WATER AND CLIMATE RISKS:

A PLEA FOR CLIMATE PROOFING OF WATER DEVELOPMENT STRATEGIES AND MEASURES

co-operative programme on water and climate

WATER AND CLIMATE RISKS:

A PLEA FOR CLIMATE PROOFING OF WATER DEVELOPMENT STRATEGIES AND MEASURES

4th World Water Forum, March 2006

Prepared by:

Hester Biemans (Wageningen University and Research Centre)[1]
Ton Bresser (UNESCO-IHE)
Henk van Schaik (Co-operative Programme on Water and Climate)
Pavel Kabat (Wageningen University and Research Centre)

March 2006

With contributions and comments by:

Paul Lucas (Netherlands Environmental Assessment Agency)
Marcus Moench (Institute for Social and Environmental Transition)
Kees Klein Goldewijk (Netherlands Environmental Assessment Agency)
Barbara Miller (World Bank)
David Gray (World Bank)
Joseph Alcamo (University of Kassel):
Ton Manders (Netherlands Environmental Assessment Agency)
Erik de Ruyter van Steveninck (UNESCO-IHE)

[1] Contact address:

Co-operative Programme on Water and Climate
Research Partnership
P.O. Box 47
6700 AA Wageningen
E-mail: Pavel.Kabat@wur.nl, Hester.Biemans@wur.nl

KEY MESSAGES

While mitigation of the sources of atmospheric greenhouse gases causing accelerated climate change continues to be a key target of climate policies, the reality is that atmospheric pollution caused by economic activities over the past century have already resulted in a process of climate change that will not be reversed for many decades to centuries, even if all additional pollution were to cease tomorrow. It therefore is essential that we take measures *today* to adapt to the inevitable impacts of climate change on water resources and water management strategies. In contribution to starting debate between water sector and climate and development policies, the Co-operative Programme on Water and Climate and associated water resource management communities conclude that

1. *Strategies for achieving the MDG's do not account for climate variability and change* (MDG-report 2005, UN[2]).

   Climate impacts on hydrological systems (IPCC, 2001[3]) and on livelihoods threaten to undo decades of development efforts. A 2003 call by Ministers and Heads of Organisations to mainstream climate impacts into planning processes for poverty reduction has yet to be heard.

2. *Climate related risks are not sufficiently considered in water sector development and management plans.*

   To meet the MDG targets substantial investments in structural (storage, control, conveyance) and non-structural (demand side management, flood plain management, service delivery, etc.) approaches to water management are required. Such investments are long term and hence should be designed in ways that reflect the risks associated with climate variability and change. Using historical / statistical data alone will not suffice when preparing for a future under climate change. Design standards and management strategies should take account of likely future changes in the hydrological cycles and climate.

3. *Investment in climate disaster risk reduction is essential.*

   The costs of disasters, especially those related to water (hydro-meteorological events: heat waves, storms, flood and droughts) are increasing. Emergency aid alone is already more than 20% of official ODA (IFRCS-World Disasters Reports[4]) and the total cost of disasters in ODA-countries is substantially larger than the assistance itself (see e.g. Thematic document Area no. 5 for the WWF4[5]). At present, policies do little to reduce the high recurrent costs of emergency aid and rehabilitation. Unless substantive efforts are

[2] The Millennium Development Goals report 2005, UN, New York
[3] Climate Change 2001. Impacts, Adaptation and Vulnerability. IPCC Working Group II
[4] International Federation of Red Cross and Red Crescent Societies (IFRC), World Disasters Reports.
[5] Risk Management, Baseline Document for Framework Theme 5, WWF4

made to mainstream climate risk reduction as part of development and post-disaster reconstruction, the recurrent costs of emergency aid will only keep increasing.

4. *The trend of increasing costs has to be reversed. This can be done through the 'Safety Chain' concept (prevention, preparation, intervention, risk spreading, recondition, reconstruction).*

   Most ODA-institutions and countries take action after disasters have occurred. The steeply rising costs of disasters necessitate action. Rather than financing relief, it is essential to think of risk management as a coherent suite of actions including prevention, preparation, intervention, risk spreading, reconditioning, and reconstruction. Although not all risks can be avoided, preventive measures should play an important role and have proven to be cost effective. In case a disaster does strike, reconstruction needs (i) an early start (to limit the period for emergency relief), (ii) continuity (to make sure that a new secure situation can be reached) and (iii) to explicitly incorporate measures that manage future risks.

5. *Coping measures need to combine a suite of technical / structural and non structural measures.*

   Structural defence or resistance type measures include dams, dikes and reservoirs. The 'no regret' principle is useful for the design of these structures. Non-structural measures include early warning, spatial planning, 'living with water', insurance, etc. The safety-chain-concept advocates a combination of both types of measures. In turn, the safety chain concept encourages economic and societal innovations and provides for investment opportunities (see e.g. Kabat et al. 2005[6])

[6] Climate Proofing the Netherlands. Nature, 2005; vol. 438, 283-284

TABLE OF CONTENTS

KEY MESSAGES 7
1 INTRODUCTION AND EXECUTIVE SUMMARY 11
2 WATER RELATED CLIMATE RISKS: A BRIEF OVERVIEW 13
3 MILLENNIUM DEVELOPMENT GOALS AND CLIMATE 19
4 CLIMATE VULNERABILITY AND DEVELOPMENT: THE AFRICAN CASE 26
5 IMPROVING THE COPING CAPACITY 30
REFERENCES 33

1 INTRODUCTION AND EXECUTIVE SUMMARY

This document intends to support and to enhance a debate about current and future climate related risks in the water sector and related economic development. Africa and Millennium Development Goals (MDG's) are used here to illustrate the potential risks associated with not adequate consideration of the effects of climate variability and change.
This report will be presented and discussed at the Fourth World Water Forum held in March 2006 in Mexico City.

At the United Nations Millennium Summit in September 2000, world leaders adopted the Millennium Development Declaration. From this Declaration emerged the Millennium Development Goals, a set of clear and quantifiable targets to address extreme poverty in its many dimensions. In its progress reports, the UN Millennium project group recognizes the risks posed by climate change and climate variability on the achievement of the goals (UN Millennium Project, 2005a-e). However, these adverse impacts are not taken into account in their key recommendations.

Integrated Water Resources Management (IWRM) is the key concept the water sector should be using for water related developments and measures, and hence for achieving the water related MDG's. However the potential impacts of climate change and increasing climate variability are not sufficiently addressed in the IWRM plans (Kabat et al, 2003; Kabat and van Schaik, 2003). In a review of IWRM plans at different levels, Ghezae (in preparation) finds that neither the IWRM handbook nor any of the IWRM national plans mentions climate change as a risk to be taken into account.

With the exception of the IPCC, most of the key international reports and assessments which are directly or indirectly targeting the water sector, such as the UN World Water Development Report, the World Water Vision and the Human Development Report, do not explicitly address and treat the risks posed by climate change. Since these global visions and strategies are often the basis for sectoral and regional strategies and Country Assistance Strategies (CAS), it is important that climate risk factors are covered in essential documents at all levels.

Some agencies, like the African Development Bank (ADB) and the World Bank, already recognise the need to prepare guidelines for climate proofing (= coping with climate variability and change) in CAS and related economic development strategies. The CAS's have to be further included into National Adaptation Programmes of Action. Only a very limited number of these plans have been prepared until now. One of the reasons is the lack of operational instruments to deal with climate change and climate variability issues. The World Bank has prepared working papers and reports on the integration of natural catastrophes into development planning (e.g. World Bank, 2002; World Bank Global Climate Change Team, 2004), in which reducing disaster vulnerability is recognized as one of the most critical challenges for development in the 21st century. However the tools to take the potential adverse effects of climate change and extreme events into account in investment planning are not yet fully operational.

In this report, we first show some examples of (global) distribution of hydro-meteorological events over the past 20 years. The losses both in terms of mortality and in terms of proportion of GDP are highest in developing countries. We illustrate that the probability of an increase in weather related extreme events like droughts, floods and cyclones will result in an increase in the costs of disasters. In Chapter 3, we discuss how climate may influence the MDG agenda. Severe climate impacts are expected mainly in the sectors agriculture (food), health and water supply for drinking and sanitation, which are all essential to meet MDG's. The absence of climate consideration in the implementation agenda for the MDG's will undermine the sustainability of MDG-investments and the operational goal of poverty alleviation. In Chapter 4, the negative impacts of climate change and climate variability on development are discussed, using the example of Africa. Here, some progress reports on MDG's frequently note the goals being affected by natural disasters. Droughts in Tanzania and flooding in Mozambique are cited as important causes for continuing high levels of rural poverty in these countries. Analysis show that recent drought and flooding events in Kenya and Mozambique had a large influence on economic growth and the damage costs amounted a considerable proportion of the annual GDP. Model estimations of the impact of historical rainfall variability on future economic growth in Ethiopia to 2015 suggest that climate variability may cause a 38 % decline in average projected GDP growth. The agricultural sector will be hit the hardest.

