dialogue on water and climate

First “White” (Position) Paper

VERSION 28-02-02

Editors Kabat and all lead authors

Contributing authors: *(lead authors in italics)*
T.D. Mitchell, T. Allan, E.Stakhiv, E. van Beek, M.Acreman, J. Alcamo, R. Connor, C.Figueres, P.Kabat, W.Cosgrove, H.Hoff**,** J.M. Fritsch, J.Aerts, H.Savenije, A.Y. Hoekstra, C. Pahl-Wostl, R.Schulze, J.Rockstrom, R. Boers, J.Veraart, R. Feddes, G. Können, Z. Kundzewich, T.Bucx, A. Tuinhof, A. Sonoski, , H.van Schaik, C. van de Guchte, Donald Boyd, M.Helmer, M.Maksimovic, R.Hafkenscheid, J.Francis, F. Kansiime, P. Balabanis, T.Bresser, K.Dorland, C.Jaeger, J.Kwadijk, J.Rasmussen, (additional contributors)

Colophon

Editors		Pavel Kabat (p.Kabat@Alterra.wag-ur.nl)
	:	Tel +31 (0)317 474314 / Fax +31 317 419000
		Jeroen Veraart (j.a.veraart@alterra.wag-ur.nl
	:	Tel. +31 (0)317 474447
Secretariat IS-DWC	:	Henk van Schaik (hvs@ihe.nl), Tel 015 215 1882
Version/date	:	Draft 2, 04-002-2002
Document name	:	Whitepaper_v040202_LayJV1

Contents

Preface

In many parts of the world, variability in climate conditions is already having major impacts. These impacts are many, and the link to water management problems is obvious and profound. Variability is already observed to be increasing. Floods, droughts and other extreme climate events, such as hurricanes, add to the major problems water managers' face from population growth, urbanisation and land use changes. Every year they inflict severe damage on humans and the environment in many parts of the world, although there are 'hot spots' where the frequency of occurrence is greater and the devastation more severe. We can do little to control the timing and intensity of such events in the short term. Emissions control measures being adopted will help in the long term but we can increase our capacity to cope, if we have the knowledge to do so.

Box 0.1, Key Issues in relation to climate & Water in Third assessment of IPCC (2001)

"*Climate change will lead to an intensification of the global hydrological cycle and can have major impacts on regional water resources, affecting both ground and surface water supply for domestic and industrial uses, irrigation, hydropower generation, navigation, in-stream ecosystems and water-based recreation. Changes in the total amount of precipitation and in its frequency and intensity directly affect the magnitude and timing of runoff and the intensity of floods and droughts; however, at present, specific regional effects are uncertain".*

"The impacts of climate change will depend on the baseline condition of the water supply system and the ability of water resource managers to respond not only to climate change but also to population growth and changes in demands, technology, and economic, social and legislative conditions. In some cases - particularly in wealthier countries with integrated water-management systems - improved management may protect water users from climate change at minimal cost; in many others, however, there could be substantial economic, social and environmental costs, particularly in regions that already are water-limited and where there is considerable competition among users."

(Intergovernmental Panel on Climate Change (IPCC), 2001)

Both present variability and long-term climate change impacts are most severe in the developing world, and particularly affect the poor, the segment of society least able to buffer itself against impacts. The vulnerabilities that climate variability and change create are in consequence a key issue in any poverty reduction programme. The impacts are widespread, but there are hot spots where they are particularly severe: countries, regions and communities where the capacity to cope with and adapt to climate variability will affect their overall development prospects.

The implications of climate variability and climate change have not been fully considered in current water policy and decision-making frameworks. This is particularly true in developing countries, where the financial, human and ecological impacts are potentially greatest, and where water resources may be already highly stressed but the capacity to cope is weakest.

At a meeting in Delft at the end of November 2001, about 50 hydrologists, climate scientists and water managers discussed the issues. A summary of the most important issues and recommendations is reflected in this “white” position paper.

The International Dialogue on Water and Climate is a platform that bridges the information gaps between the water and climate sectors to improve our capacity to cope with the impacts on water of increasing climate variability and change.

Following on the main themes elaborated in the Dialogue “white” position paper, the goal of the Dialogue is to develop a knowledge base, generate widespread awareness, identify policy and management options that build such capacities, learn from the experience of all, and make this knowledge available to the most affected communities.

There are already several regional and international initiatives underway that focus on various aspects of water resources management. By co-operating with these, the Dialogue on Water and Climate will seek to raise greater awareness of the issues relating climate vulnerability to water resources management, and to set in motion a political process designed to bridge policy gaps. The Dialogue itself will have different components where the water resource managers and climate scientist communities will be engaged in a process to build confidence and understanding, identify options and define strategies applicable at regional, national and river basin levels. The outcome will be policies and actions that create conditions where more effective coping and adaptation mechanisms for dealing with water and climate vulnerability are developed and applied at the international, national, and community levels.

Summary of the Key Issues addressed by the White Paper

The nature of the problem

- Even without climate change, most developing countries will be confronted with serious water problems by the middle of the century.

- For water managers in developing countries, the impacts of changes in climate appear minor compared to the problems they are facing already. Population growth, urbanisation, land use changes and other drivers are causing lack of access to water, over-abstraction, pollution, and drying up of rivers and wetlands. Addressing climate change impacts would direct attention away from where it is really needed.

- No non-OECD country can presently afford actions to deal with the impact of climate change on water resources. At best, only actions that directly address the immediate water management problems are affordable. So let's forget about climate change and water and focus on the real and immediate issues.

- Climate is becoming more variable through intensification of hydrologic processes caused by global warming. The overall number and intensity of water related disasters have increased and will increase significantly in the future. Increased climate variability and climate change will exacerbate vulnerability of water resources because of poor resource management practices.

- The poor of the world are most vulnerable to the impacts of climate variability and change on water, but they have the least capacity to cope.

- Small islands and coastal zones are highly threatened by both extreme events and sea level rise. In view of the irreversibility of sea level rise during our lifetime and in that of future generations, adaptation is the only option.

- Climate variability and change have been identified as key drivers of ecosystem health and the growth and spreading of water-related diseases.

- As the largest contributor to anthropogenic climate change, the North puts an additional burden on management of water resources in the South.

- Coping with present-day climate variability would take us a long way down the road towards coping with climate change.

What can be done in water management?

- There is an impressive catalogue of specific management measures that water managers routinely use to adapt to climate variability, which will also serve adaptation to climate change. However, a single and universal remedy does not exist.

- Integrated Water Resources Management (IWRM) and Integrated Coastal Zone Management (ICZM) are prerequisites for adapting to contemporary climate variability and encompass a wide range of accepted water management practices that will readily serve adaptation to climate change. In addition to IWRM and ICZM, a paradigm shift is required in water management strategies towards “living with floods and droughts”.
- Although long-term climate scenarios cannot meet the needs of today's water managers, short and medium term weather and climate forecasts have improved considerably. Improving short-term forecasting (3,15 and 90-day) is the single largest technological breakthrough that will improve our adaptive capacity

The political and institutional dimension…

- The political and institutional dimension is the most critical element in coping with climate variability and climate change in water resources management.

- The world's political leadership, with the support of international financing agencies, should invest in capacity building in the South to help mitigating the impacts of climate variability and change.

The role of the private sector…

- The future of some private sector groups, like (re) insurance, transportation or agriculture, could be particularly affected by climate change. Private sectors that traditionally have not cared about water resources management should envisage the effects of climate change in the near future. The effects will not always be negative. New business opportunities will emerge.

- The impacts of climate change on crop production and food security are alarming. They must be considered in the next trade negotiations under the WTO.

- Biotechnological advances to improve crop yields and tolerance to aridity and saline water, coupled with climate and weather forecasting will bring the biggest payoffs for a "no regrets" strategy of adaptation

- Opportunities exist for innovative approaches to financing the required doubling of investments in water infrastructure and environmental protection.

1 State of the Art in science about Water and Climate

"What we know about water and climate"

The status of current scientific knowledge examining the linkages between climate variability and change and water resources management, including weather and climate forecasting tools, hydrological models, extreme events (floods and droughts) and scenario analysis

Lead author: Timothy D. Mitchell
Tyndall Centre for Climate Change Research, ENV, UEA, Norwich, NR4 7BL, UK
t.mitchell@uea.ac.uk, 01603 593904

Contributing authors:

Reinout Boers	KNMI	boers@knmi.nl
Reinder Feddes	Wageningen	reinder.feddes@users.whh.wau.nl
Jean-Marie Fritsch	ORSTOM, WMO	fritsch_j@gateway.wmo.ch
Holger Hoff	PIK	holger.hoff@pik-potsdam.de
Pavel Kabat	Wageningen	p.kabat@alterra.wag-ur.nl
Günther Können	KNMI	konnen@knmi.nl
Zbigniew Kundzewich	Poznan, PIK	kundzewich@yahoo.com

Summary[TDM1][TDM2]

Key statements for the summary key issues up-front

- For some regions we are **observing increases** in magnitude and frequency of extreme events.
- **Future extremes** will be much more severe than what we have seen up to now
- **Current** capacity on short to medium term forecasts for water management is not enough used in many parts of the world.
- Expectations of water managers in terms of spatial and temporal resolution of climate scenarios for **future** water resources will not be met.
- A **new dialogue** is required to mediate between climate community and water managers, including e.g. risk analysis, assimilation of meteorological and hydrological data etc. for predictions.
- A **paradigm shift** is required towards "living with floods and droughts"

1.1 Introduction

Purpose of chapter I is to describe:

„Water resources in a climate context with emphasis on extremes"
or
„Water management in a climate context emphasising resources and extremes"

Persuasion and honesty must mark this description.

We are not rewriting the IPCC, but:
- summarising their findings for people who will never read the IPCC summary report
- building upon the IPCC assessment

In aiming to make the chapter comprehensible to water managers, we aim to make it comprehensible to all stakeholders.

By selecting from the literature (particularly the IPCC), we introduce the concepts and key facts (on water and climate) that will be addressed in the white paper, aiming at water resource managers.

Chapter 1 will select concepts and key facts, addressing water resource managers
*
Focus on / starting from „real world problems" / societal relevant issues

* Focus on vulnerable regions (talking in general terms, using examples where possible, and referring to the hot spots chapter for further examples); the examples will ideally be of areas under both present and future stress, from both climatic and socio-economic sources
* Foci on current state (past to present) and future development (emphasising the contrast between linear and non-linear change),
including
gradual changes, abrupt changes (noting that abrupt does not mean instantaneous, and the difficulties in prediction), and thresholds

Express the idea of selecting examples that explain

- key processes
- key concepts
- key facts

Societies are becoming increasingly vulnerable to droughts and water deficits. There is a significant increase in losses caused by extreme hydrological events due to the soaring anthropogenic pressure. Massive deforestation, urbanisation and river regulation reduce the available water storage capacity and amplify flood waves. Water runs off faster to the sea, yet may be acutely missed in a period of low flows and droughts. The rapid growth of industry and service in Asia during the 1990s resulted in a considerable change of land use pattern. In Thailand for example, it caused a reduction of natural retention and over-bank storage in the lower Chao Phraya river basin, contributing to the downstream flooding by about 3,000 m^3/s.

Mechanisms of climate change and variability are intimately interwoven with the more direct anthropogenic pressures. Scenarios for future climates indicate the possibility of amplifying the water-related extremes. Observations confirm that atmospheric moisture is increasing in many places of the warming planet. The reason is that the atmosphere's capacity to absorb moisture, and thus its absolute water content, increases with temperature. Thus, the potential for intensive precipitation, and likewise floods, is also increasing.

Adverse effects have already been observed in water-related extremes linked to climatic variability. The frequency and intensity of El Niño–Southern Oscillation (ENSO) have been unusual since the mid 1970s, when compared with those of the previous 100 years. Warm phase o ENSO episodes have become more frequent, persistent and intense. During this El Niño phase, extreme water-related events occur more frequently - intensive precipitation (and floods) in some locations and precipitation deficits and droughts in other regions.

1.2 Issues for water

Focus on water-related extreme events for their societal relevance
(Not much evidence for change in the extremes, but poss. in the vulnerability to extremes)

Other extremes, such as hurricanes, landslides, heat waves etc will be mentioned

Why do they matter, what data do we have / need (why?), what tools and methods do we have / how can we use it?

Issues to be addressed under the „water and climate“ heading: health, food, ecosystems *etc.*

Past to present data and data gaps (on climate variability and hydrological and water resources variability, including land use, population...),
Future: models (GCMs, regional models), downscaling, scenarios, risk analysis etc
including honest assessment of scientific ability to reproduce the „real world problems“

Include not only negative effects, but also potential positive effects of climate variability and change on water resources.

Water-related extreme events: floods and droughts. General considerations about why they matter?

- The risk is likely to grow in the 21st century: a century of water scarcity, while flood losses also show a rising tendency
- Increasing vulnerability to water-related disasters is due to growing exposure, which in many cases cannot be matched by an appropriate adaptive capacity. Recent climate variability and change seems to have adversely affected flood and drought hazard in several areas and this tendency is likely to continue. Water-related extremes hit the most vulnerable settlements: rural ones, concentrated in fertile river deltas and scattered around big towns in less developing countries,

1.2.1 Floods

Why do floods matter?

For millennia, people have settled in floodplains in order to till fertile soils,

- use the flat terrain for settlements,
- have easy and safe access to water,
- use the river for transport.

Floods are natural phenomena: they have always occurred and people have tried to benefit from them to the extent possible.

However, in recent decades humans have become more exposed to the risk of floods. Different pressures have combined to increase population density in flood-prone areas:

- economic development of flood-prone areas;
- shortage of land cause encroachment into floodplains,
- The mushrooming of informal settlements in endangered zones around mega-cities in developing countries. Hopes to overcome poverty drives poor people to migrate,

frequently into places vulnerable to flooding and where effective flood protection is not assured. In fact, in many countries such places are left uninhabited on purpose, exactly because they are flood-prone.

Thus in recent years floods have affected large numbers of people – more than 100 million people a year on average. In 1990-1996 there were six floods, in each of which the number of fatalities exceeded 1000 and 22 floods with losses exceeding 1 billion USD each. According to the Red Cross, floods in 1971-1995 affected more than 1.5 billion people world-wide. This total includes 318,000 killed and over 81 million homeless (IFRCRCS, 1997).

Floods have become more and more disastrous for:

- human health (*e.g.* the increased spreading of diseases such as diarrhoea or Leptospirosis in flooded areas),
- settlements and infrastructure,
- coastal areas,
- financial services (incl. insurance and reinsurance),
- transport,
- water supply,
- agriculture,
- ecosystems.

What do we know from the past?

Berz (2001) examined inter-decadal variability of great flood disasters, understood as those where the ability of the region to help itself is distinctly overtaxed, making international or interregional assistance necessary. Based on the data for the period 1950-1998, presented by Berz (2001), one could state that the number of great flood disasters has grown considerably world-wide in the past decades (six cases in the 1950s, seven in the 1960s, eight in the 1970s, 18 in the 1980s, and 26 in the 1990s). The number of great flood disasters in the last decade was higher than in the three decades 1950-1979.

In 1990s, there have been over two dozen flood disasters world-wide in each of which either the material losses exceeded one billion US dollars or the number of fatalities was greater than one thousand, or both. In the most disastrous storm surge flood in Bangladesh, during two days in April 1991, 140, 000 people were killed. The highest material losses, of the order of 30 and 26.5 billion US dollars, were recorded in China in the 1996 and 1998 floods, respectively.

As far as the geographic distribution of most disastrous floods is concerned, the majority of recent large floods have occurred in countries of Asia. Yet, few countries world-wide are, indeed, free of flood danger. Even countries located in dry areas, such as Yemen, Egypt and Tunisia have not been flood-safe. It is counter-intuitive that in dry areas, more people may die of floods than from lack of water, as the dryness is a normal state to which humans have adapted, while floods strike suddenly unprepared populations.

