

**D R A F T**  
Discussion Paper

# **DISASTER RISK MANAGEMENT**

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# **IN A CHANGING CLIMATE**

A contribution to the World Conference on Disaster Reduction in Kobe, Japan prepared by F. Sperling and F. Szekely on behalf of the Vulnerability and Adaptation Resource Group (VARG).

VARG is an informal network of bi- and multilateral agencies created for sharing information on the impacts of climate change on development processes and possible remedial measures.

This paper is an informal discussion document. The views expressed in the paper are those of the authors and do not necessarily represent official opinions of their affiliated organizations, nor of the voluntary reviewers and their affiliated organizations or institutions.

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In general, we hope that the paper has captured many of the comments. Given the breadth of the issue it is however impossible to cover every issue. The present draft discussion paper reflects a compendium of issues the authors thought were important. It is hoped that the messages conveyed will spark a constructive discussion at the World Conference on Disaster Reduction and beyond on how the international community can further strengthen a comprehensive risk management approach, which captures disaster risk, climate change and other environmental hazards and thereby supports sustainable development efforts.

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## EXECUTIVE SUMMARY

Strategic coordination including the exchange of information, methodologies and tools between experts and institutions working on disaster risk management, climate change and development is essential for diminishing the impacts of natural disasters and improving the sustainability of development processes.

Important synergies exist between the policy frameworks and practical methodologies for disaster risk management and the course recent scientific advances suggest will be required for adaptation to climate change.

Many of the impacts associated with climate change exacerbate or alter existing threats (such as those associated with droughts, floods and extreme events), and adaptation measures can benefit from the practical experience in disaster management. However, some effects of climate change, such as global changes in sea levels, are new within recent human history. As a result little experience is available to tackle such impacts. For these reasons, coordinated action to address both existing and new challenges becomes urgent.

While uncertainty remains regarding the precise impacts of climate change, this does not justify inaction. Because climate projections are scenario based and the climate system is complex, uncertainties will always remain. This is also the case with many economic and other projections that play a central role in political decisions and policy formulation. The advances in climate

science can help to inform choices and reduce decision making risk.

When dealing with climate change risks it is important to recognize that the starting point for adaptation measures is the existing vulnerability to climate variability and extremes. Improving the capacity of communities, governments or regions to deal with current climate vulnerabilities is likely improving also their capacity to deal with future climatic changes, in particular if such measures take a dynamic approach and consequently can be adjusted to further changes in risks and vulnerabilities.

To promote an integrated approach to disaster risk management it is necessary to:

- Identify and appreciate the information, experience and methodologies that disaster risk, climate change and development experts can provide and design a system to share such experience and knowledge.
- Overcome some institutional barriers (structural, managerial, information, financial) to facilitate the integration of experience, information and knowledge of development, climate change and disaster risk management experts.

The World Conference on Disaster Reduction in Kobe, January 18-22, 2005, represents a unique opportunity to call for a comprehensive risk management approach, which addresses risks associated with natural hazards and climate change and thereby helps to promote the sustainability of development processes.



## INTRODUCTION

1

Whether it is heat waves in Europe, hurricanes in the Caribbean, droughts in Africa, or flooding in Asia, weather-related disasters are exerting an increasing toll on developing and developed countries, destroying lives and livelihoods and hampering development processes. The World Conference on Disaster Reduction is a testimony that international cooperation is needed to prevent natural hazards from translating into disasters.

The challenges will be extended further through changes in climate. This will change profiles of natural hazards, alter underlying environmental risks and introduce new threats.

As we are aware of the problem today, there is a real opportunity to reduce current and future vulnerabilities to climate risks by building on and expanding existing disaster risk management efforts.

The paper discusses inter-linkages and differences between disaster risk management and adaptation to climate change, and outlines opportunities and barriers for collaboration. We hope that the outcomes of World Conference of Disaster Reduction (WCDR) will lead to an improved coordination of policies and measures concerned with disaster risk management and adaptation to climate change.

## 2

# CLIMATE CHANGE IMPACTS ON NATURAL HAZARDS AND UNDERLYING RISK FACTORS

Climate change is a reality, not a distant possibility in the future. The Intergovernmental Panel on Climate Change (IPCC), the international authority on the science of climate change, concluded in its most recent report that climate change is already happening. Not only has an increase in the global average temperature by 0.6°C over the last century been observed, which largely can be linked to increases of greenhouse gas concentrations in the atmosphere due to human activities, but also a growing number of physical and biological responses, such as the melting of glaciers in most regions of the world and changes in the behavior and distribution of species, are being detected (IPCC 2001 a, b). The ten warmest years on record have all occurred since 1990, including every year since 1997 (WMO 2004).

Projections of future changes suggest that the global average temperature will increase by 1.4 to 5.8°C by the end of the 21<sup>st</sup> century in com-

parison to 1990 levels. This magnitude of change is likely to be unprecedented for at least the last 1000 years (IPCC a). This average increase in temperature is associated with local and regional changes in climatic conditions.

Climate change has implications for disaster risk management as it impacts on the exposure to hydro-meteorological hazards (e.g. storms, floods and droughts), and also modulates underlying risk factors, which influence the vulnerability to environmental hazards and therefore the probability of a disaster occurring. In general, the following changes should be recognized in their implications for managing disasters:

### *Changes in the magnitude and frequency of climatic extremes*

Disasters are associated with extreme events. Climate change directly interacts with the exposure to climatic extremes. For example, climate change

will lead to higher maximum temperatures and heat waves over almost all land areas (IPCC 2001). That heat waves can have devastating impacts even in developed countries became glaringly clear in 2003, when a heat wave—with temperatures rising above 40°C (WMO 2004)—was linked to more than 35,000 excess deaths in France, Italy, the Netherlands, Portugal, Spain, Germany and the United Kingdom (Koppe et al. 2004). Recent research suggests that past human induced greenhouse gas emissions have at least doubled the risk of this heat wave occurring (Stott et al. 2004).

In addition, climate change is expected to lead to more intense precipitation events for many areas causing a higher probability of floods, landslides, avalanches and soil erosion with associated damages (IPCC 2001). Conversely, for most mid-latitude continental interiors increased summer drying is likely with respective consequences for the risk of droughts. Peak wind intensity of cyclones, hurricanes and typhoons is likely to intensify in some areas. While it is not fully established, it is also possible that the distribution of tropical cyclones may change (IPCC 2001). Since the mid seventies, El Niño events have become more frequent in comparison to La Niña episodes. Climate change is likely to intensify droughts and floods associated with El Niño events.

According to an analysis of Munich Re (2000), the number of great natural catastrophes per decade increased fourfold and the number of economic losses 14 times, if the period 1990-1999 was compared to 1950-1959. The increase in disasters is due to many factors, including improved information and reporting, uncontrolled urbanization in hazard prone areas and environmental degradation. It is, however, striking that

the intensity and frequency of weather related (hydro-meteorological) hazards has increased in many regions, while the number of geological hazards (e.g. earthquakes, volcano eruptions) reflects long time-scale variations, but not trends (UN/ISDR, 2004).

As climate change alters the magnitude and frequency of extreme events it is important to recognize that coping and response mechanisms and economic planning for disasters, based on past vulnerabilities, may no longer suffice for what is to come. Indeed, in many countries, these existing mechanisms are already insufficient of the current level of vulnerability.

### *Changes in average climatic conditions and climate variability*

Beyond affecting the climatic extremes, climate change also alters average climatic conditions and climate variability. While more subtle in nature and not necessarily a hazard in itself, these changes affect underlying risk factors and thereby the ability to cope with and recover from climate extreme events and other natural hazards, compound their impact.