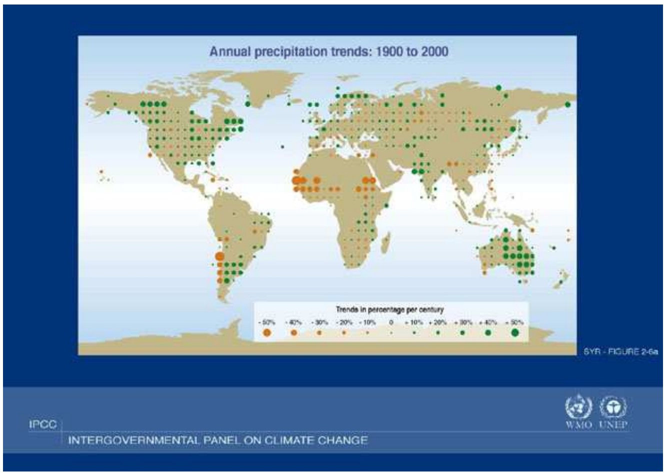
The World Disasters report states that emergency aid alone is already more than 20% of official development aid (ODA). In the view of climate change, this cost is expected to further increase. The trend of increasing emergency costs has to be reversed by increasing the preparation expenditures for preparedness. In terms of the risk management cycle this means there should be a shift in attention and money from response to preparedness. Recent studies indicate that for every $1 spent on preparing for disasters, a further $7 is saved in the cost of recovering from it.

In order to increase the coping capacity of developing countries and decrease the vulnerability to climate change, economies should be less dependent on climatic extremes, such as floods and droughts. All developed countries have a water storage capacity per capita that is much higher than in most African countries. This storage capacity can function as a buffer to absorb climatic shocks like droughts and floods.

One way of increasing resilience is implementing an integrated 'climate proofing' concept (Kabat et al, 2005). The idea of climate proofing is to combine hard infrastructure to reduce the risks to a quantified level, accepted by society or economy, with a new generation of measures towards risk management. Increasing the water storage capacity is an important component of this strategy. Successful coping measures always need to combine a suite of technical / structural and non structural measures. Non-structural measures include for example early warning, spatial planning, 'living with water', and insurance.

2 WATER RELATED CLIMATE RISKS: A BRIEF OVERVIEW

2.1 Climate change and the water cycle



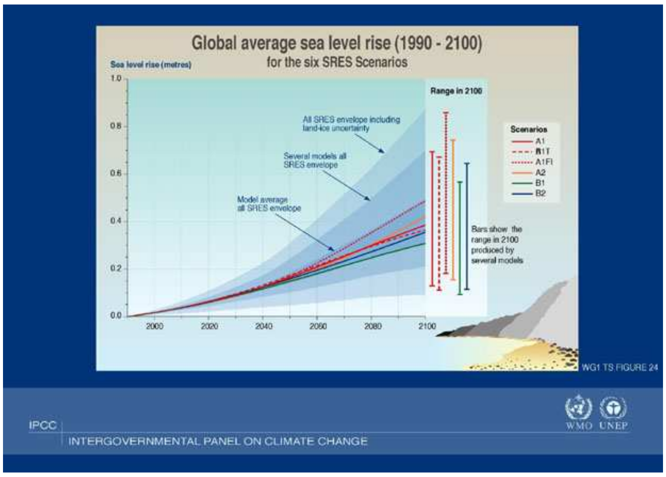


Figure 2.1 Annual precipitation trends 1990-2000 and projected global average sea level rise (1990-2100) (IPCC, 2001a)

In their third assessment report, the Intergovernmental Panel on Climate Change (IPCC) concludes that the Earth's surface is warming, average precipitation patterns are changing and global sea level rises (IPCC, 2001).

Spatial variability in the hydrological cycle and its development are large, leading to large differences between the regions, as compared to a global average. There is still relatively high uncertainty in prediction of regional climate development. Across most climate change scenarios, an increase in annual mean precipitation in high latitudes and Southeast Asia, and decreases in central Asia, the area around the Mediterranean, southern Africa and Australia is projected (IPCC, 2001).

However, climate change will not only induce a gradual change in annual means. Climate change (natural and man-made) has a significant impact on the hydrological cycle. Higher greenhouse gases concentration in the atmosphere causes changes in the energy balance on the Earth surface, resulting in a higher atmospheric temperature, and thus, according to the basics of thermodynamics, an ‘intensification’ of the hydrological cycle.

As a consequence, it is expected that climate extremes will increase substantially (e.g. Scott et al, 2004; Milly et al, 2002). Small changes in climate may have a large impact on the probability distribution of extreme weather events (floods, drought, storms) in space and time, and on the intensity of extremes (IPCC, 2001).

Recently, a number of groups and institutions analysed the occurrence of hydro-meteorological disasters and the corresponding human and economic costs posed on societies (e.g. World Bank, 2005; UNDP, 2004; IFRC, 2001). A trend in the increasing number of disasters can already be documented (see figure 2.2).

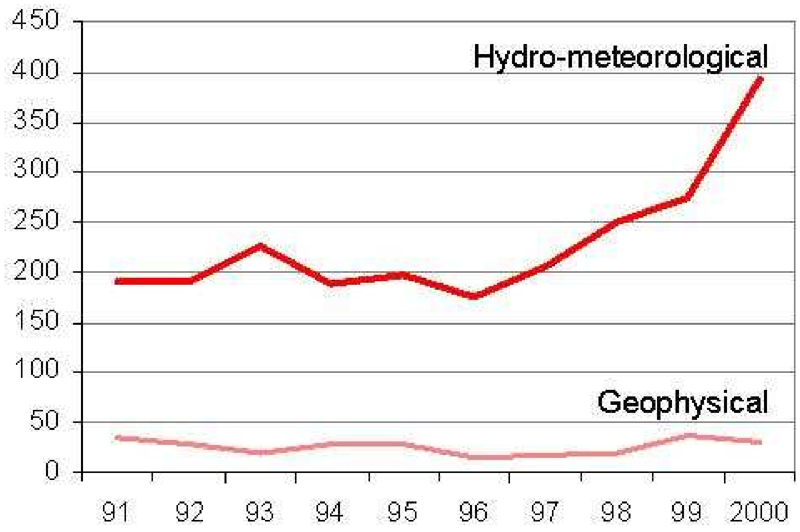


Figure 2.2 Number of disasters reported (source: IFRC, 2001)

2.2 Droughts

In a recent report, the World Bank analysed world wide reported disasters and associated economic and human life losses (World Bank, 2005). Figure 2.3 shows drought frequency and spatial distribution over a period 1980 to 2000 and can be interpreted as the current drought risk. This figure presents a count of the reported drought events, but does not consider intensity of the event

It should be noted that droughts are defined here as a *meteorological drought*, defined as a deviation from the average precipitation pattern. The consequences of hydrological droughts will then depend on regional / local circumstances (soil type, crop type, availability and depth of groundwater, water storage etc.).

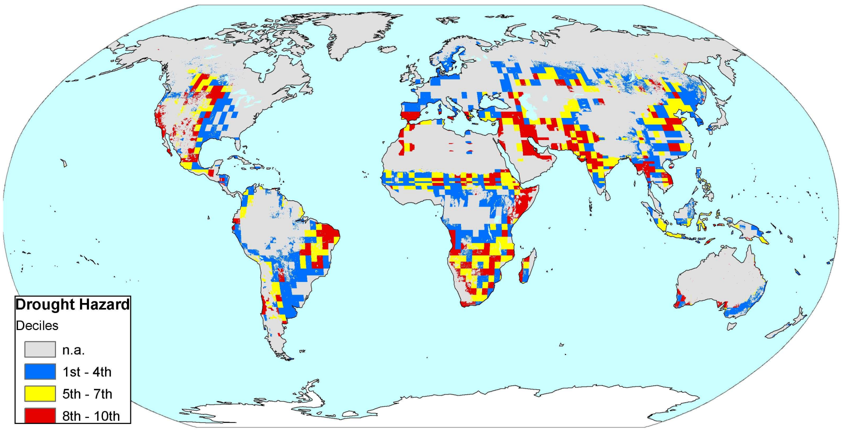


Figure 2.3 Global drought hazard frequency and distribution[7] *(World Bank, 2005)*

Climate change causes a decrease in precipitation combined with an increase in evapotranspiration and therefore enhances the drought situation in most of the regions that are already suffering. It makes already marginal areas into drought areas. Increases in agricultural intensity and population density on top of changing climate only contribute further to drought situations.