Although water-related extremes strike developed and less developed countries alike, their consequences are largely different. In developed countries, the material flood losses continue to grow, while the number of fatalities decreases. Advanced flood preparedness systems can save lives - the fatality toll in developed countries is far less than in the less developed ones. For catastrophic floods in developing countries, material losses per one fatality can be as low as 21 thousand USD, while in developed countries they can go up to 400 million USD.

Precipitation is a critical component in causing floods, and the location, form, amount, and intensity of precipitation is changing. During the 20th century precipitation has increased in many areas, by between 0.5 and 1.0% per decade over much of mid- and high latitudes of the Northern Hemisphere. In regions where the total precipitation has increased, there have been even more pronounced increases in heavy and extreme precipitation events. Moreover, increases in intense precipitation have been documented even in those regions where the total precipitation has decreased or remained constant. However, one has to be careful with generalisations: some regions have shown decreases in precipitation and precipitation intensity.

Changes in runoff are generally more difficult to detect generally. Nonetheless, increasing number of large floods has been observed and increasing flood damages in several areas, e.g., the US. Changed seasonality of floods has been detected. It has partly to do with earlier flow maxima following milder winters and El Nino state becoming more persistent. However, it would be a gross over-simplification to state that floods have exhibited growing trends everywhere. Greenhouse signals found in some river flow data have not been confirmed in other works. The time series of flood data show a complex response (due to other, non-climatic factors), the behaviour of which is not necessarily in tune with gross climate-related prognostications.

The costs of extreme weather events have exhibited a rapid upward trend in recent decades and yearly economic losses from large events have increased ten-fold between 1950s and 1990s. A part of the observed upward trend in weather disaster losses is linked to socio-economic factors, such as increases in population and wealth as well as developing settlements in vulnerable areas. However, these factors alone cannot explain the observed growth. A part of losses is linked to climatic factors, such as the observed changes in precipitation.

Pielke & Downton (2000) studied the rates of change in flood characteristics and socio-economic indicators in the USA for the time period from 1932 to 1997. They found that the total annual flood damage, adjusted for inflation, has grown at an average rate of 2.92% per year, that is more strongly than population (+1.26%) and tangible wealth per capita (in inflation-adjusted dollars +1.85%).

The increase of flood damages is evident in many regions. For example, the statistics of flood damage maintained by the Department of Public Welfare and the Department of Local Administration for the years 1978 to 1997 in the provincial areas of Thailand show a clearly increasing trend.

Table 1.1, Increase of flood damage between 1978 and 1997 in Thailand (Source: ???)

Year	1978	1979	1980	1981	1982	1983	1984	1985	1986
Damage Value	21	3	1,549	314	224	1,104	321	350	628
Year	1987	1988	1989	1990	1991	1992	1993	1994	1995
Damage Value	832	7,54	11,739	6,652	2,620	5,240	2,181	45	11,558

Unit : million Baht (1US$ = 26 Baht then)

Box 1.1, Example of flooding: the Odra / Oder flood of 1997 (Source Kundzewicz et al., 1999)

One of the most devastating recent floods in Europe was the July 1997 flood on the Odra (Oder in German), the international river whose drainage basin is shared by the Czech Republic, the Republic of Poland and the Federal Republic of Germany. The flood, caused by a sequence of intensive and long-lasting precipitation, reached disastrous levels in terms of both river stage/discharge and consequences.

From the hydrological point of view, the Odra flood was a very rare event with return period in some river cross-sections of the order of several hundred years or more. In large parts of the region in which the flood originated, the July values of precipitation were more than 300 % of the monthly mean, in the mountainous areas even more than 400 % (Malitz, 1999). In Racibórz-Miedonia, on the Polish stretch of the Upper Odra, water reached the culmination stage over two meters higher than the maximum observed to date and the corresponding flow was about twice higher than the historical record. When moving downstream, the flood became less intense. However, even in several downstream river reaches, the peak discharge exceeded return periods of 100 years. The summer of 1997 flood on the Oder lasted several weeks. Even the exceedance of historical absolute maximum water levels persisted up to 16 days.

The number of flood fatalities in Czech Republic and Poland reached 114 (Grünewald et al., 1998). In all three riparian countries, and the economic losses were immense, though, there is a very high uncertainty in quantifying the economic losses. The values range between 0.55 and 2.2 billion US$ in the Czech Republic, between 2.5 and 4.0 billion US$ in Poland and between 0.3 and 0.7 billion US$ in Germany.
Since for several years before 1997 only minor floods had occurred in Poland, the awareness and preparedness of the nation was largely inadequate (Kundzewicz et al., 1999). The structural flood defences, for several larger towns upon the Odra and its tributaries and for vast areas of agricultural land, proved to be dramatically inadequate for such a rare flood. Flood defences, designed for smaller, more common floods, fail when exposed to a much higher pressure.

Organisation was also a weak point, especially in the beginning of the flood. Legislation was inadequate; e. g. financial aspects and division of responsibilities and competence. As a result, regional and local authorities were uncertain as to their share in the decision making (with financial implications).

The upsides were accelerated awareness raising and generation of national solidarity. Combating the flood at the Polish reach of the Lower Odra was a real success story. The impression of disorder gradually decreased. Indeed, if a surprise of such an extraordinary scale occurs, time is needed to adapt.

An analysis of the course of the flood and related damages clearly shows up the necessity for a series of flood protection and management strategies in all three riparian countries (Bronstert et al; 2000). They include the creation of increased water retention potential in the river network system, measures to reduce and delay flood runoff generation and operational needs such as an improved and transboundary flood forecasting system. Research needs comprise an inter-disciplinary perspective of flooding, including human factors. Finally, it should be emphasised that a change of people's view towards a culture that lives with risks needs political initiatives and related, long-term conceptions.

Box 1.2, Example of flooding: the Southern Africa / Mozambique flood of 2000

In the beginning of February 2000, torrential rains of return periods in excess of 200 years in places poured over parts of Southeast Africa (Smithers et al., 2001). The combination of the two cyclonic systems and high levels of antecedent soil moisture from a wet early summer resulted in extraordinary flooding. Mozambique has been most severely affected, but other countries in the region such as South Africa, Zambia, Zimbabwe, Botswana, Swaziland and Madagascar also suffered. Mozambique experienced the biggest flood ever known in the history of that country. A year later, in February 2001 Mozambique once again faced a flood disaster, while still suffering from the effects of previous year's devastating floods.

The damage in 2000 was catastrophic: whole villages covered by water, entire crops destroyed, arable land rendered unusable for the next three years, people seeking refuge on roofs of houses and tree tops. Whole sections of main roads were also washed away isolating many towns and villages, including Maputo, the capital city. The disaster left 700 people dead and half a million homeless. According to the UN World Food Programme, Mozambique lost at least a third of the staple maize crop and 80 percent of its cattle. A quarter of the country's agriculture has been damaged.

The 2001 flood disaster carried away thousands of homes, inundated vast areas of farmland. At least 400,000 have been affected, with more than 40 people killed and 77000 rendered homeless.

During and after the catastrophic flood of 2000, it became clear that as well as food and medicine, availability of clean water is a critical issue. The threat of diseases, malnutrition and lack of clean water after the flood cause a higher death toll than that directly by the flood. That implies that besides the direct assistance during the inundation it is most important to start with the post-flood aid as early as possible. Here, international aid started late (with the exception of that from the Republic of South Africa), as the international press coverage on the flood was initially scanty. The heavy rainfall began on February 3, inundations already started on February 9, but there were no major press reports in, e.g. the USA until March 1.

An expert workshop organised by the Mozambique government, the preparatory secretariat of the 3rd World Water Forum and the IAHR (3rd WWF, 2000) listed the required actions for an improved flood mitigation of the southern African catchments. This list includes the pledge for an improved hydrological observation network, well balanced non-structural and structural measures, and an integrated approach for flood management, including the involvement of the local people and the establishment of regional river boards for the international river basins in that region.

What do we expect for the future?

There are a number of possible reasons why the frequency of floods may increase in the future in any particular region:

- more frequent wet spells in mid / high latitude winters,
- more intense mid-latitude storms,
- more El Niño-like mean state of El Niño-Southern Oscillation (ENSO),
- an increased frequency of extreme precipitation events,
- an increased magnitude of precipitation events of high intensity,
- land-use change and surface degradation (e.g. deforestation, urbanisation).

How reliable is our information?

Assessment of precipitation information.

There has been broad spatial coverage of river flow data in general, yet the spatial coverage is far from being uniform. There is a dearth of data from catchments where the human impacts have been truly minimal. Long time series of records of river flow and other hydrological data are urgently needed (including proxy data).

Progress is needed in development of a toolbox for trend detection - allowing one to disentangle climatic and other drivers in flood data. This is, in general, a very difficult task, as there are problems with data, and with methodology.

How do we prepare for the future?

Flood protection measures can be structural or non-structural. Structural measures include: dams;

- flood control reservoirs (constructing reservoirs where the excess water can be stored allows a regulated temporal distribution of streamflow and helps alleviate the flood problem by flattening flood peaks);
- dikes.

Non-structural measures include:

- zoning (*i.e.* regulation for flood hazard areas development leaving flood plains with low-value infrastructure);
- forecasting systems (for warning, evacuation, relief and post-flood recovery);
- flood insurance (*i.e.* division of risks and losses among a higher number of people over a long time);
- capacity building (improving flood awareness, understanding and preparedness);

enhancing participatory approaches.

Forecasting systems hold considerable promise for the future, and may be divided into:

- Short-term forecasts (*e.g.* for flash floods) require use of high technology (remote sensing), which could give a basis for quantitative precipitation forecasts.
- medium-term forecasts include information on snow cover and the use of climatological seasonal forecasts
- long-term forecasts need to be developed for designing flood protection systems.

It is important to rectify common misconceptions about floods, such as:

- floods occur at semi-regular intervals;
- the future will be similar to the past.

1.2.2 Droughts

Why do droughts matter?

Droughts often have multiple adverse consequences:

- people starve,
- people lack basic hygiene and suffer from diseases,
- people are forced to migrate (*e.g.* to the big cities),
- regions cannot develop,
- poverty cannot be overcome.

Such effects depend on both:

- a lack of moisture, from a lack of precipitation or from a lack of available soil moisture or groundwater,
- the inability of humans or ecosystems to cope with the lack of moisture.

Semi-arid to arid regions generally have strong climate variability (temporal and spatial) and hence have to cope with extremely dry situations on a frequent basis. Future climate changes are expected to change the frequency, severity, and location of droughts. However, in addition to climate variability and climate change, socio-economic changes are generally increasing vulnerability of particular populations to drought:

- population growth,
- increasing demand for water per capita,
- loss of traditional knowledge and practices adapted to the risk of drought,
- urbanisation.

What do we know from the past?

Droughts have occurred in many places around the world. In the developing world they often bring extremes of human suffering; we particularly note:

- Afghanistan/Pakistan/India,
- Middle East,
- Sahel,
- North-East Brazil.

It is the poor who suffer most from droughts. Yet it is the poor countries and the poorest within countries who often:

- do not have the capacity to adapt,
- are not in a position to influence the mitigation of anthropogenic climate change.

This raises issues of equity.

It is worth noting that political factors often exacerbate the problem:

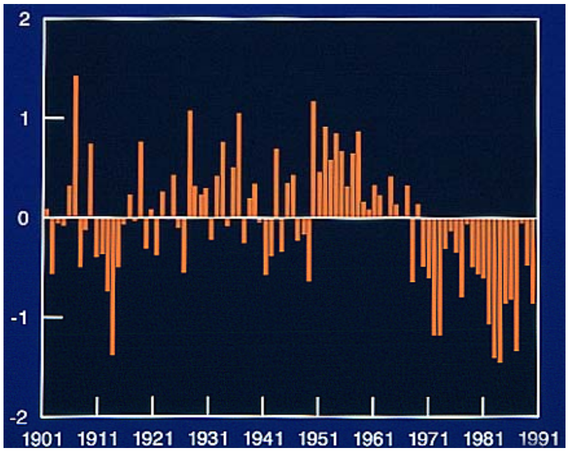
- political priorities do not always favour adaptation options such as demand side management;
- national self sufficiency in food production is a strong priority;

- many water resources (surface and groundwater) are transboundary and give rise to the possibility of conflicts over water allocation and use.

Even in developed countries, an extreme drought may cause considerable disturbances: environmental, economic and social losses. It is assessed that the 1988 drought in the USA may have caused direct agricultural loss of 13 billion US$. The more recent 1998-9 drought affected the eastern region of the country and the vegetative period in 1999 was the driest on record for four states.

We also know that some droughts have been man-made. An extreme example comes from the Aral Sea basin where, due to excessive water withdrawals from the tributaries Syr Darya and Amu Darya, the Aral Sea has shrunk dramatically. However, there has also been a more widespread loss of moisture: in the latter half of the 20th century there has been increased drying out of land in summer in some areas in the 20th century, bringing with it an associated risk of drought.

Box 1.3, example of drought: Sahel



The Sahel is a zone with high variations in annual rainfall averages over decades. During the past century, several severe droughts have occurred, including a long-lasting extraordinary drought, without precedence in the observed climatological record. Significant drops in precipitation, and in consequence, a decreasing flow tendency has been observed in the past decades over large areas in Africa (Sehmi & Kundzewicz, 1997). For example, since 1970 the mean discharge of the Niger River at Koulikoro has nearly halved from its levels in the sixties. The river virtually dried up at Niamey in 1984 and 1985. The Senegal at Bakel nearly stopped flowing in 1974 and 1982, and again in 1984 and 1985. The mean annual discharge of the Nile has fallen from the long-term mean of 84 km^3 (1900-1954) to 72 km^3 in the decade 1977-1987, whereas the mean flow between 1984 and 1987 was as low as 52 km^3, with an absolute minimum of 42 km^3 observed in 1984 (Howell & Allan, 1994).

Usually, the causes of drought are complex and interacting and not attributable to one single factor. However, beside meteorological effects, there are a variety of clearly identifiable human-induced factors for the Sahel droughts. The traditional reaction of humans in the Sahel during periods of low rainfall was nomadism or semi-nomadism. The governmental aided establishment of permanent settlings with a maximisation of livestock and cultivation programmes led to an over-exploitation of water resources. An accompanying problem is the soil and vegetation deterioration by overgrazing, with rising potentials for increased wind and water erosion. The related increase in surface albedo might adversely affect regional rainfall mechanisms. Mainguet (1994) proposes a variety of small and specific actions for the gradual rehabilitation of the environment in the Sahel. Among these, the reduction of arable land to those areas with reliable irrigation possibilities is required. The widespread use of solar energy could be considered as an alternative to burn wood. Further drilling of wells for water supply should be restricted. However, the demographic growth in the Sahel region will render any measures to combat drought and desertification extremely difficult. The high vulnerability to climate change can aggravate social and environmental problems (Sokona and Denton, 2001). Awareness building is therefore urgently needed as an area of bilateral and international aid programmes.

In the Horn of Africa, a complex emergency can be observed where drought interplays with political instability. Long-lasting civil wars in Eritrea, Ethiopia and Somalia hamper the establishment of reliable political systems and the development of stable economies. A prolonged drought threatens the countries' main grain harvest. A large proportion of the vital sorghum crop has already failed due to drought, and insects have damaged much of the remainder. Drought-displaced populations in urban centres of Somalia and Ethiopia live under poor sanitation and hygiene conditions, which have led to serious health problems and deaths among children. The repatriation of war-affected Eritrean refugees from Sudan causes enormous problems to handle the large number of returnees. The lack of water, massive land erosion and the presence of landmines with an alarming increase in mine incidents hinder the re-establishment of agricultural activities and a long-term food production. A large proportion of the population, which produced a major part of the countries' food supply in former times now, depends on emergency food delivered by international donor programmes.

Box 1.4, Example of drought: Northeast Brazil

Northeast Brazil has a semi-arid climate, with strong spatial and temporal variations of rainfall. Water scarcity is a major constraint for agricultural production, quality of life and development of that region. The future situation might be aggravated by the impacts of climatic change.

