endorsed by a national process, either through Parliament, or some other prevailing process for national plans. These steps in the NAPA preparation guarantee that a NAPA is fully mainstreamed with national development upon its completion.

We, therefore, propose the following definition of mainstreaming with respect to NAPA: *Mainstreaming in the context of NAPA, is the process of integrating or incorporating major development plans and priorities in the design and implementation of NAPA.*

Why mainstreaming or integrate development goals, priorities and projects into NAPA? The reason is quite straightforward. To ensure NAPAs are synergistic with broader development activities, it is important to take into account those development activities that are related to the NAPA.

<u>Mainstreaming climate change into development</u>

Another context for mainstreaming is that of integrating climate change in development planning. This is quite different from the mainstreaming context of NAPA, and is a broader issue of integrating climate change concerns in national development planning and programming, which belongs in the development planning sphere. National development planning is a process that has traditionally taken into account core issues of poverty, health, land use, agriculture, etc., in the process of identifying priorities and implementing development projects. If climate change is thought to be another core issue along with these issues, then mainstreaming climate change would involve appropriate steps to ensure that climate change considerations are considered appropriately in the development planning.

An important distinction between how a developed country might address this mainstreaming of climate change in development from and how an LDC might do it, lies in the fact that climate change is a multilateral problem, and there must be a clear boundary between sovereign actions at the national level from those that can discussed and agreed upon in a multilateral setting.

<u>What would mainstreaming NAPA in national development mean?</u>

The idea of mainstreaming NAPA in national development that is sometimes suggested would be an exercise that essentially develops a new development plan that takes into account elements contained in the NAPA. A project like this would be cyclic and illogical. The NAPAs have already taken into account development goals and priorities, to then come back and say let us integrate the NAPA into development planning, would essentially amount to merging two documents describing the two plans. There would be no added value.

If on the other hand, the intention was to return any further action on the NAPA to a national level process to fund outcomes, then mainstreaming the NAPA in national planning would imply that the LDC governments should fund adaptation to climate change from their national budgets. This would amount to prescribing a burden of an obviously multilateral phenomenon onto national governments, and those that not only had the least contribution to the problem, but also those that have the least capability to do anything about it. As a LEG, we have a duty to advise on NAPA preparation and implementation, and clarifying the issues from a nonpartisan point of view is our humble contribution.

The Conference of the Parties needs to clearly elaborate on who will pay for adaptation in LDCs, and within that, who would pay for urgent and immediate needs. For those activities and programmes that the climate change process cannot assist developing countries with, it should be a sovereign issue to pursue alternating planning and funding to address climate change locally, and this would therefore, be outside the multilateral process of the UNFCCC.

Chapter 17

Malawi Sample NAPA

1. Introduction to the NAPA Simulation Exercise

The following is a hypothetical case for Malawi as used in part at the LEG regional workshop for NAPA preparation in African Anglophone countries, held in Ethiopia in May 2003. Some of the background material is drawn from the NAPA proposal that was submitted by Malawi to the GEF, prepared by the Malawi NAPA Team. It is presented here to demonstrate key steps and potential sources of information, and to show how these can be used to produce a NAPA. An actual NAPA for Malawi is likely to be very different because it will have broad stakeholder input, and is likely to be based on a more diverse information base. The following are options for carrying out a NAPA for Malawi. The final approach would be decided by the country NAPA team.

Option 1. Choose the most vulnerable region and conduct a NAPA for that area only (one can also choose the most populous region or the region with the highest economic activity or productivity as a proxy for the rest of the country)

- If a country is large, or some obvious priorities in parts of the country exist, one can choose to concentrate on a region of the country;
- One can also choose a region that is at greater risk to climatic hazards based on some obvious physical features;
- Carry out an integrated assessment to identify adaptation activities.

Option 2. Choose a few critical sectors that are sensitive to climate changeand base the NAPA on those.

- Based on economic performance or relative ranking of the different sectors, select one or few sectors to assess;
- Develop priority activities to safeguard sectors from different climate change hazards.

Option 3. Select a priority sector for each district or region, and conduct an integrated assessment based on the most likely climate hazards for each region.

- To ensure regional balance in activities, select representative sectors/issues to address in each district.

Option 4. Full Assessment of sectors and regions taking into account all possible climate hazards.

- This could be a useful start in the exercise and would identify a logical next step/stratification for the process;

- For example, construct matrices of climatic factor versus sector by region and score orders of priority.

2. Sample NAPA for Malawi: Introduction & Setting

Malawi is a small, land-locked country in Southern Africa, with an estimated population in 2000 of 10.8 million. It is one of the poorest countries in Africa with around 65% of the population below the national poverty line and 28% living in extreme poverty. Health and social indicators are also among the lowest in Africa. Infant mortality in 2000 was 134 per 1000, compared with an average of 92 for sub-Saharan Africa, and average life expectancy (now 37 at birth) is declining as a result of HIV/AIDS, which in 1999 affected 16% of the adult population and 31% of women in ante-natal care. Adult literacy is under 60% and only 78% of children attend school. Malawi experiences drought and floods almost every year, and occasionally, is hit by cyclones coming in from the Indian Ocean.

A large lake, Lake Malawi, flows out into the Shire River, which in turn has several hydroelectric installations that provide over 90% of the country's electricity. The Lower Shire basin is a major producer of cotton, sugar, beef and rice; most of which occurs in low lying flood plains and wetland systems that are vulnerable to flooding, or to water shortages in times of drought conditions. Extensive land use in the basin has resulted in siltation problems in the river, seriously impacting electric power generation and fisheries. A rail line connecting the basin with the major economic center of Blantyre and a road going from north to south are the major access routes, and these are highly vulnerable to disruption from excessive runoff and erosion, especially at a few critical bridges. Several large rivers flow into Lake Malawi, contributing about 55% to its input water, while the remaining 45% is from direct rainfall over the lake surface. Most of these rivers pass through high land use areas or cities, resulting in heavy pollution from human use of the river for laundry, or through siltation inputs from agriculture, in which chemicals and fertilizers are heavily applied.

Over 98% of the electricity is generated from hydro-power plants along the Shire River in Southern Malawi, thus the production of power depends on the amount of flow from Lake Malawi into the Shire River. Erosion resulting in excessive siltation of the Shire is a major problem for power generation.

Flood plains and wetlands associated with the Shire are important for wildlife conservation, sugar production at Nchalo, and rice production etc. The Shire basin is also one of the most densely populated areas of Malawi, with many rural people farming the rich alluvial soils of the flood plains. In turn, many people are impacted by flooding in Lower Shire resulting in disaster declarations every few years. The higher areas of the Shire Basin are susceptible to drought, causing many hardships.

Major cash crops include:

- Tobacco: grown in Kasungu and Zomba and some areas in between, contributes to 61% (2000 figures) of foreign income; some irrigation carried out;
- Sugar: produced in Dwangwa in Nkhota-kota District in Central region by Lake Malawi; and in Nchalo in the Lower Shire in the South. Production is irrigated. Delivery to main markets in cities is by road, and in particular, through singular main roads with several key bridges involved (on Bua River for Dwangwa, and one on Shire River for Nchalo);
- Tea: grown in Mulanje and Thyolo Districts;

- Cotton: in the Lower Shire river basin;
- Increasing emphasis on soya beans and chillies as cash crops and a possible alternative to tobacco.

Intensity of land use is quite high, with almost all land under active agricultural use except for areas under protection and conservation. In many areas, land scarcity has resulted in cultivation of hill-sides and very steep slopes. Given a lack of new land to convert, there are few solutions for increasing food production by intensification versus expansion.

Malaria is widespread, except in high elevation areas. Malaria testing clinics are available in the big cities and have had a great impact in helping targeting medication to those infected. HIV/AIDS is also a major problem for Malawi and is having substantial impacts on all aspects of life.

3. Synthesis of available V&A plans and policies

Several assessments of vulnerability have been carried out for Malawi, the most relevant being the First National Communication and the FEWSNET/WFP assessments of food security (www.fewsnet.org; www.wfp.org). A summary of key impacts of climate change is presented in Table 17.1, based on the First National Communication.

Another useful document is the National Action Plan for Development for the decade 2001-2010 presented to the UN LDC III Conference in 2001. This document provides an assessment of the state of development and highlights targets for the next decade. The Malawi National Statistical Office publishes annual statistical summaries and archives other national data such as census data. These data are available through their web site at http://www.nso.malawi.net.

Table 17.1. Climate Related Adverse Effects, Sectors and Impacts in Malawi (Source: Malawi First National Communication, 2003)

Climate Hazard	**Region/Sector Impacted**	**Impacts**
Floods	Low lying areas: Shire River Valley and Lake Malawi. In year 2001 floods affected 18 out of 27 districts in Malawi.	• Loss of life, loss of crops, loss of animals, loss of human and animal habitats; loss of critical infrastructure; outbreaks of pests and diseases; destruction of fish and wildlife habitants; displacement of people; and environmental degradation. Major floods often lead to complex human disasters such as severe food shortages and famine. Impacts of floods often worsened by drought.
Droughts	Low lying areas up to mid-altitude areas (0 to 1000 metres asl). During the 1948/49 and 1991/92 intense and widespread droughts, over 80% of the country was affected.	• Crop failure, water scarcity, heat waves, drying of water reservoirs (dams, fish ponds, lake levels, rivers), famine, loss of human and animal lives, loss of biodiversity, environmental degradation.
Strong Winds	Country-wide but especially during the rainy season from residual tropical cyclones and tornado type wind systems.	• Loss of life from collapsing structures. • Damage to structures (rural community houses, school blocks, hospitals, etc.) due to sub-standard constructions. • Destruction of crops, forest plantations & natural trees. Change in prevailing wind direction have caused major forest damage. • Bush fire enhancement in the dry season. • Upwelling especially over lake Malawi causing fish mortality. In 1999 the outbreak of fish death occurred in many areas of Lake Malawi. • Loss of vessels over the lake and loss of life.
Landslides and flash floods	Over fragile mountainous systems of Shire highlands. The municipality of Zomba is located at the base of Zomba mountain, while other communities are in vulnerable locations in other mountainous areas in Mulanje, Phalombe, etc.	• Loss of life. Over 500 people perished in landslides and flash floods in Phalombe and Mulanje in 1991. • Destruction of infrastructures (bridges, roads, houses). • Loss of crops, vegetation and animals.

4. Framework for Adaptation Programme

National Vision: In 1998 Malawi launched the Vision 2020, which articulates the country's aspiration for sustainable economic growth and development including sustainable utilization of natural resources and the environment. In May 2002, the government of Malawi launched the Malawi Poverty Reduction Strategy Paper (MPRSP) for poverty reduction through socio-economic and political empowerment of the poor. The MPRSP was developed through wide participation of a broad range of stakeholders at national and district levels. The MPRS is built around four pillars. These pillars are the main strategic components grouping the various activities and policies into a coherent framework for poverty reduction:

- The first pillar promotes rapid sustainable pro-poor economic growth and structural transformation.
- The second pillar enhances human capital development.
- The third pillar improves the quality of life of the most vulnerable.
- The fourth pillar promotes good governance.

The MPRS also mainstreams key cross cutting issues such as HIV/AIDS, gender, environment, and science and technology. This strategy identifies and incorporates several cross-cutting issues relevant to the NAPA, including environment, science and technology (Figure 17.2).

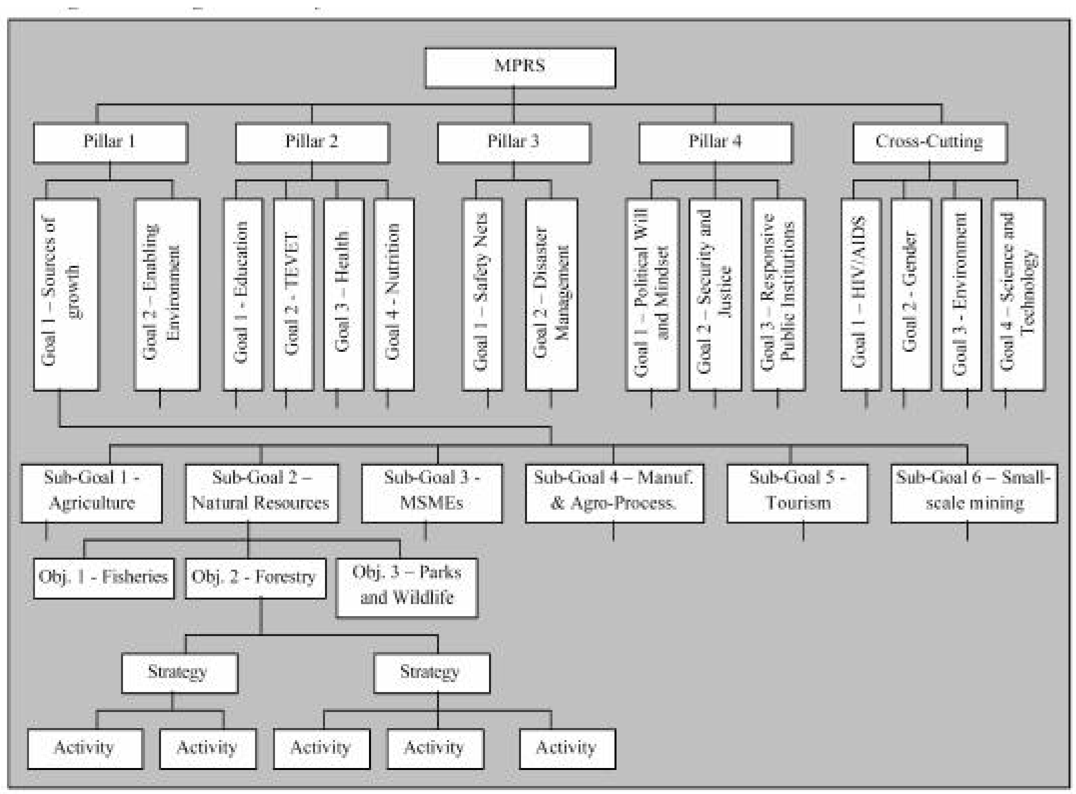

Figure 17.2. Components of the Malawi Poverty Reduction Strategy (TEVET is Technical, Entrepreneurial, Vocational Education and Training; MSME is Micro, Small and Medium Scale Enterprise)

The Malawi PRSP includes a work plan that shows specific objectives, strategy, activity, lead institution and other responsible institutions. All these are given in order of priority. Information on costs by objective is also given. Selections of objectives that have the most direct linkages with climate are shown in Table 17.2, and selected monitoring indicators and targets are given in Table 17.3.

Table 27.2. Selected objectives and strategies from the Malawi PRSP based on links with climate change (based on the Malawi Poverty Reduction Strategy, 2002).

Goal/Sub goal	Objective (in order of priority)	Strategy (in order of priority)
Pillar 1: Sources of Pro-Poor Growth		
Increase agricultural incomes and ensuring food security	Expand and strengthen access to agricultural inputs	Increase access to credit for farmers', specially the poor
	Distribute free inputs to the most vulnerable	
	Improve agricultural production through improved research and extension Services	Strengthen extension delivery services, including the implementation of the new Extension Policy
		Enhance production and dissemination of appropriate weather and production Statistics
		Conduct demand driven research to develop easily adoptable technologies
	Improve access to domestic and international markets	Develop an effective Marketing information system
		Ensure smallholder production is market-friendly
		Promote development of local agro-storage and processing industry
	Promote small scale irrigation schemes and drainage	Encourage development of small scale irrigation schemes based on manual lifting devices, and river diversions
		Support development of Small scale irrigation schemes based on motorized pumps and sprinklers.
		Promote the rehabilitation and construction of community small earth dams
		Enhance Capacity building for Irrigation Development
	Encourage production of specific crops (tobacco, tea, sugar, coffee)	Ensure continued benefits from traditional estate crops
		Encourage establishment of viable production units for selected key export crops (cotton, cassava, soya beans)
	Encourage production of livestock	Provide training for livestock producers in groups
	Reduce land shortage and degradation	Support implementation of the draft Land Policy
		Address the problem of small landholding sizes and landlessness
Sources of Pro-Poor Growth/Natural Resources	Increase sustainable utilization of fishery resources	Strengthen legal and institutional framework
		Promote alternative livelihood strategies in fisheries
Creating an enabling environment for Pro-Poor Growth/Rural infrastructure	Increase accessibility to good drinking water and sanitation	Construct and rehabilitate water facilities

Goal/Sub goal	Objective (in order of priority)	Strategy (in order of priority)
		Increase capacity to meet demand from industry and domestic users
		Reduce incidence of water borne diseases
	Increase access to affordable and sustainable rural energy	Embark on a nationwide rural electrification Programme
		Reduce pressure on wood fuel
		Expand electricity supply options
Pillar 3: Improving the Quality of life of the most vulnerable/Safety Nets		
– Productivity enhancing interventions	Improve agricultural productivity of the resource poor farmers	Provide free inputs
	Provide employment opportunities for the labour abundant land-constrained poor	Implement public works programmes in rural areas
Welfare support services	Reduce malnutrition of the malnourished under-five children, lactating and pregnant mothers	Provide food supplements and therapeutic feeding
	Provide income support to the core poor	Implement direct welfare transfers
	Strengthen capacity of families and communities to effectively support the most vulnerable	Implement capacity building programs (such as for orphan care, care centres)
Improving Disaster Management	Improving disaster management	Provide food and non-food items as basic necessities to disaster victims
		Undertake rehabilitation
		Design disaster preparedness and mitigation programmes
		Monitoring and evaluation
Cross-cutting Issues:		
Create a Science and Technology Driven Economy	Improve capacity and capability of the national system for science and technology (S and T)	Strengthen national science and technology
	Intensify application of S and T	Increase application of S and T in all sectors of the economy through research in appropriate technologies, operational research, and extension

Table 17.3. Selected Monitoring Indicators and Targets of the Malawi PRSP (2002)

Indicator	Current Status (2002)	Target 2005
Major Impact targets		
Poverty headcount measured by consumption based poverty line	65.3%	59.3%
Extreme poverty headcount, measured by consumption based ultra-poverty line	28.8%	20%
Life expectancy	39 years	43 years
GDP per Capita (constant 2001 prices)	MK 10,500	MK 11,400
Literacy rate (female)	58% (44%)	70% (60%)
Infant mortality rate (per 1000 children)	104	90
Maternal mortality rate (per 100,000 live births)	1,120	800

Agriculture		
Maize yield (kg/ha)	1137	2000
Cassava yield (kg/ha)	16618	18000
Cumulative intake of extension trainees	100	900
Farmers' groups and co-operatives formed	-	3000
Treadle pumps supplied on loan to farmers (cumulative)	-	60,000
Area under motorized pump irrigation (hectares	1,300	3,700
Area under irrigation per ADD (hectares)	-	2,000
Production of cattle	775,333	868,373
Natural Resources		
Fish farming production (tonnes)	500	1,000
Forest under private sector	-	50,000
Parks under private sector	-	50,000
Rural infrastructure		
Households with access to potable water	65.6%	84%
Rehabilitation of boreholes (% functional)	60%	100%
Construction of new boreholes	-	7,500
Households with sanitary excreta disposal	81.4%	100%
Number of new sites electrified	-	73
New biogas plants	-	105
Health		
Infant mortality (per 1,000 live births)	104	90
Under 5 mortality rate (per 1,000 live births)	189	150
Maternal mortality rate (per 100,000)	620	400
Nutrition (% children underweight)	30%	20%
Population (fertility rate)	6.1	5.5

National Plans: After the Earth Summit in Rio, Brazil in 1992, Malawi launched the National Environmental Action Plan (NEAP) in 1994 that was developed through consultations at all levels. The NEAP is Malawi's operational tool for implementation of Agenda 21. The NEAP identified several environmental issues: high soil erosion, soil fertility loss, deforestation, over-fishing, loss of biodiversity, water resource degradation and depletion, human habitat degradation, air pollution and climate change.