For example, where a shift from a productive to a marginal agricultural area occurs, it seems obvious that the impact of a drought or a flood on livelihoods represents a more difficult challenge for climate sensitive livelihoods such as farming and cattle ranching, if remedial measures are not taken. Rural livelihoods and food security in Africa are particularly threatened by climate change as shown in a comprehensive assessment by IIASA (Fischer et al. 2001).

Changing baselines of environmental conditions in which disasters occur has to be recognized in its implications for disaster risk management planning efforts. A broad overview of

climatic change impacts at the global and regional level is given in the Appendix.

### *Emerging threats*

While most impacts of climate change are exacerbations or alterations of existing threats, some impacts induced by global warming may be new to a region in recent history and, consequently, there exists no experience in dealing with such impacts.

Many such events may be threshold events. For example coral bleaching occurs when water temperatures exceed a threshold and coral expel symbiotic algae. Where the warming is sustained coral reefs may not recover and die. Such changes in combination with sea level rise are likely to increase the vulnerability of island nations, where coral reefs sustain fisheries and provide protection from storm surges. Understanding such threshold events may help to maintain the health of ecosystems by reducing compounding impacts. The globally observed retreat of glaciers is another example, where climate change may lead to new threat levels. The accumulation of water in natural dams as a result of glacial melt may lead to glacial lake outburst floods (so-called GLOFs) with destructive down-stream effects. As temperature changes increase with altitude in the lower troposphere the melting of glaciers has

been considerable in many regions, exposing areas and valleys to the risk of GLOFs. As the magnitude of the threat is new, it may therefore not have been reflected in earlier settlement policies.

Other occurrences are related to climate induced spatial and temporal changes in impacts. This includes for example, the spread of climate sensitive diseases into regions where these diseases did not occur before (McMichael 2003), the appearance of invasive species in areas where they previously did not exist as well as the disappearance of species from areas that are no longer suitable to them (IPCC 2001).

Many of such changes can be anticipated and planned for through a combination of scientific research, monitoring and foresight planning, if the thresholds are known. However, climate change may also cause unforeseen events – surprises – with negative consequences. The climate system is a complex one with multiple feed-back loops between the ocean, atmosphere and terrestrial ecosystems. The more rapidly the climate system is forced by increasing levels in greenhouse gases, the higher the potential for surprises. Therefore, reducing greenhouse gas emissions and other impacts on the environment represents also a precautionary measure, which in the long-term will reduce the risk of surprises with potential adverse consequences.

## THE EVOLUTION OF DISASTER RISK MANAGEMENT

# 3

Given the increasing concern about the impacts of disasters, the UN General Assembly declared 1990–99 the International Decade for Natural Disaster Reduction (IDNDR). The IDNDR organized the World Conference on Natural Disaster Reduction in Yokohama in 1994. This Conference conceived the Yokohama Strategy and Plan of Action for a Safer World (Yokohama strategy) which stressed that every country has the primary responsibility to protect its people, infrastructure and national, social and economic and ecological assets from the impact of natural disasters. Additionally, the strategy emphasized the urgent need to move from a mainly reactive approach to disaster mitigation to a new paradigm based on a more comprehensive approach that includes preventive measures, mainly aimed at reducing the likelihood that a natural hazard translates into a disaster

Disaster risk management implies addressing the underlying social, economic and environmental vulnerabilities and thereby reduce the

probability of a disaster occurring. In an ideal world preventive measures would make disaster relief efforts obsolete, but realistically they complement relief efforts, minimizing disaster impacts and therefore the human and economic cost of disasters.

Disaster risk management tries to address hazard risks as an integral part of development. Consequently, it is less events and more process focused. It is based on a continuous assessment of vulnerabilities and risks and involves many actors and stakeholders, such as governments, technical experts and local communities (UN-ISDR 2004).

### **Multiple-hazards**

Ideally disaster risk management would take a comprehensive multi-hazard focus, which includes simultaneous consideration of the various types of geological and/or hydro-meteorological hazards to which a particular country or region is exposed. For example, it is known that

coastal regions of Ecuador and northern Peru are particularly prone to above normal rainfall and floods during El Niño events. In addition, various areas of these countries are also prone to earthquakes, volcanic eruptions, droughts, cold spells, landslides and/or avalanches.

On the country level it would be ideal to take into account the probabilistic occurrence of all these events in economic planning. Preventive measures within a specific region, of course, should focus on the local hazards and address known vulnerabilities.

Disaster prevention and contingency plans can build on past experiences and scientific knowledge of exposure to certain type of hazards and their frequency of occurrence. For example, geological hazards are often localized (e.g., volcanic eruptions and earthquakes along zones of tectonic activity) and follow large-scale time variations. Other hazards are associated with events of semi-periodic occurrence, e.g., El Niño events occur every 2–7 years. The typical paths and seasons of hurricanes are well known. Such knowledge of exposure and vulnerabilities can be used to evaluate the risk of a disaster occurring within a specific region and take remedial measures, such as the implementation of forecasting and early warning systems, education initiatives, promoting of appropriate infrastructure and natural resource management.

A number of databases and studies exist or are under development for disaster risk assessment. For example the World Bank, together with UNDP and Columbia University, is in the process of publishing an analysis of Global Disaster Risk Hotspots with the objective to help prioritize risk reduction effort (see [www.proventionconsortium.org/projects.htm](http://www.proventionconsortium.org/projects.htm)). This analysis aims at bringing together the understanding of physical exposure and socio-economic vulnerabilities.

Previously, UNDP developed the a Disaster Risk Index (DRI), which is built on UNDP's experience with the Human Development Index incorporating data from EM-DAT, a global data base on natural disasters maintained by the Center for Research on the Epidemiology of Disasters in Brussels (see [www.em-dat.net](http://www.em-dat.net)). Furthermore, re-insurance companies such as Munich Re and Swiss Re collect considerable information on disasters. These country level data sets are complemented by local knowledge of hazard prone areas.

### **Accounting for changing exposures and vulnerabilities**

A pro-active disaster risk management approach needs to recognize the interaction of globalization processes, population and demographic trends, economic development and trade patterns, urbanization and other factors, which impact on the exposure and vulnerability to hazards. In this context it is also important to address local and global environmental issues that change risk patterns and increase vulnerabilities to various disaster risks, if no appropriate measures are taken.

As discussed earlier, climate change will alter the disaster risk associated with hydrological hazards by affecting climatic extremes as well as modulating underlying risk factors through changes in average climatic conditions and climate variability. The following sections contrast the evolution of disaster risk management with developing understanding of adaptation to climate change, discuss synergies and difference of these two concepts and the focus on the opportunities and barriers to develop an integrated approach that reduces the vulnerability to current and future environmental hazards.

## ADAPTATION TO CLIMATE CHANGE — MOVING FROM SCIENTIFIC DEBATE TO POLICIES AND MEASURES

# 4

Policy responses concerned with disaster risk management and adaptation to climate change have developed along different tracks.

Disaster risk management originated from humanitarian assistance efforts and the accumulated experiences of exposure to disasters and increasingly incorporated scientific advances. Disaster management grew from localized, specific response measures to include also broader preventive measures, which aimed to address the various underlying environmental and socioeconomic aspects of vulnerability. Conversely, the response to climate change has been more of a top-down process as it became an international issue of global importance, through advances in scientific research leading to international policy responses through the United Nations Framework Convention on Climate Change (UNFCCC).

In order to manage the ecological and economic risks associated with climate change two

approaches have emerged: *Mitigation* and *Adaptation*, which have become binding obligations to all Parties of the UNFCCC (Art.4).