The region has been struck by droughts in the past with 18 to 20 droughts per century since the 17th century. The population, especially the poor, has been directly affected by the lack of drinking water, food and work. According to some estimates, nearly half of the population (estimated total population: 1.7 million) died in the drought-related famine of 1877-1879 (Magalhaes et al., 1988). Today, during drought years, the effects on the population are not that severe, due to existence of governmental assistance and emergency programs. However, during the extreme dry year 1983, there were still a significant number of drought-related fatalities. The economy continues to suffer considerably during drought years, in particular the production of subsistence crops such as beans and manioc, which were almost totally destroyed during the extreme drought of 1983, while the total GNP of that region declined "only" by about 16%.

During the past decades, emergency programmes to combat drought events have proven to be an efficient measure in preventing starvation as well as reducing migration to the coast or to Southern Brazil (Magalhaes et al., 1988). However, sustainable development must not be based on the concept of continuing emergency programs.

With an increasing population and possibly even higher rainfall variability resulting from climatic change, scarcity of water resources is increasingly constraining development in the semi-arid Northeast of Brazil and an efficient, rational, and sustainable use and management of water resources is an imperative. This implies both water storage in small dams to improve the water availability for the local, subsistence farmers and large dams combined with long-distance water diversions for water supply of urban centres (e.g. Recife or Fortaleza) and regions with a very pronounced water deficit. Assessment of water availability and use are key issues within this context.

Taking into account both the internal process dynamics of the causal chain (climate - water availability - agricultural production - quality of life) and the changes of the driving forces (e.g. climate variations; population increase) requires an integrated interdisciplinary approach. In a recent joint Brazilian-German research project (Krol et al., 2001) this approach has been followed by means of developing an integrated model to identify sustainable management strategies on a regional scale. With this model, strategies for a sustainable system control are assessed and - under consideration of the interactions - the potential effects of alternative development strategies of social and natural systems are evaluated. First results show that an integrated model can be a suitable tool for complex and interdisciplinary studies by optimising the integrated system under study. However, it cannot produce accurate, or always reliable, results for each of the sector-specific details involved, especially regarding small-scale processes.

What do we expect for the future?

There are a number of possible reasons for an increase in the frequency and severity of droughts in any particular region:

- There is a growing risk of summer droughts in most mid-latitude continental interiors during the 21st century: less precipitation and higher temperature may coincide, causing higher evapotranspiration and reducing available water resources.
- As temperatures increase evaporative demands may increase (*e.g.* for crops); the consequent loss of water may not be compensated for by increases in precipitation.
- It is likely that in many different regions there will be an increased risk of droughts arising from El Nino events.
- In many regions changes in the seasonal distribution of precipitation may have even more dramatic impact upon water resources than changes in total annual precipitation.
- The effects of any decrease in precipitation may be amplified through hydrological systems: runoff in semi-arid and arid regions will decrease at a much higher rate, than underlying decreases in precipitation, and groundwater recharge and hence groundwater resources may decrease even more than the change in runoff.

This increased climatic pressure will exacerbate the increasing vulnerability of societies to other global change processes, notably:

- population growth,
- the increasing density of population and economic values in areas at risk, in particular within developing countries with their limited adaptive capacity.

How reliable is our information?

Positives:

Limitations: Meteorological and in particular hydrological data are not available at the required resolution and coverage. Many monitoring networks are currently degrading. Access rights to existing data are often very limited. The capability to differentiate between natural climate variability and climate trends is limited by these data coverage, quality and access issues.

How do we prepare for the future?

There are both traditional and technological approaches to coping with the risk of drought. Any technological management of drought requires medium (seasonal) to long-term (annual to decadal) forecasts and therefore the appropriate (modelling) tools. This information then has to be translated into early warning and reaction chains.

Supply-side drought protection measures include:

- Augmenting the supply of water by exploiting surface water and groundwater in the area. However, intensive groundwater withdrawal for drought management is not a sustainable remedy – it has caused severe land subsistence in many countries, including Mexico, the United States, Japan, China and Thailand.
- Making transfers from surface water sources (lakes and rivers) and from groundwater, if socio-economically and environmentally acceptable.

- Increasing the storage of water. Groundwater reservoirs (aquifers) storing water when available can be more advantageous than surface water storage, despite the pumping costs, because of the reduction in evaporation losses. However, this classical drought management policy option is becoming increasingly difficult to implement because of its consequences on the environment. When a large upland reservoir storage was created in Thailand, allowing regulation of dry season flow in the upper and middle basin to satisfy domestic and irrigation water demand, upstream activity resulted in a serious decline in water quality, particularly in the lower part of the basin area.

Recently, the emphasis in action plans to combat drought is being increasingly shifted from supply management by provision of water resources in required quantities to effective demand management for the finite, and scarce, freshwater resource, *i.e.* seeking “negalitres of conserved water” rather than “megalitres of supplied water”. Possible demand-side measures include:

- improved land use practices;
- watershed management;
- rainwater/runoff harvesting;
- re-cycling water (e.g., use of treated municipal waste water for irrigation);
- development of water allocation strategies among competing demands;
- reduction of wastage;
- improvement of water conservation via reduction of the unaccounted water
- water pricing and subsidies.

Drought contingency planning also require thorough consideration, including:

- restrictions of water use,
- rationing schemes,
- special water tariffs
- reduction of low-value uses (agriculture),

1.2.3 Sea level rise

Why does sea level rise matter?

With the expected increase in temperature sea level will rise because of the melting of ice caps and thermal expansion of seawater. Rise in sea level implies:

- an increase of salt water intrusion into fresh ground water supply,
- a change in coastal wetland ecosystems,
- increased likelihood of flooding during extreme storm surges,
- a general pressure on living space,
- changes to arable land.

In isolated cases whole islands are under thread of disappearance.

Many coastal regions of the world are heavily populated and are at present situated just above sea level. Examples include Bangladesh, the Nile River Delta, and several Island Groups in the Pacific Ocean.

What do we know from the past?

rates?
the nature of the problem, causes (thermal expansion, ice-melt)

What do we expect for the future?

The main causes of sea level rise are the melting of glaciers, the Greenland and Antartic Ice Sheets, and thermal expansion, the latter being the most important at around 0.27 ± 0.28 m attributable rise between 1990 and 2100. On Greenland and Antarctican glacier melt is largely balanced by increases in precipitation, so sea level rise is predominantly attributable to glacial melts at 0.12 ± 0.16 m in the same period. In total 0.44 ± 0.49 m rise in sea level is expected between 1990 and 2100.

The changes to sea level rise are expected to be gradual. Abrupt events such as instabilities to the West-Antarctic ice sheet are not likely to occur this century.

How reliable is our information?

data for sea level is good? global versus regional?

How do we prepare for the future?

In view of the irreversibility to sea level rise during our lifetime and that of the next generations, adaptation is the only option.

Already committed to rises throughout the 21st century and beyond, but still must respond by mitigating emissions

1.2.4 Water resources

Why do water resources matter?

At the global scale, withdrawal and net consumption of water will grow substantially during the next 50 years, due to the increase of population, to the improvement of the quality of life and to the needs for increasing food production. Even if in several of the most developed countries, the net consumption of water per capita currently shows a significant decrease, according to the *Vision for Water, Life and Environment* (Cosgrove and Rijbersman, 2000), the global increase of water use by 2025 would be in the range of 25-50%, according to several scenarios of development.

Facing this growth of water uses, the renewable water resources are finite in essence, as their are limited by the flux of freshwater brought to and withdrawn from the continent by the process of the hydrological cycle.

Nevertheless it is generally accepted as such, the concept of water resources is not equivalent to the sum of the annual river flows to the oceans. Floods compose a large proportion of the flows, and for the extreme events, they characterise rather a disaster than a beneficial resource. Rivers flows are very unevenly distributed with time. Almost everywhere on the Earth, river regimes show a strong seasonal variability and over extended areas such as the tropics, or Mediterranean type of climates, flows are ephemeral and limited to a few weeks over the year. In cold regions, winter flows are dramatically reduced due to the retention of water in the form of snow and ice.

The variability in space of the surface flows is also striking either when considered at latitudinal scale or at the scale of a small river basin, at which the distance for accessing the water can be a major drawback for human life. According to favourable geological features, groundwater is a convenient option, but all groundwater might not be usable, because of its natural chemical composition (salt, arsenic, etc.) or because of a Man-induced pollution (nitrates, etc.). Shallow aquifers may not withstand the dry season and groundwater resources may dry up as well as surface flows.

To overturn the variability of water resources in time and space, water schemes have been developed for long (dams, transfer of water by canals and pipes, ..), but the required investment in labour or money implies the grouping of users around or in cities or market towns. But a sizeable proportion of mankind lives in scattered rural habitats and these people depends on the availability of water in its natural form, for satisfying their basic needs (drinking, watering of the cattle, agriculture). In contrasted climates (tropical, semi-arid, Mediterranean-type), such "natural" availability of water is regularly reduced to the edge of survival. Any tiny reduction in the amount of water resources or small change in their distribution in time will definitely lead to serious impacts for these communities which according to their way of living are unlikely to become potential customers for a commercially-driven water supply

The perception of freshwater shall not be reduced to a mineral flowing through channels, canals and pipes. It is an essential driver of the terrestrial ecosystems and it constitutes directly the support of freshwater ecosystems. The distribution of terrestrial ecosystems on the Earth corresponds to a stage of equilibrium between climate variability (variability of rainfall, temperature, humidity, wind speed and direction, etc.) and the resilience capacity of these systems to the variability. Any change in the variability of climate or any trend in any of its component will lead to latitudinal and altitudinal shifts in the distribution of terrestrial ecosystems (rainforests, savannahs, steppes, etc.). On a given watershed, these changes might have tangible effects on the water balance and thus on the availability of water resources. Freshwater ecosystems (such as ponds, lakes, wetlands and rivers channels) are essential components of the environment. They provide support of existence for aquatic and terrestrial wildlife, environmental services (such as flood mitigation, depletion of organic pollution, etc.). In many regions the fish is a key element in the social and economic organisation of human communities and is the first source of proteins, and sometimes the only one, especially for the poor.

Unfortunately, water is also associated with specific diseases, either because it can directly be the vector of dissemination (contamination of drinking water by arsenic or other natural chemicals, cholera, etc.), the support of live for harmful parasites (bilharziose, etc.), or because water is an element in the life cycle for specific flies, mosquitoes and other vectors, onchocerciasis (or river blindness) and malaria being here among the most common examples. Aquatic ecosystems considered under the angle of water-related diseases are extremely sensitive - for the best and the worst - to any change, among which are those related to climate change (temperature of water, depth of water, speed in water streams, etc.).

Thus, nevertheless figures show that at the global level the increase of water demands and uses appears as being the determinant driver in what can be considered as a looming crisis, it must be pointed out that the relation of Man with water is largely defined at the local level, water being either considered as a resource or as an ecosystem. Global or even national indicators hide the obvious fact that for living beings, scarce water means survival and no water at all means death within a few days. In many stressed environments, the resource component in the demand/supply balance may indeed become the key issue if the resource is modified in total amount or in its temporal or spatial distribution, which climate change is very likely to trigger in many regions.

What do we know from the past?

A significant part of the solar energy received by the Earth (*30% ? I have to check*) is consumed for "turning" the hydrological cycle, I.E. for evaporating astonishing quantities of water of which 40 000 km3 are moved and precipitated over the continents every year. The increase of greenhouse gases concentrations in the atmosphere means will lead to an increase of the available energy and thus, according to the basics of thermodynamics, an "intensification of the hydrological cycle" will occur. At the global scale, all GCMs simulations have verified this.

The oceans play a major role in climate, as they are able to store and to release sizeable proportions of the incoming energy. Thus, experience and most advanced knowledge on climate processes are consistent in predicting that the expected intensification of the hydrological cycle will not be experienced as a smooth linear trend, but rather in the form of oscillations of the variability of climate. The oscillations will be more frequent than in the past and the amplitude of the variability may also increase over some areas. From the past decades, we also learnt that the sequencing of wet and dry years is not randomly distributed, but rather dry and wet periods have alternate in some regions, the drought experienced in West Africa during the70' and the 80' being one of the most illustrative example in this matter. (*Table X1, can or should be replaced by a graph*)

Table 1.1, Decrease of precipitation for countries in West and Central Africa compared to decrease of river flows in the same region (Average of period 1970-1989 compared to period 1950-1969), Source : Servat et al.(1998)

Country	Precipitation reduction (%)	River	Station	Reduction of annual flow (%
Cameroon	16	Comoe	Aniassue	50
Togo	16	Chari	Ndajmena	51
Central African Republic	17	Logone	Lai	39
Benin	19	Niger	Malanville	43
Ghana	19	Niger	Niamey	34
Nigeria	19	Bani	Douna	70
Guinea	20	Oueme	Sagon	42
Chad	20	Sassandra	Semien	36
Ivory Coast	21	Senegal	Bakel	50
Burkina Faso	22	Bakoye	Ouali	66
Guinea Bissau	22	Black Volta	Dapola	41
Mali	23	Black Volta	Boromo	46
Senegal	25	Oubangui	Bangui	30
		Sangha	Salo	22

The effects of rainfall decrease have been amplified on river discharges and the interannual average flow of the major rivers in the has been reduced sometimes by more than 50%

This example also illustrates how climate variability is being amplified in the hydrological cycle: while decrease of precipitation during the two decades was in the magnitude of 25% for the considered countries, the major rivers flowing through them have experienced reductions in annual flows in a magnitude of 50% *(Table X1, can be replaced by a graph)*.. In others words, what can be considered as a minor change in total or in temporal pattern of precipitation may well have tangibles effects on the water resources. Past and current experience, also show situations of positive anomalies in runoff, which may not be totally welcomed: the succession of high flows of the Volga River which contributes for 85% of the incoming water in the Caspian Sea (Shiklomanov and Shiklomanov, 2000) has triggered an elevation of the sea level of nearly 3 meters since the last seventies, although important uptake of water are – fortunately - taking place in the river and its tributaries. Such high level of the sea had never been reached since the 30's, and as Man's memory is rather short, infrastructure and property have been established and subsequently lost in the flooded area.
It has also been experienced that water resources are extremely sensitive to complex feedback mechanisms (**Figure *x*1***, to be taken from IPCC WG2 report*), to threshold effects and to the non-linearity of most processes.

Sediment flows in rivers provides a vivid illustration of these concepts (**Figure *x*2**) : it is known that sediments are significantly mobilised only during major floods and that sediment discharge increases exponentially with the intensity of the floods. If the river is dammed, these sediments are trapped in the reservoirs and subsequently they reduce their storage capacity. Especially in semi-arid areas, the operational lifetime of a reservoir depends on the siltation rate and these water schemes are economically viable for a given sedimentation rate, corresponding to the conditions prevailing at the moment of their design. If climate change would be associated with more floods, characterised by greater magnitude (or even by similar magnitude) than in the past, any sediment discharge model will show that a doubling of the sedimentation rate in the reservoirs can easily be achieved. This would mean that the life expectancy of the scheme would be half of what was initially planned. Many financial paying off plans would not withstand such reduction.