2.3 Floods

Figure 2.4 shows flood frequency and spatial distribution over the period 1985 to 2003. This figure presents a count of the reported flood events, but does not consider intensity of the event. Future climate change will influence the floods caused both by sea level rise and increased river flow discharges, and as a consequence of a higher probability and strength of torrential rainfall (especially cyclones/hurricanes).

Sea level rise at the moment is about 10-20 cm per century, but the climate change will increase the speed of absolute SLR due to thermal expansion of water at higher temperatures and the melting of glaciers and land ice. Recent global estimates show a rise of several to a number of decimetres above the 1900-level at present and up to a metre in the coming century on top of the ongoing land

[7] This 2.5 by 2.5 minute gridded data set was developed using the Weighted Anomaly of Standardized Precipitation (WASP) developed by IRI using average monthly precipitation data at 2.5 degree resolution for the time period 1980 through 2000. The WASP assessed the precipitation deficit or surplus over a specified number of months, weighted by the magnitude of the seasonal cyclic variation in precipitation. A three-month running average was applied to the precipitation data and the median rainfall for the 21-year period calculated for each grid point. A mask was applied to eliminate grid points where the three-month running average precipitation was less than 1 millimeter per day. Drought events were identified when the magnitude of a monthly precipitation deficit was less than or equal to 50 percent of its long-term median value for three or more consecutive months. The grid cells were then divided into ten classes having an approximately equal number of grid cells. Higher grid cell values denote higher frequencies of drought occurrence.

subsidence in certain areas (IPCC, 2001, see also figure 2.1). However, there are large differences between regions in relative sea level rise.

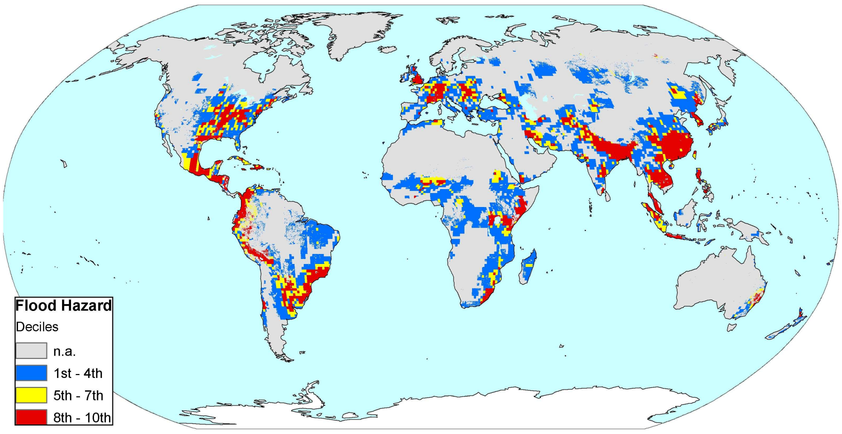


Figure 2.4 Global flood hazard frequency and distribution[8] *(World Bank, 2005)*

Several factors contribute to the increase of river floods. In almost al mountainous regions, glacier retreat is causing a decrease in snow melt, leading to a lower base flow in rivers. However, with higher temperatures winter snow melts quicker, leading to an increase in peak flows. Furthermore, almost all models predict more dynamics in rainfall patterns leading to even more pronounced peak flows in rivers. Regional climate change projections differ substantially with respect to peak rain fall, snow and glacier developments. In combination with climate drivers, changing land use will still remain to be on of the main culprits behind increased flood risks in the future.

2.4 Tropical Storms

The hazard frequency and spatial distribution of tropical cyclones between 1980 and 2000 is depicted in figure 2.5.
The influence of global warming on the occurrence and magnitude of tropical storms is subject to an ongoing scientific discussion. Webster et al. (2005) observed an increase in the number and proportion of hurricanes reaching the highest categories in the past 35 years. Emanuel (2005) has found a high correlation between the tropical sea temperature and the net destructive hurricane power dissipation. Many climate models (but not all) also predict an increase in the magnitude of tropical storms. Furthermore, with increasing sea water temperatures, the geographical area in which cyclones can develop could extend, resulting in larger coastal zones under risk.

[8] This 2.5 by 2.5 minute gridded data set was derived from a global listing of extreme flood events between 1985 and 2003 (poor or missing data in the early/mid 1990s) compiled by Dartmouth Flood Observatory and georeferenced to the nearest degree. The resultant flood frequency grid was then classified into 10 classes of approximately equal number of grid cells. The greater the grid cell value in the final data set, the higher the relative frequency of flood occurrence.

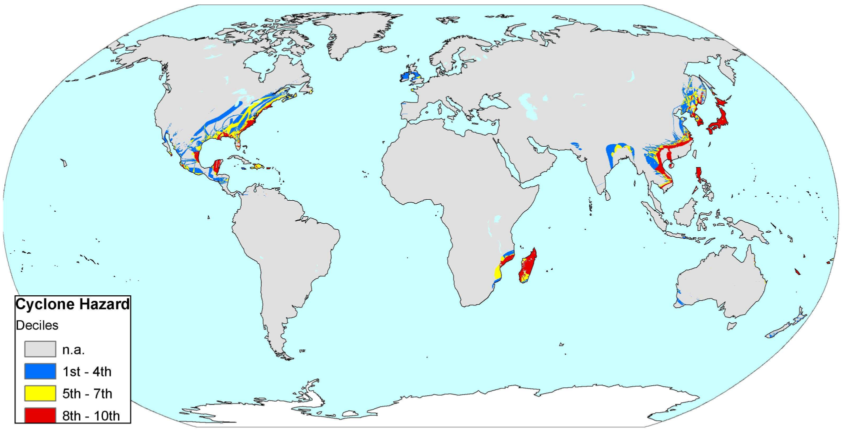


Figure 2.5 Current global cyclone hazard frequency and distribution.[9] *(World Bank, 2005)*

[9] This 2.5 by 2.5 minute gridded data set is based on more than 1,600 storm tracks for the period 1 January 1980 through 31 December 2000 for the Atlantic, Pacific, and Indian Oceans that were assembled by UNEP/GRID-Geneva PreView. Wind speeds around storm tracks were modeled to assess the grid cells likely to have been exposed to high wind levels. Post-modeling, the cells were divided into 10 classes consisting of approximately equal number of grid cells. The higher the value of the grid cell, the higher the deciles are ranking and the greater the frequency is of the hazard relative to other cells.

2.5 Overall exposure to hydro-meteorological hazards

Figure 2.6 shows (by hazard type) regions that have experienced the highest economic losses proportional to their GDP. It is clear that developing countries in Africa, the Middle East and South-East Asia have seen the largest relative economic losses in the past 20 years. We can therefore conclude that the developing countries are already the most vulnerable and will probably be hit the hardest by climate change and an increasing variability.

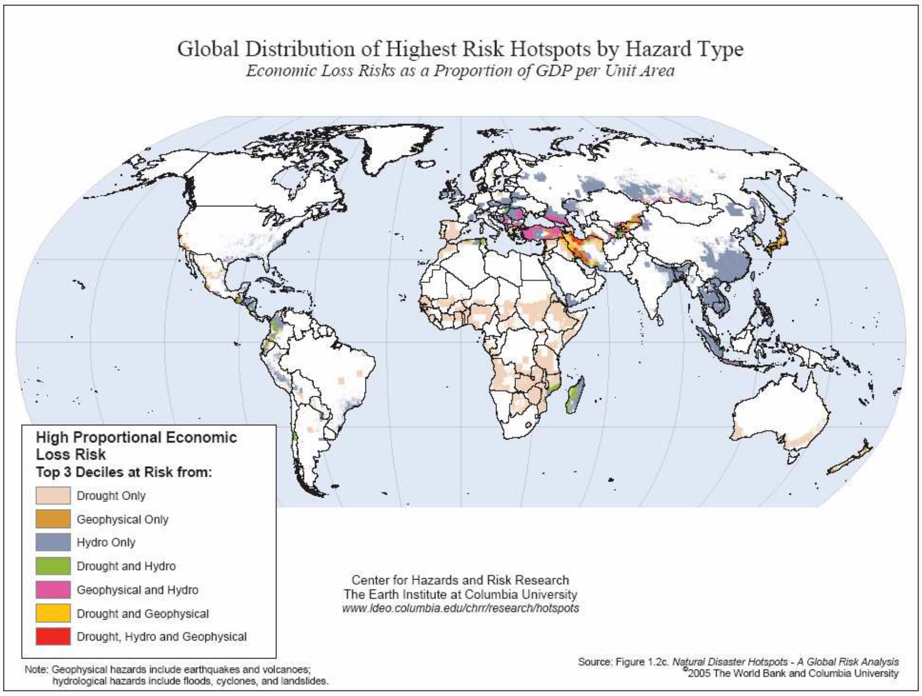


Figure 2.6 Global distribution of highest risk hotspots by hazard type (World Bank, 2005)

3 MILLENNIUM DEVELOPMENT GOALS AND CLIMATE

3.1 Water related MDG's and climate

Changes in weather patterns and extreme events only affect people if (parts of) societies are sensitive to these changes. The impact can depend on region specific situations like current water stress, water storage capacity, groundwater stock, and potential for expanding agricultural area.