Mitigation encompasses all efforts focused on reducing the concentration of greenhouse gases in the atmosphere. It therefore addresses the cause of climate change and influences the rate and magnitude of *future* climatic changes. The emphasis on *future changes* is important. Due to the thermal inertia in the ocean-atmosphere system, there is a delay in the warming associated with increases in atmospheric greenhouse gases. This means that the warming observed at present is due to past greenhouse gas emissions and the warming associated with the current increase in greenhouse gases will be observed in the future. Therefore we are already committed to a certain degree of climate change.

Adaptation, which is here generally defined as the adjustment in natural or human systems to a new or changing environment due to effects

of climate change (see IPCC 2001 for a more detailed definition and discussion of climate change adaptation), include all measures aimed at reducing the negative impacts resulting from climate change as well as the identification of new opportunities and benefits associated to new climates. Adaptation is the complementary part to climate change mitigation. In dealing with climate change, mitigation and adaptation are interdependent measures. Mitigation addresses the physical exposure, while adaptation focuses on the physical and socioeconomic vulnerability associated with a given exposure, i.e. rate and magnitude to climate change.

### **Conceptual Frameworks and Methodologies for Adaptation**

The challenge in the context of adaptation is to move from the understanding that climate change is occurring to concrete measures that reduce existing vulnerabilities of human and natural systems.

The understanding of climate change effects is driven by scientific advances, which often constitute the starting point for practical measures. In order to understand likely changes of the climate system caused by increases in greenhouse gas concentrations, the evaluation of climate impacts is dependent on simulations, which model climatic conditions according to a given scenario of future atmospheric greenhouse gas concentrations. Such models and the validity of their outputs of future climate change are tested by the ability of the model to reproduce general climate characteristics under current conditions. Furthermore, trends in physical and biological systems are observed to detect current changes. Data on past and present climatic conditions provide indications on the relative magnitude of the pro-

jected climatic changes and help to determine whether observed changes are within the normal variability of the climate in a region. In addition, analog methods are also being used to compare projected changes with past climatic changes.

As outlined by Mirza (2003) in greater detail, the initial framework on adaptation was particularly concerned with elucidating the regional climate change regions are faced with. For example the IPCC released guidelines for adaptation studies, which focused on identifying the possible impacts (Carter et al. 1994).

In recent years there has been a growing focus on considering biophysical impacts in the context of socio-economic trends and vulnerabilities. The *Adaptation Policy Framework* (APF) developed by UNDP outlines concrete steps aimed at developing concrete measures. Interestingly, the APF encompasses current climate risks and future climate change. Other methodologies exist. For example, the *Caribbean Risk Management Guidelines for Climate Change Decision Making* can be applied in other regions (see *Adapting to Climate Change in the Caribbean – ACCC – Project*, 2003). In addition, the UNFCCC has established a set of guidelines for communicating urgent needs of the least developed countries to adapt to climate change (UNFCCC, 2002) providing a set of criteria for selecting priority areas of action.

Within the institutional level there is also a growing emphasis to systematically assess the risk development processes are exposed to through climate change and how such risks can be reduced through appropriate planning. The World Bank is developing a screening tool to identify climate sensitive projects and vulnerabilities to climate change. Similar initiatives are on the way by USAID, CIDA, WHO and others.

## *The Funding Framework*

The financing framework for adaptation is largely an outcome of the UNFCCC process. In the so-called Marrakech Accords an agreement on various funds was reached that support adaptation measures. These funds include the *Least Developed Countries (LDC) Fund*, the *Special Climate Change (SCC) Fund* and the *Adaptation Fund*. The Global Environmental Facility (GEF) is the fund-

ing mechanism for these activities (see [www.unfccc.int](http://www.unfccc.int); decisions 5/CP.7 and 6/CP.7). The GEF has also allocated 50 million USD in its business plan for 2005-2007 to strengthen the learning effort on how to best address adaptation issues with the aim to provide future guidance for adaptation related efforts in the new funds. In addition various agencies have started additional funding programs for adaptation.

### **FUNDING FOR ADAPTATION**

**LDC Fund:** The “Least Developed Countries” Fund will contribute to the enhancement of adaptive capacity to address the adverse effects of climate change, including, as appropriate, in the context of national strategies for sustainable development.” Emphasis is currently placed on providing LDCs with equitable access to funding for implementation of National Adaptation Plans of Action (NAPAs). In this context GEF is requested to develop criteria for supporting activities arising out of the NAPAs on “an agreed full-cost basis, taking into account of the level of funds available”.

**SCCF:** The “Special Climate Change” Fund supports the implementation of the Convention, contributes to the achievement of the World Summit on Sustainable Development and the Millennium Development Goals by addressing the integration of climate change considerations into development activities.”

**Adaptation Fund:** The Adaptation Fund was established under the Marrakech Accords and is linked to the Kyoto Protocol. The fund should finance concrete adaptation projects and programs in developing countries, which are also Parties to the Protocol.

All funds are open to bilateral and multilateral contributions (\$15M has been pledged for the LDC fund) and in addition the Adaptation Fund will receive a share of the emission reduction credits arising from CDM activities (excluding small scale projects). This is estimated to amount to only \$3M to \$5M per year over the first commitment period of the Kyoto Protocol.

**GEF Trust Fund:** \$ 50M have been allocated on the Strategic Priority “Piloting an Operational Approach to Adaptation”

For further information, please visit: [www.unfccc.int](http://www.unfccc.int) and [www.thegef.org](http://www.thegef.org)

## 5 CONVERGING AGENDAS

In the policy debate on climate change there has been a growing need to address vulnerabilities to climate change through adaptation efforts, complementing mitigation efforts aimed at reducing the rate and magnitude of climate change. At present, this development has taken place largely in parallel to the increasing shift from disaster management to disaster *risk* management.

Due to the converging agendas there is an outstanding opportunity for improved information sharing and strategic and practical collaboration between these two focal areas in order to develop a comprehensive risk management approach, which addresses current and future hazards and environmental risks *taking a dynamic forward looking perspective*.

In order to do so successfully, it is important to be aware of the synergies and differences in disaster risk management and adaptation to climate change.

### **Commonalities between Disaster Risk Management and Adaptation to Climate Change**

As with disaster risk management, policies and measures concerned with climate change represent a *risk management approach*. Both disaster prevention measures and climate adaptation measures aim to address underlying vulnerabilities, which would otherwise put the natural and human systems at risk to suffer disasters or climate change impacts.

The degree of vulnerability to a natural hazard or climate change is a function of the magnitude of physical exposure and prevalent environmental and socioeconomic conditions, which may lessen or exacerbate the risk for a negative impact associated with a hazard or climate change. Therefore, both concepts depend on evaluating risks, vulnerabilities and possible remedial measures. This is a *continuous process* that in both cases needs a forward looking perspective rooted in an understanding of present day conditions.

In the context of dealing with risks related to climate change, it is important to recognize that *the starting point for adaptation measures is the existing vulnerability to climate variability and extremes*. Improving the capacity of communities, governments or regions to deal with current climate vulnerabilities is likely to improve their capacity to deal with future climatic changes.

## Differences

While the emphasis on a continuous and forward looking process of risk evaluation is similar, the time horizons tend to be different. Disaster risk management is more concerned with the present. Emphasis is placed on vulnerabilities revealed through past disasters is particular strong and the focus tends to be more on near term trends (the next 5–10 years) rather than long-term changes.