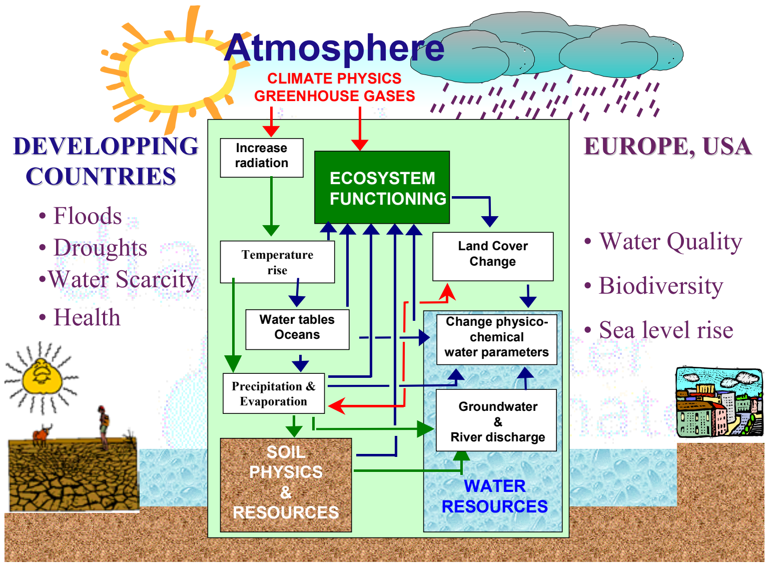
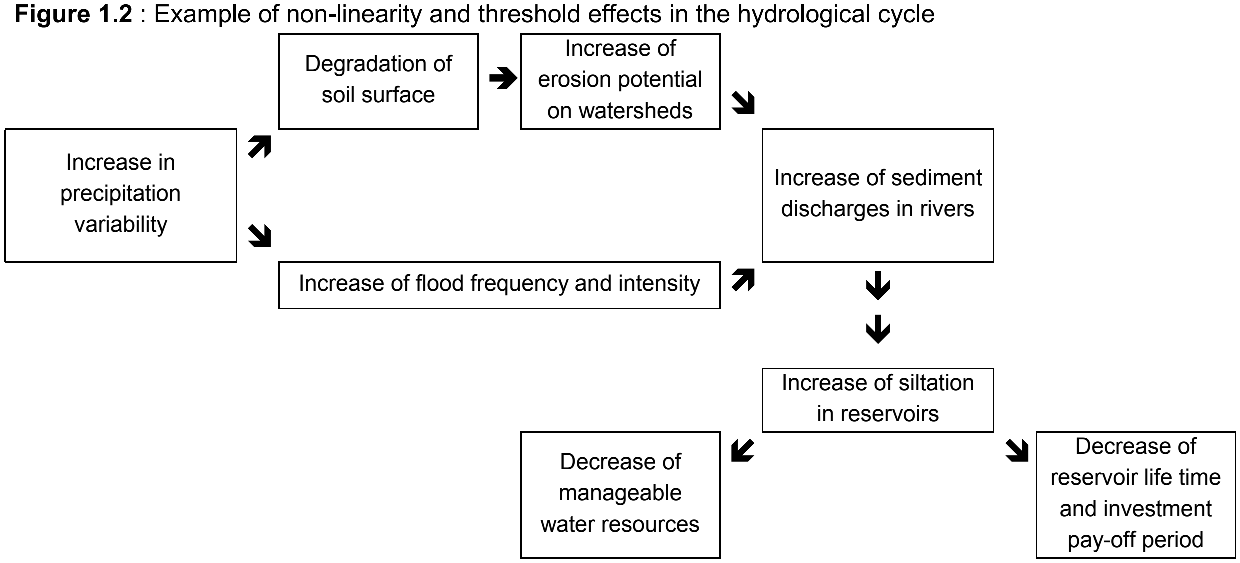


Figure 1.1, Overview of Interactions between atmosphere, ecosystems, soils and water resources and potential impacts within LCD and DC countries.

Experience has shown that the hydrological cycle has certain resilience, i.e. it is able too accommodate a certain level of external forcing, such as a reduction in precipitation. But if the forcing is too strong, or maintained for to long, river flows may drop suddenly and sharply, with the associated consequences for the different users of water (the ecosystems and Man). The behaviour of the Bani River, a major tributary to the Niger River in Mali, illustrates this concept (**Figure *x*3**).

Figure 1.2 : Example of non-linearity and threshold effects in the hydrological cycle



Small change in precipitation patterns may lead to very significant increases in sediment flows, which will have definite impacts on the management and on the financial conditions of water resources planning. Source : Fritsch (2001)

We also know that most of the geochemical and biochemical characteristics of the water are acquired during its travel from the clouds to the rivers, through the biosphere, the soils and the geologic layers. Changes in amount or pattern of precipitation will alter the route and the residence time of water within the watershed and change its quality, in such way that the resource might be lacking, not because of the quantity, but because its new quality may have render it unsuitable for the required use. The risk of an increase of the concentration of dissolved salts due to the increase of evaporation under higher temperature being a trivial example, but the risk might also be associated with excess of water : under such conditions the water tables, which were previously kept at a given distance under the surface, may rise and reach horizons of soils which may be salinized, contain agrochemicals or industrial wastes. The water from these shallow aquifers may eventually de drained into the river network and spoil the quality of the water further downstream.

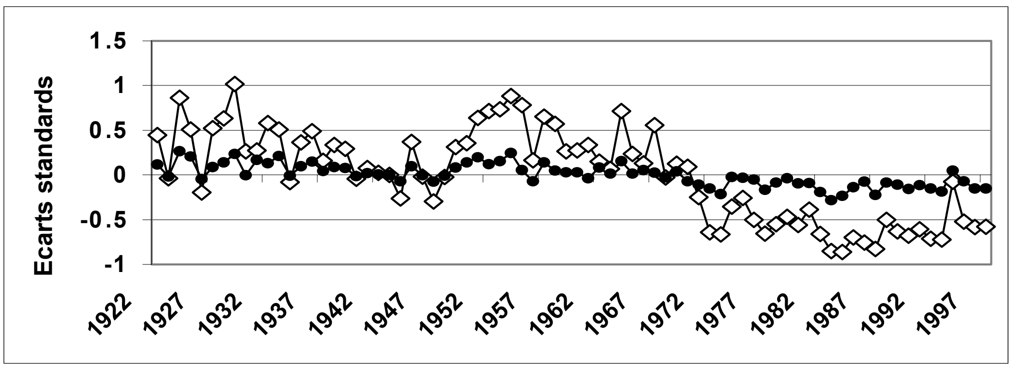
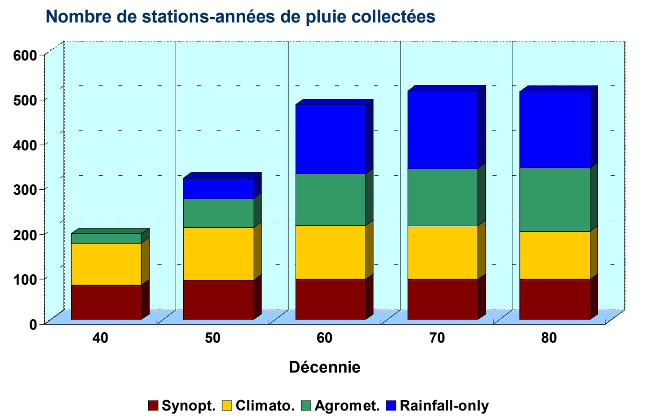
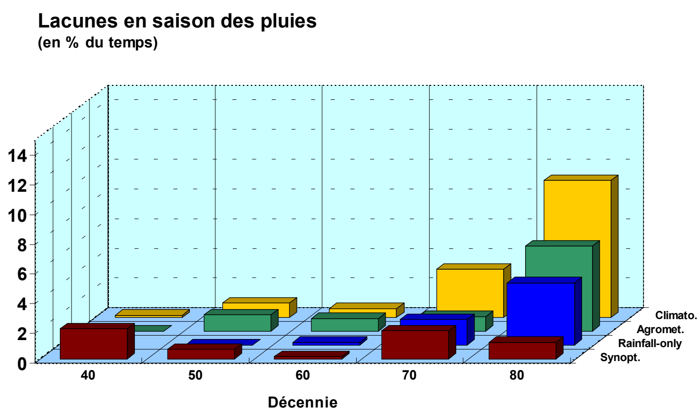


Figure 1.3 : Bani River at Douna (Mali). Compared evolution of precipitation (black circles) and river flow (white diamonds) for the period 1922 to 1997. Units : Standardised departure to the interannual mean, Source: Mahé et al. (2000)

To be able to access the changes in rivers flows, aquifers levels or freshwater ecosystems status (would they come from climate forcing or from anthropogenic influence) and to predict their behaviour in the future, two ingredients are compulsory: the capacity of modelling of the hydrological processes (i.e. "universal" science) and sufficient and reliable local data and information to address the issue for a given basin or region.

Contrary to climate information, which is collected for scientific purposes (weather forecast), most information on water is collected for management purposes. The consequence is a fragmentation of the process country by country, and even within a single country where different water users (energy, navigation, agriculture, domestic supply, etc.) may operate specific different networks and use different procedures for the collection, storage and retrieval of data. Moreover, while there is a long lasting tradition for exchanging or disseminating freely atmosphere relate-information at the global level, water data is still in many cases a sensitive matter as it applies to an economic resource. Several initiatives, among which Resolution 25 (Cg-XIII) adopted by the WMO Congress, are advocating for better sharing of hydrology-related data, but there still a long way to go to match the effectiveness of the World Weather Watch. The degradation of the situation of the National Hydrological Services, and consequently of the maintenance and operation of the networks field station is another very serious reason of concern. As the governing concept is that the water crisis is firstly a management crisis (or a supply side issue) rather than a resources crisis – which is true in global terms -, political interest and financial support for the monitoring of the resource has been shrinking dramatically in most countries. The effects of such perverse rationale are definitely jeopardising our capacity for addressing the issues of water resources under climate variability and change, for forecasting and monitoring accurately water-related disasters and for planning the share of the benefits of water in large transboundary river basins.

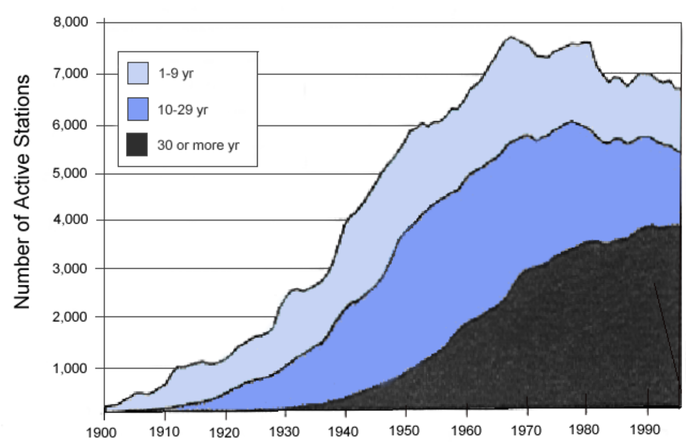




Degradation of data collection can show different styles: the number of stations may have declined, but in other cases while the number of stations has been maintained steady, the quality of the data (i.e. its accuracy or the continuity of time series) might be so degraded that it becomes unusable. **Figure x4** shows such a case for a country of Sub-Saharan Africa. It has to be noted that the decline in monitoring activities is not necessarily limited to the developing countries (**Figure x5**).

Figure 1.4, Degradation of the quality of hydrometeorological data in a country of Sub-Saharan Africa Source: Sub-Saharan Hydrological Assessment, (1991)

Figure 1.5, Number of active discharge monitoring stations in the US from 1900 to 1996 Source : Landfear & Hirsch, EOS, V.80, N.50, p605-607



Although, the number of rainfall stations has been steady, the frequency of observation gaps has dramatically increased, thus turning unusable the time series of a number of rainfall stations.

What do we expect for the future?

Minor changes in total and temporal distribution of water will have major effects on the availability of drinking water (via quantity of water flows, and quality of flows)
Note importance of changes in groundwater flows for drinking water availability
Note dependence of many ecosystems on freshwater flows

How reliable is our information?

Observational networks are in decline
Importance of maintaining observational networks
Information technology links models and data
Remote sensing data requires translation into hydrological parameters

How do we prepare for the future?

- More and better quality water-related information freely available
  - In many countries, it is necessary to rehabilitate the water-related data collection systems. According to the conditions, this may require to strengthen the technical capacity of the National Hydrological Services (NHSs) which are most generally in charge of these duties, to rehabilitate the field networks, to improve the processing, storage and distribution of the data and information and to provide the NHSs with a decent budget to cover their operational costs for the next decade. This would require combined efforts from the individuals Nations and from the international community.
  - Once the data collection has been re-established, international standards should apply for the measurements, the data validation, encoding and distribution.
  - The prerequisite for external input in the water-related data collection in any country should be that all data will be available easily and freely, at least for the science community, through the modern communication media (Internet).
- Actual co-operation between institutions dealing with Water, Weather and Climate, would they be operational agencies or research groups. As far as possible, the aim is to generalise the forecasting of the status of water resources at all time scales (from days to months for tactical management and from years to decades for taking wise strategic decisions). It has to be noted, that in many countries, the relations between practitioners and scientists dealing with the atmosphere and whatsoever those of the water sector are non existent: there are no communications links and no procedures for receiving and using weather and climate information and forecasts in water management.
- Improving our knowledge on the processes of the hydrological cycle in relation to the atmosphere and the biosphere. It has been noted that in the IPCC reports, the climate change predictions are more accurate and reliable for temperature compared to precipitation and for precipitation compared to river flows and aquifer levels. This is due to the lack of reliable water-related data as previously mentioned, but also to the stage of the knowledge and in particular to the fair performances of the hydrological models for integrating in prediction mode all feed-back effects with the land surface and the biosphere. GEWEX-BAHC and similar programmes should be strengthened and the

selection of their experimental observation sites should be made taking into account water management issues in the context of climate variability and change.

- Besides the needs for improving the operation of national and regional measurement networks for water management purposes, it appears necessary to implement a global system, more dedicated to address scientific issues, for assessing the predicted "intensification of the hydrological cycle" and for predicting and monitoring the effects on water resources. This may not require to implement a specific network of ground stations, but rather to include existing key-stations into the system, to update and standardise equipment and operating procedures, including a near real time distribution of the data, as it is the case for the climate and weather research programmes. The World Hydrological Observation System (WHYCOS) of the World Meteorological Organisation and the Global Terrestrial Network –Hydrology (GTN-H) of the GCOS Programme would provide, among others, convenient frameworks for implementing such initiative.

1.3 Climatic information

Climate research has a two-fold task with respect to water issues (Hulme and Carter, 1999):

1. to increase our understanding of the climate system;
2. to articulate and (where possible) quantify the uncertainties that remains.

Our knowledge in the light of uncertainty

Our understanding of changes in the past is often constrained by a lack of observational evidence. Despite this restriction, it is likely that most of the observed global warming over the last 50 years is due to the increase in greenhouse gas concentrations arising from anthropogenic emissions and land use change.

However, uncertainties concerning changes in the future arise from a combination of sources. Some sources of uncertainty are inherent, such as:

- the future socio-economic, political, and technological changes;
- the emissions of greenhouse gases in the 21st century;
- the variability within the climate system.

Other sources of uncertainty are not inherent, and may be reduced. For example, confidence in the ability of global climate models to provide useful predictions of future climate has improved since their accuracy has been demonstrated on a range of spatial and temporal scales.

To cope with the various sources of uncertainty it is best to use a probabilistic approach, which takes science into the realm of risk assessment. The latest assessment of the IPCC addresses uncertainty by considering a variety of different scenarios:

1. four ‚storylines‘ of future world development are included;
2. forty scenarios of greenhouse gas emissions for the 21st century have been developed;

3. the amount of warming for a doubling of atmospheric greenhouse gas concentrations is permitted to vary from 1.7 to 4.3 °C;
4. five different global climate models represent the regional climate changes.

Climatic extremes

Since extremes are of particular importance for water issues, the confidence that may be attached to our understanding of changes in climatic extremes in the past and in the future is summarised in a table drawn from the latest IPCC assessment and based on the approach to uncertainty outlined above:

Table 1.2, Summary of already observed changes, prospective for the futures and impact on water resources

Climatic change	climatic change already observed?	to occur in the 21^{st} century?	effects on water
higher maximum temperatures and more hot days over nearly all land areas	likely	very likely	water resources reduced
higher minimum temperatures, fewer cold days and frost days, over near all land areas	very likely	very likely	water resources reduced
diurnal temperature range reduced over most land areas	very likely	very likely	
increase of heat index over land areas	likely over many areas	very likely over most areas	water resources reduced
more intense precipitation events	likely over many northern hemisphere mid-to-high latitude areas	very likely over many areas	more frequent and more severe floods
increased summer continental drying and associated risk of drought	likely in a few areas	likely over most mid-latitude continental interiors	more frequent and more severe droughts
increase in tropical cyclone peak wind intensities	not observed in the few analyses available	likely over some areas	more frequent and more severe storm-surge floods
increase in tropical cyclone mean and peak precipitation intensities	insufficient data	likely over some areas	more frequent and more severe floods

Regional climate change

Although a globally averaged temperature increase of 1.4 – 5.8 C is expected by the end of this century, there appears to be large regional variability. For instance, at high latitudes the temperature increase is several degrees C larger than at lower latitudes, in part due to the areal variation (i.e. reduction) in land ice and snow. Precipitation change is likely to be even more spatially variable. Although a general increase in precipitation is expected, some regions may see large increase, while others may see reductions.