Malawi has participated in UN Commission on Sustainable Development (UNCSD) conferences. It was involved in the World Summit on Sustainable Development (WSSD), where a national paper was presented in August/September 2002. The country is in the process of compiling a second NEAP 2002, which incorporates recommendations from the WSSD.

Based on these various national activities, the following development goals for Malawi can be isolated to guide NAPA preparation:

- Achieve food security;
- Alleviate poverty;
- Attain and maintain positive economic growth;
- Improve welfare of women and their access to production resources;
- Address special needs of orphans, recognizing the role of women and the elderly as heads of households;
- Safeguard (hydro-) electric power generation;

- Minimize loss of life and livelihoods due to natural disasters including climate-related disasters;

5. Assessment of main vulnerabilities

Malawi suffers from chronic food shortages in several parts of the country in most years. This is further exacerbated by the high incidence of HIV/AIDS that has created a large number of highly dependent orphans, and has also severely impacted rural household food production as well as quality of life. Increasing incidence of floods and droughts are major concerns with far-reaching impacts on food, water, health and energy. Erratic rains have resulted in serious crop failures despite efforts to improve seasonal forecasting of the start of the growing season.

6. Potential barriers to implementation

Besides very limited internal capacity to fund any adaptation activities, the following are some major constraints to implementing NAPA activities:

- A large percentage of the population are in dire need of intervention;
- Extreme poverty in many rural populations and associated low literacy rates, make outreach challenging, and long-term planning difficult;
- Access to some parts of the country is limited due to poor condition of roads and bridges, limiting access to markets, fertilizers and seed, or access to aid;
- Regional food shortages make supply of food from Malawi's neighbors difficult, further increasing the costs of coping with current drought and associated food shortages;
- Large numbers of HIV/AIDS orphans are a major drain on family energy, funds and food, more so in rural areas and among the poor. Those tending the sick have little or no capacity to maintain farms, and are very susceptible to disease;
- Poor health conditions among the poor, leading to low body weight and high rates of malnutrition in children and the elderly, limit the ability of the population to respond to opportunities for work; and
- Very limited analytical capability in Malawi are a barrier to the analysis of threats and potential impacts, and to the development of viable solutions.

7. Identification of Priority Adaptation Needs

Food and health are critical factors for Malawi, followed by access to clean water and energy. Recent weather extremes have led to cascading food shortages and hunger, compounded by the displacement of people by floods, droughts and other disasters, as well as extreme poverty in rural populations making them incapable of buying food, or unable to enhance their crop production with fertilizer. A major effort is needed to achieve food security, and in fact, to achieve food excess to allow rural folk to sell extras and generate disposable income. The challenge is to understand their situation and to provide them with sensible solutions.

The following are country-driven criteria that could be used to rank priority adaptation needs:

- Address plight of most vulnerable and most poor in the country;
- Ensure geographic balance and regional equity;
- Ensure synergies with NGO/Government efforts in addressing critical issues related to food, water, health and energy, as well as critical commercial enterprises;
- Protection of critical foreign income generating activities;

- Potential to reduce long-term food shortages and dependence on food aid; and
- Key criteria to be a combination of the potential number of people helped out of food insecurity and the geographic distribution of the target communities.

Suggested adaptation needs for Malawi include: (Specific activities and projects to address these needs could be developed subsequently)

1) Address food insecurity at the national and community levels:
    a. Seek food security in areas hit by famine due to droughts and other complex factors including HIV/AIDS;
    b. Increase national food reserves to achieve a 3-5 year buffer against natural disasters and climatic effects;
    c. Explore implementation of a regional approach to food supply in collaboration with SADC.
2) Improve early warning capability to monitor and forecast climate variability and growing season conditions;
3) Identify then address root causes of flooding and drought impacts, and improve coping ability of most vulnerable communities;
4) Enhance capacity of HIV/AIDS orphans to develop meaningful livelihoods that will make them self-supporting at household and community level;
5) Enhance resilience of vulnerable populations (children and the elderly) through improvements in nutrition;
6) Safeguard energy supply (hydro-energy) against erratic rains and adverse impacts of land use change in critical watersheds due to excessive siltation;
7) Build scientific knowledge and methods to improve productivity of marginal and degraded areas;
8) Build technical expertise and capacity in integrated assessment, climate change adaptation analysis and a critical mass of expertise to plan and implement adaptation activities.

The above list can be ranked and reduced to a list of priority adaptation needs by applying the criteria outlined above. This can be carried out through a stakeholder consultation. For the purposes of this exercise, we will assume that issues of food security, and needs to address floods and droughts, are at the top of the list.

8. Development of a List of Adaptation Activities and Projects, Ranking

Table 17.4 draws upon the Malawi First National Communication and presents a list of identified adaptation activities by sector. These could constitute elements to be further ranked into a short list of priority adaptation activities. Information about costs and benefits (inputs and outputs) in the broadest sense would be used in the ranking. This list can be adjusted to highlight major climatic hazards (droughts, floods, seasonal variability).

Table 17.4. Suggested adaptation activities for Malawi (modified from: Malawi First National Communication, 2003)

SECTOR	**SUGGESTED ADAPTATION ACTIVITIES**
Water	• Improve management of rain water through small dams and other rain harvesting techniques in drought-prone areas identified in a spatial analysis of

	drought risk, potential impacts and coping ability • Improve public awareness campaigns in water conservation measures • Improve water flow management through construction of dykes and canals to re-direct/divert overflows in vulnerable townships to mitigate flooding • Rehabilitate flood forecasting and warning systems • Improve assessment of flood and drought zoning to facilitate decision making and outreach
Fisheries	• Promote alternative uses of water weeds (invasive alien species) • Breed *tilapia* and cat fish for restocking programmes in the lakes and other water bodies • Improve management of the barrage at Liwonde on Shire river to maintain fish habitats for breeding to sustain fishing at this high density area
Forestry	• Identify species with special characteristics such as drought resistance, water logging resistance and resistance to frost damage; and develop a seed bank to protect genetic resources • Promote planting of traditional tree species that are better suited to local conditions and explore tree breeding to enhance resistance to increased climate variability
Wildlife	• Build capacity to translocate wildlife in response to extremes and other conditions that endanger wildlife • Provide artificial water supplies in conservation areas that are under water stress
Agriculture	• Improve basis for decision making in seasonal planning for planting date, choice of species (cultivars) and other interventions to minimize climatic threats • Promote drought tolerant crop varieties and livestock in areas vulnerable to drought • Promote crop growing using residual moisture especially along dambos to enhance coping • Develop infrastructure for irrigated agriculture to increase coping with climate variability (drought conditions) especially for rural communities with limited financial resources • Improve monitoring and control of migratory and seasonal pests and diseases • Promotion of yield increasing technologies e.g. manure and other crop and animal husbandry practices • Improve research capability in use of marginal lands and crop selection and yield improvement
Meteorology/Hydrology	• Improve weather data collection to cover the country to provide basis for forecasting and assessment of trends and impacts of climate variability and changes on all sectors • Strengthen capacity in seasonal weather forecasting and trend analysis of climatic patterns for all parts of the country to support farming and other activities • Build capacity of end-users of climate information in use of meteorological information and warnings especially in disaster prone areas as well as for agricultural planning (decision making under uncertainty)
Integrated Solutions: Increase Recovery Mechanism	• In cases where damages are inevitable such as during climate disasters, build financial mechanisms to help people recover • Build networks of climate information producers, researchers and local users to improve planning with climate information

Suggested activities for the priority needs can then be used in a ranking exercise using Multiple Criteria Analysis (as described in the LEG Annotated NAPA Guidelines, and in the UNITAR/LEG Examples from Regional Workshops Report – see www.unitar.org/climate and www.unfccc.int/ldc or www.napaprimer.org for more details). The outputs could be a ranked list of priority needs and adaptation activities. These could be used in the final step to rank for urgency.

9. Rank Needs and Adaptation Activities for Urgency

The above priority needs and ranked adaptation activities have to be assessed in the context of urgency and the need for immediate action. This would help separate activities to be implemented under the NAPA from those activities that can be implemented in the medium to long term.

To complete this exercise, let us suppose that the various rankings were carried out successfully, and led to the following urgent priority needs and activities for adaptation to constitute the NAPA for Malawi:

1) Address food insecurity at the national and community levels:
    a. Improve productivity through increased application of irrigation in all parts of the country
    b. Improve early warning systems for seasonal forecasts by combining weather forecasting, crop modeling and outreach
    c. Improve productivity of marginal lands through better seed and inputs
    d. Increase national food reserves to achieve a 3-5 year buffer against natural disasters and climatic effects through nationally funded food farms.
2) Identify then address root causes of flooding and drought impacts, and improve coping ability of most vulnerable communities;
    a. Conduct a flood and drought zonation for the country to support disaster preparedness and adaptation planning
    b. Weather proof critical infrastructure such as bridges that serve as key access routes to disaster prone areas
3) Enhance capacity of HIV/AIDS orphans to develop meaningful livelihoods that will make them self-supporting at household and the community level
    a. Develop targeted programmes and improve education in communities with high numbers of AIDS orphans and high vulnerability to climatic disasters. Use a small grants model.
    b. Ensure long-term sustainability of efforts to address climate change by mainstreaming climate change considerations in orphan care programs
4) Safeguard energy supply (hydro-energy) against erratic rains and adverse impacts of land use change in critical watersheds due to excessive siltation;
    a. Plant trees in severely degraded areas of the catchment areas that feed into the hydro-electric installments in the Lower Shire River basin.
    b. Implement drought and flood mitigation measures at the hydro-electric generating installations. Link with existing efforts and projects to improve electric generation.
5) Build technical expertise and capacity in integrated assessment, climate change adaptation analysis and a critical mass of expertise to plan and implement adaptation activities.

a. Implement training programs at national universities in climate change analysis, assessment and adaptation planning.
b. Develop a national integrated assessment model that integrates economics, environment and social welfare to provide decision support in planned development and efforts to reduce poverty and attain positive growth in all areas.

10. IMPLEMENTATION STRATEGY:

This section would develop required sections on project profiles, coordination of implementation and execution of each project, and would explore synergies with existing projects and activities, and at the regional level with activities in neighboring Mozambique, Zambia, Zimbabwe and Tanzania, especially in the areas of food security, early warning systems and efforts to address droughts and floods.

Chapter 18

Hypothetical NAPA for the Maldives Based on their First National Communication

Preamble: *This Maldives NAPA is an example of a NAPA that builds on a completed National Communication to highlight emergency needs. The integrated assessments to identify main vulnerabilities and adaptation options is adequate from the NC work, what remains is a process of ranking of activities and development of cost-effective options to implement priority activities. This sample is taken by merging NC outputs almost verbatim. The Maldives NAPA team has not been involved in the development of this hypothetical but realistic case study.*

1. Introduction

The Republic of Maldives comprises 1,192 small, low-lying coral islands in the Indian Ocean. The islands exist as a chain of coral atolls, stretching 860 km from latitude 706'35"N, crossing the Equator to 0042'24"S, and lying between 72032'19"E and 73046'13"E longitude (Figure 18.1). The total land area of the Maldives is estimated at around 300 km^2. The islands are surrounded by coral reefs, which protect these islands from the impacts of strong waves and other such effects. The Maldives enjoys a warm and humid tropical climate, with the weather mainly being dominated by two monsoon periods: the southwest monsoon (the wet period, from May to November); and the northeast monsoon (the dry period, from January to March).

The population of the Maldives, according to the census in 2000, is 270,101 with an annual growth rate of 1.96%. About 25% of the total population resides in the capital, Malé, where most of the economic and commercial development activities take place. The main contributors to the economy are the tourism, fisheries, constructions and commercial sectors. The tourism and fisheries sectors are very much dependent on the coastal environment of the Maldives. All the economic activities rely heavily on the smooth functioning of the Maldives' only international airport, on the island of Hulhulé, in Malé.

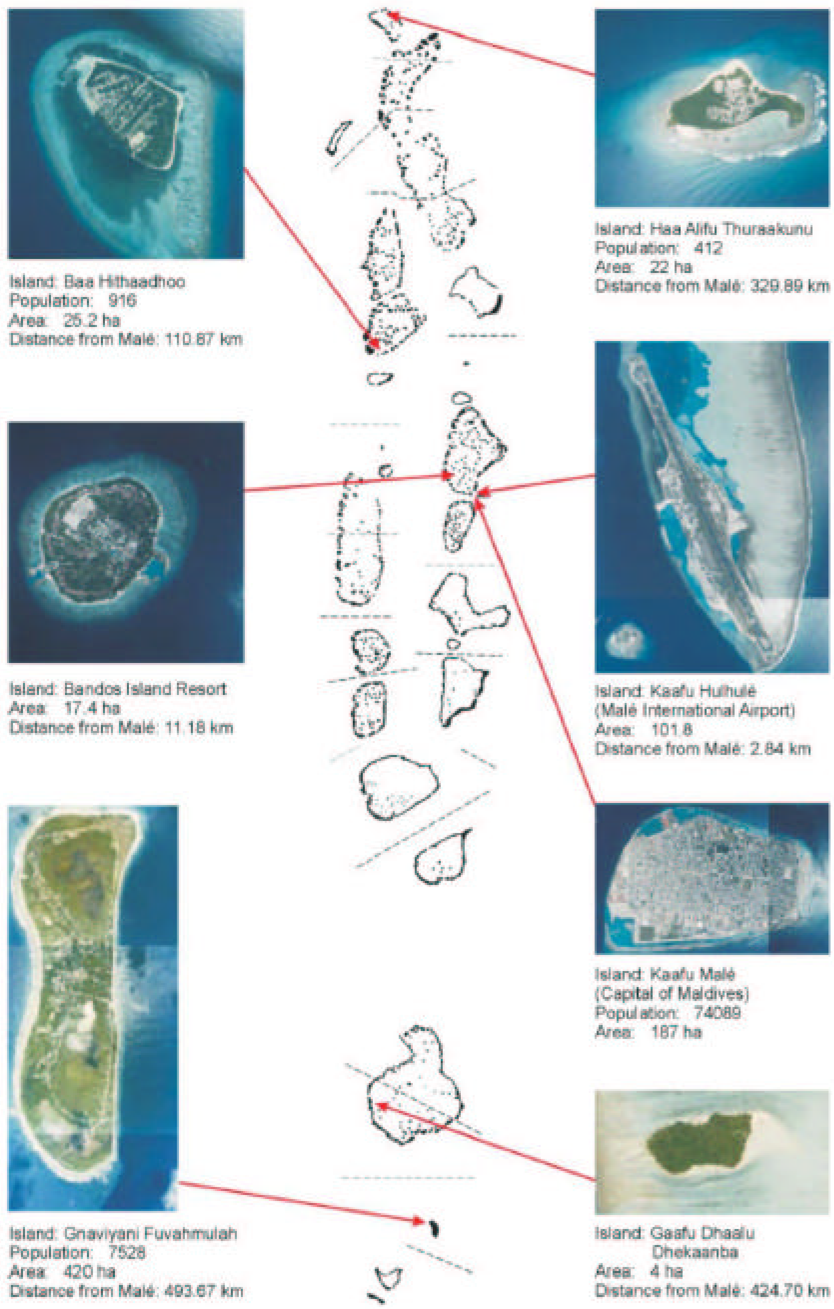

Figure 18.1. Aerial photographs and location maps of the islands selected for V&A Assessment (from the Maldives First National Communication)

2. Vulnerability to climate change

A National Vulnerability & Adaptation (V&A) assessment team has developed an Initial National Communication (submitted in 2001, available at http://www.unfccc.int), and has identified seven main areas of vulnerability:

2.1 Land loss and beach erosion

Over 80% of the land area in the Maldives is less than 1 m above mean sea level. Being so low-lying, the islands of the Maldives are very vulnerable to inundation and beach erosion. Presently, 50% of all inhabited islands and 45% of tourist resorts face varying degrees of beach erosion. Climate change and projected sea level rise would aggravate the present problem of beach erosion. It is expected that even a 1 m rise in sea level would cause the loss of the entire land area of the Maldives.

2.2 Infrastructure damage

The entire human settlement, industry and vital infrastructure in the Maldives is situated very close to the shoreline. Therefore, the projected rise in sea level poses a grave threat to the existence of these structures. *According to research, Malé International Airport on Hulhulé Island needs to be given priority, as this is the only gateway to the Maldives.* The height of the runway is only 1.2 m above mean sea level and is extremely vulnerable to climate change related sea level rise. Other important vulnerable structures include the investments on tourist islands.

2.3 Damage to coral reefs

The low-lying islands of the Maldives are surrounded by coral reefs. These coral reefs not only provide protection for the islands, but are related to the success of the main economic activities: tourism and fisheries. Studies show that the corals are very sensitive to changes in sea surface temperature. Unusually high sea surface temperatures in 1998 caused mass bleaching of coral reefs in the central regions of the Maldives. If the observed global temperature trend continues, there would be a threat to the survival of the coral reefs in the Maldives.

2.4 Impacts on the economy

The threats posed by climate change to the beaches, reefs and infrastructure on resort islands makes the tourism industry very vulnerable to climate change. This greatly affects the economy as tourism contributes to about a third of the GDP of the country. Fisheries in the Maldives are another economic activity, which relies on the health of the reefs. Although no conclusive links have been established between tuna fishery and climate change, it has been found that seasonal monsoon changes do in fact affect the tuna fishery in the Maldives. It has been found that in El Niño years catches of certain types of tuna increase while the others decrease, and the reverse catch pattern is seen with regard to other types of tuna during La Niña periods.