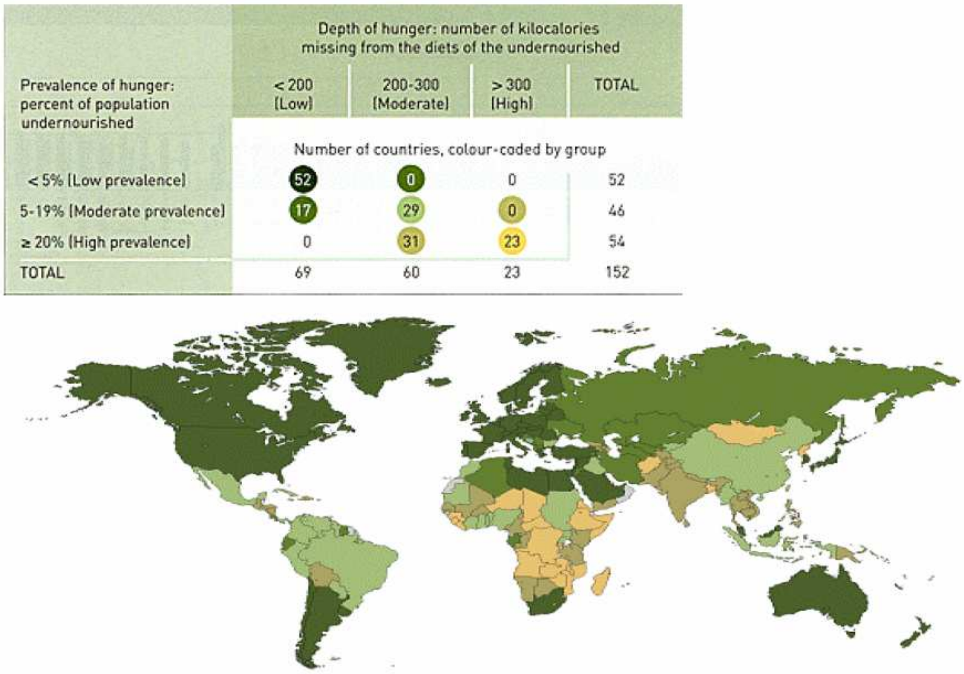
As shown in figure 2.6, climate hits developing countries hardest and can therefore threaten the achievement of the Millennium Development Goals (MDG's). Table 3.1 lists the MDG's that are specifically related to water and could be affected by climate change and increasing climate variability.

Table 3.1The Millennium Development Goals and targets which are especially sensitive to climate change and extreme events

Millennium Development Goals	**Targets for 2015**
Eradicate extreme poverty and hunger	2 Halve proportion of people who suffer from hunger
Reduce child mortality	5 Reduce by two-thirds, the under-five mortality
Improve maternal health	6 Reduce by three-quarters the maternal mortality ratio
Combat HIV/AIDS, malaria and other diseases	8 Have halted and begun to reverse the incidence of malaria and other major diseases
Ensure Environmental sustainability	9 Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources 10 Halve the proportion of people without sustainable access to safe drinking water and basic sanitation

3.2 Food

Several of the MDG's that could be affected by climate change and variability are related to nutrition and therefore require a high degree of food security. The need for food to halve hunger is obvious (target 2). However, also for reduction of the under-five mortality rate (target 5) food security is a prerequisite. Although diseases are mostly the direct cause of child mortality, proper nutrition is part of prevention Figure 3.1 shows the current state of food security in the world.



Prevalence of hunger: percent of population undernourished	Depth of hunger: number of kilocalories missing from the diets of the undernourished			
	< 200 (Low)	200-300 (Moderate)	> 300 (High)	TOTAL
	Number of countries, colour-coded by group			
< 5% (Low prevalence)	52	0	0	52
5-19% (Moderate prevalence)	17	29	0	46
≥ 20% (High prevalence)	0	31	23	54
TOTAL	69	60	23	152

Figure 3.1The degree of food deprivation, 1996-98 (source: FAO, 2000)

Relative chronic famine is on the decline. Progress however has slowed over the past several years, and the absolute number of people suffering hunger increased between 1990 and 2002 (The Millennium Development Goals Report, UN, 2005). Yet in the worst-affected regions – sub-Saharan Africa and Southern Asia – the number of people suffering hunger has increased by tens of millions. Most of the worlds hungry live in rural areas and depend on the consumptions and sale of agricultural products for both their income and their food. Hunger tends to be concentrated among the landless or among farmers whose plots are too small to provide for their needs.

Figure 3.2 shows an increase in global food crises since the 1980s. Combining the two diagrams indicates an absolute increase in food crises caused by droughts over the last 20 years.

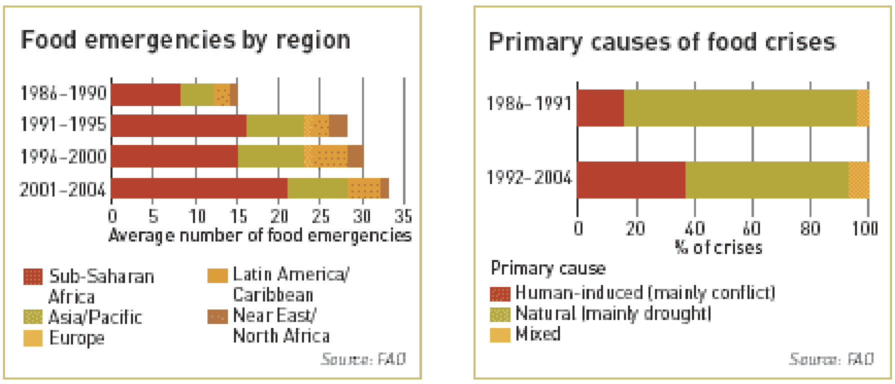


Figure 3.2 History of food emergencies by region and the primary causes of food crises.

Although the food security situation largely depends on global agricultural markets and policies, the threat of a changing climate with higher temperatures, higher potential evapotranspiration and more frequent and longer droughts in these already water-marginal areas adds to the bad prospects especially in parts of Sub-Saharan Africa and Asia.

A recent study at the effects of average climate change on global food production shows a slight to moderate (0 to 5%) negative impact on simulated world crop yields, even with beneficial direct effects of CO_2 and farm-level adaptations. This means that under a growing world population, food insecurity will increase (Fisher et al., 2002).
What is more concerning is that the impact of climate change on food security varies significantly by region, and is likely to increase the disparities in cereal yields between developed and developing countries (Parry et al, 2004). According to the IPCC (2001), crop yields are projected to decrease in most tropical and subtropical regions due to changes in temperature and rainfall. Figure 3.3 shows the climate change implications for rain-fed cereals as calculated by Fisher et al (2002). As in Africa the share of rain fed agriculture is relatively high; food security in this continent is particularly vulnerable to climatic changes.

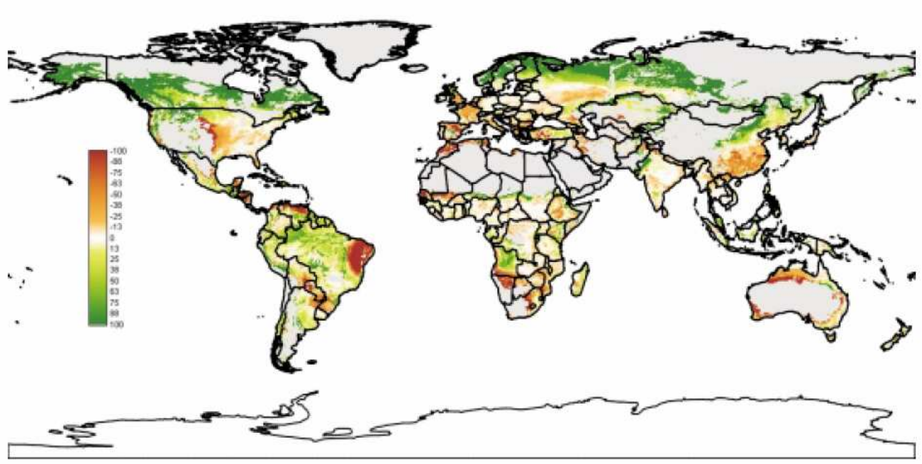


Figure 3.3 Climate change implications for rain fed cereals (Had3-A1Fl, 2080s) (Fisher et al, 2002)

However, not only average climate change will have an effect on food security; extremes and especially droughts have an even more pronounced effect. With severe drought events in row or multiple years, consecutive droughts likely to increase as a result of climate change at least in certain regions, crop failure risk becomes higher, especially for rain fed agriculture.