There is large uncertainty in the prediction of precipitation for two reasons:

1. Precipitation as a process is poorly represented in global climate models, and

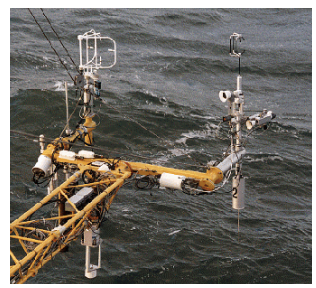
2. (heavy) precipitation systems may occur on scales that are smaller than the typical grid scale of a global climate model.

In order to obtain information at spatial scales smaller than a grid-box in a global climate model, it is necessary to 'downscale'. There are two possible approaches to downscaling, neither of which is inherently superior to the other, and either of which may be appropriate in a given situation. These approaches are:

- Statistical downscaling, where an equation is obtained empirically to capture the relationship between the small-scale phenomenon and the large-scale behaviour of the model.
- Dynamical downscaling, where a high-resolution regional climate models is embedded in a global climate model.

Important to note is that 'System Earth' is a non-linear system. Changes in precipitation and evaporation are not linear with temperature, in part because of the involvement of elementary physical principles, and in part because of the complexity of pathways and feedbacks affecting the link between temperature and other relevant climate variables.

1.4 Hydrological information



Relevant information may be obtained from two particular varieties of models:

- Hydrological models, which simulate the transformation of precipitation into runoff, are not an always a routinely applied part of a real-time flood prediction system. Under conditions of extreme rainfall, the physically based hydrological models may not work well.
- Hydraulic models provide details (flow rate and stage for different places and times) of propagation of the flood wave in the river channel. These models are highly developed for many large river systems, and they have served to produce flood level projections for many years. Since such models mimic propagation of a flood wave, which already exists in a channel, they only work for relatively short lead times. While for the river Rhine in Cologne this lead-time is only slightly longer than two days, for smaller rivers the lead times are short and hydraulic models are of little use for real-time flood forecasting.

The challenge for the future lies in the improvement and coupling of these modelling systems to allow for improved early warning times in accordance with increased reliability of weather forecasts. Another challenging area is modelling extreme events under future climatic conditions.

Recent advances in predictability augur well for improvements in preparedness systems for water-related disasters. In particular, improved understanding of the role of the land surface in coupled land-atmosphere-ocean models and of hydrological response of very large river basins offers new challenges and opportunities.

Wood et al. (2001) applied this approach during the summer 2000 drought in the eastern and central U.S. Climate forecasts (precipitation and average temperature for six-month lead times, updated monthly) were downscaled, and spatial model output and streamflow were generated, for each month of the six-month forecast horizon. More recently, this streamflow forecasting strategy has been implemented over the Columbia River basin to produce six month lead time forecasts, allowing the probability of reservoir refill to be assessed.

Box 1.5, The need for more data on extreme events.

Present climate is characterised by natural variability in climatic events, such as droughts, heavy precipitation and gales. The risk to the human population is governed by the occurrence of extremes in these events and related hazard, such as floods. Changes in extreme events may have a profound impact on humans. In many areas of the world, little is known about even the natural occurrence of extreme events, although such information is often buried in local data sets. Without this baseline information, information about future changes in climate extremes looses much of their significance.

An important part of the program to raise awareness of the link between water and climate should be data mining in developing countries. This should be followed-up by an investigation of the statistics of extremes in the baseline periods defined by the availability of the local sources. This is in particular relevant in those regions that are identified as hot spots. Once these statistics are known, can we answer the question whether how vulnerable society is for natural hazards and how the effect of climate change introduces a change in this vulnerability.

1.5 Conclusion

- To improve flood and drought forecasting at a whole range of time horizons of concern. This is where applied research and technology has a role to play. Substantial developments in short- and medium term weather forecasting and quantitative precipitation forecasts are needed for flood preparedness. Improving long-term predictability, based on climatic variability and sea surface temperature, emerges as an important tool of drought preparedness
- Strengthening knowledge about “preparedness of the water systems”: risk assessment, watershed management (source control), and increasing water storage, serving both drought and flood protection.
- A “concerted action”, effectively co-ordinated across sectors. A number of institutional and organisational issues have been identified to strengthen the preparedness systems, such as enhancing co-ordination, division of competence, tasks and responsibilities among different agencies acting in watershed, rather than administrative boundaries, and assuring participation of stakeholders.
- New dialogue on the equity issues: less developed countries do not have adequate financial and manpower resources and cannot cope with hydrological extremes without

foreign and international assistance. Increase of effective assistance to the less developed countries is badly needed.

- For some regions we are **observing increases** in magnitude and frequency of extreme events.
- **Future extremes** will be much more severe than what we have seen up to now
- **Current** capacity on short to medium term forecasts for water management is not enough used in many parts of the world.
- Expectations of water managers in terms of spatial and temporal resolution of climate scenarios for **future** water resources will not be met.
- A **new dialogue** is required to mediate between climate community and water managers, including e.g. risk analysis, assimilation of meteorological and hydrological data etc. for predictions.
- A **paradigm shift** is required towards "living with floods and droughts"

Actions, conclusions

What is the state of knowledge?

Which methods, tools, knowledge can the dialogue offer (esp. to developing countries)?
Need for ethical framework.

2 Policy analysis and institutional frameworks in climate&water

'Water flows uphill to money and power.'

Marc Reisner, 1994

'It is normal for a good idea to be subject to between 25 and 50 years of contentious politics before it appears as policy.'

Lead author: Prof. J.A. (Tony) Allan
SOAS, London University, Thornhaugh Street, Russell Square, London WC1H 0XG, United Kingdom, email: Ta1@soas.ac.uk, phone: 020 7637 2388, fax: 020 7436 3844

Contributing authors:

William Cosgrove	World Water Council	wjcosgrove@compuserve.com
Frank Kansiime	Makerere University	muienr@muienr.mak.ac.ug
Panagiotis Balabanis	European Commission	panagiotis.balabanis@cec.eu.int
Hubert Savenije	IHE-Delft	hbs@ihe.nl
Arjen Hoekstra	IHE-Delft	arjen@ihe.nl
Claudia Pahl-Wostl	Swiss F. Inst. For Env. Sci. & Techn.	claudia.pahl@eawag.ch

Summary[TDM3]

Key statements for the summary key issues up-front

- To find institutional solutions economic stability and access to markets are a prerequisite.
- New concepts for public & stakeholder participation within multiscale integrated assessment processes & modelling. A new role of science as an active participant in polycentric policy processes
- It will be a challenge to institutionalise the responsibility of the rich North towards the South both in terms of adaptation and mitigation policy in relation to water management and climate change.
- An institutional framework around climate change & water resources is a start for a global environmental institutional framework.

2.1 Setting the scene (lead Tony Allan)

> *'Water flows uphill to money and power.'*
> **Marc Reisner, 1994**
>
> *'It is normal for a good idea to be subject to between 25 and 50 years of contentious politics before it appears as policy.'*

2.1.1 purpose

The purpose of chapter two has four elements:

The first (and main) purpose is to emphasise the central role of politics in determining water using and water managing outcomes. And especially to draw the attention first of the 'climate change/climate variability' science community, secondly of the water management community, thirdly of water policy makers and fourthly, (in due course) of water users to the political significance of anthropogenic climate change. It will be shown that science information inputs can influence and shape outcomes. But such particular knowledge inputs are always subordinate to long established discursive political processes. Only during exceptional windows of opportunity are new ideas adopted quickly enabling new policy initiatives. Extreme, or emblematic, events can open such windows of opportunity. It is normal, however, for a good idea to be subject to between 25 and 50 years of contentious politics before it appears as policy. This is true whether the science community or a social movement launches the new idea.

The second purpose is to provide a critical review of how societies currently deal with ‘climate variability’ and water resource management.

The third purpose is to review critically water management institutions and political processes in which they engage.

The fourth purpose is to identify and evaluate solutions to existing and predicted variations in water availability.

2.1.2 definitions, concepts and analytical frameworks

Definitions, concepts and analytical frameworks – why we are where we are
Definitions – the environment, water management, society

Environment

Freshwater – includes all the easily managed water; namely surface and groundwater. Water usable in economic systems also includes **soil water**, which is impacted by agricultural and other types of land use.

Climate variability - ……..

Climate change - ………

Allocation and management

Sustainability. The achievement of ‘sustainable’ water allocation outcomes is a political process. Sustainability has three dimensions. It is necessary for a political economy first to achieve a sustainable society; secondly a sustainable economy as well as thirdly a sustainable water environment. The water environment provides the underpinning environmental services that enable the other two dimensions of sustainability.

Water scarcity occurs when a community’s demands for freshwater for social, economic and environmental functions exceed the waters available. Water scarcity is ameliorated by improving productive (technical) and allocative (economic) efficiency and by accessing water outside the watershed or the political economy. Water can be conveyed by pipeline or by vessel, can be accessed as virtual water and it can be desalinated. The first order *scarcity of water* is much less important than the second order *scarcity of social adaptive capacity* to ameliorate the physical water scarcity. (Ohlsson and Turton, 1999)

Productive (technical) **efficiency** – the use of technical measures to increase the returns to water – dams, canals, drip irrigation, water treatment etc.

Allocative (economic) **efficiency –** the use of institutions, regulations and economic instruments to allocate water to activities which bring a higher return to water.

Integrated water resource management (IWRM) is a political process. The integration of the interests of water users, water services providers from both the public and the private sectors and of regulators is a contentious political process. It may be necessary to give the environment a voice to achieve comprehensive sustainability.

Adaptive management. Diverse approaches to water allocation and management exist in the South and the North. Long evolved customary practices and long evolved 'analytical techniques for examining economic environmental policies . despite their many imperfections .. provide … valuable framework[s] for identifying essential questions that policy-makers must face when dealing with climate change.' (Stakhiv 1998, p163, IPCC 1996 p9) There is a simultaneous adaptation 'to the exigencies of greater resource use efficiencies.. Each sector will be on a somewhat comparable "no regrets" adaptation strategy that, collectively (i.e. via political adjustment), will beneficially affect water resources management and reduce water demands and freshwater withdrawals.' (Stakhiv, E.Z. 1998 p163)

……..

……..

Society and politics

Politics – explains 'who gets what, when and how.' (Laswell 1958)

Knowledge, discourse, power

Knowledge can be based on verifiable facts. Knowledge can also be constructed. The political process accepts both kinds of knowledge. Constructed knowledge is as likely to determine policy as scientifically assembled data. The contentious process of achieving a consensus which is known as 'knowledge' is achieved via discourse. Decision-makers and politicians on whom the discursive process impacts will tend to make decisions reflecting the degree of consensus achieved in a discourse. The power to change policy is available when knowledge is widely held. Knowledge is power and it rests where the contention in the discourse places it. A politician at the centre of such contention 'only stands firm when pressed from all sides.'

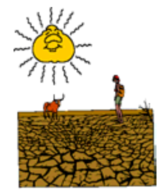
Introducing 'new knowledge', for example that climate change will affect the availability of water resources, will influence water policy discourses insofar as it is cleverly constructed. Whether there are accurate predictions based on robust and precise methods is less important.

Sanctioned discourse

A sanctioned discourse occurs where a very long evolved fundamental idea is embedded in a discourse. Where a large population has experienced millennia of adequate water availability it is extremely difficult to contradict that communal sense of security. Politicians are unwilling to pay the political price of communicating the bad news. The discourse is sanctioned by the mutual need to hold on to the essential lie. (Allan 2001 p xxi)

North and South

North – Northern economies are industrialised, have developed comprehensive public sector institutions capable of enabling and controlling their productive private sectors. Both engines of change and development are diverse and strong – government and the market. Northern political economies are rich in social adaptive capacity.



South – Southern political economies are characterised by non-diverse weak economies and poor social adaptive capacity.

Social adaptive capacity

The scarcity of the social resources of adaptive capacity is more important than the scarcity of water. The ameliorative measures enabled by social adaptive capacity can always solve a water shortage. Abundant freshwater does not determine the development of a strong and diverse economy.

Concepts and analytical frameworks

Discourse

Recent anthropogenically induced climate variability and climate change have been contributing to the discourse on environment and water since the late 1980s. The IPCC process has been remarkably effective in discursive terms. There have been a number of prominent 'knowledge establishing' victories, such as in Rio in 1992 (UNCED 1992) and in the Kyoto Protocol of 1997 (?). But as in any discursive process there have been setbacks. In 2002 the US withdrew its commitment. For a variety of political reasons the US president stood firm at the position where the voices in the discourse pressed him.

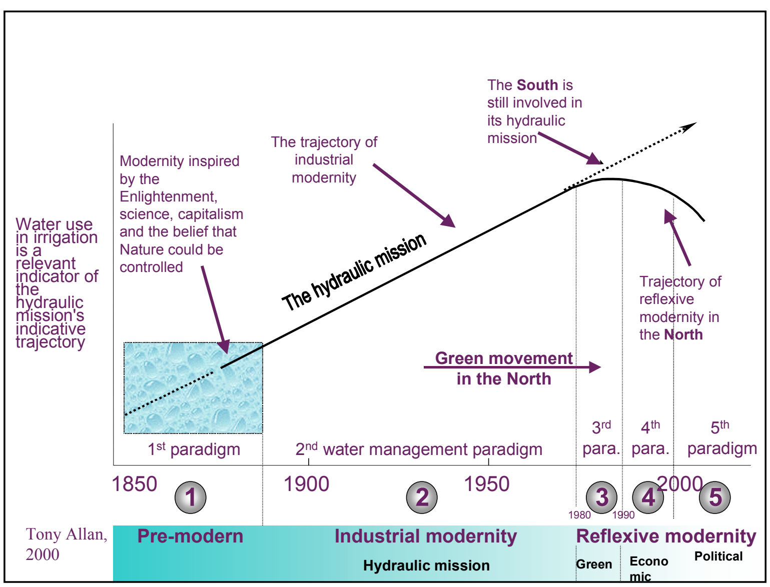


Figure 2.1, The five water management paradigms between 1850 and 2000 (source Tony Allan, 2000).

Trajectories of modernity - see Figure 2.1

The way water has been managed in the North fit well the concept of modernity. It is possible to identify five paradigms in the way water for irrigation has been mobilised and managed over the past two centuries. In the first pre-modern paradigm the capacity to use water was limited. In the second paradigm of industrial modernity, societies became imbued with a sense of certainty through the development of science, engineering, effective bureaucratic government and entrepreneurial capitalism. Everyone was certain that using more and more water in irrigated farming were a good idea. The end of this phase in the North came with the Green Movement's introduction of the notion that certainty was dangerous. After three decades of discourse there was a dramatic shift in ideas and policy in the 1970s regarding the management of water in the North. (Reisner 1984) Uncertainty replaced certainty and northern communities became intensely aware of environmental risk. Late modernity [post-modernity] has three paradigmatic phases. The third paradigm, starting in the 1980s in terms of policy impact, was inspired by the green message. Much water has been returned to the environment from agriculture. The fourth paradigm -the 1990s

Sustainability and discourse

2.2 Critical review of present approaches and policy response in both climate and IWRM (Cosgrove)

The present unfulfilled demands, mismanagement of water resources and rapidly shifting changes in socio-economic structure, demographics, technology and public preferences pose water management issues and opportunities that generally are greater than those that are forecast to result from climate change. On the positive side, for example, agricultural and irrigation technology have made it possible to continue feeding a world population that has tripled in the last century. On the negative side, many water management systems and policies are not well adapted to responding to the modern paradigm of water management that calls for managing the resource in a sustainable manner under conditions of uncertainty. If we did have such systems and policies in place, they would provide resilience to deal with the additional largely unknown impacts of climate change.