In anticipating climate change, the scientific and policy debate usually takes a much longer time horizon than disaster risk management. Climate projections are usually made for the next 20, 50 and 100 years. 2025, 2050 and 2100 often represent the reference years of comparison to present day situations. It is important to understand, which economic policies, sector strategies and infrastructure developments tend to set off long-term processes, which are difficult to reverse at a latter stage. In such cases it is particularly useful to incorporate longer-term time horizons and pool knowledge from disaster and climate change risk assessments.

Another difference exists in relation to physical exposure. Natural hazards, as their name implies, are largely perceived as a given and therefore beyond human control. *Mitigating disasters* has therefore a very different connotation

from *climate change mitigation*. Disaster mitigation is focused on limiting the adverse impact of a particular hazard, but not the onset of the hazard itself.

This contrasts with climate change mitigation. It is now well established in the scientific community, that climate change is largely anthropogenic. This means that humans have changed the exposure to climatic risks. Mitigation measures recognize that the amount of greenhouse gases in the atmosphere will influence the rate and magnitude of climate change. Therefore it is within the capacity of humans to influence their exposure to change.

The scope of disaster risk management goes beyond climate related disasters. Preventive measures address hydro-meteorological (torrential rain, floods, droughts, storms) and geo-morphological (earthquakes, volcanic eruptions) hazards<sup>1</sup>. Adaptation to climate change on the other hand is not only focused on extreme events, but also, as outlined earlier, on changes in average climatic conditions and climate variability, which may modulate the vulnerability to certain disasters.

The goal should therefore be to build a comprehensive risk management framework, which recognizes current and future vulnerabilities as well as the compound effects of multiple disasters within a given region.

## Note

1. General disaster risk management includes also addressing technological hazards. However, in the context of the paper emphasis is placed on the interaction between climate change and natural hazards and their implications for disaster risk management.

# 6

## DEVELOPMENT PROCESSES — THE INTEGRATIVE FRAMEWORK FOR RISK MANAGEMENT

Both approaches, dealing with disasters and climate change, have recognized that remedial measures aimed at reducing vulnerabilities need to be part of the development process (e.g., UNDP 2003, Sperling ed. 2003, UN-ISDR 2004, Simms et al. 2004). It is poor people who generally tend to be more exposed to natural hazards and suffer the most from disasters. While hazard management and climate change are issues which are also addressed by professionals within development institutions and there exists considerable overlap, comprehensive risk management approaches have been limited, being more ad hoc than systematic. Better integration of disaster prevention and climate change adaptation measures, provides a tremendous opportunity to strengthen progress towards sustainable development.

Development is the integrating platform for disaster and climate change risk management. It has the broadest scope. It provides the “Big Pic-

ture”, because it needs to recognize all the dimensions relevant to poverty reduction and development ranging from important issues such as economic growth to education, from large scale infrastructure to basic health care. There are many pressing issues that need to be considered and prioritized. Disaster risk management and climate change adaptation is concerned with the sustainability of progress on these issues and therefore should be an integral part of these. Depending on how development activities are planned and executed, they can be impacted by and impact on environmental risks to development (UN-ISDR, 2004).

Furthermore, development activities generate knowledge or compile information that is directly relevant to disaster and climate change risk management. For example, development agencies like UNDP and the World Bank compile large data sets of micro and macroeconomic information. The diversity of a country’s econo-

## **DEVELOPMENT TRENDS AND FLOOD RISKS IN THE MEKONG DELTA, VIETNAM**

Mekong delta in Vietnam is the prime agriculture zone in Vietnam. The developments in the recent decades rendered this zone more vulnerable to floods.

During pre-1970s single cropping of rice was predominant, in consonance with rainfall and seasonal floods in the rainy season. Floating rice was grown from April to November, and this crop could tolerate various flood levels. Though yield was low, a minimum production was guaranteed to preserve the livelihood system.

During 1980s the introduction of high yield varieties (HYVs) with short growing periods brought about a drastic change in cropping patterns. Double cropping of rice, consisting of both traditional and HYVs, has been widely disseminated to every region in the Mekong Delta. The cropping system was also adjusted to seasonal flooding. The short duration varieties were planted during non flood season.

Since early 1990s a diversified cropping system was introduced, with shrimp farming gaining importance. These systems are exposed to annual floods. This strategy, although providing high income, also rendered the cropping systems vulnerable to periodic floods. Hence, the incidence of floods in the recent years has increased when compared to the previous decades. The latest cropping patterns and livelihood systems are not well adapted to annual floods in Mekong Delta.

*Source: Subbiah, ADPC.*

my, trade patterns, and the economic volatility among other issues can have a positive or negative influence on preparing for environmental shocks and recovering from a disaster. This is complemented by knowledge residing in NGOs, which may for example provide important insights on community level development concerns and lack of resources that may undermine the ability of the community to withstand wind-

storms, torrential rainfalls and other adverse environmental events and changes. This knowledge is often readily available within the development community, but it takes the interaction with experts concerned with disaster and climate risks to identify the vulnerabilities and adaptation measures in light of current and future environmental change.

*Integration of climate change concerns on the institutional level:*

#### **BRINGING THE CARIBBEAN DISASTER MANAGEMENT AND CLIMATE CHANGE CONSTITUENCIES TOGETHER.**

From 1997 to 2001 the Global Environment Facility (GEF) funded the Caribbean Planning for Adaptation to Climate Change project (CPACC). The project was a coordinated effort by the World Bank, the OAS, the University of the West Indies and 12 countries of the Caribbean Community (CARICOM), and focused on planning for adaptation to the impacts of climate change, specifically the impacts of sea level rise on coastal and marine resources. Given the strong coastal focus, the adaptation strategies and activities identified under CPACC were closely related to those being called for in mitigating the impact of coastal storms and hurricanes.

In preparing for the follow-on project to CPACC, called Mainstreaming Adaptation to Climate Change (MACC), the two constituencies were brought together. Led by the Caribbean Disaster and Emergency Response Agency (CDERA) and the MACC team, national disaster coordinators, climate change focal points, and representatives from specialized regional institutions, the University of the West Indies and the insurance industry, identified a program of common actions for adapting to climate change and mitigating hydro-meteorological hazards. Specific recommendations were made to explore synergies between disaster risk management and adaptation to climate change and some are now being implemented under the MACC project. Further strengthening and expansion of the cooperation between the two constituencies is needed however to have a lasting impact, and this will require interventions of an institutional nature.

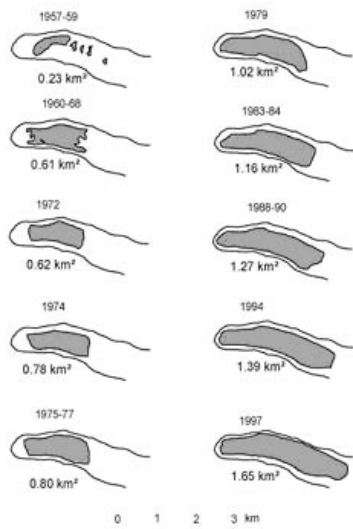
An example of such an institutional initiative was taken by the Caribbean Development Bank (CBD) when it started a review its environmental impact assessment (EIA) procedure. Initially the CBD was considering evaluating the risks of climate change and hazards separately, as part of the review process. The EIA process is concerned with analyzing the impact of projects on the environment and can relatively easily be extended to incorporate an analysis of the impact of environmental hazards on the success of the project. Hence, the revised EIA process would assess the impact of the project on the environment and the potential impact of environmental conditions on the project. Upon further analysis, CBD decided to combine climate change and natural hazard risk in the EIA review process, thereby bringing a multi-hazard risk management approach and climate change adaptation together.

*Source:* Jan Vermeiren, OAS.