2.5 Food security

Due to the poor soil quality in the Maldives, agriculture is a minor industry. The lack of locally grown food items creates a high dependency on imported food, except for tuna and coconut. Therefore, the Maldives is vulnerable to changes in productivity of agricultural lands beyond its borders [regional connectivity]. The imported food items are first brought to the capital and later distributed to other islands by sea transport. The distribution of food to these islands is very vulnerable to changes in weather. Extreme storm events have led to food running scarce in certain islands. These events have been noted to last for a period of 1-30 days [important threshold]. With climate change and the rise in sea levels, it is expected that more storm events would occur, thereby threatening food security in this island nation.

2.6 Water resources

The population of the Maldives mainly depends on groundwater and rainwater as a source of freshwater. Both of these sources of water are vulnerable to changes in the climate and sea level rise. With the islands of the Maldives being so low-lying, the rise in sea levels would force saltwater intrusion into the freshwater lenses. The groundwater is replenished by bursts of rain and although there is a predicted increase in the amount of rainfall to the region, the spatial and temporal change in rainfall pattern is uncertain. Therefore, for the Maldives, climate change poses a threat to water availability.

2.7 Human Health

The effects of climate change and sea level rise on the health sector need to be studied further. Notable relations to changes in climate have been seen for dengue and dengue hemorrhagic fever in the country. Although malaria has been eradicated from the Maldives, climate change might bring back the threat of malaria outbreaks occurring in the country. Poor sanitation on the islands of the Maldives, combined with any future increase in rainfall, would cause more outbreaks of waterborne diseases, such as diarrhea. Access to health services and facilities during severe weather is a major concern for rural island communities of the Maldives. Other major concerns from climate change are poor human health due to heat stresses, and poor urban air quality. Based on the IPCC regional climate change scenarios, it is estimated that air temperatures in the region may rise by 2 - 3.8°C by the year 2100.

2.8 Adaptation to climate change

Adaptation options for the low-lying islands of the Maldives, which have been identified as especially vulnerable, are limited, and response measures to climate change and its adverse impacts are potentially very costly. Adaptation options have been identified and can be grouped into two main types:

- Actual *physical adaptive measures* targeted at the sectors identified as highly vulnerable. High importance is given to protecting the islands by building appropriate structures for coastal protection. Several other projects have also been identified for the various sectors.

- Activities designed to *enhance the capacity to adapt* in the Maldives. The Maldives lacks the capacity both technically and financially to undertake actual adaptive measures. The main areas identified are human resource development, institutional strengthening, research and systematic observation and public awareness and education.

3. National Implementation Strategy and Details about Integration of Projects and Activities in National Policies

Proposals for adaptation activities are presented in a National Implementation Strategy – policy matrix. Activities are grouped according to the following themes: [

- Participating in international advocacy
- Reflecting climate change concerns in regulatory processes
- Creating sustainable financial mechanisms for programmes related to climate change activities
- Building national capacity to adapt to climate change
- Incorporating adaptive measures to climate change into national development planning
- Developing appropriate measures to mitigate greenhouse gas emissions

Activities proposed under each of these will be used as a basis for ranking at the national level using a streamlined integrated assessment. Criteria for ranking would be decided upon, followed by short-listing of activities and subsequent ranking and development of project profiles.

The following is a hypothetical list of country-driven criteria that a national NAPA team could have derived after consultation with stakeholders:

4. Criteria for Ranking Priority Areas/Objectives

- Potential to save lives in the immediate future;
- Potential to seriously impact on major economic activities for the country;
- Potential to stop onset of serious erosion damage; and
- Potential to introduce new (health) threats.

5. Potential List of Activities under the NAPA (unranked)

The following is a list of activities extracted from the climate change policy matrix in the Maldives first National Communication; which is used as a basis for a ranking exercise to arrive at a list of priority activities.

1. Protect critical coastlines against onset of erosion or further damage
    a. Develop feasible engineering solution for coastal protection
    b. Provide incentives to promote the use of imported construction materials to reduce the use of coral in construction

2. Improve land use management to minimize number of people affected by adverse impacts including disasters
    a. Develop guidelines for land reclamation projects taking into consideration climate change and associated sea level rise
    b. Continue ongoing population consolidation programmes to reduce the number of inhabited islands for cost effective coastal protection and development

3. Protect critical infrastructure especially the International Airport in Male
    a. Extension of the current insurance policies to cover all equipment and infrastructure of the International Airport for climate related incidents
    b. Promote insurance of resort investments to be adequately covered by insurance policies for natural disasters and episodic events
    c. Develop alternative international airport to ensure food delivery and evacuation at all times

4. Diversify economic activities to enhance economic base for the inhabitants of the Maldives

a. Identify feasible economic activities for diversification in order to reduce dependency on tourism
b. Expand the fisheries industry
c. Diversify products in the tourism sector to reduce dependency on the marine environment

5. Improve food security
    a. Promote local food production through sustainable agriculture practices and fisheries
    b. Introduce new technologies for food production
    c. Diversify sources for importing food products
    d. Develop and maintain emergency relief measures
    e. Strengthen food distribution and enhance capacity of food storage throughout the country
    f. Upgrading of domestic airports as backups for continued international links

6. Water Resource Management
    a. Protect the available groundwater resources by strengthening guidelines for development of sewerage, wastewater management systems, handling of hazardous waste and solid waste disposal methods
    b. Introduce alternate distillation and desalination technologies as a water resource for the high density populated islands to reduce dependency on fossil fuel desalination technologies
    c. Develop effective storm water management mechanisms

7. Enhance preparedness against natural disasters
    a. Establish a contingency plan for effective mechanisms for disaster reduction

8. Protect against the spread and transmission of vector borne diseases
    a. Increase monitoring and treatment of dengue and dengue hemorrhagic fever to prevent epidemics exacerbated by climate change

6. List of Priority Activities and Projects for the NAPA

The following is a sample of priority projects/themes that could comprise a NAPA for the Maldives. This list could have been selected guided by the selection criteria list above. Subsequently, a project profile is developed for each of these to complete the NAPA.

a) Enhance food security in the Maldives
b) Build capacity to protect against epidemic outbursts of vector-borne diseases especially dengue and hemorrhagic fever
c) Develop solar distillation capability for freshwater production for outer islands and Male
d) Appraise soil erosion in the Maldives to guide adaptation to sea level rise
e) Upgrade Gan Airport for international operations

7. List of Urgent and Immediate Activities and Projects for the NAPA

From the above list of priorities, a final list of urgent and immediate needs could be developed that could essentially include numbers 1-4. The airport upgrade would be relegated to a longer-term assessment process, as it is not in need of being addressed immediately.

a) Enhance food security in the Maldives
b) Build capacity to protect against epidemic outbursts of vector-borne diseases especially dengue and hemorrhagic fever
c) Develop solar distillation capability for freshwater production for outer islands and Male
d) Appraise soil erosion in the Maldives to guide adaptation to sea level rise

8. Project Profiles

1. Project Name: Enhancement of Food Security in the Maldives

Soil characteristics in the Maldives are major constraints towards the development of successful conventional agricultural production systems. Limited availability of arable land also suggests that an alternative crop production system should be considered . Hydroponics is one method that can increase the production of agricultural products.

- Project rationale and objectives:

Hydroponics agriculture in the Maldives on a sustainable basis, at a commercial and household level can improve food security and reduce dependence on imports of various types of vegetables and fruits. It will also enhance income and employment opportunities for the new generation in rural islands, and direct domestic investment towards promoting food security.

- Expected outcomes:

1. Development of hydroponics production systems on a commercial scale; and
2. Reduction of dependence on imported vegetables and fruits to achieve accessibility and availability.

- Planned activities and outcomes:

1. Train the staff already working in established hydroponics systems in Hanimaadhoo Agriculture Centre as trainers. The trainers will train the required staffs for the projects by using the training facilities in Hanimaadhoo Agriculture Centre.

2. Set up three greenhouses with hydroponics systems in three different regions of the country, each with a total built up area of 8,000 ft^2 or 2 units of greenhouse with similar built area but each unit having four compartments of 1000 ft^2.

2. Project Name: Build capacity to protect against epidemic outbursts of vector-borne diseases especially dengue and hemorrhagic fever

- Project rationale and objectives:

The vulnerability and adaptation assessment for the adverse effects of climate change on the health sector identifies vector borne diseases as an area where further research is required. Dengue and dengue hemorrhagic fever, both transmitted through vectors, have been identified as endemic in the country and in recent years morbidity has increased. Therefore, this project proposes to undertake a study with the following main objectives:

1. Systematically collect and manage climatic and health data for use in a climate impact analysis; and
2. Undertake a study on the effects of climate change on the spread and transmission of vector borne diseases based on the collected data.

- Expected outcomes:

1. Enhanced capacity at the Ministry of Health to undertake an analysis of the climatic influences on the spread and transmission of vector borne diseases.
2. Continuous, short term and long term reporting on the status of vector borne diseases in the Maldives.

- Planned activities and outcomes:

1. Provide Ministry of Health with the technical capacity to undertake such a study.
2. Train Ministry of Health personnel in the ongoing design, implementation and analysis of such studies. Specific trainings to be given on the use of GIS, data analysis and background on climate change and vector borne diseases.
3. Establish and maintain a database of vector borne diseases in a climate change context.
4. Ministry of Health to establish a network with the Department of Meteorology, and other environment related agencies, to incorporate relevant climate information into the health database.
5. Produce short term and long-term reports on the effects of climate change on vector borne diseases in the Maldives.

3. Project Name: Develop solar distillation capability for freshwater production for outer islands and Male

This project is aimed at acquiring appropriate technology to provide freshwater to populated islands in the Maldives.

- Project rationale and objectives:

Acquiring appropriate technology to provide portable freshwater to populated islands is a priority area identified in the NEAP II. The Maldives lies on the equator and receives on average seven hours of daily sunshine. Populated islands have limited space for harvested rainwater storage. The groundwater cannot meet the demand for water for these islands. To acquire appropriate technologies for solar distillation for desalination as a source of freshwater, which can meet the demand in the dry season for the population of the islands.

- Expected outcomes:

1. The islands will have desalinated water as a source of water even in the dry season.
2. The amount of GHG emissions will be reduced
3. The risk of polluting the groundwater with diesel will be reduced.
4. The production of water would be less vulnerable to the fluctuating price of diesel.

- Planned activities and outcomes:

1. Carry out a study on water demand in the medium densely populated islands.
2. Quantify water demand, taking into consideration the increase of demand for water for the predicted climate change for the region.
3. Identify the appropriate technology for the Maldives and educate the communities for their acceptance for the new technology.

4. Project Name: Appraise soil erosion in the Maldives to guide adaptation to sea level rise

This three-phase project is designed to address the issue of coastal erosion in the Maldives. The initial phases are aimed to enhance the capacity required to formulate a coastal erosion management strategy.

- Project rationale and objectives:

The Maldives face severe constraints in adapting to increased erosion expected with rising sea level. A major constraint is the lack of capacity to evaluate the magnitude of erosion and identify quantitatively the major causes of erosion. Without such knowledge, appropriate adaptation strategies cannot be formulated. The aims of this project are to build capacity of an Environment Research Centre to:

1. Quantify the magnitude of erosion on islands in the Maldives;
2. Determine the importance of natural vs. human induced erosion on islands in the Maldives;
3. Quantify changes in process mechanisms promoting erosion.

- Expected outcomes:

1. A trained Environment Research Centre that has instigated a network of erosion studies and is actively assessing the magnitude and causes of erosion throughout the Maldives.
2. Technical summaries quantifying long-term rates and importance of natural vs. human induced erosion on representative islands in the Maldives
3. Quantitative summaries of the process regimes (waves currents, sediment budgets) that characterize representative types of islands in the Maldives.

- Planned activities and outcomes:

    1. Provide Environment Research Centre (ERC) with technical capacity to undertake erosion studies.
    2. Train Environment Research Centre in design, implementation and analysis of erosion studies. ERC to establish a network of monitoring sites that reflect differences in island morphology and undertake detailed studies to document changes in island morphology and the process controlling island change.

Chapter 19

Integration of NAPA in National Development

Case Study of Zambia

1. Introduction

The NAPA process is designed to build on existing development programs and activities, to ensure mainstreaming of NAPA outcomes in national goals and programs. We use the case of Zambia to show climate–development linkages. Zambia is a landlocked country situated in the southern African sub-region and lies between the 8^{th} and 18^{th} latitude south and between the 22^{nd} and 34^{th} longitude east. The country is approximately 752,617 km^2 in size. Most of Zambia lies between 1,000 and 1,600 metres above sea level with an average altitude of 1,200m. The highest parts of the country are in the north east with the plateau gradually sloping to the south east.

The climate is subtropical with an annual mean of 21^oC and has three distinct seasons; the cool dry season (April to mid-August) with temperatures ranging from 16^oC to 27^oC; and the hot dry season (mid-August to early November) and the warm rainy season (November to April) with temperatures ranging from 27^oC to 38^oC. The country receives an annual average rainfall of about 1000mm which varies from 1400mm in the north to 600mm in the south. The climate is influenced by three main factors, namely: - the Inter-Tropical Convergence Zone (ITCZ), altitude and El Nino.[1]

Zambia, with a population of about 10 million people, is one of the poorest among the LDCs. According to CSO (Central Statistical Office) (2000), the sectoral share of GDP for 1999 was: Agriculture (18.2%), Mining (6.6%), Manufacturing (10.5%), Electricity (2.9%), Transport (6.2%) and Finance (9.2%). Over the period 1980 to 1990, the country's economic growth was the second lowest in the Southern African Development Community (SADC) after Mozambique. Over the period 1990 to 1999, it had the least average annual growth rate in SADC region at 1%. This was also below the sub-Saharan Africa rate of 2.4% (MFNP, 2002). At the end of 1999, the country had an external debt standing of $6.5 billion. This is considered unsustainable given the size of the economy and its marginal growth over the years. Eradication of poverty in Zambia is a daunting task given that it is very widespread. In 1991, up to 68% of the households were living below the poverty line. The percentage rose to 78% in 1996 and declined slightly in 1998 to 73% (CSO, 1998). The policy response of the Government of Zambia has been to implement a Poverty

[1] *ITCZ* is an area where two air masses from the northern and southern hemisphere meet producing an active convective area that in turn causes rainfall. The movement of the ITCZ from north to south and back to the north in each rain season is the mainly factor for the north-south variation of rainfall in Zambia. *Altitude* causes low temperatures in the broad belt plateaus, shielding the areas from what would be a harsh tropical climate. *El Nino* results from the warming of the sea surface temperature in the Pacific Ocean in certain years causing temperature conditions in some parts of the globe. The frequent effect of El Nino events on Zambia, as is the case in most of southern Africa, has been droughts.

Reduction Strategy Paper (PRSP), for the period 2002 to 2004, as a first step to address poverty reduction by placing a high premium on strategies for reviving broad-based economic growth.[2]

Zambia's resource profile suggests that the country has a great potential to generate wealth for its people. However, a close analysis of the natural resources sectors would reveal that important barriers have hitherto prevented the sustainable utilization of the country's natural resources and undermined the contribution of these resources to effectively contribute to wealth creation. Policy shortcomings, institutional constraints and external conditions are jointly perhaps the biggest barriers. A number of these resources remain vulnerable due to over-exploitation.

2. Climate Variability

Recent studies (CEEZ, 2002; Mumba & Chipeta, 1984; 1995) on climate variability in Zambia show seasonal changes over the twenty-five year period, 1972/73 to 1997/98. These studies show that the major variable in Zambian climate is drought and to a lesser extent, increase in temperature. The following are some of the observations;

- The start of the rainy season over the last 5 years has tended to start in the second dekad (11-20) or third dekad (21-30) of November in many areas of the country. In general, there has been a tendency for a late onset of the rainy season since the early 1980's;
- There has been a general tendency for early withdrawal of the rains since the 1980s. By the end of March, the rains would have virtually stopped in most parts of the country, although a spell of widespread rain may occur in April or sometimes as late as May;
- There is no apparent indication of changes in the trend of total seasonal rainfall over the country but there have been several rainy seasons that have exhibited mean seasonal rainfall below normal;
- In terms of seasonal rainfall changes, the period from 1972 to 1996 has experienced the most severe droughts over the whole country. The most affected has been Region I, which experienced not less than 8 droughts. These droughts have been largely due to the El Nino phenomenon; and,
- As regards to temperatures, it is shown that since the early 1970s, there has been a modest warming in the cool season (June, July and August) mean minimum temperature, whilst considerable warming (by about $1^{o}C$) of the mean maximum temperature has been observed in the hot season (September, October and November) especially over the northern half of Zambia.

It should therefore be noted that the effect of variable climatic factors of El Nino, poor precipitation, high temperatures and excess evapo-transpiration, particularly in the drier southern region of the country has in a number of years culminated into drought periods. Figure 1 presents rainfall indices statistically calculated which depict seasonal changes over the last twenty five years (1972/73 – 1997/98) over Zambia as a whole.

[2] PRSP is, simultaneously, the vehicle through which national governments are expected to elaborate nationally owned poverty-reducing policies, through which the IMF and the World Bank identify satisfactory policy environments, and through which bilateral donors are expected to align their assistance for poverty reduction.

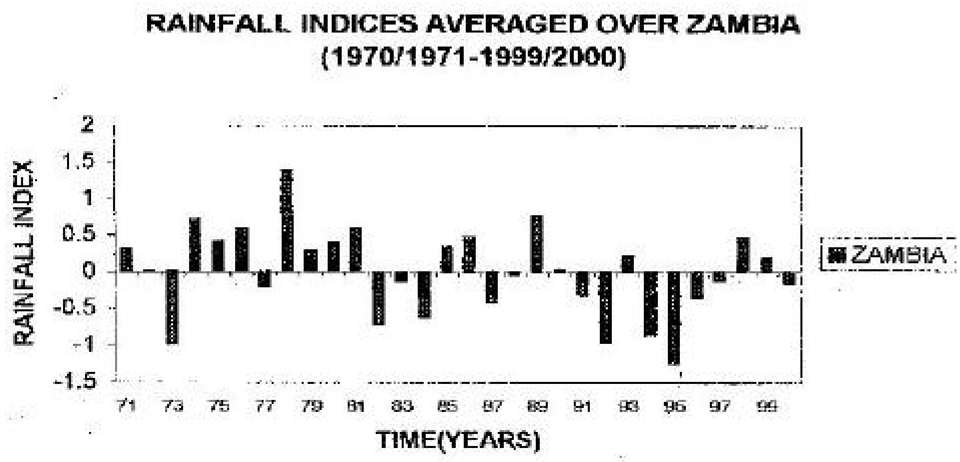

Figure 19.1. Rainfall indices averaged over Zambia 1970 to 2000

Figure 19.1 clearly shows that 1972/73, 1981/82, 1983/84, 1991/92, 1993/94, 1994/95 seasons have seen the most severe droughts, whilst 1973/74, 1977/78, 1980/81 and 1989/90 seasons stand out as very wet years. When considered over a longer time, it is found out that, in the recent past, the frequency of droughts has accelerated. Nkomoki (1998) reports a few severe droughts during the decade 1921 to 1930. During the two decades that followed, 1931 to 1950, dry years alternated with wet years, but on the whole the rainfall season was relatively good. Moderate to severe droughts were reported between 1930/31 and 1932/33 followed by the much talked about drought triggered famine of 1946/47. The 1967/68 season is said to have marked the beginning of a period of successive dry years across Africa, including Zambia and wet years have been rare. Since then severe droughts have been reported in 1981/82, 1983/84, the so called “drought of the century” of 1991/92, which also affected the whole of southern Africa, 1997/98 and 2001/02. The 1997/98 El Nino phenomenon had two effects over Zambia – excessive rains (floods) over the northern half of the country and drought over the southern half.