The effect of floods on food security is less straightforward. On the one hand, river floods are necessary in many regions to maintain soil fertility by depositing fertile sediments. On the other hand, floods can have devastating effects on crop growth. Low-lying coastal areas will have to deal with sea level rise and storm levels. These may lead to coastal flooding and salinization and render agriculture areas unproductive for a number of years. River floods can devastate crops and wash away fertile grounds.

The impact of tropical storms on food production is limited to relatively small regions. The frequency of severe damage is rather low and most of the time the damage is only temporarily, unless the storm is accompanied by a severe flood.

3.3 Malaria

Malaria is one of the world's most serious and complex public health problems. Forcing back the prevalence and death rate of malaria is a direct target under the Millennium Development Goals (target 8). However, also to reach other targets malaria needs to decrease. Child mortality and maternal mortality (target 5 and 6) are directly influenced by the occurrence of malaria, because these groups are particularly susceptible to this disease (Sperling, 2003). In fact anaemia, resulting from malaria, is responsible for a quarter of maternal mortality (Sperling, 2003).

The global distribution of malaria prevalence is estimated by Snow et al (2005). They estimated 515 million episodes of malaria in 2002. The highest malaria risk is in Sub-Saharan Africa, where most of the area currently has an infection prevalence of 50% or more. Most areas on the Indian subcontinent and in South East Asia have an infection prevalence of 11% to 50% (Snow et al, 2005). Ninety percent of the 1 million malaria deaths each year occur in sub Saharan Africa (UN, 2005).

Malaria has been identified as a disease most likely to be affected by climate change (WHO/WMO/UNEP, 2003). Countries that are at greatest risk from malaria owing to climate change are those at the fringes of its current distribution, particularly where malaria control programs have broken down (e.g. in central Asia and Eastern Europe). Figure 3.4 shows the potential malaria transmission changes for 2020 (Martens et al, 1999). Environmental conditions are already so favourable for malaria transmission in tropical African countries that climate change is unlikely to affect overall mortality and morbidity rates in hyper endemic lowland regions. The new vulnerable areas are those where transmission is currently limited mainly by temperature in highland areas, such as in East Africa.

The most recent modelling of climate change effects on malaria indicates that the global population at risk of malaria would increase by an extra 260-320 million people in the 2080s (Martens et al., 1999). These models also project a widespread increase in the seasonal duration of transmission in current and potential new areas.

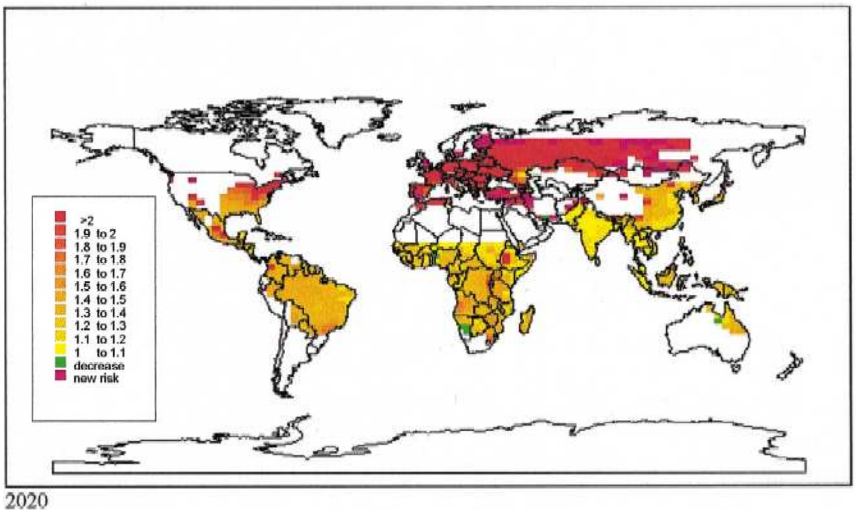


Figure 3.4 Potential malaria transmission changes for the 2020s due to climate change, compared to the baseline(1961-1990), due to the HadCM3 climate change scenario (based on monthly mean temperature and precipitation) (Martens et al., 1999).

3.4 Drinking water supply and sanitation

Improve the access to clean drinking water and sanitation is a target under the Millennium Development Goals (target 10). Clean drinking water however is also a prerequisite for the reduction of the under-five mortality rate (target 5) and the maternal mortality rate (target 6), because clean water is essential in the prevention of diseases. Contaminated water is the main cause of diarrhoea and the occurrence of this disease is therefore directly related to the access to improved water and sanitation. The conservation of environmental resources (target 9) also requires sufficient water supplies.
According to the WHO/UNICEF (2000) rural populations generally have a lower access level to both water supply and sanitation than urban populations. In Africa, the rural water supply is lowest with only 47% covered. Latin America has rural water supply coverage of 62% and in Asia it is 75%. The urban water supply coverage only varies from 85% in Africa to 100% in Northern America and Europe. For sanitation the rural coverage is lowest in Asia with 31%. Africa has rural sanitation coverage of 45% and in Latin America it is 49%. The urban sanitation coverage varies between 78% in Asia to 100% in Northern America.

The risk of poor quantity and quality of drinking water and sanitation increases with more extreme climatic conditions. The sensitivity with respect to health risks is mainly dependent on alternatives and coping potential available to people. A gradual decrease of available water due to climate change, combined with an increase in population and water use per capita, in areas with already marginal water resources, makes people more sensitive to (extreme) events and shortfall of supply. In rich countries emergency drinking water supply can be organised (bottled water) and people can afford it. In most developing countries this is not an option. Therefore long term planning of drinking water supply is necessary, taking into account the changing resources and growing water demands but also taking into account climate change and variability.
'Western style' sanitation is a large water consumer. Shortage of water will have consequences for transport and treatment possibilities of waste water, leading to environmental and health hazards. Adaptation to changing conditions might include consideration of different sanitation options that depend less on water supply (Bos et al, 2004).

3.5 Overall vulnerability of water resources: a global picture

Climate change is already underway and it is putting development goals for food, health and drinking water at risk. Water stress occurs where competition for water results in higher water demands as compared to water availability. Although agriculture is the dominant user of water, it is important to note that water quality requirements are different for all sectors and that the impact of shortages on domestic use will be more critical than for agriculture (Kabat en van Schaik, 2003). Hot spots for risks of not meeting water demand for agriculture, industry and domestic use are calculated by e.g. Alcamo et al. (2002), figure 3.5. This analysis compared the change in water withdrawals caused by socio-economic changes, with the change in water availability, caused by long-term average changes in precipitation and temperature due to climate change. The influence of extreme events is not accounted for in this analysis.

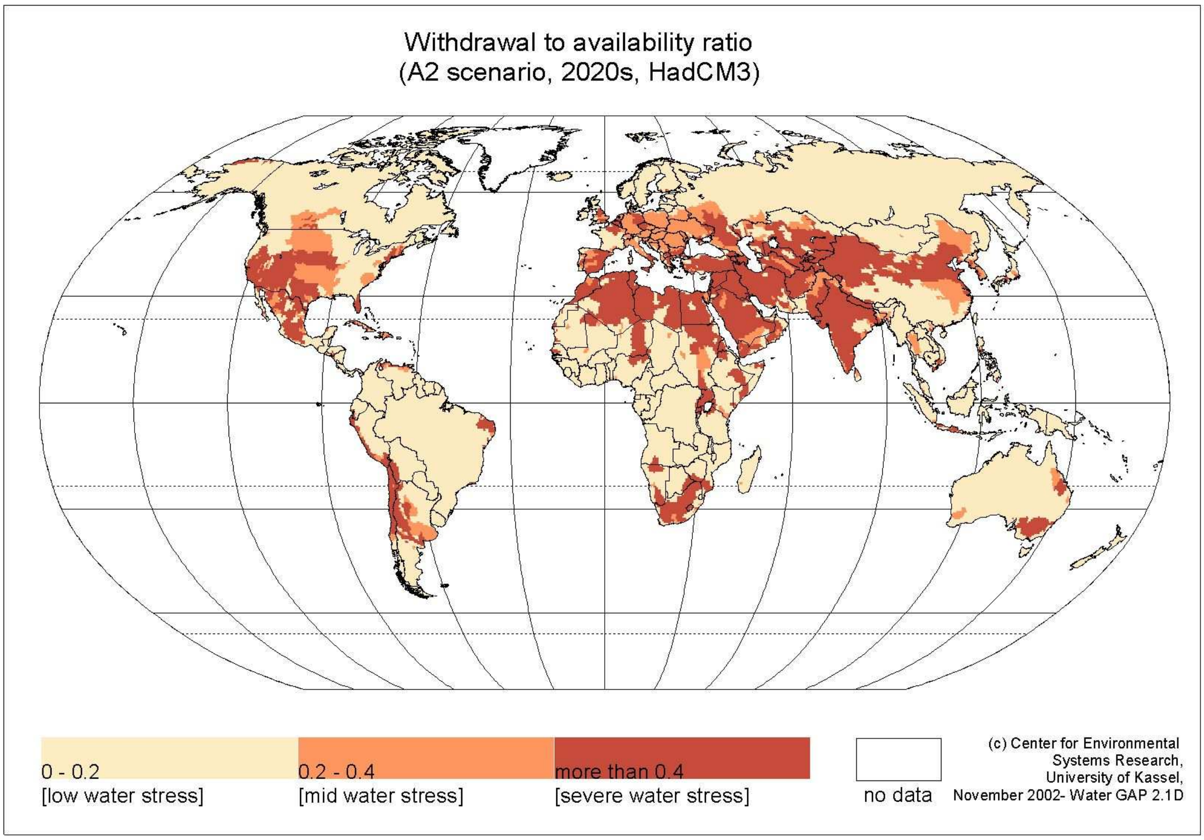


Figure 3.5 Water to availability ratio (water stress index) in the 2020's as a result of combined effects of climate change and socio-economical development (Alcamo et al., 2002)