*Integration of climate change concerns on the project level:*

### **TSHO ROLPA RISK REDUCTION PROJECT IN NEPAL AS OBSERVED ANTICIPATORY ADAPTATION**

Several Himalayan glacial lakes have witnessed significant expansion in size and volume as a result of rising temperatures. This increases the likelihood of catastrophic discharges of large volumes of water in events which are known as Glacial lake Outburst Floods (GLOFs). One of the most dangerous glacial lakes in Nepal is the Tsho Rolpa lake at an altitude of about 5000m, and whose size increased from 0.23 square kilometres in 1957-58 to 1.65 square kilometres by 1997.



The Tsho Rolpa glacial lake project is one of the most significant examples of collaborative anticipatory planning by the government, donors, and experts in GLOF mitigation. Tsho Rolpa was estimated to store approximately 90-100 million m<sup>3</sup>, a hazard that called for urgent attention. A 150-meter tall moraine dam held the lake, which if breached, could cause a GLOF event in which a third or more of the lake could flood downstream. The likelihood of a GLOF occurring at Tsho Rolpa, and the risks it posed to the 60MW Khimti hydro power plant that was under construction downstream, was sufficient to spur HMG to initiate a project in 1998, with the support of the Netherlands Development Agency (NEDA), to drain down the Tsho Rolpa glacial lake. To reduce this risk, an expert group recommended lowering the lake three meters by cutting an open channel in the moraine. In addition, a gate was constructed to allow water to be released as necessary. While the lake draining was in progress, an early warning system was simultaneously established in 19 villages downstream of the Rolwaling Khola on the Bhote/Tama Koshi River to give warning in the event of a Tsho Rolpa GLOF. Local villagers have been actively involved

in the design of this system, and drills are carried out periodically. The World Bank provided a loan to construct the system. The four-year Tsho Rolpa project finished in December 2002, with a total cost of USD 2.98 million from The Netherlands and an additional USD 231,000 provided by Government of Nepal. The goal of lowering the lake level was achieved by June 2002, which reduced the risk of a GLOF by 20%. The complete prevention of a GLOF at Tsho Rolpa necessitates further reducing the lake water, perhaps by as much as 17 meters. Expert groups are now undertaking further studies, but it is obvious that the cost of mitigating GLOF risks is substantial and time consuming. The cost, however, is much less than the potential damage that would be caused by an actual event in terms of lost lives, communities, development setbacks, and energy generation.

*Source: Agrawala, OECD (see also OECD 2003a).*

# 7

## IDENTIFYING AND ADDRESSING CHALLENGES TO THE COORDINATION OF CLIMATE CHANGE AND DISASTER RISK MANAGEMENT

It seems obvious to integrate climate change adaptation and disaster risk management efforts. Some successful initiatives have happened, but there is still considerable fragmentation. Why is this so? And what can be done to overcome it?

### **CHALLENGE: *Uncertainty — A reason for delaying adaptation efforts?***

Uncertainty in model projections is often cited as a reason for a wait-and-see approach for action. This is wrong, since a lot can already be achieved by utilizing the existing information on climate change. It is also important to recognize that uncertainty in the model projections will never be fully resolved (as is the case in projections of economic growth, population growth and other socioeconomic variables). However, this uncertainty does not necessarily have to be associated with inaction.

The fact that climate change is occurring has already considerable implications for disaster risk management strategies. The knowledge of *change*

*itself* is already useful. Even if uncertainty exists about the direction of change, change should imply precaution. Change means that past experiences upon which disaster risk planning efforts have previously been based on may only be of limited use for disaster preparedness in the future (if at all). Knowledge of change implies flexibility and the continuous re-evaluation of risk and re-adjustment of measures when necessary. Ignoring climate *change* when planning for hydro-meteorological disasters and implementing development strategies, may lead to solutions which do not have the capacity to adapt to changes in physical exposure in the future and thereby may exacerbate vulnerabilities to environmental hazards in the long run. Instead of choosing for example a rigid structure to control floods, it may be better to explore natural resource management options.

Usually, however, there exists more specific information on climatic changes which gives insights into at least the qualitative, if not quantitative direction of change. In connection with

## **ADAPTATION TO CLIMATE CHANGE IN DISASTER RISK MANAGEMENT FOR THE BÚZI WATERSHED AREA, MOZAMBIQUE**

Globally, weather events will become more extreme and intense. Human-induced climate change is one of the causes. Several regions of Mozambique are already experiencing intensified hurricanes and the disasters that seem to follow the changing climate. Because of this, the Government of Mozambique decided to actively include disaster risk management in the national plan of action to reduce extreme poverty. At provincial level, the population of the Búzi district in the Sofala province is aware of the destructive nature of floods and cyclones, but an integrated DRM concept including adaptation measures and an early warning system is still at an early stage. Hence, the local government of Sofala and its German partner GTZ agreed on a project to additionally include adaptation to climate change in its disaster risk management planning.

The project aims to prepare the local population to better manage the mounting threats of cyclones and floods. Climatic conditions are worsening in the long term; disaster risk management plans have to adapt to this challenge. Activities to build capacity for and raise awareness about adaptation to climate change target the members of municipalities and local committees. This will be accomplished through governmental consultation at provincial and district level, seminars, studies and best practice examples. To strengthen the early warning system of the Rio Búzi watershed area, a more precise and comprehensive record and forecast model for gauge water levels will be introduced.

The experience gained in the Búzi district will be distributed widely through the National Adaptation Programme of Action process and the committee in charge.

The project is supported by the Climate Protection Programme of the GTZ, and is embedded as a complementary element within the German technical cooperation programme titled "Rural development Mozambique".

*Source:* H. Liptow, GTZ.

an understanding of current vulnerabilities, such knowledge provides insights whether a specific climatic risk is likely to be exacerbated in the future and therefore should receive further attention.

Much information can be gained by separating likely from unlikely impacts. Furthermore some impacts are more immediate than others as illustrated in the cases of changes in drought and flood frequency and intensity and glacial melts and coral bleaching. For example, in a series of case studies the OECD uses a qualitative metric, based on degree of uncertainty of climate change projections, the urgency of the impact and the significance of the sectors affected (OECD 2003 a-d, 2004 a,b). Such approaches help to identify priority areas of concern and can be incorporated into disaster risk management and devel-

opment planning efforts to ensure that systems are not further stressed, but rather that their adaptive capacity is enhanced.

In some cases, there is at least some knowledge of the magnitude of change that can be expected at regional to sub-regional level. Sea level is expected to rise by 0.09 to 0.89 cm by 2100 in comparison with present day levels. While there is still considerable difference in the minimum and maximum values, the projection given an indication of the likely range. In conjunction with knowledge of local environmental conditions, natural resource management issues and disaster risk such information can be used to guide for example coastal infrastructure development and settlement policies.

It is important to keep in mind that weighing uncertainty is not a new challenge, but rather an integral part of disaster risk management.

Uncertainty is also part of disaster risk prevention efforts that deal with probabilistic events such as earthquakes or hurricanes. Experience gained through disaster risk management can therefore help to inform climate change adaptation measures how uncertainties can be addressed.

Climate change means that further precaution needs to be applied. In the case of engineering efforts this may mean to increase safety factors to ensure that building structures could withstand possible increases in the peak winds of hurricanes or increases in the magnitude and frequency of extreme events (IPCC). What changes through climate change is the time perspective for weighing risks, which brings us to the next barrier to integrated approaches.

#### **CHALLENGE: *Short-term thinking***

Often risks to investments are not considered for the full life-time of the project, discounting the impacts of climate change. For example, a major infrastructure investment such as a bridge, should serve for several decades, and therefore the design needs should incorporate potential hazards and environmental change over that time period. Already in 1999 Burton and van Aalst suggested that a “*full risk analysis*” of development projects is needed, which addresses natural hazards as well as increases of risks due to climate change over the life-time of the project.