There are few countries in the world that have developed comprehensive national water management plans and strategies. In the absence of these, fragmented approaches by a proliferation of government agencies and other stakeholders make implementation of integrated water resources management difficult, at times impossible. For example, in Canada (as in several other countries) water is considered a natural resource under the jurisdiction of the provinces. The distribution of water resources and the demands vary widely. Legislation on environmental protection and even standards for drinking water also vary. This will make it very difficult for Canada to take positions in negotiating international agreements related to trade involving virtual water or water transfers. In most developing countries, the policy and institutional frameworks are much weaker.

There is almost unanimous agreement among water resource managers and the international community on the Dublin and Rio principles. There probably is no country in the world that has fully integrated them into their policy framework. The degree to which they can be implemented and put into practice depends on the adaptive capacity of countries' institutions. It is not surprising, therefore, that developing countries are even further from reaching the ideal of integrated water resource management (IWRM) that embodies these principles.

In 1993 the World Bank adopted a policy paper that established IWRM as the objective for all of the countries to which it lends. In reviewing that policy now, the Bank's staff recognise that many countries are so far from this objective, and are so lacking in adaptive capacity, that the immediate goal should be to make incremental improvements in the policies and institutions. Through a series of such measures, adaptive capacity will be gradually increased.

In response to water scarcity, the approach that is simplest to implement and meets the least resistance is to increase the production efficiency of water, e.g. by improving irrigation efficiency. This approach will therefore be the first choice of farmers, engineers and politicians alike. When this has proved to be inadequate, they will turn next to possible ways to allocate water among users. Somewhere around this time they will likely recognise that in satisfying human needs they have done significant if not irreversible harm to the environment. At the next stage they may be forced to recognise that self-sufficiency is not possible, and that water must be imported - either physically (usually not cost-effective) or in virtual form in goods and produce from other regions or countries. Each stage in this process is more difficult and involves more actors. Ultimately, the last stage requires international negotiations and co-operation.

The above approach may be described as "reactive". IWRM would be based on an approach that is "anticipatory", based on the "precautionary principle", and including the application of preventive actions so that there are "no regrets" throughout the process. If such an approach were taken, it would certainly, as noted above, create the resiliency to deal with the additional complications of global warming. The reality is that the "reactive" approach is still the one that predominates and is likely to continue to predominate in the absence of political leadership.

It is often noted that even when policies are in place, they are not implemented because one or more of the parties responsible for implementation fails to follow through. Political will and leadership are required also to overcome this implementation gap.

Up until now there has been inadequate attention to the implications of the need water for human uses, especially for agricultural production, and the need for environmental sustainability. More research and discussion will be needed to develop policy alternatives and strategies to manage water to meet these competing needs so as to reduce the uncertainties and ambiguities surrounding this issue. There are ongoing debates too about appropriate policies and strategies to ensure equitable access to water, especially for the poor. Finally, there still is a need to develop appropriate strategies and policies to deal with floods and droughts, even in the absence of climate change. The same must be said for coastal zone management, as there has been inadequate attention to the impact that land-based activities have on these areas that are important to an increasingly large human population that lives in them and the ecosystems themselves. The sea level rise that is forecast will acerbate the need for policies to address this.

2.3 Decision-making institutions of water & climate variability and change (Kansiime and Balabanis)

2.3.1 Spatial political structures

There is a big gap between the developed countries and the developing countries in terms of socio-economic and political and political development. This has an implication on decision-making institutions on water, climate variability and climate change. The North is at about 90% of development when the south is at about 30%.

Socio-economic and political gaps

There is a big gap between the Developed Countries (DC), the North and least developing Countries (LDC), the South. The can be seen in social, economic and political dimensions. The DC countries have many other pressing issues and the issues of climate variability and climate change on water resources management might is usually not be given a proper attention. However, at times the policy makers appreciate these issues if they contribute to their stay in power, especially where the soliciting of votes is involved.

Decision making process in developing countries

Adhoc decisions

Most decisions in the South are taken on adhoc basis to manage certain crises. This is either because there is no data available or because the government never invested in the in the generation of data. Examples are lack of flood warning systems (accurate and reliable) in Mozambique and the infestation of water hyacinth in Lake Victoria or fish poisoning in Lake Victoria and subsequent ban on fish export from East Africa. In the latter case, there wasn’t adequate resources to assess (human and financial) the extent of fish poisoning and nor was a good functioning laboratory to test fish samples. One would have expected a laboratory to in place, as there is revenue collection from fish!

Information based decisions

In South decisions are made without scientific data, ether due to lack of the data or the data is available but the government takes the decision on what they want. Examples of these are drainage of wetlands to set up industries, which temper with hydrological and ecological functions. Even when such systems are modified not measures are put in place to mitigate the repercussions like construction of proper drainage channels. On example is the deforestation in favour of agricultural schemes.

It should, however, be noted that at time data in not available from the scientific community or when it is available it cannot easily be used by politicians to take decisions.

North-South collaboration and dialogue

Financial support from the north to the south is one of the prime drivers to cope up with climatic variability, climatic change and water resources management. It should be emphasised that the North should, through a mutual understanding or dialogue, advise the countries of the south on the best way forward, which should be, integrated one. This could be for example through supporting the health sector and at the same supporting projects in water supply and sanitation. This support could even go further to other sectors like climate prediction and monitoring. This could be followed by afforestation in areas, which are to siltation and flooding. However, the North should monitor the support and advise accordingly.

Good governance

There is a common debate on the need for good governance by the north when referring to the south. The empowerment of people through the bottom up approach could be one the best approaches to tackle problems related to water and climate. However, this depends on the socio-economic and political conditions. In some cases daily survival is more important that the problems that are likely to come in the future.

Capacity building

Capacity (both human and infrastructure) in not adequate to handle water and climate relates issues. The little that is available is in the state of despair. The infrastructure is deteriorating whereas for human capacity there either brain drain or lack of finical resources and incentives to carry out water and climate related activities (e.g. data collection, storage and analysis).

2.3.2 Regional power structures

Regional co-operation

There is some regional co-operation in the south, which could be enhanced to influence decision-making in integrated water resources management and climate issues. These include Southern African Development Co-operation (SADC), East African Co-operation (EAC), etc. However, when encouraging these initiatives it should be noted that countries working together are at different states of socio-economic development.

Conflict resolution

There are conflicts, both national and regional which hinders efforts to come up with common approaches on issues related to water and climate like water quality monitoring and assessment.

2.3.3 National power structures

Differences exist between countries on how decisions are taken. In some countries there is bottom up approach in decision-making, whereas in others the local populations are rarely consulted. Projects implemented through the top have in most cases not been sustainable. Whereas there is need to empower the local communities, this should be work on national governments with some aid from the north.

2.3.4 Barriers to sustainability of current practices in water resources management

Water policies are usually pursued through technological development. However, this is quite limited and insufficient, if a sustainable development goal is sought. The achievement of such goal requires the analysis of the policy formulation process, its actors, context and dynamics.

Very often the effect different institutional arrangements – such as privatisation, pricing and integrated management – will have on water supply, water quality and risk management, are not assessed.

Structure and management system designed in such a way that they don't facilitate involvement by the responsible authorities at different levels. Roles and responsibilities are not clearly established and in the case there are shared. Co-ordination is weak.

In transboundary water resources management, there is a difficulty to accept that national interest may have to be sacrificed.

Policies do not consider adequately the interplay between varied local and regional conditions and the policies set at national, European and international levels.

The EU Water Framework Directive stimulates co-operation and implementation of agreed policies on water. It prescribes the catchment, river basin as a unit for water management and provides for harmonisation of regulations across a range of water-related activities, but the responsibility for monitoring compliance currently rests with the member states.

2.4 Identification of solutions – Lead: Savenije

In order to improve the capacity to cope with climate variability through the political and institutional dimension, a wide range of aspects need to be addressed, involving economic, institutional, social and political aspects. These aspects are worked out in the following.

2.4.1 Economic stability and access to markets

As a consequence of climate variability and climate change a wide range of water-related products and services are at risk. The concept of virtual water trade can provide a network to absorb climatic shocks. For countries to take part in the network of virtual water exchange they need to have access to markets and to be part of a system were a minimum of economic and political stability is guaranteed. In the North an example of such a system is the European Union, which developed from a common market into a political union. SADC (in southern Africa) and ASEAN in the Far East take similar steps.

2.4.2 Institutional capacity for water management

There is a need for a community of water professionals that are fully conversant with the concepts of IWRM and who operate in a network of stakeholders, officials, researchers and educators. Such a network of individuals and institutions is a powerful mechanism to absorb shocks related to water and climate such as floods, droughts, pollution hazards, allocation conflicts, etc. A good example of such a network is WaterNet in southern Africa. WaterNet has a joint education, research and training programme in IWRM with about 20 institutions in the region. An important part is the modular IWRM Master Programme that is shared between the universities of the region, which feed the network with a new generation of international professionals. At annual assemblies topical issues are discussed between politicians, researchers, professionals and stakeholders.

Box 2.1, Example of policy changes following a flood: Mississippi-Missouri

The Great Flood of 1993 in the Mississippi-Missouri system has been labelled as the most devastating deluge in the modern history of the USA. Historical flood records on the main stem of the Missouri were broken at several observation stations by up to 1.2 m. In St. Louis on the Missouri, the previous record stage was exceeded for more than three entire weeks (*cf.* Natural Disaster Survey Report, 1994). The Great Mississippi Flood had significant impact on flood policy. The recommendation of the US Interagency Floodplain Management Review Committee after the 1993 flood was that federal, state and local governments and those who live or have interest in the floodplain should have responsibility for development and fiscal support of floodplain management activities (cf. Galloway, 1999). The Committee recommended that the administration should fund acquisition of needed lands from willing sellers and buyout of structures at risk in the floodplain. The number of families relocated from the vulnerable floodplain locations in the Mississippi Basin and in other regions in the USA is of the order of 20000 (after Galloway, 1999).

2.4.3 Participation in water management

The process of water resources planning and decision making should be shared with the four main stakeholders in society: the civil society, the private sector, the NGO's and the relevant government entities. Only if these four groups of actors are actively involved in a participatory process can the process become efficient to address the challenges in water resources management.

2.4.4 Information sharing and awareness

For politicians to become fully committed to the issues at hand, there should be awareness on the importance of the issues, and unbiased information on the extent and complexity of the problems. In northern societies there is no lack of awareness, often rather the reverse. But in developing countries the access to information and the awareness of the public is reduced. As a result the issues on climate variability and climate change are often not recognised as politically important. There is a need for better sharing of information and access to media.

2.4.5 The facilitating role of Government

Governments should share the burden of managing the resource with the other actors in society, particularly with civil society, the private sector and NGO's. Government should be the director of this process in the role of caretaker (responsible for the conservation and wise use of the natural resources), regulator (to safeguard the public interest and to enforce the law) and facilitator (to facilitate that the other actors play the role they need to play). Concepts of good government are important aspects in this regard, providing legal security, transparency, accountability and the freedom to express one's views.

Government should promote the development of coping strategies by supporting research, pilot projects and mainstreaming good practices.

2.4.6 Co-operative agreements

Co-operative agreements between farmers, water supply companies and nature conservation bodies as an instrument to meet both environmental standards and economic efficiency.

Analysis of the impacts of introducing a socially efficient price of water, and identification of potential reforms.

2.4.7 Identification of solutions (Addition by Pahl-Wostl)

Solutions requires that problems have been identified

1. Fragmentation of responsibility in different political areas
2. Problems of fit and interplay between institutional settings at different scales
3. Tradition of risk management by technology and control

Solutions - tasks

- Change the technology driven tradition of water resources management to an integrated management perspective where the human dimension has a prominent place.
- Adopt a new comprehensive notion of policy and polycentric governance that includes the design of flexible and adaptive human-technology-environment systems (of particular importance in times of increasing uncertainty due to climate change).
- Bridge the science-policy gap by defining a new role for science as active participant in polycentric policy processes rather than being an external observer.
- Develop new concepts and methods for public and stakeholder participation in multi-scale integrated assessment processes and modelling.

The role of water policy in the light of an integrated management of water resources at different scales implies to manage major societal transformation processes towards sustainability. In such cases it is important to adopt a broad understanding of a polycentric policy making. Polycentric governance involves processes of social learning that are essential for processes of innovation and the adoption of new strategies in heterogeneous actor networks.

This implies that a command and control approach that characterised environmental policies in a number of countries (including the EU) in the past has to be replaced by the use of market based instruments in combination with incentives for self-organisation and public participation. This also reflects a changing role for the government.
The participatory process will include formal relationships - e.g. public authorities that have formal, legal and/or contractual relationships. In particular, it will have to address groups that communicate only informally, or do generally not communicate at all, but who are affected by an integrated management approach. The latter participatory process will have to proceed the implementation of novel policies and/or institutional settings. Any water resources management plan that includes environmental/economic/social objectives and changes in technological/institutional settings has to be developed in a participatory setting. This will guarantee that those issues relevant to the actors are captured. And it will take into account the importance of procedural implying that the preferences regarding an outcome of a decision are highly dependent on how the decision was derived.

Participation needs to include both stakeholders and the public at large. Stakeholders should not be confused with the public at large. A stakeholder is only defined in reference to a particular issue. Public and stakeholder participation has to be based on a careful analysis of the current institutional setting (role of different stakeholder groups, formal and informal rules, and type of organisation) and a subsequent design of a participatory process.

Co-operation will play an important role. The importance of co-operation and the difficulties in achieving it have been on the research agenda of the social sciences for quite some time (key word - tragedy of the commons). It is now well recognised that trust, reciprocity and reputation are norms that have to be shared by a collective of actors in order to achieve voluntary agreements, engage in co-operative action, adopt novel strategies and escape from social dilemma situations.

The lack of information and the lack of an ability to make decisions often prevent citizens from becoming more involved. In contrast, empowerment implies that citizens really take an active role in defining an issue. This embraces a number of important points:

- Access to comprehensive and timely information about an issue that must provide different perspectives and uncertainties.
- Citizens have to be enabled to take over responsibility in important decisions.
- Institutional settings must permit citizens to phrase and communicate their perspective and clearly articulate their voice.
- Citizens must have a real stake in an issue to be motivated to make an active contribution.

Citizens should be involved in different areas of decision making in water resources management. On one hand, they may participate in making choices on transformation processes towards entirely new management schemes. On the other hand they may become active participants in daily management practices. Hence, one can make a distinction of three different areas for citizen participation:

- Integrated assessment where informed citizens judge risks and benefits of different development trajectories and management schemes.
- Technology assessment where single technologies and their risks and benefits are judged.
- Risk management where citizens take an active role in assessing and managing risks on a routine base.

Economic incentives and market-based instruments will have an important role. However, dealing with water as an economic well is not free of controversies. It is a major difference if water is required for survival or if it is used for leisure purposes. The lack of access to financial resources and market power should not prevent underprivileged groups in a society from their access to water as an essential resource.

Water is unequally distributed among the regions of the world. Whereas water markets and participatory water resources management (water user associations) may be quite efficient to allocate water among different competing demands at a regional scale water is not a commodity that could be traded at a global scale. Here the importance of virtual water comes into play. The supply of the megacities of the world will have to be based on a global supply network. Given the potential and/or the perceived increase in vulnerability that may arise from the dependencies in global supply networks resolving this issue will require a multi-scale participatory process with numerous stakeholder involved.

2.5 Challenges and Recommendations – Arjen Hoekstra

2.5.1 The political debate on 'the poor'

The tragedy of the poor is strongly linked to the access to water. Eighty percent of the diseases (check) in developing countries are water-related. The poor generally live in a critical balance with the water resources available. For that reason, the people that are most vulnerable to current climate variability are the poor. And if – in the context of global climate change – we speak about changes in climate variability in the long term, it is again the poor that will suffer most. Whereas in the rich regions of the world, people have a relatively large coping capability, in developing countries a slight change in climate variability – a bit higher frequency of extreme events or a bit shorter growing period – can have very large effects in terms of health, mortality, and economic damage.