Besides the geographical locations of areas under risk, the number of people involved is an important aspect to look at. Parry et al (2001) estimated the additional numbers of people at risk globally due to climate change in the 2050's and the 2080's. A distinction is made between risk of water shortage, risk of malaria, risk of hunger and risk of coastal flooding (see figure 3.6).

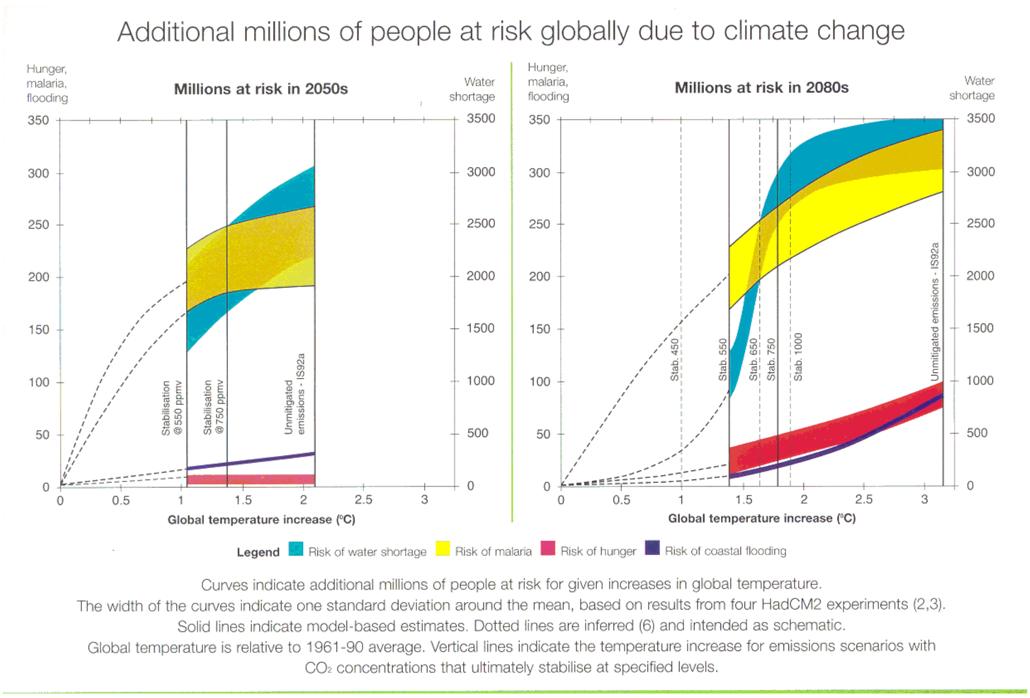


Figure 3.6 Source: Parry et al. (2001)

4 CLIMATE VULNERABILITY AND DEVELOPMENT: THE AFRICAN CASE

In this section we use the African case to illustrate that the increasing climatic hazards and associated economic costs negatively affect the targets of the countries towards the MDG's, and that these negative impacts are currently not sufficiently taken into account in the MDG agenda and in related economic development plans.

4.1 Disaster risk and climate in Africa

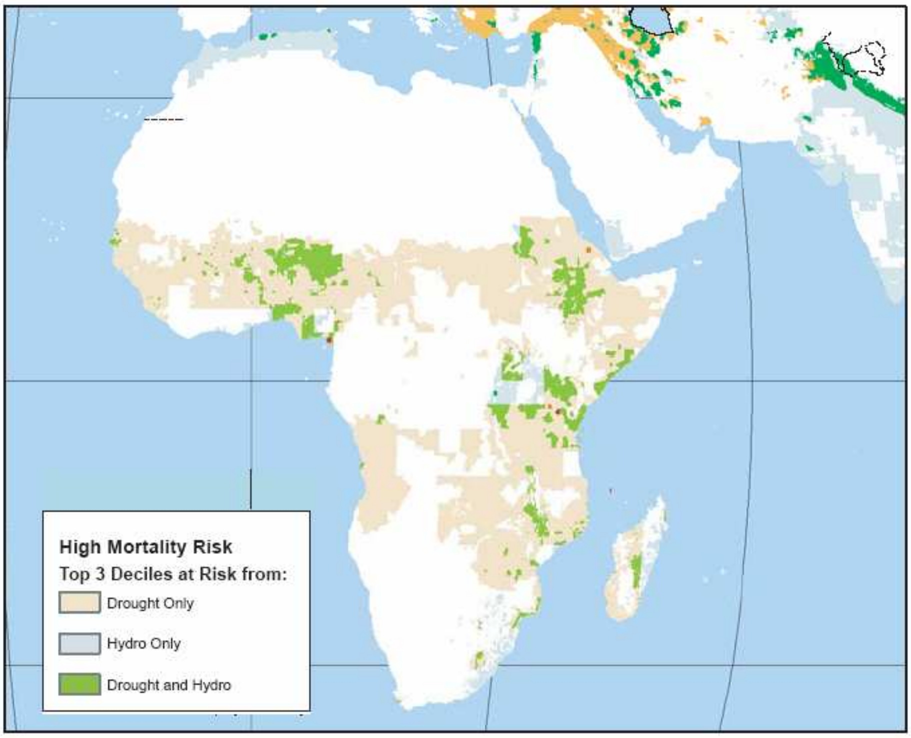


Figure 4.1 Regions with the highest global mortality numbers for droughts, floods and cyclones (World Bank, 2005)

Analysis on past disaster records shows that disaster related mortality numbers (measured between 1980 and 2000) for hydro meteorological events in Africa are amongst the highest in the world (figure 4.1).

This picture may get worse. Climate projections for Africa suggest that land areas may warm by as much as 1.6°C over the Sahara and semi-arid parts of southern Africa by 2050. Equatorial countries (Cameroon, Uganda, and Kenya) might be about 1.4°C warmer. Sea-surface temperatures in the open tropical oceans surrounding Africa will rise by less than the global average (i.e., only about 0.6-0.8°C); the coastal regions of the continent therefore will warm more slowly than the continental interior. In southern Africa and parts of the Horn of Africa, rainfall is projected to decline by about

10% by 2050. All of these changes could increase the drought frequency. Changes in sea level of about 25 cm might be expected by the year 2050 (IPCC, 1997; IPCC, 2001).

4.2 Impacts on development

Hydro-meteorological disasters impact on different aspects of development, as shown in chapter 2. Impacts can be felt directly (for example trough the loss of life, crops, livelihoods or infrastructure), but also indirectly (for example through the transfer of funds from development to humanitarian aid or wider effects on economy and society) (DFID, 2005).

The economic impacts of disasters can put a huge constrain on economic growth. According to Pak Sum Low (2005), 1993-2002 totals of economic losses due to disasters in this region derived from the EM-DAT database were US$ 424 million for droughts and famine, US$ 1109 million for floods and US$ 841 for windstorms. Although these numbers are not likely to be very accurate, they give some idea of the size of economic impacts on the continent's developing countries.
Another, arguably more accurate estimates are available for Africa at country level. For example, the government of Mozambique shows that the 1999/2000 floods slowed annual economic growth from 9% to 5.4% between 1999 and 2000 (table 4.1).