#### **CHALLENGE: *Information collection, dissemination and implementation***

Accounting for climate risks within the development context is often hampered by lack of information, lack of information dissemination and implementation of appropriate response structures. Climate change is superimposed on exist-

ing vulnerabilities. In this context it is even more paramount that information is efficiently collected, and user-friendly systems to access and disseminate information are put in place.

Understanding climate risk and climate change depends on the continuous collection of data of the most crucial climate variables. Such data is important to develop forecasting models, test and validate climate models and detect regional climate trends. It is therefore important that meteorological stations are maintained and climate data is shared. This is particularly true in developing countries, where the network of meteorological stations is sparser.

Often lack of climate information is not the challenge. Rather the challenge lies in appropriately accessing and communicating information derived for example from seasonal forecasts. Uncertainties need to be addressed, but the information has also to be clear enough for stakeholders to act. Here, the barriers are often institutional. Forecasting information needs to be provided in a format that is useful to vulnerable groups, e.g. farmers. This means understanding the information needs of such groups and the sociological processes that need to be taken into account to ensure that the information is taken up and becomes part of the internal decision making process. Hence, a two way communication process needs to take place, which also recognizes relevant local and traditional knowledge and knowledge networks.

There are global early warning capabilities for tropical cyclones as well as many other hazards, but to be effective these information capabilities need to be utilized and connected with appropriate response infrastructure on the country and regional level. The World Meteorological Organization’s Global Observation System

represents the international framework for collecting weather and climate information around the globe through. The success of this system is dependent on collection and sharing of country level climate data and additional oceanographic data and is therefore dependent on the input from countries. In addition the WMO Global Data Processing and Forecasting System (GDPS) fosters the cooperation world, regional and national centres to process data and provide countries with analysis and forecasts, including early warnings of severe events. Such services, however, are only useful if there exists also an institutional framework that reacts efficiently to such warnings. This was again apparent during the 2004 hurricane season, where Hurricanes *Charley*, *Frances*, *Ioan* and *Jeanne* struck several countries and island nations and the differences in levels of preparedness are partly the reason for the different magnitude of losses in life and economic assets.

Finally, information concerned with disaster risk management and adaptation to climate change is inherently complex, since it not only has to include biophysical information about the disaster risk, but also environmental and socio-economic information of underlying risk factors. This requires a multi-disciplinary understanding of the issue combining specialist knowledge with an understanding of the “big picture”. Often institutions lack one or the other. Rotational schemes, which expose professionals to various topics, are for example common in many organizations. These professionals bring a broad and important understanding of various development issues into the picture of risk management, but need to be complemented by specialist understanding of the nature of risk. There is no general recipe here, but consideration should be given to how *a consistent programmatic approach to risk*

*management efforts* at various level of governance and decisionmaking within the development context can be facilitated, so progress does not get lost and scientific advances are captured in their practical implications.

### **CHALLENGE: *Institutional Structures***

A comprehensive response to natural hazards and climate change is often constrained by an institutional fragmentation and resulting communication barriers regarding responsibilities concerned with disaster management and climate change adaptation. This can explain in part by the different evolution of both concepts (as outlined earlier) and the resulting different policy and financing frameworks.

On a country level responsibilities concerned with disaster management, including prevention and relief, is often traditionally associated with Civil Defense, and the Ministries of Interior. Climate change policies and international exchange of information are usually serviced by the Ministries of Environment and Energy.

Similarly, disaster risk management and climate change issues within the development context are many times serviced by different departments (divisions, etc.) within bi- and multi-lateral organizations. For example, disaster management is often affiliated with infrastructure while climate change is anchored with environment. This makes sense historically as a considerable component of disaster relief efforts had to focus on reconstructing viable infrastructure. Climate change was initially regarded as an environmental problem before it was recognized in its threat to development processes.

As a result different cultures of thinking and incentive structures exist, while the focus of disaster management and climate change adapta-

tion has converged through their emphasis on risk and vulnerability reduction.

This separation is further mirrored in the international policy environment. As earlier mentioned climate change negotiations take place within the UNFCCC, which is an outcome of the 1992 UN Conference on Environment and Development Earth Summit in Rio known also as the "Earth Summit". This resulted in regular annual international conferences (Conference of Parties) and additional technical meetings aimed at developing policies, which address the threat of climate change. The Kyoto Protocol is an outcome of these meetings, and as it is now entering into force will constitute an international framework for mitigation climate change through reducing greenhouse gas emissions. The emphasis on adaptation, while recognized also in the UNFCCC, has initially gained less international attention and is only now seen as a necessary complementary (but not alternative) measure to mitigation. Usually, adaptation issues are largely attended to by the same ministerial delegates, who dealt with mitigation issues and are usually different from the ministerial staff that focuses on disaster reduction initiatives, given that policies and measures concerned with disaster management in a different international political forum. Consequently, this limited the exchange of information.

### **CHALLENGE: *Financing Frameworks***

Another outcome of the parallel evolution of the concepts of disaster risk management and climate change and the distinct policy frameworks, are different financing frameworks, which do not necessarily promote a comprehensive risk management approach that addresses multiple natural hazards *and* climate change.

Measures concerned with disaster prevention are often implemented during reconstruction efforts following a disaster. In the wake of the disaster, institutional weaknesses, lack of warning systems and issues become glaringly apparent. This was tragically illustrated in the recent tsunami, where over 160,000 people lost their lives, families and livelihoods have been destroyed and development progress has been set back. In the face of the disaster the obligation is felt by many to ensure that this does not happen again. In this context the relief efforts, the magnitude of international compassion and support in conjunction with the financial commitment to reduce the vulnerability to such hazards in the future, are heartening. Many of these regions impacted by the tsunami are vulnerable to various kinds of hazards and the compounding effects of climate change. What can be done to avoid such a range of hazards from turning into disasters in the first place or at least minimize their impact in the cases where the disaster risks are known?

There is an imbalance in the level of funding spent on natural disaster relief and reconstruction in comparison to what is spent on disaster prevention. Although many disaster management institutions have adopted a preventive approach to manage the risk of disasters some institutions have their financial resources still bound to be used only to finance relief efforts. In a recent press release UNESCO highlighted figures from its division of Basic and Engineering Science, which suggested that for every \$100 spent by the international community on risks and disasters, \$96 go to emergency relief and reconstruction, and only \$4 on prevention (UNESCO 2005). However, every dollar invest-

ed in prevention reduces the losses incurred through natural disasters by up to \$25. The absolute values have to be treated with caution since they present estimates and there will be differences on a case by case basis. However, it is important to recognize that creating incentives for disaster prevention is often associated with considerable cost savings, not to mention helps to avoid loss of life, human tragedies and suffering (not captured in economic analysis).

Rather than discussing a separate funding framework for prevention measures, it may be better to consider how incentives for integrating risk reduction measures can be strengthened within the development context, given that the reduction of risk would benefit the sustainable achievement of development objectives. Where disaster risks are known, it would make sense to integrate risk mitigating measures into development processes that influence physical and socioeconomic vulnerabilities. Yet, while the implications of disaster and climate risks for development have been recognized in the literature, these risks have not been systematically recognized and addressed in development strategies. Burton and van Aalst (2004) point out, that for example, most Poverty Reduction Strategy Papers (PRSPs) do often not recognize natural hazards, while PRSPs would provide a good stra-

tegic framework for addressing such risks (as well as climate change impacts) within the development context. The integration of disaster risk management into PRSPs and country assistance strategies is increasing, but not yet systematized.