Through affecting climate and climate variability, the rich hit themselves, but more and in particular the poor. The political issue that thus emerges is which mechanism can be put in place to 'institutionalise' the responsibility of the rich (North) towards the poor (South). On the one hand, this responsibility can be translated into international agreements on the reduction of greenhouse gas emissions that has to take place particularly in the North. On the other hand, the North should take the responsibility to contribute to demand-driven institutional capacity building in the South in order to increase the capacity in the South to cope with climate variability and climate change.

2.5.2 The political debate on 'climate change'

The global debate on climate change and the strong global institutional framework that has grown around this debate is a good starting point to get politicians together on the issue of availability and access to water in relation to climate variability.

Climate change is strongly induced by the North but most affects people in the South. Reason: climate change will have global effects in terms of changes in climate variability, but vulnerability to changes is much larger in the South.

2.5.3 Institutional capacity building

Proper coping with climate variability particularly requires that proper institutional frameworks be in place.

Institutional capacity building is needed at various levels. At global level, the current institutional setting for trade between nations is not well prepared to address problems that evolve from changes in climate variability. Poor countries are not well represented in the WTO debates. Although a free global market can offer opportunities for developing countries, it also carries great threats if vulnerable regions are not well prepared or protected.

Also at the national and subnational level institutional framework are insufficient. Particularly developing countries are insufficiently prepared.

2.5.4 Challenges for the Dialogue on Water and Climate

- get the South into the debate
- get the various actors into the debate

Provide different platforms for discussion, tuned to the particular interests of the various actors

3 Coping with climate variability and climate change (Eelco van Beek, Eugene Stakhiv)

'Even Julius Caesar, and the Roman Empire, could not conquer the blue sky, so everywhere you go always take the weather with you'

Neil Finn, 1992

Lead authors:

Prof.Dr.Ir. E. van Beek, WL-Delft Hydraulics, p.o.box 177 2600 MH Delft, the Netherlands, email: eelco.vanbeek@wldelft.nl, phone 0031-15-285-85-85, fax 0031-15-2-85-85-82

Dr. E.Z. Stakhiv, US Army Corps of Engineers Institute for Water Resources, Telegraph Road, Case Building Alexandria, Virginia 22315-3868, USA, email: Eugene.Z.Stakhiv@wrc01.usace.army.mil, phone: 703 428-08077, fax: 703 428-6124

Contributing authors/workshop participants:

Ronald Schulze	University of Natal	schulzer@nu.ac.za
Johan Rockstrom	UNESCO	jro@ihe.nl
Jeroen Veraart	Alterra, Wageningen-UR	j.a.veraart@alterra.wag-ur.nl
Jaap Kwadijk	WL-Delft Hydraulics	jaap.kwadijk@wldelft.nl
Kees Dorland	IvM Free Univ. A'Dam	kees.dorland@ivm.vu.nl
Jorn Rasmussen	GWP	Jar@dhi.dk

Summary[TDM4]

Key statements for the summary key issues up-front

- Prerequisite to adaptation and coping is the application of Integrated Water Resources Management
- from individual households to local communities to catchment to (inter)national
- There are fundamental differences in adaptation and coping strategies between developed and developing countries
- For water managers in many developing countries the impacts of changes in climate are minor compared to the problems they are facing already with the present climate variability
- 'Coping for present day climate variability' already takes us a long way down the road towards 'coping for climate change'
- due to climate change the variability is likely to increase

Other:

- Start by implementing what we have to do anyway to cope with our WRM problems (and know how to do it: IWRM – 'no regret approach')
- next: discuss the precautionary principle as option and discuss what the implications for countries like Mozambique will be
- Define the thresholds for what 'water management' can do (and where others have to take over)
- There is a limit on resilience of our systems and own capacities to plan and operate based on anticipated climate 'surprises'
- From the watermanager's perspective this kind of stuff is something that international fora should discuss at high levels (e.g. 4th IPCC)
- Don't overreact / overestimate the impacts – stay realistic

3.1 Introduction

Changes in climate and climate variability will force mankind to adapt themselves to the new conditions. Within the framework of the Dialogue on Water and Climate the perspective of the watermanager is taken. What options does he have to deal with the changes around him? What are best practices? This chapter provides an overview of possible approaches and strategies.

Adapting approaches and coping strategies are not new. Since the time of Noah's flood, societies and civilisations have adapted to the vagaries of climate variability through various coping mechanisms and adaptation strategies. Societies and political systems were organised around the need to control, regulate and distribute water for irrigation and food production. Hence, adaptation and coping strategies are as old as civilisation itself. What is new are the improved technologies for more efficient use of water; storage and conveyance; treatment of water; predicting its availability, and improved biotechnology for increased crop yields.

Before describing how watermanagers can cope with changes in climate variability we first have to define what we mean with water managers (par. 4.1.1). The fact that coping can be done from many different points of view and at different scale levels is highlighted in par. 4.1.2. In section 4.2 the principles and prerequisites for good water management, and thus for coping and adaptation, are given, including some observations on the differences between developed and lesser-developed countries. The actual description of the coping and adaptation strategies is given in section 4.3. Given the framework of DWC, special attention is given in this section to indigenous coping strategies. Section 4.4 presents some examples of coping strategies while in the final section 4.5 some key-issues in adaptation and coping are highlighted.

3.1.1 Water management and water managers

Water management is an organised activity, which inherently deals with actions and strategies to ameliorate the vagaries (uncertainties) of climate variability and change on the availability of water resources for society's multiple purposes and uses, including maintenance of aquatic ecosystems. Management typically includes a range of activities and programs, encompassing all levels of government, the private sector and individuals. It spans the development of new supplies, control of floods, provision of water for instream uses such as navigation, hydroelectric power, recreation and environmental flows, as well as offstream withdrawals and uses such as irrigation, power cooling and municipal and industrial water supply. Water resources development typically is concentrated in a few agencies or ministries. Water management also involves the regulation, control, allocation, distribution and efficient use of existing supply. All levels of government, and especially the private sector and individuals, are routinely engaged in the management of use of water. Hence, technically, every individual who uses water and every woman in a village who draws water from a well are a water manager. Those who pay for its delivery and treatment are also responsible for its efficient use and conservation. Nevertheless, water managers typically

are considered to be those people who are formally trained and involved in some institutionally organised component of water development, delivery or regulation, and who have responsibility and accountability for the decisions that are made.

However, from the perspective of DWC we use the wider definitions of watersystems and watermanagers. Besides the large-scale, mostly technical systems we will take also the small-scale rural systems and rainfed agriculture in our discussions into account. This means that we consider all users, and in particular the farmers, to be watermanagers. It is even anticipated that addressing the options that farmers in the lesser-developed countries have, might be more important for solving the issues around water and climate then answering the question how the big technical systems of the developed world can cope with the changes.

3.1.2 Situational and scale differences

There is no general panacea for coping with climate variability. The 'best' solution will depend on the specific situation and the position of the involved watermanagers. A watermanager has to take many other (non-climate) aspects and constraints into account which, in some cases, will be conflicting which what he would like do to in order to cope for climate variability.

Another difficulty arises from the wide range of spatial and temporal scales that have to be taken into account in the water and climate discussion. Schulze (2001) mentioned for example the following spatial scales involved:

- global scale issues, e.g. water conventions, climate change, El Niño-Southern Oscillation (ENSO) scale events
- international scale problems, e.g. international rivers
- national issues, e.g. national water management agendas
- catchment scale issues
- local government scale initiatives
- community scale issues
- household scale problems, e.g. in poorer countries household food security or household water poverty.

With respect to the temporal scales Schulze (1999) lists:

- *climate scales* at intra-seasonal, inter-seasonal and decadal time frames, which 'drive'
- river flow scales, which for:

- Surface water range from high flow/drought 'cycles' related to ENSO at multiple year scales, and associated inter-seasonal variability, the seasonality and concentration of streamflows within a year and intra-annual variability, the forecastability of river flows up to a season ahead and extremes such as floods, while for

- Groundwater temporal recharge patterns and water table fluctuation are of importance

- *ecological time scales*, which are determined by magnitudes, frequencies and duration's of low and high flows as biological triggers
- Agricultural time scales where for crops the intra- and inter-seasonal timeframes are important, whereas for forestry, inter-seasonal to decadal timeframes are of significance.
- *economic time scales*, ranging from longer term international to national, regional to local to shorter term individual rural subsistence household time scales
- *Political time scales*, which need to distinguish between (a) essentially stable government structures vs potentially unstable government structures and (b) inter-election time scales for national to local governance structures.
- *management and planning time scales*, often of the order of 10-20 years and
- *Wealth/development level time scales*, where wealthy countries tend to have longer term planning horizons while for poorer countries they tend to be shorter.

3.2 Principles and Prerequisites for Water Management

3.2.1 IWRM as a prerequisite for coping and adaptation

The core of water management has been its historically evolving adaptive capacity and capability. It is redundant to think of adaptation and coping strategies for climate change as something new or apart from basic water management practices. Currently, there are no approaches that are uniquely suited for adaptation to climate change that would be measurably different than those already employed for coping with contemporary climate variability. The only substantive difference is whether one adopts a more conventional and incremental "no regrets" approach, versus a more anticipatory "precautionary" approach. Clearly, water management practices and preferences have changed over time, e.g., from hard structures (dams, levees) to "softer" solutions (flood plain relocation). The range of solutions and strategies has been broadened over time by improvements in technologies and availability of cheaper energy. But few measures have been discarded from a growing toolbox of management measures whose utility and cost-effectiveness has been demonstrated in numerous settings.

Figure 4.1, Integrated water Resource management and Coastal zone management. Source: Wageningen Water Impulse (http://www.wageningen-ur.nl/water/).

What has changed is our understanding and implementation of the integrated ensemble of water management measures that conform to modern principles and policies. We no longer start with the presumption that certain measures (dams, levees) are the best solutions. Rather, we begin our planning by asking what are the objectives for management. These usually now include such factors as social and community well being, women's roles in water user groups and environmental restoration. Integrated Water Resources Management (IWRM) is now the encompassing paradigm for adaptation to contemporary climate variability, and it is the prerequisite for coping with the highly uncertain consequences of global warming and associated climate change.

IWRM, like its counterpart Integrated Coastal Zone Management (ICZM), requires the harmonisation of policies, institutions, regulatory frameworks (permits, licences, monitoring), planning, operations, maintenance and design standards of numerous agencies and departments responsible for one or more aspects of water and related natural resources management. Water management can work effectively (but not efficiently) in fragmented institutional systems (such as those of the U.S. and the U.K. as examples), where there is a high degree of decision-making transparency, public participation, and adequate financial support for planning and implementation. It does not work well in most other cases where these prerequisites do not exist. Setting up the proper institutional framework is the first step towards IWRM.

True IWRM requires at least 5 levels of integration:

(a) **Vertical integration**: from the lowest level of user to the top policymakers in a ministry and all levels of government; from irrigation district to municipality to regional administration to national water commission;

(b) **Horizontal integration**: co-ordination and collaboration among all the institutions responsible for resource management at a watershed scale;

(c) **Interdisciplinary integration**: involving all relevant disciplines, socio-economic, engineering, hydrologic, economic and ecological;

(d) **Functional integration**: planning, regulatory, design, operations, maintenance, monitoring, data;

(e) **Stakeholder integration:** involvement of non-governmental interests, user groups, native groups, etc. in all aspects of water management and decision-making.

Usually the complex, intersecting requirements of IWRM are best managed through a permanent co-ordinating body such as a River Basin Commission, whose trained staff are versed in both the technical needs of water management as well as in the requirements for multiple layers of co-ordination.

The hallmark of IWRM (and ICZM) is the routine updating and incorporation of fundamental principles for modern water management, as well as improvements in technology. This progressive adaptation of policies, analytical tools and procedures increases the prospects for implementing socially acceptable water projects. It will simultaneously contribute to effective adaptation not only in response to shifting societal needs and preferences but to climate variability as well, as better and more detailed information and longer hydrologic and weather records are incorporated into the planning, design and operation of water resources systems. It is also the constant updating of socially determined management principles and planning objectives that define the evaluation context and rules that allow water managers to differentiate among various management measures and select those which are consistent with the planning objectives established through the public participatory process. These principles have been developed over decades, and are derived from numerous international conventions, and have been codified as follows:

Box 3.1, Example of living with recurring floods: Rhine and Moselle.

An example of a success story is the flood mitigation along the rivers Rhine and Moselle and their tributaries, where people have learned to live with recurring floods. Large floods, each considered a nearly 100-year flood magnitude, and occurred repeatedly on the Rhine within 13 months. In December 1993 the level of the Rhine in Cologne reached 1063 cm, while in the beginning of 1995 it went up to 1069 cm. Yet, the damage during the second deluge was much lower than during the first. The establishment and continuous extension of precautionary measures over the past decades and informing the local population helped to withstand major floods. The adverse effects of river straightening and the building of dykes along the Rhine are presently compensated by Integrated River Programmes (e.g., Demuth, 1999) and the restoration of floodplains through polder systems.

- Water is essential for food production and self-sufficiency.
- Water is a social and economic good, and its values must be formally taken into account in evaluating projects.
- Every person should have access to a safe and reliable source of water.
- Public participation is an essential component of effective water resources management and all attempts should be made to engage women in water resources management.
- Water is managed most effectively at the level for which decisions and responsibilities are routinely exercised (principle of subsidiarity).
- Financial subsidies of water resources development should be minimised, and costs should be recovered by the users to ensure efficient use of water.
- Privatisation of selected water resources management functions should be promoted to the extent possible, especially for vendible outputs and services, such as hydropower, irrigation and municipal and industrial water supply.

3.2.2 IWRM and developing nations

The focus of the Dialogue on Water and Climate is on solving the water problems of the lesser-developed countries (LCD's). Although the approach to IWRM as described in the previous section applies to lesser developed countries as well, and some definitions and descriptions of IWRM are directly oriented at those lesser developed countries (see e.g. GWP TAC Background paper no. 4 on IWRM), we do have to keep in mind that major differences exist in the way IWRM can be implemented. Table 3.1 (Schulze 2001) gives an overview of these differences. Developed countries tend to focus more on quality of life and environment and on long-term issues while IWRM in lesser developed countries frequently has to address more basis issues (Schulze, 1999) such as basic water supplies (vs water of highest quality), managing supply (vs demand management), poverty alleviation (vs quality of life), harnessing the environment (vs sustaining it), creating an infrastructure (vs maintaining, improving it), etc.

With the tendency for concepts on IWRM and ICZM to emanate largely from the developed world, a re-focus is necessary on problems of IWRM in LCD's. Schulze (2001) states the following generalities for LCD's:

- that decisions on water management are often made 'from a distance' in a far-away capital city;
- that poor peoples' water needs are frequently overlooked or underestimated in broader scale IWRM;

- that amongst stakeholders there are major disparities in wealth, influence with government, opportunity, skills, resource endowments and capacity for management as well as for economic performance (Frost, 2001);
- that government project failures abound because funds have run out, or they are behind schedule, or operation and maintenance are inadequate;
- that the main need is for basic infrastructure development to provide for water security; and
- That priorities pertaining to environmental issues are frequently lowered, and where considered, often focus on economic benefits such as erosion and river control.

Moreover, for most LCD's, change in climate variability is just one of the many problems they are facing, and depending on the magnitude of these changes, often not the most pressing. This should be taken into account when climate change is discussed in the context of LCD's. Also the 'solutions' that should come out of the discussions will have to take the specific conditions of LCD's into account, e.g.:

- application of local catchment planning methodologies that are both technically sound and participatory, building on local peoples (= vernacular) knowledge, experience and practice;
- planning initiatives that are accessible to, and involve, local community organisations and which include appropriate capacity building and technical support; and
- Development of a framework of local-level collaboration amongst NGOs, CBOs (community-based organisations) and government departments with relevant government agencies.