The effects of drought have included shortages of drinking water, food shortages, a high mortality rate of livestock and wild animals, reduced hydro-generated power and shortage of water transport. The urban poor are especially impacted as the cost of food rises, especially maize meal that is the staple food in Zambia. A variety of short-term coping strategies are employed to mitigate the effects of drought and these include eating honey, wild fruits and roots (GRZ, 1992). There are some wild fruits that are reported to be plentiful during drought years. Their abundance is not just an indicator of drought but provide a source of survival to the starving people. Other strategies include exchanging cattle and other animals with grain, selling or eating them, exploiting natural resources for sale (timber, wild fruits, fisheries, wildlife, etc). Household and other assets are also sold to raise money to purchase grain. Others from rural areas decide to shift temporarily to urban areas in search of livelihood.

On the part of government, importation of grain and distribution of relief food to severely affected households becomes its emergence response. At the same time, the government has tended to look at medium to long term strategies such as the introduction of drought resistance and quick maturing varieties of crops such as sorghum, millet, cassava, sweet potatoes to replace maize in some areas, introduction of goats and donkeys, provision of water through drilling of boreholes, wells and building of dams and irrigation canals. Other measures include the promotion of indigenous techniques such as crop rotation, green manuring and application of livestock manure; crop diversification to reduce the risk of crop failure under drought conditions; and the creation of markets for traditional cereals like sorghum, millet and root crops. Government policies stemming from the colonial era, which encouraged the growing of maize at the expense of traditional crops even in areas that are not well suited for the crop, are widely blamed for contributing greatly to Zambia's current vulnerability to crop failures. The 2001/02 drought, for instance, prompted the government to look at medium to long term strategies apart from the emergence response of providing food, water, medicines for people and livestock and farming inputs for the next season (Box 19.1).

3. Vulnerability and Adaptation

Both the country study and the initial national communication enabling activities project identified the most vulnerable sectors to be agriculture (crop farming and livestock raising), wildlife, forestry, water resources and the health sector. In this regard, the overall objectives of the GEF enabling activity were to identify possible technological improvements and practical adaptation measures designed to minimize the adverse effects of climate change. A number of climate change scenarios based on IPCC guidelines and General Circulation Models (GCMs), were used to evaluate how climate change affects human activities and natural systems, and to evaluate sensitivities, thresholds and vulnerabilities of natural systems. The results of the vulnerability assessment are analyzed in Table 19.1.

Box 19.1 Government Response to 2001/02 Drought

Size of Problem: Of the 74 districts in the country, 38 were severely affected by drought and flash floods. Some 2.9 million people were in need of food relief. Total maize production had fallen by more than half from the previous season giving a maize deficit of 635,000 metric tones. Government policy on genetically modified maize meant that most donors could not provide relief food. Besides food, water scarcity for human and livestock was a serious issue. With water sources drying up in some areas and people forced to use non-portable water for drinking, the threat of a breakout of disease epidemics was real. Most farmers lost their investment in failed crops and were left with no means to buy food or to cultivate for the next cropping season.

Government Response: The government, as in usual cases of drought, responded by declaring a state of disaster and appealed for food aid from donors. Upon realizing that most of the food being offered was genetically modified the government declined, citing scientific uncertainty on GMOs and that the country had no biotechnology and biosafety policy and legislation in place to deal with GMO safety matters. Applying the precautionary principle, the country would refrain from actions that might adversely affect human and animal health as well as the environment. The World Food Programme was requested to remove the 26,000 metric tones of GM maize that was already in district depots, ready for distribution.

The emergency measures included the provision of relief food, the facilitation of private sector maize imports, financing the purchase of strategic food reserves, supporting farmers to grow the next season crop, and providing extension support to mitigate the effects on livestock. These measures were included in a project proposal of the Emergency Drought Recovery Project (EDRP) to be funded by the World Bank. Apart from the short-term emergency measures, the government also requested assistance to enhance its capacity for longer term disaster management. The capacity building components included in the EDRP included strengthening the Zambia Meteorology Department in terms of equipment and instruments as well as of capacity for data analysis and forecasting; streamlining the organizational/institutional arrangements for early warning in the government; establishment of an emergency operations response centre at the Drought Mitigation and Management Unit; technical assistance to review and finalize government's disaster mitigation and management policy; and capacity building of monitoring, evaluation and coordination of safety nets.

Prior to approaching the World Bank for assistance, the government had hurriedly put together a Drought Mitigation Plan of October 2002, in which it articulated drought mitigation policies, strategies and interventions for short, medium and long-terms. In order to take care of activities that did not fit in the US $50 million EDRP, the government initiated an Agricultural Sector Development Programme which would support medium to long term measures such as the diversification of agriculture, increased access to inputs, encouragement of reliable and ecologically sustainable agriculture practices and a reduced dependence on livelihoods vulnerable to drought.

The government immediately gave incentives for irrigation so that maize could be available during the winter season. The market was assured at a favourable price. The government immediately started working on an Irrigation Policy to promote the use of the country's vast water resources for agriculture.

Zambia is highly vulnerable to climate change because of the high dependence of its economy and human livelihood on natural resources, and because of its high poverty levels. Increased unemployment has forced a lot of people to be engaged in informal sector activities (agriculture (semi-shifting cultivation), harvesting of trees for firewood and for charcoal, logging of timber, gathering of plant materials for various uses, illegal commercial hunting and unregulated fishing) as a coping strategy. But these activities, if unchecked as the case has been, result in the degradation of the natural resource base which further increases Zambia's vulnerability to climate change. For instance UNDP (2001) reports that the agricultural sector, which determines the overall economic performance of the country, is so vulnerable because of its dependence on weather conditions. The El Nino conditions of 1997 that washed away crops in the north due to heavy rains and caused crop failure and livestock deaths in the southern and western parts of the country, led to a 3.4% decline in the agricultural sector. Consequently, the overall growth rate of the economy was reduced to 3.5% despite remarkable growths in other sectors, namely, construction (33.8%), business services (12.4%), tourism (9.2%), manufacturing (7.4%) and electricity, gas and water (10.6%). Besides climatic factors, the agricultural sector is also vulnerable because of the prevalence of HIV/AIDS that has reduced the workforce in rural areas; the government's failure to maintain its input supply policy due to budgetary constraints; and the policy to grow maize all over the country, even in areas which are not well suited for its cultivation (IDA, 2002).

Table 19.1. Potential Impacts of Climate Change on Key Sectors in Zambia

SECTOR	POTENTIAL IMPACTS	THREATS TO HUMAN LIVELIHOODS
Forestry	- 50% of area under miombo woodlands replaced with other vegetation type - mopane, munga to predominate vegetation coverage in the country - total wooded areas in the country projected to decrease	- survival and livelihood patterns of people who depend on miombo threatened (less useful wood resources for energy and other provisions predominate)
Agriculture	- reduction of at least 60% in rain-fed maize yield in agro-ecological region I and 20% in region II. - increase in yield of sorghum in all regions (40% region I, 16% region II and 20% region III), no significant change with groundnuts - livestock sensitive to drought and excessive rainfall - reduced production of both natural and agriculture fisheries due to reduced nutrition levels in drought prone areas. - inundation of swamps and dambos into fisheries areas in wetter climate.	- affect the social well-being of people as a result of the reduction in maize, the main food crop (increased maize meal prices due to increased demand on inputs such as fertilizers). - increased food insecurity as change from growing maize to groundnuts which is a cash crop and reduction in animal draught power. - increased rural–urban migration in search of employment opportunities. - increased efforts in poor fisheries rendering hikes in fish prices. - depletion of fish stocks due to over fishing.
Wildlife	- reduced diversity and abundance of wildlife as result of poor quality fodder (drier climate). - wetland animals from abnormal inundation while bush animals thrive on abundant food (excessive rainfall)	- increased human pressure on remaining land for agriculture purposes and encroachment on protected areas. - reduction in tourism due to ecological stress on protected areas and reduction in animal populations and diversity.
Water	- southern province extremely vulnerable to drought	shortage of water for various uses including irrigation, livestock, etc
Health	- incidence, transmission and distribution of malaria reduced by high temperatures (20^0 – 25^0C) above mosquito survival rate	incidence of malaria continue to affect life expectance and productivity

The largest river basin in the country (and southern Africa), the Zambezi – an economic lifeline for the country – is also highly vulnerable to climate change. According to CEEZ (2002) major effects of climate change on the Zambezi River basin can occur through changes in the hydrological cycle, the balance of temperature, and rainfall. For example, the Zambezi has a low runoff efficiency and high dryness index, indicating a fairly high sensitivity to climate change. Such an occurrence will lead to reduced hydropower electricity generation, and shortage of water for all other uses.

The draft Initial National Communication for Zambia (MTENR, 2002) elaborates on the policy responses required to cope with the potential impacts of climate change. These include the following;

- ***Agriculture*** – development of drought-tolerant and early maturing crop varieties, crop diversification and improvement of crop management through information dissemination to farmers and construction of supporting infrastructure like dams for water storage in drought-prone areas of the country;
- ***Livestock*** - encouraging farmers to use crop residues of groundnuts, cotton, beans and urea molasses and minerals to supplement livestock during drought as well as sinking wells and boreholes at community level to boost water supply in vulnerable areas;
- ***Fisheries*** - promotion of fish farming and encouraging fish conservation;
- ***Forestry*** - promoting the use of alternative sources of energy in order to reduce pressure on natural forests;
- ***Water*** - improvement of water resources management through development and implementation of well-costed and phased integrated river basin management plans;
- ***Wildlife*** - culling of game to create conditions for wildlife sustainability; and,
- ***Health*** – creation of a malaria database for various components of a malaria programme. This database would form the basis for a surveillance system. Also, strengthening the program for malaria awareness.

A number of these adaptation measures have been recommended before in policy documents, strategies and studies. However, most of these recommendations were not based on climate change considerations but rather on other social, economic and environmental considerations. Implementation of most of the recommended measures has not been consistent. This shows that although adaptation options, including traditional coping strategies, are theoretically available, their implementation is hindered in practice by a number of factors. Simwanza and Maguswi (1999) found out that irrigation, for instance, was dominated by medium to large-scale schemes developed mainly through private commercial and parastatal initiatives. The main constraints towards the full development of irrigation facilities for small-scale irrigation include unclear government policy on support to irrigation development; lack of credit facilities to support investment into irrigation; low involvement of women; inadequate knowledge of water management and appropriate systems among farmers and extension staff; and a dependence syndrome created by top-down approaches.

4. The NAPA Process

Zambia has already had her NAPA proposal approved for funding by GEF, with UNDP as the implementing agency. The process of NAPA preparation has thus started.

Previous sections of this primer have clearly elaborated on the contents of the NAPA guidelines and attempted, to the extent possible, to address some of the misconceptions about the NAPA process. For Zambia, the fear that the NAPA process may duplicate the NC process is expressed. To some, the NAPA process will only add value to the NC by way of short-listing the adaptation measures already recommended by the NC. However, it is clear from the NAPA guidelines that the justification for the NAPA process is for the NAPA is to address the special circumstances of LDCs *viz* LDCs 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 the most. NAPAs are, therefore, conceived as vehicles through which the LDCs would communicate their urgent and immediate developmental needs in relation to the adverse effects of climate change.

In any given country, the NAPA process being what it is – bottom-up, country-driven, participatory, etc – makes it difficult to predict beforehand how the process would be carried out and what the outcome (projects) would be. However, based on the guidelines, it is possible to discuss what processes and policies would benefit the NAPA process given that the extent to which the NAPA is *integrated* and *mainstreamed* in the overall country development process is essential to the success of its implementation.

There is probably no better point of departure on the discussion of using NAPAs to mainstream and integrate climate change in the development process than starting by reviewing the NC process. One of the stated goals of the initial national communication enabling activities was to attain “enhanced capacity for decision makers to integrate climate change concerns into planning”. The modality for achieving this was through, first, constituting a national climate change steering committee, whose composition would include senior policy planners drawn from key economic sectors, and, second, undertaking training sessions on education and training on climate change for national development planners. The steering committee would be entrusted with the added responsibility of ensuring successful integration of study results into national development plans. However, the final evaluation of the GEF supported enabling activity on national communication carried out by UNEP (2001) found out that the above stated objective was not met. Several reasons may have attributed to this finding. Firstly, the steering committee was formed towards the end of the project (in 2000) and only met once before the end of the project. Clearly, the steering committee had no meaningful input into the process and did not appreciate climate change as an issue. As a result they were not able to buy in the recommendations on their sectors presented to them without having been involved in the process. Secondly, the training of planners was not adequate as it was conducted in a day’s workshop to an audience with little understanding of climate change. Thirdly, the initial national communication is seen as a document meant to fulfil reporting obligations under the Convention, rather than provide an opportunity to meet the needs of the country.. The process did not produce a “national action plan to mitigate and adapt to climate change” as was intended at the beginning. Although the initial communication will be considered by Cabinet for adoption, the strength of its recommendations would not carry the same weight as a national action plan which all stakeholders aspire to implement. For this reason there are no indications of follow-up activities on the initial communication.

5. Prospects of a Successful NAPA Process in Zambia

The NAPA guidelines issued by the COP, together with the annotation carried out by the LEG contain enough detail to guide the process of NAPA development taking into account specific circumstances of individual LDCs. However, taking into account the enabling activity and similar processes, there are a few points that need to be elaborated using the Zambian situation. These are linkages to other initiatives and integration/mainstreaming in the development plans.

Composition of National NAPA Team. The composition of the NAPA team should be given more thought as a way of ensuring stakeholder participation and, consequently, fostering ownership of the process. While it is true that the National Communication and other outputs of the country study would serve as a basis for any future work on climate change, it is also true that value addition on these documents can only be possible through the participation of a wide section of stakeholders. One of the weaknesses of the country study was that it did not mobilise wider participation especially at policy making and grass-roots level. Technical staff from a number of institutions did take part in the studies except in their individual capacities. The studies were seen more as a technical process although efforts were made towards the end to try and get non-technical stakeholders like policy makers to ‘buy in’ the process. However, this proved a little too late. Even in critical stages of the study such as in the vulnerability assessment there was no attempt to get the inputs of the most vulnerable sections of the society.

Given this background, the NAPA process should be used to add value to the country studies by adding stakeholder views to the technical results. The NAPA guidelines provide for this process by conducting "a participatory assessment of vulnerability to current climate variability and extreme weather events …". Therefore, this process should not be left to technical staff at the expense of others such as policy makers and representative of civil society, especially given that the NAPA process can also be used to develop an adaptation plan of action that elaborates time-bound measures that are going to be undertaken by the country, indicating which stakeholders will play which role. The output of such an important process can only be acceptable to all stakeholders if they fully participated in the process.

Linkage to Other Policies, Strategies, Programmes and Projects. There are some on-going initiatives by the government that offer some possibilities for achieving synergies between climate change adaptation and sustainable development. These are at various stages of implementation and are already 'owned' by key sectors that are vulnerable to climate variability and change. Table 19.2 presents some of these policies, strategies, programmes and projects that are relevant to the NAPA process.

A review of these on-going initiatives and their recommended measures shows that most of them are relevant to climate change and could pass the "adaptation sensitivity" test. However, it is also true that climate change was not directly one of the key considerations behind these recommended measures. Rather, the measures were recommended on the basis of other social, economic and environmental concerns. The NEAP, for instance, was greatly successful in bringing to the fore environmental concerns in each of the sectors of the Zambian economy. The sectors, in turn, attempted to integrate environmental concerns in their sector policies, strategies and programmes. Climate change, and indeed adaptation, however, was not a dominant theme in the NEAP.

The NAPA process could benefit greatly from such synergetic relationships with other initiatives. By allowing multi-disciplinary teams to raise vulnerability and adaptation concerns in their sectors, these considerations could be taken back to their sectors and prioritized.

Linking NAPA to National Development Planning. After several years of abandoning the 5-year national plans, the government has decided to go back to this system that will be complemented by other long-tem, medium term and operational plans (MFNP, 2002). The Vision 2025 which is under preparation will set the long term vision of Zambia. Next in the hierarchy are medium term strategic plans that include the Poverty Reduction Strategy Paper (PRSP), Provincial Strategic Plans, Public Investment Programme (PIP) and the Medium Term Expenditure Framework (MTEF). These will be synchronized to roll over every three years in view of their linkages. Then the Annual Budget and the PRSP Annual Operational Plans would be at the bottom.

Climate change activities, including adaptation measures, need to be considered at all levels including at the Vision 2025. In this way it will be possible to synchronise measures according to time frames in which they are required to be achieved. For instance, given the urgent and immediate nature of NAPA activities, they need to fit in the medium term framework (3-year rolling plans). It is a fact, however, that the first PRSP (2002-2004) was developed before the Transitional National Development Plan (TNDP) and Vision 2025. Since we are already in the last year of the first PRSP, it is an opportune time to ensure that the next cycle of PRSP integrates climate change issues. This could be easily done by using the NAPA process so that information generated during steps 2 to 7 of the NAPA process, described in part II of this primer, is allocated a planning period (immediate, medium-term and long-term) and accordingly fitted in the respective plans. Certainly, this will only be possible if representatives of the key sectors are fully involved in the NAPA process from its inception and assume ownership of adaptation measures regarding their sectors. Adaptation measures that are integrated in the PRSP are likely to be funded given that the government and its cooperating partners give priority to the implementation of poverty reduction programmes. The other advantage of aligning adaptation to this planning process is that adaptation measures that would have been integrated in the PRSP would have passed the ‘pro-poor’ test, therefore making them more relevant to the national objectives of “poverty reduction through sustained economic growth and employment creation”.

Table 19.2. Policies, Strategies, Programmes and Projects Relevant to the NAPA Process.