There has been considerable support for climate change adaptation through bilateral and some multilateral initiatives. Other funding sources for climate change adaptation are linked to the UNFCCC process. A potential overlap between funding climate change adaptation and disaster prevention exists for example in the Special Climate Change Fund (SCCF), which should promote the “strengthening existing and, where needed, establishing national and regional centres and information networks for rapid response to extreme weather event, utilizing information technology as much as possible” (see [www.unfccc.int](http://www.unfccc.int), decision 5/CP.9).

Initial steps have been taken which support disaster risk management and climate change adaptation initiatives by focusing on addressing underlying vulnerabilities and the integration into development processes. There is the opportunity to maximize the resources already available by exploring inter-linkages in the existing financing frameworks through comprehensive risk management approaches.

## CONCLUSION

Climate change is happening, changing disaster risk profiles, underlying environmental socioeconomic vulnerabilities and introducing new environmental hazards that further impact on development processes.

Given the influence of development processes on vulnerabilities to current natural hazards and climate change, it is paramount that risk management takes place within the development context. At present there are institutional, political, financial and information barriers for doing so. In the discussion of the barriers the paper has pointed to some general ideas to overcome these challenges in order to create risk management approach that addresses the vulnerability to current disasters, but also *adopt a long-term planning horizon with the capacity to dynamically adapt* to changes in the exposure to climate related hazards with time.

The first step to climate change adaptation begins with addressing existing vulnerabilities to

current climatic extremes and thereby links directly with disaster risk management. Measures that reduce the impact of hurricanes and other weather related hazards on livelihoods, infrastructure and economic sectors are likely to strengthen the adaptive capacity to climate change. This is particularly the case, when likely climate changes over the life-time of the project or the envisioned impact of the project are considered. In contrast to geological disasters, it is important to ensure that current disaster prevention efforts aimed at weather related events have the built-in capacity to accommodate changes in frequency and magnitude over time.

In addition to recognizing the impact of climate change on climatic extremes, it is also important to address the more subtle, but ongoing changes in average climatic conditions and climatic variability. Such changes may not lead to disasters by themselves, but—by modulating underlying vulnerabilities—may impact on the

coping capacity of a country, economic sector or community to deal with a specific hazard. Finally, some climate change impacts will be new to a specific region and coping strategies cannot be based on previous experiences of the population and sector in that region.

Disaster risk management on the other hand goes beyond addressing weather related hazards. Hence, building a *multi-hazard approach* would allow for a more comprehensive accounting of the various risks that impact on human well being and socioeconomic development.

The converging focus of disaster risk management and climate change adaptation on addressing underlying vulnerabilities provides an opportunity for collaboration. However, such collaboration has been limited to date due to institutional barriers, different policy and financing frameworks, competing communication structures and agendas.

*Climate change adaptation and disaster risk management require similar professional expertise that captures the scientific and socioeconomic dimensions*

*of managing hazard risks and environmental change. Both issues face also the common challenge of integrating remedial measures into development processes.*

*The next step would therefore be to shift to a programmatic approach, which allows for a comprehensive communication of natural hazard and climate risks within the development process.*

With the increased focus on disaster prevention, the World Conference on Disaster Reduction presents an outstanding opportunity to call for a more comprehensive approach to risk management, which takes into account multiple hazards as well as climate change. Not recognizing these synergies means competing agendas, incompatible and complicated policy frameworks and separated communication channels. Working together means promoting development processes which can cope with current natural hazards, but also have the built-in capacity to adapt to changing risk patterns. Such enhanced cooperation will help to ensure the sustainability of efforts aimed at the alleviation of poverty and human suffering.

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## APPENDIX — OVERVIEW OF CLIMATE CHANGE IMPACTS

### **Fact Sheet: Global Climate Change**

*General Trends and Projections of global and regional climate (robust scientific findings; IPCC 2001)*

#### *Observations:*

- The earth's surface is warming. The global mean surface temperature increased by  $0.6 \pm 0.2$  °C over the 20<sup>th</sup> century; land areas warmed more than oceans.
- Globally, 1990s very likely warmest decade in instrumental record
- Most of observed warming over last 50 years likely due to increases in greenhouse gas concentrations due to human activities. Continental precipitation increased by 5-10% over the 20<sup>th</sup> century in the Northern Hemisphere, although decreased in some regions, which includes north and west Africa and parts of the Mediterranean.
- Heavy precipitation events increased in mid- and high northern latitudes.
- Increased summer drying and associated incidence of drought in a few areas. In some regions, such as parts of Asia and Africa, the frequency and intensity of droughts have been observed to increase in recent decades.

#### *Observed Changes in Biophysical systems:*

- Widespread retreat of non-polar glaciers during the 20<sup>th</sup> century
- Permafrost thawed, warmed and degraded in parts of the polar, sub-polar, and mountainous regions
- El Niño events became more frequent, persistent, and intense during the last 20 to 30 years compared to the previous 100 years
- Plant and animal ranges shifted poleward and up in elevation
- Increased frequency of coral reef bleaching, especially during El Niño events

*Model Projections:*

- Global average surface temperature during 21<sup>st</sup> century rising at rates very likely without precedent during the last 10000 years
- Nearly all land areas very likely to warm more than the global average, with more hot days and heat waves and fewer cold days and cold waves
- Rise in sea level during 21<sup>st</sup> century that will continue for further centuries
- Hydrological cycle more intense. Increase in globally averaged precipitation and more intense precipitation events very likely over many areas
- Increased summer drying and associated risk of drought likely over most mid-latitude continental interiors

*Impacts:*

- Projected climate change will have beneficial and adverse effects on both environmental and socio-economic systems, but the larger the changes and the rate of change in climate the more the adverse effects predominate
- The adverse impacts of climate change are expected to fall disproportional upon developing countries and the poor within countries
- Ecosystems and species are vulnerable to climate change and other stresses and some will be irreversibly damaged or lost
- In some mid- to high latitudes, plant productivity (trees and some agricultural crops) would increase with small increases in temperature. Plant productivity would decrease in most regions of the world for warming beyond a few °C.
- Many physical systems are vulnerable to climate change (e.g. the impact of coastal storm surges will be exacerbated by sea level rise, and glaciers and permafrost will continue to retreat).

*Implications:*

- Adaptation can complement climate change mitigation (reduction of greenhouse gas emissions) in a cost-effective strategy to reduce climate change risks; together they can contribute to sustainable development objectives.
- Adaptation has the potential to reduce adverse effects of climate change and can often produce immediate ancillary benefits, but will not prevent all damages
- Inertia in the interacting climate, ecological, and socio-economic systems is a major reason why anticipatory adaptation and mitigation actions are beneficial.

**Fact Sheet: Climate Change Effects and Impacts, Africa**

*General*

Africa is highly vulnerable to climate change (IPCC 2001). The adaptive capacity of human systems is low due to lack of economic resources and technology, and vulnerability is high as a result of heavy reliance on rain-fed agriculture, frequent droughts and floods, and poverty. Climate change is superimposed on existing climate variability and extremes and represents a growing additional challenge to efforts to alleviate poverty.

*Climatic trends and projections*

Observational records for Africa show a warming of about 0.7 °C over most of the continent during the 20<sup>th</sup>, rainfall decreased over large portions of the Sahel, while increases in rainfall were observed in east central Africa.

The project average future warming for Africa range from 0.2 °C per decade (low scenario) to more than 0.5 °C per decade (high scenario). The warming is expected to be greatest over the interior of the semi-arid margins of the Sahara and central Africa. While no clear trend in precipitation can be detected for low warming scenarios, intermediate warming scenarios suggest that by 2050 north Africa and the interior of southern Africa will experiences decreases in precipitation during the growing season. Parts of equatorial east Africa will experience increases in rainfall in December-February and decreases from June to August.