Table 4.1 Economic impacts of climate variability in Mozambique

	Actual		**Projection**			
			Before the floods		**After the floods**	
	1998	**1999**	**2000**	**2001**	**2000**	**2001**
Real GDP (ann. Growth rate)	12,0	9,0	7,0	7,2	5,4	7,9
Inflation (ann. Average, %)	0,6	2,0	6,6	5,0	9,5	5,0
External current account:						
Before grants	-20,5	-31,7	-23,0	-15,7	-31,5	-18,4
After grants	-1,.4	-21,5	-16,3	-9,1	-19,7	-11,0
Fiscal Balance:						
Before grants	-10,7	-12,1	-12,1	-10,7	-16,0	-11,5
After grants	-2,4	-1,2	-5,2	-4,4	-7,0	-5,1
Memorandum: **(GDP (Mt billion)**	46.134	52.913	60.177	67.790	61.471	69.673

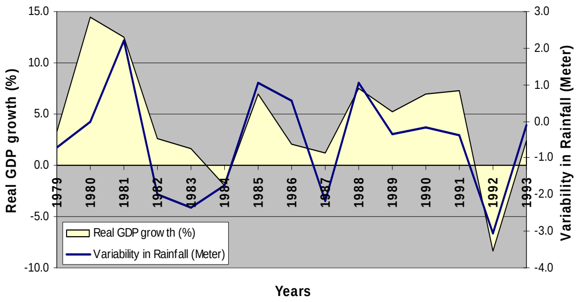
Source: Staff estimates, IMF and Government of Mozambique

Floods and droughts experienced in Kenya due the climate variability associated with a sequence of El-Nino and La Nina period 1997 – 2000 cost the economy an average of 22% of GDP per year over a 2.5-year period. See table 4.2.

Table 4.2 Economic impact of climate variability in Kenya

10/97-02/98 flood	Infrastructure damage		$ 2.39b
10/98-05/00 drought	Crop loss	$ 0.24b	
	Livestock loss	$ 0.14b	
	Reduce. HP production	$ 0.64b	
	Reduce. Industry. Production	$ 1.39b	
	Total		$ 2.41b
10/97-05/00	Cost of climate variability		$ 4.8 b
	Approx. (annual) GDP	($ 9b/yr)	$ 22 b
	Impact as % GDP/annum		**22%**

African natural heritage is a large seasonal and inter-annual variability in rainfall. Most African countries are mainly depending on rainfall for their water supply. The correlation between rainfall variability and GDP growth is therefore strong, as shown for example in Zimbabwe and Ethiopia (see figure 4.2). This correlation explains why the African economies are to such a large extent vulnerable to climatic extremes.



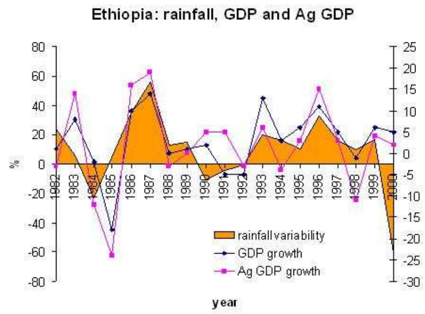


Figure 4.2 Correlation between rainfall and economic growth for Zimbabwe (left) and Ethiopia (right) (after D.Grey and World Bank)

In another analysis the historical (measured) levels of rainfall variability are used to estimate impacts on future GDP growth rates for Ethiopia (figure 4.3). When historical levels of variability are assumed, the average decline in average projected GDP growth is 38%; in agricultural GDP growth the decline is even estimated 40%.

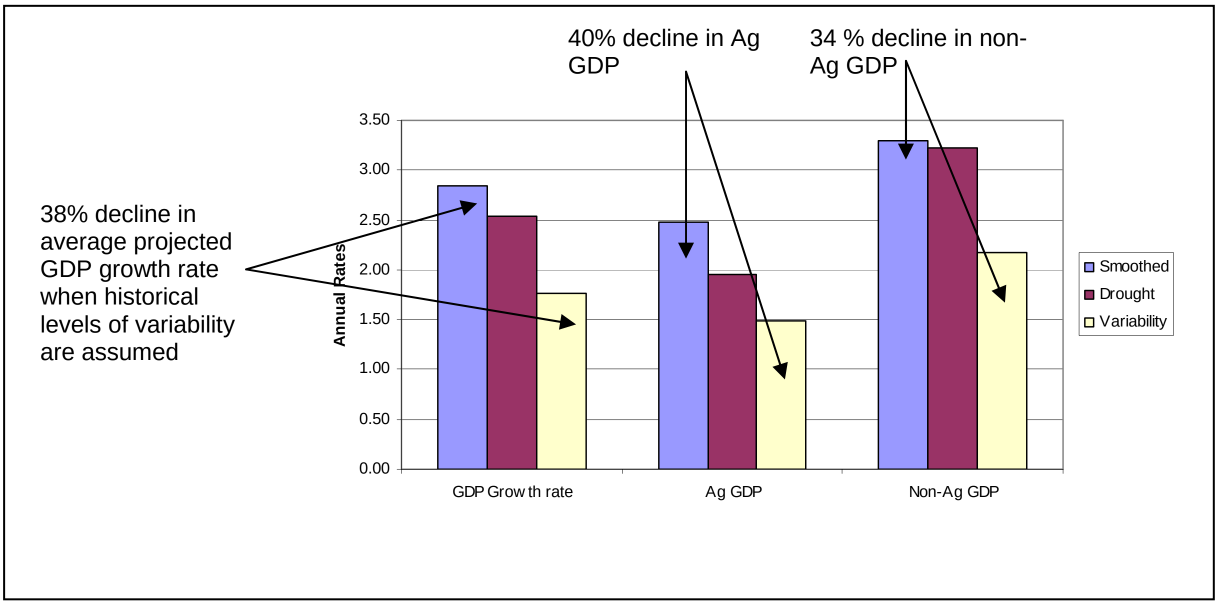


Figure 4.3 Impact of historical levels of variability on2003-2015 economic growth projections for Ethiopia. (After D. Grey and World Bank)

Country progress reports on MDG's frequently note progress on MDG's being affected by disasters. Droughts in Tanzania and flooding in Mozambique are cited as part causes for continuing high levels of rural poverty in these countries (DFID, 2005).

5 IMPROVING THE COPING CAPACITY

Despite of mounting evidence about the impacts that climate can have on development, coping with the potential impact of extreme climatic events on economic growth is not explicitly on the development agenda. Climate risks are not taken sufficiently into account in development programs to achieve the MDG's like Poverty Reduction Strategy Papers or Country Assistance Strategies. Also in the Handbook for Integrated Water Resources Management (IWRM) (GWP, 2004), climate risks are not mentioned. Ghezae (in preparation) reviewed several IWRM plans and concludes that none of those plans mention climate risks to be taken into account. When searching through projects reports (e.g. several WB project evaluations), climate risks are often not mentioned at all and sustainability of the project is only interpreted as institutional continuity.

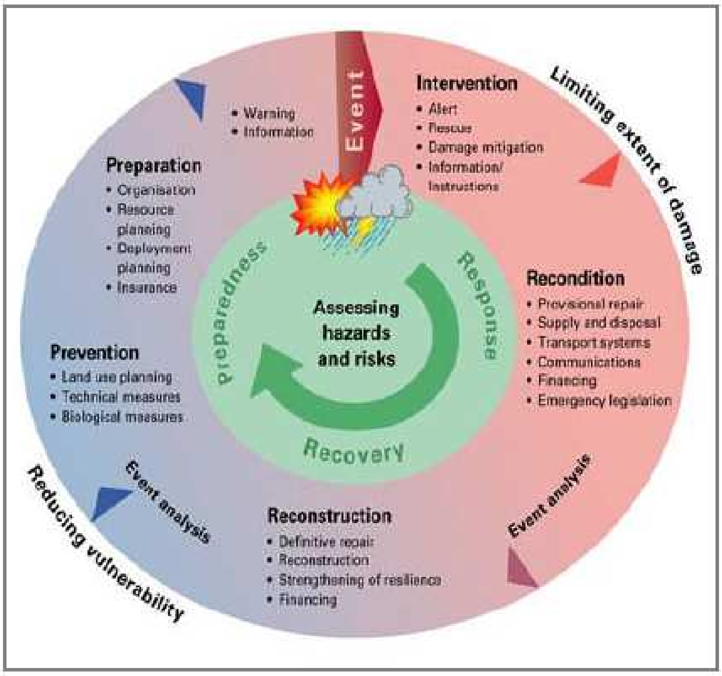


Figure 4.4 Risk management cycle (Source: Swiss civil protection)

In developing countries a structural disaster prevention therefore still remains relatively under-funded by donor countries, resulting in an unjustifiable overemphasis on a post-disaster aid (only). For example, six months before the Mozambique flood disaster of 2000, its government appealed to the international community for $2.7 million dollar to prepare for the floods. It received less than half of this amount. After the floods came, Mozambique received $100 million on emergency assistance and a pledge of $450 million for recovery (Simms and Reid, 2005).

Recent studies indicate that for every $1 spent on preparing for disasters, a further $7 is saved in the cost of recovering from it (Simms and Reid, 2005). Therefore, a lot of money can be saved by adequately taking disaster risks into account when planning development.