Title	Objectives
National Environmental Action Plan (NEAP), 1994	Provides an overview on Zambia’s environmental problems, existing legislation and Institutions, and strategy options for improving environmental quality. Environmental problems identified included Soil degradation, Deforestation, Water pollution & inadequate sanitation, Air pollution, Wildlife depletion.
National Environmental Policy (under preparation)	Provides environment and natural resources management policies to address current and future threats to environment and to human livelihoods and provides a policy guidelines for sustainable development
Forestry Policy, 1998	To ensure rational & sustainable management & utilisation of forest resources using a broad based & participating approach to ensure that all stakeholders are recognised & active. Main areas of concern are; resource management and development; resources allocation; capacity building; and, gender equality
Zambia Forest Action Plan (ZFAP), 1995	ZFAP aims at establishing a framework for strategic planning in forestry & entry point for raising awareness of issues related to the forest sector, preparing & updating the forest policy, preparing specific action programmes/projects & stimulating financial & political support to implement the initiations.
National Agricultural Policy, 1995	To facilitate and support the development of a sustainable and competitive agricultural sector that assures food security at national and households levels and maximizes the sector’s contribution to GNP. Sector policies and objectives include food security, contribution to industrial development, income and employment and sustaining the resource base
National Biodiversity strategy & Action plan, 1999	(i) Ensure the conservation of a full range of Zambia’s natural ecosystem through a network of protected areas; (ii) conservation of genetic diversity of Zambia’s crops & livestock; (iii) improve the legal & institutional framework & human resources to implement the strategies for conservation of sustainable use & equitable showing of the benefits from bio-diversity; (iv) sustainable use of & management of biological resources; (v) develop an appropriate legal & institutional framework & the needed human-resources to minimise the risks of the use of genetically modified organisms; and, (iv) ensure equitable sharing of benefits from the use of Zambia’s biological resources.
Zambia National Action Plan for combating desertification, 2002	To contribute to sustainable environmental management through the reduction/control of land degradation thereby contributing to poverty reduction, food self sufficiency, & ultimately contributing to economic

	growth. Its immediate objectives are: reduce the destruction of land resources in affected areas; promote sustainable use of land-resources; increase public awareness & information dissemination on matter of land degradation; provide a suitable policy & legislature framework for implementation of NAP; establish & support effective administration & coordination of NAP; introduce & improve assessment planning & monitoring systems for effective management of NAP; establish partnerships with multilateral & bilateral institutions in the management of arid areas.
National Energy Policy, 1994	Promoting optimum supply and utilization of energy, especially indigenous forms, to facilitate the socio-economic development of the country and maintenance of a safe and health environment. Specific policies include; reducing dependence on wood fuel; increasing accessibility and development of the most cost effective hydro-electricity power sites; improve efficiency in the importation and consumption of petroleum; promote the role of coal in meeting energy demands while minimizing the environmental impacts of coal mining and utilization; and, overcome the constraints preventing wider use of new and renewable sources of energy
Poverty Reduction Strategy Paper, 2002	Overall framework for national planning and interventions for development and poverty reduction. Identifies priority measures in each sector to be implemented in three years with the support of annual national budgets
National Water Policy, 1994	Promoting sustainable water resources development with a view to facilitate an equitable provision of adequate quantity and quality of water for all competing groups and users at acceptable costs and ensuring security of supply under varying conditions. Specific policies include; promote a holistic approach to water management; to manage water quality and maintain its fitness for use on a sustainable basis; and, increasing accessibility to safe drinking water and sanitation facilities for all people
National Policy on Wetlands Conservation, 2002	To promote the conservation and sustainable (wise) use of wetlands in order to sustain their ecological and socio-economic functions for the benefits of the present and future well being of the people of Zambia
National Health Strategic Plan, 2002-2005	To implement an integrated approach to health care giving priority, among others, to eradication of Malaria within the framework of Roll Back Malaria Initiative; control of TB; and, improved public health surveillance and control of epidemics
Disaster Management action Plan, 2000	(i) Creation & Ensuring an effective system of integrated development and disaster management at national, Provincial, District & Community levels including the active involvement of communities in the processes; (ii) Reduction of the loss of life & damage to natural resources and property by protecting vulnerable communities from human induced and natural disasters (iii) Strengthening & enhancing the technical & managerial capacities of all institutions involved emergency & disaster services by promoting institutional, public & individual awareness of disasters & their effects; (iv) Harnessing available expertise in different areas of disaster management into integrated structure necessary for disaster reduction; (iv) Enhancing their achievement & sustenance of national Consensus at all levels on disaster issues & strategies within the context of sustainable development, and (v) Slowing down the rate of disaster occurrences by preventing and mitigating adverse phenomena that are potentially disastrous.
Disaster Management and Mitigation Policy,	To promote a ‘safety culture’ for public protection against disasters through a pro-active, community-based, developmental and multi-sectoral approach that

2004 (draft)	combines disaster preparedness, prevention and mitigation, and integrates disaster management into national development.

6. Conclusion

As mentioned before, attempting to predict the outcome of a participatory process, such as the one set out in NAPA guidelines, is difficult. However, from the above discussions, it is possible to conclude by way of indicating what types of projects are likely to come out of a successful NAPA process. Some of the considerations leading to this conclusion would include:

- ***The most likely impacts of climate change.*** It seems from the country studies and from the IPCC reports that the most likely impact of climate change over Zambia would be stress on water resources. Climate variability studies have indicated that the incident of drought has become more frequent in recent years as a result of poor precipitation, high temperatures and excess evapo-transpiration, particularly in agro-ecological region I (southern parts of the country).

- ***The most vulnerable sector.*** Agriculture seems to be the most vulnerable sector mainly because of its dependence on rainfall. In addition, given that the majority of Zambians depend on subsistence agriculture, climate change is likely to increase the risks of crop failure and mortality of livestock. Also the sectors that depend directly on water resources (hydro-electricity, irrigation and fisheries) are likely to be affected by the likely impact of climate change.

- ***The most vulnerable communities.*** The most vulnerable communities are those who directly depend on vulnerable natural resources such as agriculture, fisheries and livestock, especially those in the most vulnerable agro-ecological region I. The poor, both in rural and urban areas, are likely to suffer more from effects of climate change.

Therefore, a participatory and transparent process would give priority to projects that would cushion the people from crop failures and livestock deaths, which are likely to be the most pronounced impacts on people's livelihoods. Since Zambia complies with the World Bank/IMF conditionalities of the HIPC Initiatives, projects that fit within the PRSP are the most likely to be implemented. These should have an impact on economic growth and poverty reduction. Further, adaptation projects which have already been prioritized by sectors through various processes (policy and strategic planning), but have not been implemented due to various barriers, are likely to be the most popular projects under the NAPA. In agriculture these would include those aiming at the diversification of agriculture, the promotion of irrigation and efficient use of water resources, the promotion of early maturing/drought resistance crops, sustainable management of the agricultural resource base and strengthening of early warning systems. The removal of barriers through such measures as institutional capacity building (in agriculture, meteorology, water resources management, research, etc) are also likely to find their ways into the NAPAs.

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Appendix 1

Introduction to GIS and Remote Sensing Application in NAPA

1. Introduction

Geographic information systems (GIS) and remote sensing (RS) technologies will play an indispensable role in environmental analysis in NAPA. Rapid assessments in NAPA will involve multiple stakeholders and disciplines, and will require good visualization and the ability to easily integrate various types of data to answer specific environment related questions. This ability is the forte of GIS. Over the past three decades, GIS and satellite-based RS have become a central part of international research agendas aimed at understanding global environmental change. In this context, GIS analysis involves combining spatially explicit information on the biological or physical (biophysical) attributes of the biosphere and earth's surface derived from space-based RS data, with social and other secondary data to aid environmental analysis, management, and policy. The true value of GIS for NAPA lies in the unique integration of GIS, RS (both data and image analysis), modeling, and technologies such as the global positioning system (GPS) that tell the location of earthly phenomena. So, what is GIS?

2. What is GIS?

GIS is a computer-based information system that is used to capture, store, manipulate or analyze, and display spatial information. GIS answers the basic question: what is where on the earth's surface? The main strength of GIS lies in its ability to integrate and analyze different types and sources of data that share a common geographical location, and display the outputs in novel, visually powerful ways. Components of a GIS include people who define the tasks of the GIS, accurate and reliable data, suitable computer and related hardware, the GIS software, and well-defined institutional procedures to produce reliable and reproducible results (Mitchell, 1999). GIS related hardware includes a digitizing board and optical scanners for converting paper maps into digital format, and printers for producing paper outputs. GIS analysis generally involves large volumes of data, and programs or algorithms that require considerable hard drive storage space, computational power, and speed, but is entirely possible on current personal computers. For the purposes of NAPA, there exist relatively inexpensive GIS software packages and a growing amount of freely available basic data that can form the basis of most applications.

3. GIS concepts

GIS is both a science and a tool (the software) in the service of geographic science. As a science or geographic information science (GIScience), it focuses on the challenges of capturing and representing real-life spatially explicit data in a computer environment, and their efficient processing, analysis and display. All life on earth is spatially constituted. Geographic science deals with themes of location, place, human/environmental interaction, movement, and regions. It studies spatial patterns on the planet and the processes that contribute to those patterns. The most basic geographic principle is that location matters. In other words, location is a variable that affects social and biophysical processes and outcomes. GIS and RS software developers combine insights from geographic science and computer science to implement GIScience through computer programs.

As a tool, GIS applies GIScience to solve spatially explicit real-life problems. Although GIS technology supports the science of geography, its foundation around the organizing principle of space has resulted in a mushrooming of applications in disparate disciplines and social sectors. For example, GIS is used in geography, cartography, the biological sciences, natural resource management, the physical sciences (e.g., archaeology, geology, geomorphology, and meteorology), epidemiology and public health, engineering, urban planning and utilities management, transportation, marketing, demography, sociology, anthropology, leisure studies, and other areas.

3.1 Spatial data representation in a GIS

GIS involves the representation of real-life phenomena spatially in digital format. Before embarking on a GIS project, several steps are generally followed (Zeiler, 1999). First, a decision is made, based on a clear understanding of the problem (reality), that GIS is the best analytical tool to meet a set of objectives. Second, a conceptual model is developed, often working back from the desired outcomes to intermediate ones, and required inputs. Third, the conceptual model is used to develop a logical (diagrammatic) model that is implementation-oriented. Finally, a physical model is developed within the GIS application itself, ready for implementation. GIS data traditionally consist of the geographic or geometric form of observed phenomena, and attribute information about them. In addition, behavior, or a set of rules that determine how objects behave, is being incorporated using object-oriented spatial data models (Mitchell, 1999). An example of this is the geodatabase model used in ArcGIS software (see Table 1). Spatial data are encoded in a GIS in one of two main data structures: raster and vector.

3.2 Raster and vector data structures

The vector format represents discrete features whose position on the earth's surface is stored as sequences of x, y (and sometimes elevation or z) coordinates on a map. The main vector geometric forms are points (x, y coordinates), representing point features such as a rain gauge location or town center; lines (collection of connected points), representing linear features such as roads and streams; and polygons representing area features such as a forest or country. Attribute data about the features are stored in tabular databases that are linked to the feature geometry in what is called a relational geo-database. In contrast, the raster format encodes spatial data as a continuous surface represented by a grid-based matrix or a collection of cells (pixels) arranged in rows and columns in a similar manner to a data spreadsheet.[3] Each cell contains a single value which represents both the attribute of the phenomenon of interest as well as its graphic appearance. Each cell represents a particular area on the earth's surface. The size of the cell determines the amount of detail in a raster image. Large cells (coarse resolution) show less detail than small (fine resolution) cells. Elevation, population density or soil fertility data are best represented in raster format, which includes all satellite data and scanned photos or images.

The choice of data structure depends on the objectives and nature of analysis. The vector format is good for analyzing spatial relationships among discrete objects, flows along a network, and applications that require big databases to store attribute data. The vector format produces

[3] Note that features can be represented in three dimensions by using a special form of presentation calling triangular irregular network, TIN, that is derived from elevation data.

visually pleasing maps. The raster format is applied in continuous spatial analysis such as suitability analysis and modeling, especially in environmental and natural resources management. It is more efficient for the high computation demands of continuous data analysis because it best fits the architecture of the computer. These data formats, however, can easily be converted, one to the other, using standard GIS operations. GIS data are organized in layers. Vector data layers often contain one geometric data form (points, arcs, or polygons) on a particular theme, such as major towns in a country, or land cover classes. Each raster image represents one data layer.

3.3 Scale and error considerations in spatial data representation and analysis

There is always error associated with the representation of real-world data in a digital GIS, and this error is propagated and compounded through GIS data processing and analyses. Integrating different data sources based on a shared location requires all the data to be geocoded. Geocoding involves "tying" phenomena to a particular location in space on the surface of the earth. There are two main components to geocoding. First, one picks a projection or one of various mathematical representations of a spherical earth on a planar surface. Second, one picks a grid coordinate system. The grid coordinate system is a grid system that uses Cartesian x,y points such as latitude and longitude to denote location. Grid coordinate systems have a starting point or location of reference for the entire projection, or for a more finely defined subset of the projection called a datum.[4] The process of geocoding involves mathematical models which are approximations and are therefore associated with location and measurement errors. GIS users must understand and provide an estimate the likely impact of such errors, and additional errors that they themselves introduce through decisions that they make during data collection and analysis, on the outcomes of their analysis. Additional errors can be introduced through the choice of scale of analysis, data structure, level of data integration, choice of software algorithms and assumptions that go with them.

Scale, here defined as the hierarchical level at which social or biophysical phenomena and processes are organized, has considerable impact on spatial data construction, representation, and analysis because observable phenomena and the precision of spatial data are scale-dependent (Turner *et al.,* 1989). Social and biophysical processes occur at multiple and often incongruent scales. Because of methodological difficulties in conducting multi-scalar analysis, GIS analysts select some "optimum" scale of analysis. This fixing of analytical scale requires data aggregation to that one scale, and invariably involves information loss and errors. It also fails to capture processes operating at other scales (Constanza et al., 2001). The important message here is that GIS users must be aware of data errors, their propagation through analysis, and their impacts on the outcomes, and always work to minimize error. If sharing GIS data or using secondary data sources, it is crucial that information about the data (or metadata), such as the data accuracy and reliability, genealogy, projection, datum, coordinate system, and other information is provided or known. This helps to determine the reliability of data and outputs generated from their use. Some GIS software programs (e.g. ArcGIS) now have tools for attaching and viewing metadata for GIS data layers.

3.4 Spatial data capture and sources of data for a GIS

What are the sources of data for a GIS? This question is important for the NAPA because one of the major problems limiting the use of GIS and RS in developing countries, and particularly LDCs, is the lack of spatial data. Where data is available, it is often incomplete, of low quality, and with partial or missing metadata. Available options for obtaining spatial data are to create

[4] Spatial data integration requires all the data layers to have the same projection, coordinate system and datum.

one's own data, or to use existing secondary data sources. In many cases, the creation of new data may demand considerable resources. For most countries, the basic spatial data needed to conduct GIS analyses that can enhance the quality and value of the NAPA document are already available in digital format at the national mapping, remote sensing, and natural resources management agencies. These will be the main sources of GIS data for NAPA analysis. More information that is not spatially explicit can then be added to the existing map data without having to create new data from scratch. However there are many cases where new data is needed, and must be created.

One way to create data is to trace over exiting maps. Since most existing spatial data in the developing world are in the form of paper maps, digitizing and optical scanning are major methods to get data into a GIS. Digitizing is a process for creating spatially explicit digital datasets that involves extracting information of interest from paper maps using a specialized digitizing table fitted with an optical digitizing device that is linked to digitizing programs in GIS/RS software. Scanned maps and other images, as well as existing digital spatial data can be used as the backdrop for on-screen (computer) digitizing to create new datasets. Digitizing and scanning are important for creating baseline data that can be used for conducting historical comparisons.

Another way for generating GIS data is to create a spreadsheet table containing variables about an object of interest or phenomenon in columns, and each occurrence of the phenomenon in rows. For each case of the phenomenon, the table must also contain location information in two columns; one for the x coordinate (e.g. longitude in degrees) and the other for the y coordinate (e.g. latitude in degrees). There is a basic procedure in most GIS programs for importing all the data into point locations on a map, based on the location information. This, however, assumes that you know the geographic coordinates of the phenomenon under study, either from maps, special surveys, or other source.

Recent development of the global positioning system, GPS, technology has greatly increased the ease of bringing data on various social and biophysical phenomena into a GIS. The GPS, a hand-held device which uses a set of satellites for determining the location of phenomena on the planet, has opened more opportunities for geocoding social and biophysical data, and extended the utility of both GIS and RS. Location data collected by a GPS can be entered into a computer directly (many GIS/RS software now support direct input of GPS data, even in real-time), or the x,y locational coordinates can first be entered into a table manually, and then brought into a GIS using basic procedures. An almost limitless amount of data on the attributes of the phenomenon can also be added to the tables by theme, each entered in a separate column. For instance, if a user collects information on the location of interviewees, possible themes(columns) in the attribute table are name of respondent, place name, date of birth, marital status, annual income, views on some topic, etc. The GPS is so easy to use that rural communities in a game management project in Botswana have used it to track and monitor the movement of endangered animal species, for analysis by experts.

Remote Sensing constitutes an indispensable source of current and historical spatial data for environmental analysis and management, and is of particular importance for NAPA. A positive development for GIS analysis is the growing availability of RS and other secondary spatial data from government mapping sources, research groups and institutions, development agencies and projects, and online data sources. Examples of subsidized or free data sources for Africa include the Miombo Network, SAFARI and the Kalahari networks (research groups under the International Geosphere – Biosphere Program, IGBP) for satellite data; the UN Food and Agricultural Organization (FAO) for forestry, agricultural and soil data, and land cover and climatic data from development programs such as the USAID-supported Famine Early Warning Systems (FEWS) in many African countries. Table 1 lists a selection of potential GIS/RS data sources for NAPA.

4. Remote sensing and NAPA: Introduction to remote sensing concepts

4.1 Definition and functions of remote sensing

Lillesand and Kiefer (1994:1) define remote sensing as the “science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.” Your ability to read this page is an example of the application of RS. The eyes act as sensors of the amount of light reflected from the light and dark patches of the page. The reflected light sensed by your eye creates impulses (data) that allow the mind (mental computer) to interpret the dark parts as a collection of letters, words and sentences, which then convey specific information and meaning. Space-based or aerial RS systems operate on the same principles, except that electromagnetic sensors located in the atmosphere or spaces replace the eye and computers replace the mind.

Advances in RS and GIS technology over the past three decades are among the most significant contribution to the study of environmental systems and management. RS technologies serve two purposes: 1) as a data collection system, and an essential source of data on land-based features for GIS analysis; and 2) as a data analysis system that uses RS software programs to provide information about the features to multiple users. Many environmental analysis models that are dependent on spatially explicit data cannot function without RS data (Estes, 1992).

Remote sensing data represent an archive of the historical record of the biophysical environment going back to the early 1970s for space-based RS, and back to World War II for air-based (photographic) RS. This time series of data allows longitudinal analysis. Space-based RS is particularly useful because it makes the collection of data on biophysical phenomena over large areas possible (including in remote and inaccessible areas), on a continuous basis, at more frequent intervals, and at lower cost without having to conduct costly ground surveys. The next section relates RS concepts to environmental assessment.