#### *Areas of concern*

Climate change has to be recognized as an issues major concern with respect to *water resources, food security, natural resources productivity and biodiversity, human health, desertification and coastal zones.*

*Information Source: IPCC 2001.*

#### *Regional Impacts of Climate Change on Africa (Source: IPCC 2001)*

##### ***Impact***

- Grain yields are projected to decrease for many scenarios, diminishing food security, particularly in small food-importing countries (medium to *high confidence*)
- Major rivers of Africa are highly sensitive to climate variation; average runoff and water availability would decrease in the Mediterranean and southern countries of Africa (medium confidence). Extension of ranges of infectious diseases would adversely affect human health in Africa (medium confidence)
- Desertification would be exacerbated by reductions in average annual rainfall, runoff, an soil moisture, especially in southern, North and West Africa (medium confidence)
- Increases in droughts, floods, and other extreme events would add to stresses on water resources, food security, human health, and infrastructures, and would constrain development in Africa (*high confidence*)
- Significant extinctions of plant and animal species are projected and would impact rural livelihoods, tourism and genetic resources (medium confidence)
- Coastal settlements in, for example, the Gulf of Guinea, Senegal, Gambia, Egypt and along the East Southern African coast would be adversely impacted by sea level rise through inundation and coastal erosion (*high confidence*)

#### **Fact Sheet: Climate Change Effects and Impacts, Latin America**

##### *General*

Latin America is already highly vulnerable to extreme climate events. As the adaptive capacity of human systems is low, climate change is likely to add an additional burden, impacting in particular on the poor.

##### *Climate observations, trends and projections*

Climatic extremes associated with the El Niño Southern Oscillation (ENSO) are responsible for a large part of observed climate variability at interannual scales in Latin America. Temperature varies depend-

ing on the different subregions. For example for northwestern South America monthly mean air temperature records show a warming of 0.5-0.8 °C for the last decade of the 20<sup>th</sup> century. Columbia also shows decreasing trends of the diurnal temperature range (difference between daily Tmax and Tmin) for the past 30-40 years. In south tropical Argentina, warming is observed during the autumn season, while in extra-tropical west South America (Chile) has varied differently during the 20<sup>th</sup> century with some parts showing an increase while others showing a decrease in mean temperatures. In general, Latin America shows important variations in temperature some of which may be connected to climate change. Future projects of the mean annual surface temperature for the Latin America region suggest an increase by 0.2-2 °C from 1990 to 2100 (B1 scenario). The projected changes in precipitation remain highly uncertain. Subregions of Latin America frequently experience extremes (hurricanes, droughts, floods; some of the extremes are strongly related to El Nino). Global warming may also exacerbate the variability in climate associated with climate phenomena that already produce important socioeconomic and environmental consequences.

#### *Areas of concern*

Climate change has to be recognized as an issue of major concern with respect to water resources, agriculture, infrastructure, biodiversity conservation and natural resource management and health.

*Information Source:* IPCC 2001.

#### *Regional Impacts of Climate change on Latin America (Source: IPCC 2001)*

##### ***Impact***

- Loss and retreat of glaciers would adversely impact runoff and water supply in areas where glacier melt is an important water source (*high confidence*)
- Floods and droughts would become more frequent with floods increasing sediment loads and degrade water quality in some areas (*high confidence*).
- Increases in intensity of tropical cyclones would alter risks to life, property and ecosystems from heavy rain, flooding, storm surges, and wind damages (*high confidence*).
- Yields of important crops are projected to decrease in many locations in Latin America, even when the effects of CO<sub>2</sub> are taken into account; subsistence farming in some regions of Latin America could be threatened (*high confidence*)
- The rate of biodiversity loss would increase (*high confidence*)
- The geographical distribution of vector borne diseases would expand poleward and to higher elevations, and exposures to diseases such as malaria, dengue fever, and cholera will increase (*medium confidence*)
- Coastal human settlements, productive activities, infrastructure, and mangrove ecosystems would be negatively affected by sea level rise (*medium confidence*)

## **Fact Sheet: Climate Change Effects and Impacts, Asia**

### *General*

Adaptive capacity of human systems low and vulnerability is high in the developing countries, while the developed countries of Asia are more able to adapt and less vulnerable.

### *Climate observations, trends and projections*

Climate differs widely in Asia ranging from the humid and cool continental climate of boreal Asia to monsoon influenced climate of tropical Asia. Rainfall in boreal Asia is highly variable on seasonal, interannual and special scales. Some increases in rainfall have been observed over recent decade. Annual mean rainfall is low in most parts of the arid and semi-arid regions of Asia. In general, temporal variability of rainfall is high. Some of these regions have shown increasing trends in rainfall, while others experienced decreases. The temporal and special variations in rainfall observed in temperate Asia are greatly influenced by the East Asian monsoon. For example, the overall annual precipitation in China has been decreasing since 1965, while the summer monsoon has become stronger in northern China during globally warmer years. Precipitation in tropical Asia often varies spatially due to microclimate created in hill and mountain ranges. A long-term decreasing trend in rainfall can be observed for Thailand. An increase in extreme rainfall events has been observed over recent decades over Northwest Asia.

Climate projections suggest an area-averaged mean annual increase in temperature of 3 °C by 2050 if compared to the present (2.5 °C if effects of aerosols are taken into account). The increase in daily minimum temperatures is projected to be more pronounced than the increase in daily maximum temperatures. Simulations suggest an enhanced hydrological cycle. Area averaged annual rainfall is projected to increase over Asia. However, decline in summer precipitation is likely for the central parts of arid and semi-arid Asia adding to already existing water stress conditions. Uncertainty remains in particular in the projections of winter and summer rainfall over south Asia, where a better understanding of the impact of climate change on the monsoon cycle is needed.

### *Areas of concern*

Asia already experiences stress on environmental and socioeconomic systems due to rapid population growth and environmental degradation. Climate change is likely to exacerbate some of these impacts. Areas of concern include water and agricultural sectors, water resources, food security, biodiversity conservation and natural resource management, coastal zone management, infrastructure.

*Information Source:* IPCC 2001.

### *Regional Impacts of Climate change on Asia (Source: IPCC 2001)*

#### *Impact*

- Extreme events have increased in tropical and temperate Asia, including droughts, floods, forest fires and tropical cyclones (*high confidence*)
- Sea-level rise and an increase in the intensity of tropical cyclones would displace tens of millions of people in low-lying coastal areas of temperate and tropical Asia; increased intensity would increase flood risks in temperate and tropical Asia (*high confidence*)
- Sea-level rise would put ecological security at risk, including mangroves and coral reefs (*high confidence*)
- Sea-level rise would exacerbate threats to biodiversity due to land-use and land-cover change and population pressure (*medium confidence*)

- Runoff and water availability may decrease in arid and semi-arid Asia, but increase in Northern Asia (medium confidence)
- Decreases in agricultural productivity and aquaculture due to thermal and water stress, sea-level rise, floods and droughts, and tropical cyclones would diminish food security in many countries of arid, tropical and temperate Asia (medium confidence)
- Agriculture would expand and increase in productivity in northern areas (medium confidence)
- Poleward movement of the southern boundary of the permafrost zones of Asia would result in a change of thermokast and thermal erosion with negative impacts on social infrastructure and industries (medium confidence)
- Human health would be threatened by possible increase exposure to vector borne diseases and heat stress in parts of Asia (medium confidence).