In terms of risk management cycle (Fig. 4.4), this would imply a partial shift in attention in the safety chain concept (figure 4.4) from response to preparedness.

As shown in this document, economies in many African countries are much tied to rainfall variability and are for that reason very dependent on climate. To be able to meet the MDG's, it is therefore essential to de-link rainfall from economic growth. In high-income countries like the Netherlands, billions of dollars are spent in reducing disaster risks and adapting to climate (for example Kabat et al, 2005). These countries have invested in water infrastructure[10] and increased their storage capacity to be able to buffer climatic shocks (figure 4.5). Water storage is a coping strategy for variability and should be increased to be able to meet the MDG's.

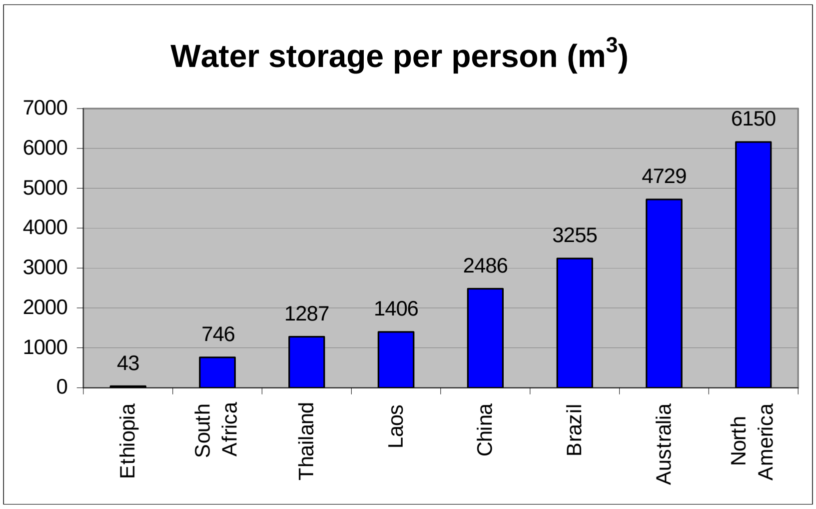


Figure 4.5 Water storage per person in developing and developed countries (World Bank)

[10] Water infrastructure can be either man-made (dams, inter-basin transfers, irrigation, water supply etc.) or natural (watersheds, lakes, aquifers, wetlands, etc) (Theme document Water for Growth and Development)

REFERENCES

Alcamo, J., M. Märker, M. Flörke, S. Vassolo, 2002. Preliminary Findings from Assessing Global Climate Impacts on Water Resources and Hot Spot Regions. Center for Environmental Systems Research, University of Kassel. *Interim Report of the project Global Analysis and Global Information for the Dialogue on Water and Climate (WAT-CLIM).* Kassel, Germany

Bos, J.J. ; H.J. Gijzen; H.B.M. Hilderink; M. Moussa; L.W. Niessen ; E.D. de Ruyter van Steveninck, 2004. Quick scan health benefits and costs of water supply and sanitation. National Institute for Public Health and the Environment. Bilthoven, The Netherlands.

DFID, 2005. Disaster risk reduction: a development concern. A scoping study on links between disaster risk reduction, poverty and development. Department for International Development. London, UK

Emanuel, K., 2005. Increasing destructiveness of tropical cyclones over the past 30 years. Nature, vol 436, pp. 686-688

FAO, 2000. The State of Food Insecurity in the World: when people live with hunger and fear starvation, Food and Agriculture Organisation of the United Nations, Rome, Italy.

Fisher, G., M. Shah and H. van Velthuizen, 2002. Climate Change and Agricultural Vulnerability. IIASA, Laxenburg, Austria.

Ghezae, N. (in preparation). IWRM and climate adaptation in selected African countries.

GWP, 2004. Catalizing Change: A handbook for developing integrated resources management (IWRM) and water efficiency strategies. Global Water Partnership Technical Committee. Stockholm, Sweden.

IFRC, 2001. World Disasters Report 2001. International Federation of Red Cross and Red Crescent Societies. Geneva, Switzerland

IPCC, 1997. The Regional Impacts of Climate Change: An Assessment of Vulnerability. Summary for Policy Makers. Geneva, Switzerland.

IPCC, 2001. Climate Change 2001. Impacts, Adaptation and Vulnerability. IPCC Working group II.

IPCC, 2001a. Climate Change 2001. Synthesis Report (+ web site www.ipcc.ch)

Kabat P, P. Vellinga, W. Van Vierssen, J. Veraart and J. Aerts, 2005. Climate proofing of the Netherlands. Nature, Vol.438, 283-284

Kabat, P, and H. van Schaik, (co-ordinating lead authors), 2003. Climate changes the water rules: How water managers can cope with today's climate variability and tomorrow's climate change. 120 p, ISBN 90-327-0321

Kabat, P, P,Gleick, J.Alcamo, R.E.Schultze, H.van Schaik and C, Jacobs, 2006. Managing Water Resources under Changing Climate. Climatic Change, Special Issue / 2 Volumes/32 papers (in preparation)

Kabat, P; R.E. Schulze, M.E. Hellmuth, J.A. Veraart and Roberto Lenton, 2003. Climate Variability and Change and Freshwater Water Management. International Review for Environmental Strategies 3(2): 294-302

Martens, P., S. Kovats, S. Nijhof, P. de Vries, M.T.J. Livermore, D.J. Bradley, J. Cox and A.J. McMichael, 1999. Global Environmental Change, Volume 9, pp. 89-107(19).

Milly, P.C.D., Wetherald, R.T., Dunne K.a. and Delworth, T.L., 2002. Increasing risk of great floods in a changing climate Nature 415, 514-517

Pak Sum Low (ed), 2005. Climate Change and Africa. Cambridge University Press. UK.

Parry, M., N. Arnell, T. McMichael, R. Nicholls, P. Martens, S. Kovats, M. Livermore, C. Rosenzweig, A. Iglesias and G. Fischer, 2001. Millions at risk: defining critical climate change threats and targets. Global Environmental Change, vol 11, pp. 181-183

Parry, M.L., C. Rosenzweig, A. Iglesias, M. Livermore and G. Fischer, 2004. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environmental Change, vol 14, pp. 53-67

Scott, P.A, Stone D.A. and Allen, M.R., 2004. Human contribution to the European heatwave of 2003 Nature 432, 610- 613

Simms, A. and H. Reid, 2005. Africa – Up in smoke? The second report from the Working Group on Climate Change and Development. International Institute for Environment and Development. London, UK.

Snow, R.W., C.A. Guerra, A.M. Noor, H.Y. Myint and S.I Hay, 2005. The global distribution of clinical episodes of Plasmodium falciparum malaria. Nature, vol 434, pp 214-217

Sperling, F. (ed.), 2003. Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation. Inter-agency report by the African Development Bank (AfDB), Asian Development Bank (ADB), Department for International Development (DFID, UK), Federal Ministry for Economic Cooperation and Development (BMZ, Germany), Ministry of Foreign Affairs - Development Cooperation (DGIS, The Netherlands), Organisation for Economic Cooperation and Development (OECD), United Nations Development Programme (UNDP), United Nations Environment Program (UNEP), and the World Bank.

UN Millennium Project, 2005a. Investing in Development: A Practical Plan to Achieve the Millennium Development Goals. New York

UN Millennium Project, 2005b. Environment and Human Well-Being: A Practical Strategy. Summary Version of the report of the Task Force on Environmental Sustainability. The Earth Institute at Columbia University, New York, USA.

UN Millennium Project, 2005c. Environment and Human Well-Being: A Practical Strategy. Report of the Task Force on Environmental Sustainability. The Earth Institute at Columbia University, New York, USA.

UN Millennium Project, 2005d. Halving Hunger: it can be done. Summary Version of the Task Force on Hunger. The Earth Institute at Columbia University, New York, USA

UN Millennium Project, 2005e. Health, Dignity, and Development: What Will it Take? Task Force on Water and Sanitation.

UN, 2005. The Millennium Development Goals Report 2005. United Nations, New York.

UNDP, 2004. Reducing Disaster Risk: A Challenge for Development. A global report.

Webster, P.J., G.J. Holland, J.A. Curry, H.R. Chang, 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science, vol 309, pp 1844-1846.

WHO/UNICEF, 2000. Global Water Supply and Sanitation Assessment 2000 Report. ISBN 92 4 1562021

WHO/WMO/UNEP, 2003. Climate change and human health: Risk and Responses. Summary. World Health Organization.

World Bank Global Climate Change Team, 2004. An Adaptation Mosaic: A Sample of the Emerging World Bank Work in Climate Change Adaptation. New York.

World Bank, 2002. Catastrophes and Development: Integrating Natural Catastrophes into Development Planning.

World Bank, 2005. Natural Disaster Hotspots: A global risk analysis. World Bank. Washington, D.C., U.S.A.