4.2 Electromagnetic energy and spatial characterization of biophysical phenomena

In RS systems electromagnetic sensors, such as an airborne camera and film, or satellite-based optical sensors, detect variations in the amount of electromagnetic radiation, EMR (mostly originating from the sun and traveling at the speed of light) that is reflected or emitted by different features on the earth’s surface. Unlike the human eye, these sensors can in addition detect invisible parts of the EMR spectrum. The data collection process ends with the generation of a pictorial or digital dataset. The basis for land cover characterization is the notion that different objects have unique reflection/emission patterns in different regions of the EMR, which create unique “spectral signatures.” RS analysts use this knowledge of spectral signatures and other reference data, with visual interpretation keys to analyze pictorial RS data (e.g. of aerial photographs). More commonly, analysts use specialized pattern-recognition computer algorithms and programs to analyze digital data and extract land cover characterization information from the digital images. This information is then made available to users in paper or digital maps and tables. It can then be integrated with other data layers of the same location in GIS analysis and modeling to provide new information.

There are different RS systems whose attributes determine the quality of data produced. The most important attributes are the spatial, spectral, temporal, and radiometric resolution of the RS data.[5] Spatial resolution refers to the minimum cell size of the area on the ground that can be detected instantaneously by the sensor. It determines the amount of detail in RS images. For instance, a 1 x 1 km spatial resolution of the Advanced Very High Resolution Radiometer (AVHRR) sensor carried on National Oceanic and Atmospheric Administration (NOAA) satellites provides coarse, reconnaissance-level data. All the land features within a 1 km square area on the ground are summarized into one reflectance signal and one digital value in the resulting image. Traditional land covers classification of AVHRR images summarize all the features with the 1-km pixel or cell into a single land cover type. Clearly, if the landscape being sensed is very varied, 1-km AVHRR data provide a very rough estimation of reality. The 250 x 250 m resolution Moderate Resolution Imaging Spectroradiometer (MODIS) sensor aboard the Terra and Aqua satellites provides intermediate level spatial resolution that provides 16 times more detail than 1-km AVHRR images. The Landsat Thematic and Enhanced Thematic Mapper (TM and ETM) sensors on the Landsat series of satellites provide data at 30 x 30 m (about 1037 times more detail than AVHRR data of the same area) and 10 x 10 m resolution. RS technology has advanced so much that there are some sensors that provide data with spatial resolutions of less than 1 m, which are not of much use except for the most detailed analysis covering small areas (e.g. precision agriculture or espionage). IKONOS satellite data is an example of such ultra-high spatial resolution satellite data.

Spectral resolution refers to the number, breadth and type of spectral bands, or region of the EMR spectrum, which the sensor detects. Thus 5-band NOAA AVHRR data have lower spectral detail than 8-band Landsat ETM^+ data, which in turn have lower spectral detail than data from hyperspectral aerial sensors that can be sensitive in over 100 spectral bands. Some bands are more suited to detecting certain phenomena than others, and so the distribution of these bands within the EMR spectrum can be as important as the number of bands. The frequency at which data for one location is collected is called the temporal frequency of the sensing system. For instance, although the NOAA AVHRR has lower spatial and spectral resolution than the Landsat ETM^+ sensor, it has a temporal resolution (twice daily) that is 32 times higher than Landsat ETM^+ (16-day cycle). The high temporal resolution of AVHRR data makes it possible to track near-daily changes in crop condition, and makes the data essential for various Famine Early Warning Systems (FEWS) monitoring programs in Africa, as well as for meteorological applications. Radiometric resolution refers to the number of possible levels or precision for recording digital data (digital numbers). For instance 8-bit data contains 256 or 2^8 levels (0-255), while 6-bit data contains 128 (0-127) possible levels. Most RS data are made available in 8-bit form. The most important point to note from the foregoing is that the choice of a particular sensor and data type depends on the objectives of analysis, nature of the phenomenon under study, and available resources. It often involves tradeoffs among these attributes. Large data volumes and high processing costs limit hyper-fine grained data to the most detailed analyses covering small areas, whereas higher resolution data and corresponding lower processing costs suit larger areas. Table 1 includes selected sources of RS data that are relevant to NAPA.

[5] For further reading on remote sensing and image interpretation, see Jensen, 1996 and 2000; Liverman *et al*., 1998; Atkinson and Tate, 1999; Lillesand and Keifer, 1994 or 1999; Lunetta and Elvidge, 1999; Avery and Berlin (2002).

4.3 Environmental remote sensing and land cover change detection

Visual interpretation of aerial photographs to characterize and map land features is well established, and dates back to the Second World War. The use of high resolution satellite imagery, however, is relatively new. Several African countries, including Malawi, Mozambique and Zimbabwe, have produced national-level land cover maps for the early 1990s based on visual interpretation of satellite imagery (Landsat and SPOT imagery). Although visual interpretation is believed to produce higher classification accuracy for dryland and patchy landscapes than computer-automated digital methods, visual interpretation is time-consuming, over-dependent on the knowledge and skills of interpreters, and may leave out potentially useful information for other analyses. Depending on needs, the full value of RS can be realized from computer-based digital land cover characterization using existing techniques (Jensen, 1996, 2000).

In traditional digital land cover characterization the analyst provides reference data to the RS computer program in order to “train” the software to recognize the “spectral signatures” of certain land features, and to assign each pixel in the input image to one of pre-defined land cover classes (e.g. forest, grassland, bare soil, and water) in the output image. This is termed supervised classification. Alternatively, the computer can use clustering statistical procedures to produce “classes” that are then labeled with real-life classes after-the-fact, using reference information. This is termed unsupervised classification.[6] Both methods require verification to determine the accuracy of the land cover classification. In addition, a time series of classification outputs can be used to detect land cover change between consecutive image pairs (see Jensen, 1996; Lunetta & Elvidge, 1999).

Recent advances in Geospatial Technologies provide various techniques that allow the analyst to look beyond the individual pixel to area and pattern characteristics that provide landscape-level information.[7] The simplest of these involve measures denoting the degree of landscape fragmentation, such as number, density, and mean size of forest patches, and perimeter/area ratio. Another development is the use of radar (radio detection and ranging) techniques involving sensors that operate in the longwave (1 mm to 1m wavelengths) or microwave regions of the EMR spectrum. Airborne radar systems provide a different landscape “view” of environmental phenomena compared to one obtained from sensors that are sensitive in the visible parts of the spectrum. Radar systems have the unique advantage of being able to penetrate cloud cover, a constant problem for RS application in the tropics. The data analysis outputs of RS are typically maps and tabular data that can be used in GIS analysis and modeling to link RS-derived variables to social and biophysical processes.

5. Spatial analysis with GIS in NAPA

Spatial characterization in NAPA can use the main functionalities of GIS, which are often expressed as the four M’s of GIS: measurement, mapping, monitoring, and modeling. One basic function of GIS is measuring both geometric and attributes data, such as distances and areas (e.g.,

[6] Since land cover classes are user defined, classification products are often not comparable. This also makes data integration problematic. However, there are now efforts to produce internationally standard classifications systems. One such system, including the software for implementing it, has been produced by the Food and Agriculture Organization of the United Nations (FAO, 2000). Simpler classification schemes have been developed for the USA (e.g. Anderson *et al*., 1992).

[7] Other advances include techniques for sub-pixel classification of images. Instead of being limited to the pixel as the minimum spatial unit and assigning the whole pixel to one land cover class, these techniques extract more information by estimating the proportion of each pixel belonging to each pre-determined land cover class.

hectares of forest cover), spatial pattern (e.g. landscape fragmentation metrics), biomass, carbon content, or population densities. Maps are the "principal transmitter of geographic knowledge for a geographic information system" (Zeiler, 1999:23). In addition, graphical display of information on the screen to show their spatial relationships is one of the most basic GIS operations. However, the immense visual appeal of GIS products often leads to a mischaracterization of GIS as only a mapping tool, and overshadows even more powerful spatial analysis and modeling functions.

There are many GIS operations. A small sampling includes data editing and transformations, determining spatial relationships (e.g. adjacency, containment, traverses), and combining various spatial data layers of the same location in overlay operations. Overlay analysis is particularly useful for conducting spatial analyses, such as land suitability analysis (e.g. for agriculture, a specific crop, or for other enterprises), hazard and vulnerability analysis to determine areas and human populations that are at risk from some natural or anthropogenic hazard. A practical example of the use of GIS is the agro-ecological zones (AEZ) program. In this program, the United Nations Food and Agriculture Organization, FAO, seeks to determine land suitability and potential agricultural productivity in general and for specific crops at the global and national levels. Such analyses help to establish baseline conditions for livelihoods and more complex uses of land. Yet, as mentioned earlier, it is the combination of GIS and RS that holds the most promise for NAPA and the global climate change science community.

Modeling with GIS

Spatial analysis with GIS ranges from basic overlay operations to spatial modeling. Modeling can involve intermediate-scale models involving predictions and what-if scenarios over small areas and sets of parameters, or it can involve complex dynamic models of land, sea and air-based processes nested into regional or Global Circulation Models (GCMs) for predicting carbon flows and global warming. GIS and RS data and techniques allow these models to integrate social and biophysical variables, and produce outcomes that are spatially explicit. At the lower end of complexity, spatial statistical (regression) models have been used to predict the probability of the spatial occurrence of deforestation based on combinations of satellite RS data; physiographic data such as soils, rainfall, elevation, and physical accessibility; market forces based on proximity to roads and towns, use of technology, and commodity prices; and social and demographic factors, such as population density, growth, migration rates, and labor availability. Probabilities of the occurrence of deforestation are produced and displayed in a GIS. These probabilities can be used to predict areas with a high risk of being cleared based on past deforestation trends, and can guide the prioritization of interventions. Spatial statistical regression models also yield statistics that indicate the relative importance of social and biophysical processes that cause deforestation. What-if-scenarios can be used to project, for instance, the environmental or forest cover impacts of building a new road. (Mertens and his colleagues (2000) have used spatial statistical models to combine household survey and remotely-sensed data in analyses of the impact of macroeconomic change on deforestation in south Cameroon.

At the higher end of complexity, GIS is linked to spatially explicit climate change molds that produce scenarios of climate change under various conditions. International scientists present such scenarios to the Intergovernmental Panel on Climate Chance, IPCC, which presents the information to national policy makers (see the website http://ipcc-ddc.cru.uea.ac.uk). One of the major challenges for NAPAs is to downscale the outputs of GCMs to make them nationally relevant. Although the teams preparing NAPAs may not be able to conduct such analyses, special projects can be designed tapping the pool of scientists and researchers in each country. At the absolute minimum, NAPA teams should be aware of the existence of regional climate change scenarios and reach informed conclusions of what these may mean for their own countries.

GIS and remote sensing software

The choice of GIS and RS software depends on a balancing of analytical needs with available resources. There is a wide and growing range of geospatial software on the market. GIS/RS software range in complexity from basic programs such as map viewers to sophisticated industrial standard ones, such as Arc/Info and Erdas Imagine. GIS software prices range from freely available software shared on the Internet, such as Multispec, to low-cost software programs (e.g. Idrisi for Windows at about $500, ArcView or ArcGIS/ArcView at around $1,500), to middle-range software in the region of $3,500 to $7,500 (e.g. Erdas Imagine, Envi, ER Mapper, TNTmips), to high-end software in excess of $10,000 (e.g. Arc/Info). Universities and students can usually get special discounts. For most purposes, many users in developing countries use Idrisi software or ArcView/ArcGIS. The trend in recent years has been toward the integration of GIS and RS (raster and vector) capabilities, mostly through an expandable modular approach to software design. A selection of common software programs is shown in Table 2. Analytical considerations in the choice of software may include whether the user seeks a cartographic or mapping tool, GIS analysis, image processing, or a combination of these. Resource considerations include financial resources, technical capabilities of users, hardware requirements (e.g. whether a stand-alone or server installation, printers, plotters, scanners, or even digitizing tablets). The quality of software documentation and technical support are also important considerations for picking software, and other preferences. In many cases, NAPA teams can use existing GIS/RS resources within state agencies and universities.

6. Case Studies –Mozambique, Malawi, Samoa

6.1 Flood Risk Analysis and Zoning in Mozambique and Samoa

GIS can play an important role in producing quick and inexpensive analyses of flood risk for use in the NAPA documentation. This information is essential for planning adaptation measures to climate change or extreme weather events that can cause flooding, and for responding to such events once they have happened. For instance, one characterization of flood risk zones in Mozambique is based on elevation and distance from major rivers as follows:

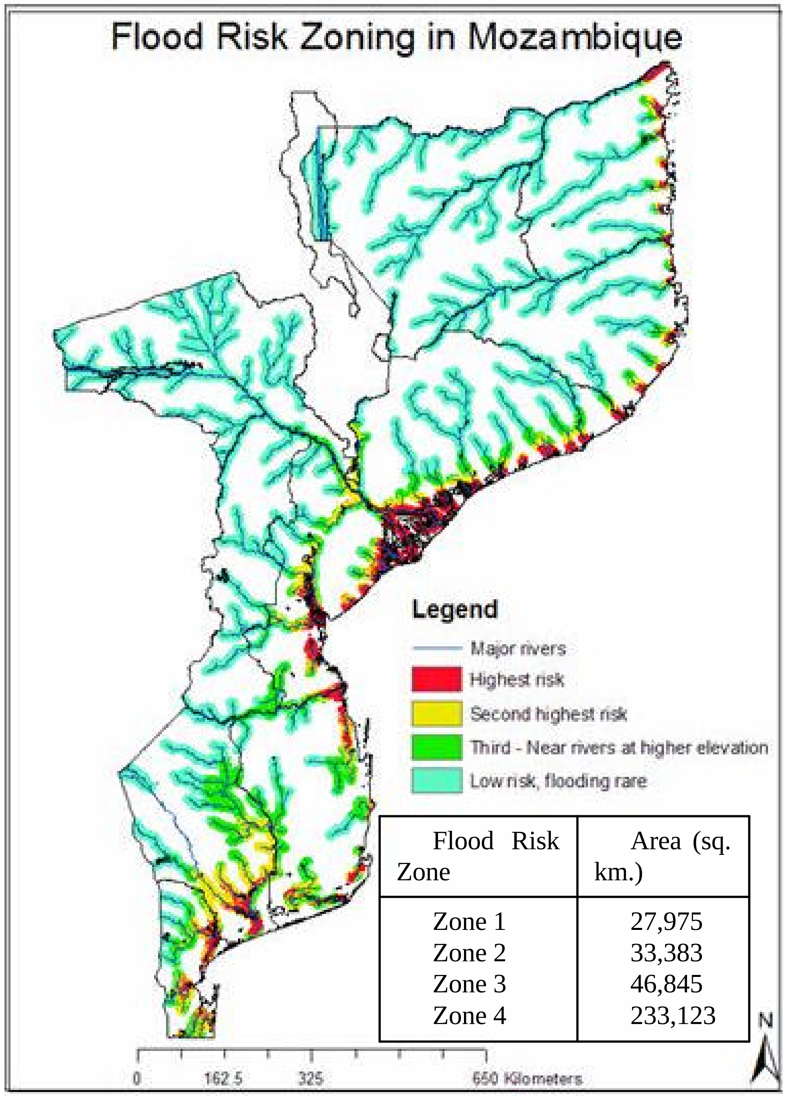
1. Risk Level 1 (highest): areas with an elevation of less than 20 meters above sea level (masl) and lying within a 10 km strip from major rivers.
2. Risk Level 2 (second highest): areas lying within an elevation range of 20 to 50 masl, and 10 km from major rivers.
3. Risk Level 3 (third highest): areas lying within an elevation range of 50 and 100 masl, and 10 km from major rivers.
4. Risk Level 4 (lowest risk): areas lying near rivers (10 km), but at high elevation (> 100 masl) and. These areas are low risk areas that are not prone to drought and would only be affected if there was regional flooding or in the event of a dam bursting.

These conditions for risk assessment for Mozambique were combined with existing map data in a GIS to produce spatially explicit flood risk zones on a map and area statistics for each zone. In this case only two types of map information (layers) were needed:

- ***A map showing elevation*** – in this case extracted from a 1 km resolution digital elevation model for the whole of Africa, but many countries have more detailed elevation data; and
- ***A map showing major rivers*** - also from a regional map, but more detailed maps are available from national survey and mapping agencies, e.g. CENACARTA in Maputo, Mozambique.

First standard GIS procedures were used to produce a buffer area 10 km on either side of major rivers. The elevation map layer was then also classified into the four elevation classes as defined above. Finally the two maps were digitally overlaid one on top of the other, and the areas that met both elevation and distance zone conditions define the flood risk zones (see map in Figure A1). The GIS was also used to calculate the amount of land that that would be affected by flood in each flood zone. Figure A2 shows people at risk from flooding in the lower Zambezi, as used during the Mozambique 2001 floods.

Having determined the flood risk zones, GIS can be used with additional map data layers to obtain more information about them. For instances, maps showing land cover can be overlaid on the zones in order to obtain information on what land cover types fall within each zone, and how big they are. This is one way to determine the spatial extent to which agricultural land or residential areas would be affected. If information on population or agricultural productivity is available for this area, then loss in agricultural productivity and the number of people likely to be affected can be calculated. From such estimates food aid requirements can be estimated. This analysis can further be refined to determine exactly who would be affected, and based on wealth levels and physical infrastructure, the ability of specific populations to respond to the impacts of (i.e. their vulnerability to) climate change or freak flood events can be determined spatially. Other information that can be included in a GIS to improve the analysis of vulnerability of populations to climate change includes physical accessibility of areas by roads; production systems for livestock, crops, and fish, market price changes for food over time, and incomes. The limit of such an exercise is finally determined by the analytical objectives and amount of suitable data available.



Flood Risk Zone	Area (sq. km.)
Zone 1	27,975
Zone 2	33,383
Zone 3	46,845
Zone 4	233,123

Figure A1. Flood risk zoning for Mozambique.

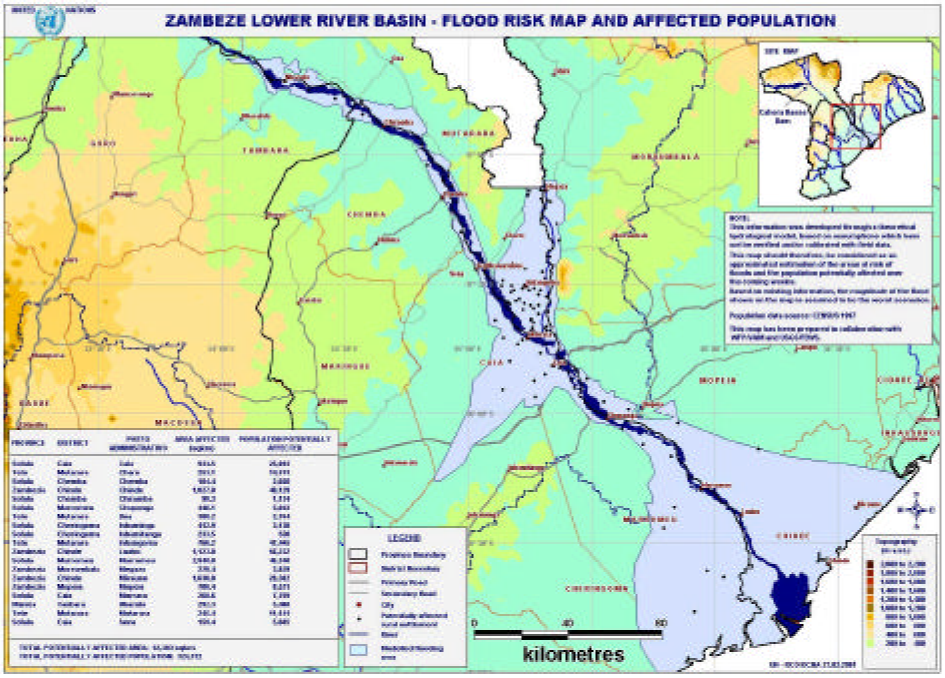


Figure A2. Map of the Lower Zambezi showing number of people at risk from flooding (from www.reliefweb.int).

Similarly, other types of risk can be analyzed. For instance risk to drought can be determined from annual temperatures in relation to long term temperature range for the area. Remote sensing analysts have developed predictive measures for drought based on a time-series of satellite data measuring the amount of green vegetation in months proceeding the rainy season. Such a time-series of satellite data has been used to develop average data for an area for both drought and non-drought years. The remotely sensed data for each year are then compared to these standards. The USAID FEWS programs in many developing countries apply similar techniques. Related research over the southern Africa region suggests that geospatial analysis of NOAA AVHRR data can be used to predict the occurrence and severity of El-Nino/Southern Oscillation (ENSO) events that bring drought to the region. Such analyses can project long-term recovery.

GIS are ideal for assessing coastal areas and the risk of erosion and flooding. There are many examples of how this has been done for many countries and in particular islands. Figures A3 and A4 show flood risk in Apia, Samoa.

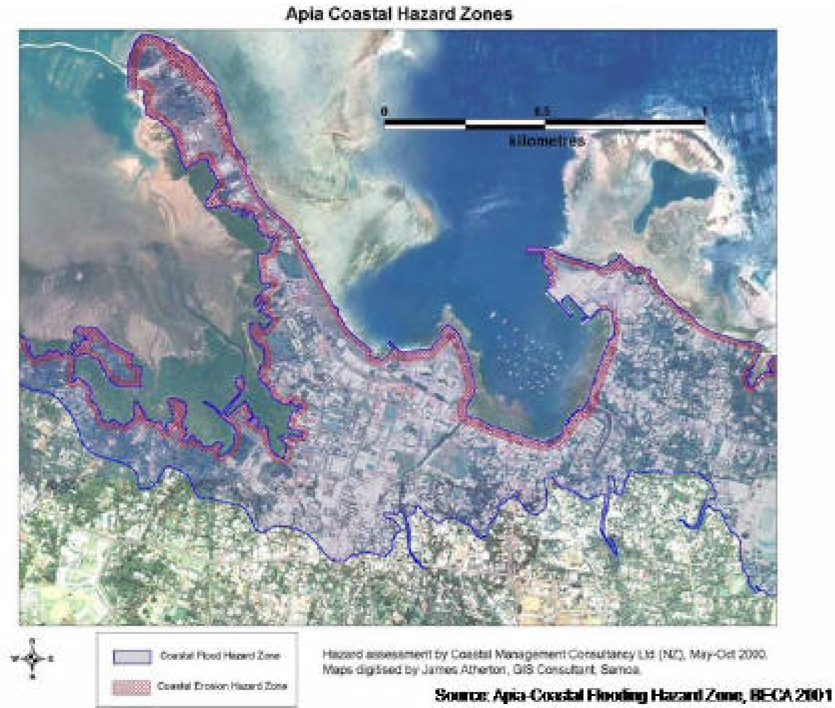


Figure.A3. Apia, Samoa coastal hazard zones

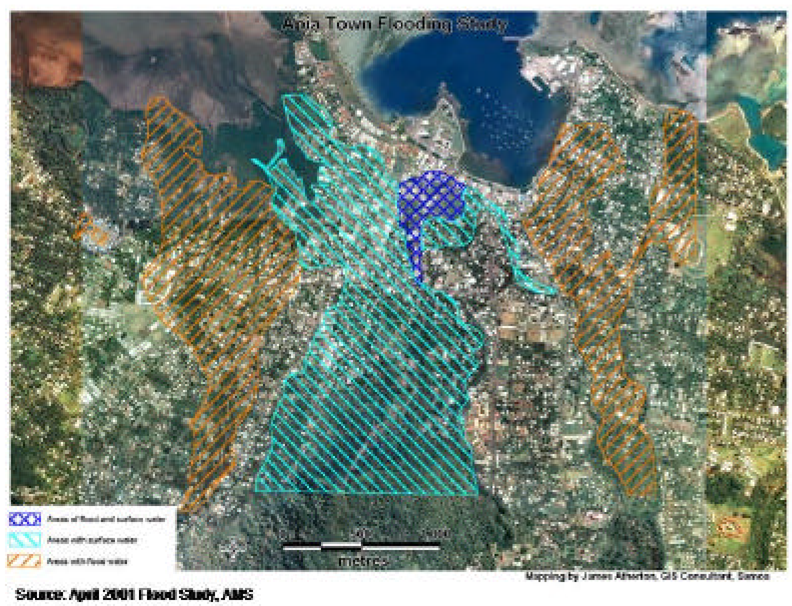


Figure A4. Apia (Samoa) Town flooding study carried out in 2001

6.2 Rapid vulnerability and risk assessment after the 2000 floods in Mozambique.

In early 2000, Mozambique experienced the worst flooding event in over 100 years when the Limpopo River burst its banks. The floods devastated the country through infrastructural, property, and crop damage, as well as considerable loss of life. GIS/RS technologies played an important role in meeting the considerable demand for information to determine the extent of the flooding, its impacts, and to plan mitigation measures. The specific goals of analysis for GIS/RS application were to provide data on the spatial extent of flooding, identify and quantify affected and vulnerable communities, assess the risk of disease spread, assess the extent of crop damage and its spatial location, and infrastructural damage to roads, railways, and telecommunications. Basic spatial data input layers were social and demographic data from the latest census, satellite RS data (Landat ETM$^+$ and radar), land use, elevation (digital elevation model), administrative boundaries, locations of main towns roads, railways, rivers, and communications installations.

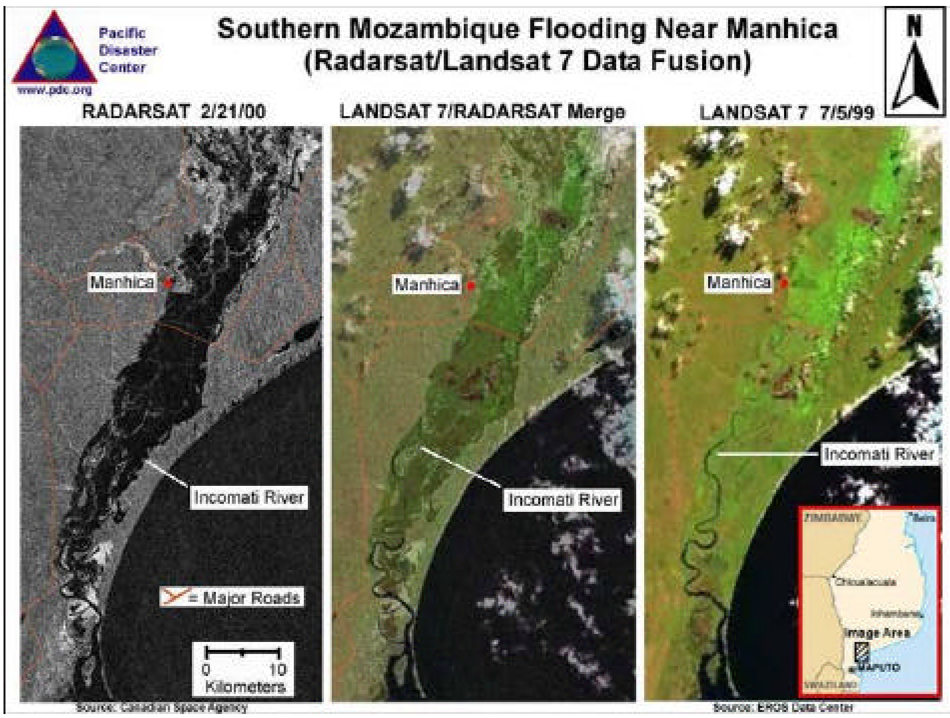


Figure A5. An example of the fusion of Landsat 7 and Radarsat data for flood monitoring in southern Mozambique

Basic GIS analysis provided essential visualization and mapping outputs for multiple stakeholder dialogue and communication. Producing some of the GIS outputs required creativity. For instance Landsat ETM$^+$ satellite data were combined with radar data to take advantage of the cloud penetrating properties of radar and the high spatial and spectral resolution of ETM$^+$, in order to produce a map showing water and dry areas for the affected region before the floods and at the peak of the floods (Figure A5). Analysis involved a simple overlay of the before-and-after maps to produce a map showing the flooded area and its area in hectares. Similar overlays of the flooded areas with the land use maps produced maps and area statistics of agricultural areas affected. Further refinement against reference crop data and field observations would produce quantitative estimates of crop damage, especially the staple maize crop. Other data overlays produced information on flooded towns, estimates of number of people (by age, gender, and socio-economic status) affected, flooded or damaged roads, blocked tributary rivers with potential to flood, and areas at risk of water-borne diseases were identified. This information was provided to task forces and aid agencies to direct immediate relief operations, such as temporary housing requirements, amount of food aid, medicines required, and other basic requirements. The information also included accessibility considerations for rescue operations and deliveries of supplies. The information generated has created a baseline for long-term planning of prevention and mitigation efforts, such as agriculture input support, and extended food requirements. For the large volumes of information indispensable for flood relief operations and planning provided by GIS/RS analysis, the analyses themselves involved basic GIS/RS operations. This example clearly demonstrates that the value of geospatial technologies for planning adaptation to climate change cannot be overemphasized.

Given time, this analysis could be extended in complexity and spatial extent. For instance water catchments area based spatial modeling that combining elevation, rainfall, water volume, and other data can be used to project the rise in water level and the areas that would be affected. Economic and biophysical impacts of different flooding scenarios could be projected. Basin-level models can be tied into regional climatic and other models to model regional causes and impacts. Geospatial technologies can also play an important role in studies on landscape or ecosystem recovery from flooding and impact on agriculture. The aim of these examples is to show that there is room for the use of geospatial technologies and analysis at the most basic level and obtain very useful information for NAPA documentation, or to conduct more complex, and perhaps project based analyses that can provide specific information.

6.3 Example of a Double Exposure: Droughts and Flood in Malawi

Drought Risk Zones

There are many ways to estimate drought risk. For purposes of demonstration, we use the ratio of precipitation to potential evapotranspiration. These data were extracted from an agroclimatic zones map of Malawi produced by the Land Resources Evaluation Project of the Government of Malawi. Based on these data, the country can be divided into three drought risk zones:

1. Zone 1: High drought risk, low precipitation in relation to evapotranspiration.
2. Zone 2: Medium drought risk.
3. Zone 3: Low drought risk - high precipitation in relation to evapotranspiration; can be affected during severe regional drought.

Flood Risk Zones

Although it is possible to conduct detailed studies of flood zones for the country, existing data can also be used to produce quick and reasonable results that can go into the NAPA document. In this case we use an elevation map of Malawi (derived from a 1km resolution digital elevation model obtained from the United States Geological Survey) and a map showing major streams. High risk flooding areas are those areas that are at low elevation and close to rivers. By way of illustration, three flood hazard zones have been demarcated:

1. Zone 1: High flood risk – elevation <1500m, and 10km from major rivers.
2. Zone 2: Medium flood risk – elevation 1500m – 2500m, and 10km from major streams.

3. Zone 3: Low flood risk – near rivers (10 km) but at high elevation > 2500 m. This zone is unlikely to flood except in major regional floods.

Areas outside these three flood zones are at minimal risk from floods.

Combined flood and risk zones (Figure A7-A11)

Using standard GIS procedures, it is possible to assess the combined risk of floods and drought; the major climate related risks to the Malawi population (see Figure A6 for a flow chart of logical steps). In this case the combined risk zones were determined as follows:

Zone 1: High flood/high drought, high flood/medium drought, high drought/medium flood risks.
Zone 2: Medium flood and drought risk.
Zone 3: Low flood/low drought, medium flood/low drought, medium drought/low flood risks.

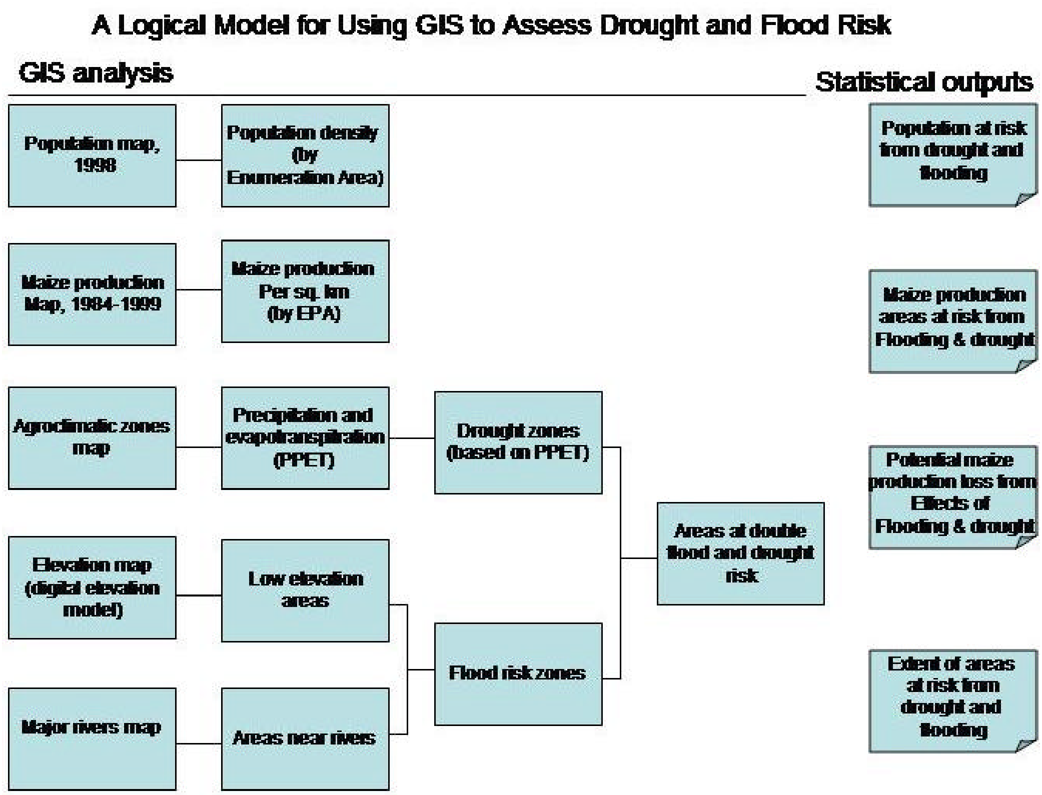


Figure A6. Logical model for using GIS to assess combined drought and flood risk

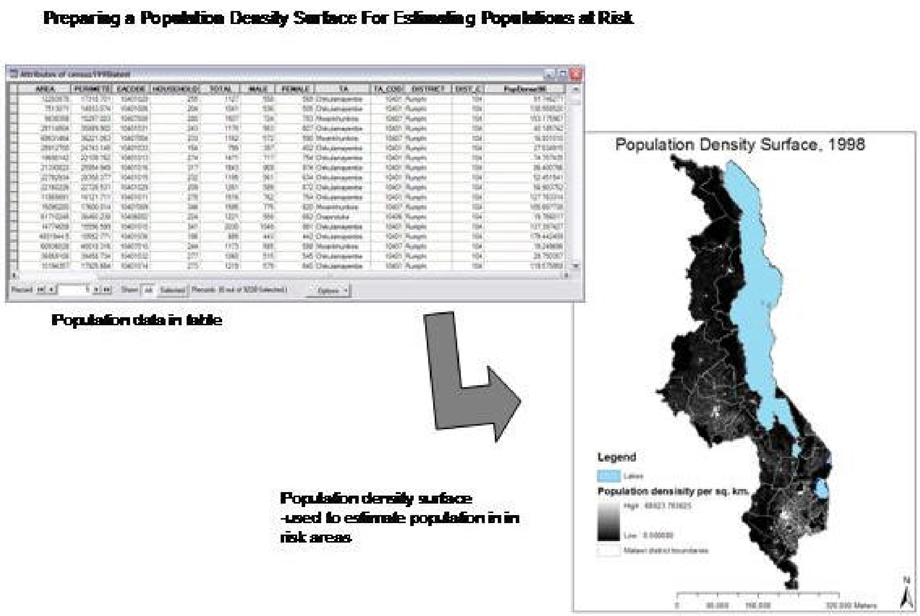


Figure A7. Preparing a Population Density Surface for Estimating Populations at Risk

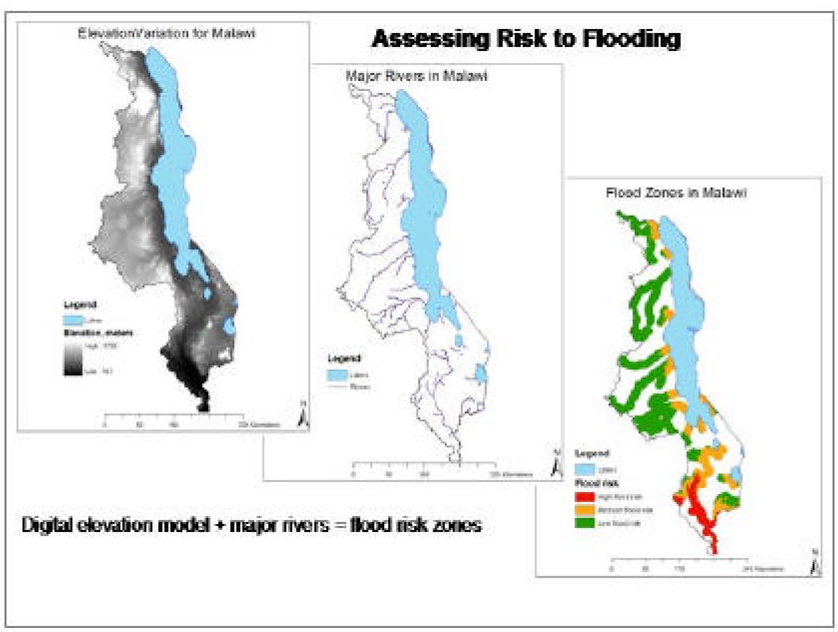


Figure A8. Assessing risk to floods

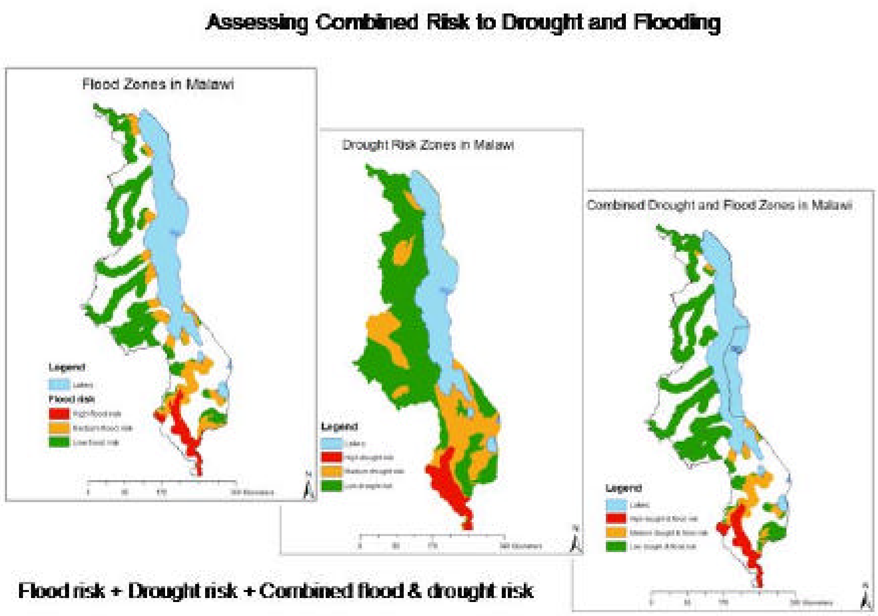


Figure.A9. Assessing Combined Risk to Drought and Flooding

Table A1. Distribution of land by areas of risk to drought and flooding

	Flood Risk Zones		**Drought Risk Zones**		**Combined flood and drought**	
Risk level	Area (ha)	Percent of land	Area (ha)	Percent of land	Area (ha)	Percent of land
High risk	491,639	5.2	734,181	7.8	525,069	5.6
Medium risk	1,669,482	17.8	2,664,631	28.3	1,094,346	11.6
Low risk	3,041,588	32.4	5,898,662	62.8	3,605,003	38.4
*Other areas	4,197,291	45	102,526	1	4,175,581	44
Total	9,400,000	100	9,400,000	100	9,400,000	100

*Other areas are those areas that have almost no risk based on the criteria used, and would be affected only if droughts and floods were so severe and regional in impact.

Maize Production Zones

A time series of annual maize production data for each Extension Planning Area, EPA (a sub-district agricultural administrative area) was used to determine low, medium and high maize production zones. The data covering 16 years from 1984 to 1999 were averaged, and then standardized by dividing the production by the area of the EPA. The zones are as follows:

Zone 1: High maize production zone, 12.6 – 72.3 tons/km^2 (25% of EPAs)
Zone 2: Medium maize production zone, 3.0 – 12.6 tons/km^2 (50% of EPAs)
Zone 3: Low maize production zone, 0 – 3.0 tons/km^2 (25% of EPAs)
Zone 4: National parks, game reserves, water bodies with no maize cultivation

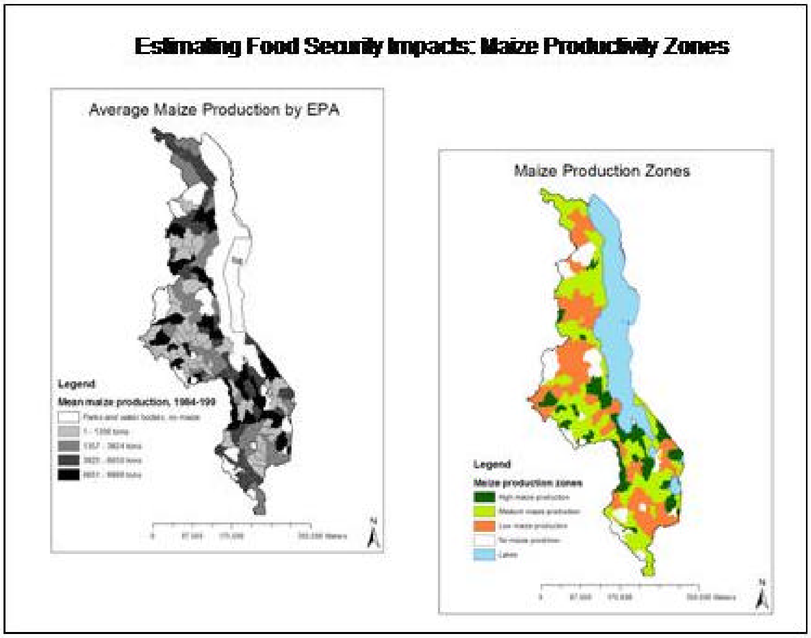


Figure A10. Estimating Food Security Impacts: Maize Productivity Zones

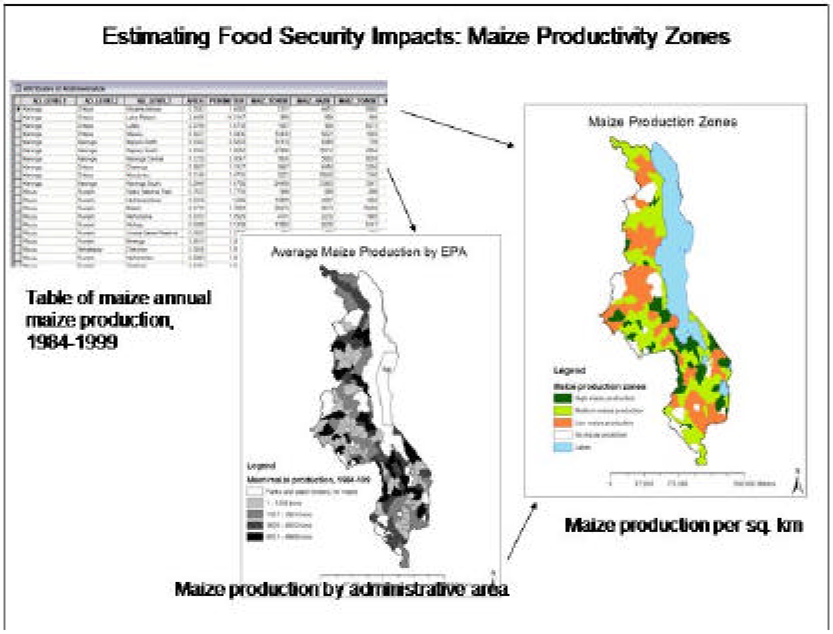


Figure A11. Assessing Estimating Food Security Impacts: Maize Productivity Zones

7. Discussion

Although GIS/RS clearly add value to environmental monitoring and analysis over alternative data collection and analysis systems, it is important to be aware of the technical limitations of the technology and constraints that limit its application in the socio-economic and biophysical context of Africa. This chapter has emphasized advantages in the provision of unique environmental data, improved efficiency in data collection and analysis in terms of time and cost savings while covering larger and inaccessible areas, the availability of RS data archives for longitudinal analysis, the visual power of GIS presentation, and the unique ability of GIS to integrate various social and biophysical data layers seamlessly to answer specific research and management questions. Recent advances in computer technology, such as faster, more powerful, but less costly computers able to handle enormous data volumes; global positioning systems technology; GIS and image analysis software and techniques; and the advent of the World Wide Web, have increasing the accessibility of GIS/RS technology and its products. These developments and the spatial constitution earthly phenomena and human life, have led to a mushrooming of its applications, and expansion into the public policy arena in the 1990s. The chapter has also emphasized the need for GIS/RS to be problem, rather than technology-driven.

Conceptual limitations of RS derive mostly from the use of the pixel as the unit of representation for geographic data that is continuous in nature, and errors resulting from this shortcoming (Fisher, 1997). The pixel model and traditional RS that assigns the whole pixel to one cover class fails to adequately capture the imprecise or fuzzy boundaries between land cover types and the mixed nature of land cover. Techniques for handling the problem, including sub-pixel classification, remain experimental. The pixel model also limits the type of data that can be captured by RS to biophysical data, and a sub-set of social data, whereas much social-cultural information is underrepresented. This limits the types of questions that can be answered by GIS analysis. Errors introduced by the representation limitations, are propagated by the user during data collection and analysis. These errors are rarely reported with GIS/RS data and products, rendering many data sources and GIS/RS analyses of uncertain reliability.

Although the potential of GIS/RS technologies to enhance development is enormous, the appropriateness and sustainability of GIS/RS within the harsh economic realities and development context of most African countries needs to be critically examined.[8] Constraints to GIS/RS application include difficulties in obtaining relevant data and reliable data, high initial and maintenance costs associated with GIS/RS technologies (computer hardware, software and accessories, RS data), inadequately trained and inexperienced experts, limited education and training opportunities, lack of or poor spatial data standards and practices, and poor organizational structures in support of GIS/RS implementation. Many GIS/RS projects tend to be supported by development aid using top-down technology transfer models that fail to sustain the projects beyond project funding. There are also emerging issues involving GIS/RS and society, which includes the low level of community participation in defining problems and inputs into a GIS and ethical concerns over privacy over the use of RS data.

Despite these constraints, GIS/RS technologies hold tremendous promise for environmental monitoring and analysis, and NAPAs should take full advantage of them. One of the major challenges NAPAs face is to identify mechanisms for integrating the social and biophysical, GIS/RS and the social sciences, in the analysis of environmental change and its implications in order to better capture complex human-environment interrelations. This will involve techniques that "socialize the pixel" and "pixelize the social" (Gheoghegan *et al.*, 1998). There are also opportunities to be seized. NAPAs should take advantage of the latest advances in GIS/RS technologies, the growing community of GIS/RS users, increasing awareness of the value and accessibility of the technology, and the growing availability of subsidized data to conduct sound environmental analyses that produces tangible outputs that benefit Africa.

8. Application of GIS in Studying Poverty Distribution

One of the major goals of NAPA is to target most vulnerable communities and design programs specially for them. Identifying these communities in an objective manner for a whole country or region can be done using GIS analysis, and can include spatial analysis to explore key determinants. A poverty mapping project (www.povertymap.org) has been mapping extent of poverty and links to food insecurity in several countries. While these products are most interesting for research and use by external agencies that wish to target humanitarian assistance, it easy to see how available assessment data can be mapped for appropriate administrative boundaries to help identify targets for project implementation.

Table A2. Selected Data Sources for GIS and Remote Sensing Analysis

Data source	Description	Contact or availability
Miombo CD-ROM. START Secretariat, LULC/DIS,and the Miombo Network	Data includes the 1 km digital elevation model (DEM) for Africa, elevation and ocean depths, 1km Africa drainage basins and systems, administrative boundaries, climatic data (1977 to 95), tropical Africa biomass (1980), CO2 emissions, White's 1983 vegetation map of Africa (1:5million scale), land cover maps (the IGBP, USGS and	More information available at URL: http://www.miombo.org.

[8] For more information on issues of GIS/RS technology and its appropriateness for developing countries, see Spector, 1989; Fox, 1991; Lauer *et al*., 1991; Yapa, 1991; Kumer, 1992; Eastman & Toledano, 1996.

	UMD 1km land cover maps), global vegetation. African population for 1960, 1970, 1980 and 1990, and World Bank socio-economic data are also included. The CD includes a spatial data viewer.	
Miombo Landsat TM/ETM$^+$. The Miombo Network, University of Virginia, USA.	Landsat Thematic or Enhanced Thematic Mapper (TM/ETM$^+$) data for selected countries covering the *miombo* region of central and southern Africa are available to members and collaborators. Data cover mid 1980s and the 1990s.	More information available at URL: http://www.miombo.org
ALCOM Water Resource Database (WRD). The Aquaculture for Local Communities Development Programme, Harare, Zimbabwe.	A comprehensive FAO supported data source on surface water resources for the southern African region. Data includes water bodies, watersheds, rivers, aquatic species distribution, wetlands, capital cities and, administrative boundaries, and other specialized databases on fish and fisheries. The map scale is 1:15,900,000. A GIS viewer is included.	Data is downloadable at URL: http://www.zamnet.zm/zamnet/alcom/wrd.htm. Email: ALCOM@harare.iafrica.com
IPCC Climate Change and Related Scenarios for Impacts Assessment CD-ROM. The IPCC Data Distribution Centre	Data include mean monthly results from five Global Climate Model (GCM) climate change experiments; a monthly-observed global climate data (1961-90) gridded at 0.5 deg, various country-based social economic environmental indicators for the 1990s, atmospheric carbon dioxide concentrations from 1957-1997, greenhouse gas emissions and non-climate information from two climate change scenarios (IS92 and SRES98). A visualization tool is included.	Data is downloadable at URL: http://ipcc-ddc.cru.uea.ac.uk/ . The CD-Rom can be ordered free of charge by email: : ipcc.ddc@uea.ac.uk
SADC RRSP CD. FAO/SADC Regional Remote Sensing Project (RRSP).	CD contains decadal Normalized Difference Vegetation Index (NDVI) data for 1984-1990, 1993, 1994, 1996-97), decadal rainfall estimates (1996-98), FAO and SADC spatial climatic data, ALCOM hydrology layers, agricultural and population statistics (1:1,100,000 scale). Land cover, soils, topography, transportation and administrative boundary maps, are included, as well as \ the WinDisp GIS/RS software.	Contact by e-mail: rrsp@fanr-sadc.org.zw
START/Miombo Regional Climate CD	The CD contains temperature and rainfall data for Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe, as well as some Landsat TM data. The CD is the output of a workshop held in Zambia in April 1999.	Available at URL: http://www.miombo.org/climatecd.
The IGBP Data and Information System global land cover product, IGBP-DISCover Dataset.	Continental-level land cover database developed from 1 km monthly NOAA-AVHRR NDVI composites covering the period 1992-1993. The dataset has 17 lands cover classes, but the classification has not been verified with ground data yet and should be used with caution, especially at national level.	Available at URL: http://edcwww.cr.usgs.gov/landdaac/gll/glcc.html.
The Spatial Characterization Tool (SCT), and Almanac Characterization Tool, ACT.	The SCT is a GIS software application tool (built on Arc/Info GIS software) that contains a set of biophysical and socioeconomic data for the earth's tropics and the North American temperate zone, and the tools to explore and query these data to provide information for decision-making for agriculture and natural resources management. It	For more information see URL: http://www.brc.tamus.edu/char/

	includes spatial climate data, soils, population density, elevation, land cover (180 classes), agricultural census, and production information. These data are combined with ancillary data such as roads, rivers, towns, political units, watersheds, water bodies, towns and cities in the GIS application. However, SCT requires ArcInfo software to work. The Texas A & M Blackland Research Center and the International Maize and Wheat Improvement Center (CIMMYT) in Mexico are building stand-alone single country SCTs, or "Country Almanacs," called Almanac Characterization Tool (ACT) with USAID funding. ACT v.2.0 (September 1999) includes data on Angola, Eritrea, Ethiopia, Kenya, Liberia, Malawi, Sierra Leone, Somalia, Uganda, Tanzania, Zambia and Zimbabwe.	
FAO Forest Resources Assessment Data. FAO, Rome	Includes land cover and change analysis on a country-by country basis, ecological zones and ecofloristic zones.	Data is downloadable at website http://www.fao.org/forestry/fo/fra/index.jsp
Degradation data, GLASOD - UNEP GRID.	Global dataset on environmental degradation.	URL: http://www.grid.unep.ch/index.html
Solar radiation, NASA Langley DAAC, USA.	Solar radiation data.	Available at website http://eosweb.larc.nasa.gov/sse/
Global Soils Databases	FAO global soils database is available for	
Digital Soil Map of the World and Derived Soil Properties CD_ROM FAO/UNESCO, Rome, Italy.	This is based on the FAO/UNESCO soil map at 1:5,000,000 scale, or is 5 x 5 arc-minute grid cells. It is available in Arc/Info export, Erdas, and Idrisi formats.	See URL: http://www.fao.org/ag/agl/agll/dsmw.stm. Contact local FAO offices or email: Publications-sales@fao.org to purchase the CD.
GIS data clearing houses	Provide links to sources of geographic data.	GIS Data Depot: http://gisdatadepot.com, Global Change Master Directory: http://gcmd.nasa.gov/, The Geography Network: http://www.geographynetwork.com/

Table A3. Selected List of Geographic Information Systems and Remote Sensing Software

Software name	Software producers	Raster/Vector capabilities	Comments
Arc/Info	Environmental Systems Research Institute (ESRI), Redlands, California, USA.http://www.esri.com	Vector and raster	Industrial standard and most widely used GIS software. Originally command based.
ArcView	ESRI, Redlands, California, USA. http://www.esri.com	Vector with raster capability as add-ons.	A popular and commonly used GIS software, simplified and inexpensive version of Arc/Info.
ArcGIS	ESRI, Redlands, California, USA. http://www.esri.com	Vector and raster, expandable with extensions	New spatial database model and reorganization of ArcView and Arc/Info into suites of software applications arranged into three integrated functions: ArcMap, ArcCatalog, and Editor. Desktop versions of ArcGIS include ArcView 8x, 9x and Arc/Info 8x, 9x.
Erdas Imagine Professional	ERDAS (subsidiary of Leica Geosystems), Atlanta, Georgia, USA. http://www.erdas.com	Raster, with vector capabilities	Industrial standard remote sensing software. Includes radar analysis and graphical modeling. Imagine Advantage is intermediate level version that excludes 3D, radar and other radiometric functions. Imagine Essentials is a low cost mapping and visualization tool. Both versions are expandable to the Professional version.
Idrisi32 for Windows	Clark University, Worcester, Massachusetts, USA. http://www.clarklabs.org/	Raster with limited vector capabilities	Inexpensive, easy to learn, GIS and image processing system, with good documentation and training materials, advanced research applications such as decision support, uncertainty management and geostatistics. Widely distributed and commonly used in Africa.
CartaLinx	Clark University, Worcester, Massachusetts, USA. http://www.clarklabs.org/	Vector.	Inexpensive, spatial data building tool with standard vector GIS analytical and mapping tools.
Envi	Research Systems, Inc., RSI (a subsidiary of Eastman Kodak Company). http://www.rsinc.com/index.as p	Raster and vector.	Advanced and powerful RS software; leader in hyperspectral analysis; can use virtually any type of data; Interactive Data Language (IDL) allows programming and expansion of ENVI's features to meet specific applications, and easily integrates GIS/RS with modeling.