Table 4.1 Characteristics influencing IWRM in more developed versus lesser developed countries (after Schulze, 1999)

Developed Countries	Lesser Developed Countries
	
INFRASTRUCTURE	
• High level of infrastructural development, with infrastructure generally improving	Infrastructure often fragile and frequently in a state of retrogression
• Infrastructure decreases vulnerability to natural disasters (e.g. floods, drought)	High vulnerability to natural disasters; heavy damage and high death toll
• High ethos of infrastructure maintenance	Low ethos of infrastructure maintenance
• High quality data and information bases available, well co-ordinated	Data and information bases not always readily available
CAPACITY	
• Scientific and administrative skills abundantly available	Limited scientific and administrative skills available
• Expertise developed to local levels	Expertise highly centralised
• Flexibility to adapt to technological advances	Often in survival mode; technological advances may pass by
ECONOMY	
• Mixed, service driven economics buffered by diversity, highly complex interactions	High dependence on land, i.e. agricultural production; at mercy of vagaries of climate
• Economically independent and sustainable	High dependence on donor aid, NGOs
• Multiple planning options available	Fewer options available in planning
• Take a long term planning perspective	Take a shorter term planning perspective
• Countries wealthy, money available for planning and IWRM	Wealth of countries limited, less scope for planning and IWRM
SOCIO-POLITICAL	
• Population growth low or even negative	High population growth rates and demographic pressures on land
• Generally well informed public with good appreciation of planning	Poorer informed public, less appreciation of science/planning
• High political empowerment of stakeholders	Stakeholders often not empowered, afraid to act or to exert pressure
• Decision making decentralised	Decision making centralised
ENVIRONMENTAL AWARENESS AND MANAGEMENT	
• High level of expectation of planning and IWRM	Lower level of expectation and attainment of goals
• Desire for aesthetic conservation	Need for basics for living

3.2.3 Dealing with uncertainties

Coping and adaptation for climate change and climate variability means that we have to deal with the uncertainties involved

…….. general ideas on working with uncertainties ……

insurance (Veraart, adapted from van Ierland et al., 2001)

The insurance industry's financial interest is inter-dependent with climate and weather. The risk of natural extreme events, is one of the factors driving the demand for insurance coverage. If insurance companies do not allocate well their insurance portfolio packages they can be over-exposed in high-risk areas. Most insurance coverage is based upon historical data, which is then extrapolated using adjustments for inflation and other economic factors. Climate variability will most likely change the previous trends involving higher uncertainty in the future in the dimensions, location, or timing of extreme weather events. Insurance companies can no longer calculate risks based on historical data, but should look to the future in calculating and mitigating risk. Climate change is a global phenomenon and insurance is a global, as well as a local, market service. The insurance sector consists of three main players: policyholder (the insured), primary insurers, and re-insurers. Primary insurers are actually providing insurance and being insured by re-insurance companies at the same time. Therefore they spread the risk of large damages. Local insurance companies will partly be affected by climate change impacts within the region, but also climate catastrophe all over the world, which will result in, changes to their reinsurance rates and availability.

The main re-insurance companies do the major research on climate change. Munich Reinsurance Company reports, that the number of natural catastrophes in this decade is four times greater than in 1960's; economic losses are eight times greater, and insured losses are 15 times greater, even adjusting for inflation.

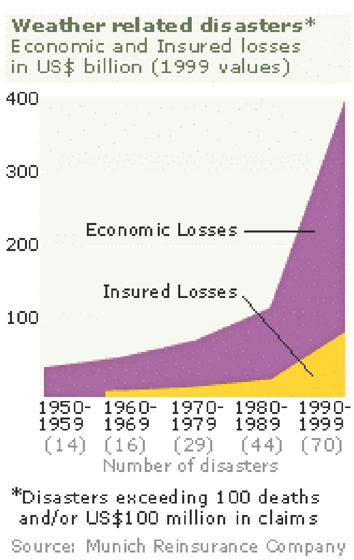


Figure 4.2 Weather related disasters - Economic and Insured Losses in US$ billion (1999 values) Disasters exceeding 100 deaths and/or US$100 million in claims are considered.

There are several factors behind the dramatic rise in catastrophe losses (Nutter, 1999):

- Population growth and increasing concentration of population in high risk areas
- High increases in insured values
- Expansions of coverage by insurance companies
- Insecurity of building structures
- Climate change and the incidence of more frequent extreme event.

Table 4.2 Large scale economic losses related to flood hazard in the Netherlands.

Date	Disaster	Losses
September 1998	Heavy rainfall in south western Holland	Several hundred million USD economic loss. Many crop losses. Partial compensation from the government.
January 1995	River flooding on Rhine and Maas	USD 1.2 billion economic loss. USD 250 million compensation from the government
December 1993	River flooding	USD 150 economic loss.
February 1953	Storm surge disaster	1835 fatalities. 1650 km^2 of land under water. NFL 2 to 2.5 billion economic losses. 3000 houses destroyed, 43000 damaged.

Source (Swiss Re, 1998)

Table 4.3 Most significant historical storm events with insured losses in Europe.

Date	Countries	Insured loss (USD billions)	Return period (years)
October 1987	UK, F, NL	4.3	5
January 1990	Europe (mainly F, D, UK)	5.8	8-10
February 1990	F, D	1.1	< 5
February 1990	UK, F, NL, B, D	3.4	< 5
February 1990	D, CH, A	1	< 5
January 1995	Northern Europe	1	< 5
December 1999	DK, D, UK, SW	1.5	< 5
December 1999	F, D, CH	5.8	8-10
December 1999	F, CH	2.4	< 5

Source (Swiss Re, 2000).

Storm activity, however, is covered with property insurance, and is one of the main climatic hazards, that cause large-scale damages in the Netherlands and across Europe (table 3.14). Reinsurance companies apply risk assessment model to determine the insurance premium and their long-term strategy. The key factors integrated in the model are: the actual hazard (storm path, storm frequency and intensity), vulnerability (loss experience specific to buildings, to the utility of structures and to countries), the geographical distribution of all insured values, and the existing insurance covers with their specific treaty conditions. The traditional approach of historical time-series analysis was replaced with probabilistic models, which provide more information on the expected return period (or frequency). Probabilistic models are used to determine the relationship between loss frequency and intensity. (Swiss Re, 2000).

Adaptation options within insurance

A study of Leggett (1996) reviews three strategies to climate change. The first strategy is a status quo or business-as-usual scenario, where insurers hope that the rise of large-scale losses from storms and other weather related disasters is temporary. The second strategy is an adaptation option: globalisation of insurance industry and capital accumulation in order to allocate the liabilities in more global way. In case of large-scale catastrophes there is enough coverage from other insurance portfolios. Similarly a well-structured re-insurance net could be built up, to cover large scale damages, without threatening the viability of the insurers. One of the adaptation options is to slowly going out from highly exposed markets, first with sharply increasing premium, and then in a later stage leave the market. In case of a non-adaptation policy, the insurance industry would cancel the coverage on the most vulnerable coastal areas in the long term. The third strategy involves actions for mitigation options. At one hand lobbying governments to act to reduce CO2 emissions, at the other hand promoting shifting investment away from fossil fuels and towards non-carbon based energy sources with premium differentiation. Insurance companies can also follow green investment strategies by investing their funds in new, less carbon-intensive technologies (forming a kind of climate venture fund). Finally, insurance companies could spur the development of less threatening energy system (Flavin, 1994).

3.3 Coping strategies

3.3.1 Coping Mechanisms and Adaptation Strategies

As mentioned in the previous sections, water management has always been dealing with climate variability. This means that DWC is not looking for real new strategies, specifically designed for the conditions that climate people expect now to happen. It might mean that we would have to add or emphasise certain strategy components, which is a bit more of the same. But it also might mean that we have to follow a different approach to watermanagement, e.g. to step down our efforts to 'harness' the water and to start 'living with it'. Actually, such change in approach is already taking place in several European countries.

No really new strategies do not mean that it will be 'Business as Usual'. The effects of changes in climate variability can be of a different nature and/or could take place as sudden events, situations that are different from the ones that we now take into account in our watermanagement planning and operation.

In the report 'Water: the potential consequences of Climate Variability and change for the water resources of the United States', Gleick et al (2000) lists the following major categories for coping and adaptation:

- Water planning and management, among other:
- Taking into account new design standards, assumptions, contingency planning, etc.
- including a vulnerability assessment to plausible climate change
- Based on co-operation between water agencies and leading scientific organisations.
- Modifying operation of existing systems
- can they handle possible changes; and at what economic and ecological costs
- New supply options
- Combining new infrastructure with other supply oriented measures such as desalinisation, re-use, water marketing, etc.
- Demand management, conservation and efficiency
- Leakage repair, drip irrigation, reuses pricing policies, etc.
- Economics, pricing and markets
- based on the treatment of water as an economic good, insurance
- Legislation

IPPC (Climate Change 2001, Impacts, Adaptation and Vulnerability, Section Hydrology and Water Resources, table 4-13) presents a more or less similar list of possibly supply-side and demand-side adaptive options.

Box 3.2, Example of flood management: Japan

A comprehensive flood control management in Japan was initiated in the late 1970s after several dyke collapses along major rivers. Realising that the physical control works alone could not completely protect from floods; the basic strategy of this management was an integrated approach to flood damage mitigation, especially promoting the storage and retardation functions of river basins, including urban ones.

A discharge suppression strategy, sometimes called "law of discharge conservation", implies that new developments should not increase the flood discharge from the area when compared to the original state. Storage and retardation function of disappearing paddy fields and the infiltration capacity of forests, grass and farm lands converted to industrial or urban areas should be replaced by artificial storage and means enhancing infiltration (and storage underground).

Furthermore, land use zoning, flood-proofing, publicising flood hazard maps, strengthening community systems for evacuation were also emphasised. Other very expensive means were underground storage facilities. Some tunnels cost more than US$ 120000 per meter, such as an underground water-storage tunnel in Tokyo (at depth of 40 m, of diameter 12.5 m, planned to be extended to the length of 30 km).

The current Japanese strategy for flood protection management embraces different components for distinct cases:

- <u>Strategy for large rivers</u>: structural means such as dams, levees, flood diversions, channel improvements, upstream sediment control; and non-structural means such as flood forecasting, warning, evacuation and community self-protection teams.
- <u>Strategy for major cities</u> along major rivers where absolutely no embankment collapse is allowed: protection by "super levees", high and wide (300-500 m).
- <u>Strategy for small urban basins</u>: retardation facilities such as district ponds, building storage’s, emergency use of school playgrounds and parks, underground retardation and drainage pipes; infiltration facilities, conduits with infiltration holes, permeable pavements, improved drainage facilities including drainage pumps in lowlands, flood proofing by elevated house foundations and district walls, protection of subways from floods to enter. The runoff forecast based on quantitative precipitation forecasts.

<u>Strategy for environmental concerns</u>: artificial restoration to a more original state of the hydrological system by enhancement of water storage and infiltration of rainfall in urban areas and in river basins is an efficient solution to both ecological and water resources requirements and implementation of nature-oriented river improvement works. This is of importance for both flood and drought protection.

Both lists show again that there are indeed no major changes in coping with climate change and climate variability compared to what is being done (or should be done) in Integrated Water Resources Management already. The difference can be found in how serious we take climate change and variability into account, i.e. the amount of variability and the level of the unexpected event.

As far as specific management measures are concerned, as a general rule, reservoirs provide the most robust, resilient and reliable mechanism for managing water under a variety of conditions and uncertainties. However, other combinations of non-structural measures (conservation, pricing, regulation, relocation, etc.) may provide comparable outcomes in terms of gross quantities of water supply, but not necessarily in terms of system reliability. The choice of alternatives depends on the degree of social risk tolerance and perception of scarcity as well as the complexity of the problem. The permutations for coping with the uncertainties of climate change and variability are limitless – both in the number of strategies and in the combinations of management measures that comprise a strategy.

There is no single “best” strategy – each depends on the factors listed above. However, depending on the criteria used to determine the “best” choices (economic efficiency, risk reduction, robustness, resiliency, reliability) it is clear that an emerging technology, which has the potential to improve virtually all forms of water management, is short-term mesoscale weather and hydrologic forecasting for 15-, 30-, and 90-day periods. Substantial advances are being made in applying this technology in the U.S. and Europe. More reliable short term weather forecasting for water management purposes represents a key example of how scientific breakthroughs can aid real-time water management and operations, which in turn improve the overall responses to climate variability and greatly increase the efficiency of water management and use, especially for irrigation – by far the largest user of water globally.

Another ‘new’ technology that might me very promising are the expected rapid breakthroughs in biotechnology, greatly increasing crop yields while reducing water use and making the crops less dependent on water conditions. This has great potential in water-stressed areas and in areas of saline and brackish water.

3.3.2 Indigenous coping strategies

Some 40 % of the world’s land area is located in water scarcity prone environments hosting a hydro-climatic spectrum from arid to dry sub-humid. The major characteristic of these landscapes often denoted “drylands” is not necessarily low cumulative annual precipitation, but rather the extreme spatial and temporal variability of precipitation. Coefficients of variation generally range from 20 – 40 %, increasing with lower average annual precipitation. Societies, evolving in these environments over millennia, have developed a broad range of mechanisms to cope with climatic variability. In rainfed based agrarian communities, for large parts of the semi-arid tropical world, this has focused on local development of social, economic and bio-physical management strategies to bridge droughts and dry spells, and to cope with floods from intensive storms. The indigenous knowledge base on climatic coping strategies certainly dates back at least 7000 years, which represents the most recent paleo-climatic period with more or less constant natural climatic conditions (Nicholsson and Flohn, 1980). Indigenous strategies to cope with climatic variability vary between different geographical locations and between social-religious-cultural settings, and between livelihood cores (e.g., between agro-pastoral communities depending on livestock raising compared to sedentary farming communities depending primarily on crop production). It is thus impossible to give a generic overview of coping mechanisms. It suffices to state that coping with climatic variability forms an inherent and fundamental part of societies hosted in arid, semi-arid and dry sub-humid temperate and tropical landscapes (Falkenmark and Rockstrom, 1993).

In a climate change scenario, climatic variability is expected to increase, which according to several scientists already has occurred, e.g. in the Sahel since 1967 onwards where rainfall averages seem to have decreased with 10 – 30 % compared to the long term average (Middleton and Thomas, 1992). With prospects of, or even experienced trends of, increased risks of extreme climatic variability, one would expect the proliferation of present and revival of old indigenous coping mechanisms. In general though, the situation seems to be the reverse. Population pressure, degradation of land and water resources, and migration, has in large parts of the water scarce environments resulted in the deterioration and in many cases complete loss of indigenous coping mechanisms. From the birth of agriculture until recently in tropical environments (often until late 19th century or even early 20th century) farming systems were based on shifting cultivation depending on spatial rotation of cropland and long fallow periods. In environments with large spatial and temporal rainfall variability, this production strategy was strategically designed to spread risks in space and in time. In the Sahel, fallow based rainfed farming has basically disappeared under the escalating pressure from population growth, and farmers depend for their livelihoods on continuous cultivation on small (far too small) parcels of land. Granaries were used as cereal banks, to store surplus grain from "wet" rainy seasons for use during deficit season, in accordance with Joseph's advice to the Egyptian Pharaoh in the Old Testament (save surplus from 7 good years to cope with following 7 dry years). This management strategy, dating back several millennia before Christ, formed the backbone until modern time of many farming systems in climatically variable environments.

In West Asia and North Africa coping strategies to deal with climatic variability and water scarcity date back at least to 5000 BC. In Mesopotamia, southern Jordan and the Negev desert, water harvesting systems to collect surface water from intensive rainstorms for use during droughts and dry spells, both for agricultural and domestic purposes were probably developed simultaneously with the introduction of sedentary societies (Oweis et al., 2001). In a recent study from India (Agarwal and Narain, 1997) it has been shown that water harvesting dates back 3 millennia BC. These indigenous coping strategies died out during the 20th century as a result of the modernisation of water management during the hydraulic era of irrigation developments. Interestingly these coping strategies are reviving in pace with the realisation by local farming communities that governments are not able to provide security from climatic variability.

There is a large untapped potential of improving local risk management to cope with climatic variability in many rural societies in water scarce environments. There is furthermore a scope to transfer knowledge between countries and continents, e.g., on water harvesting for food production on semi-arid regions between West Asia, India, China, and Africa (SIWI, 2001). In dealing with water for food within a climate change scenario this is important. Rainfed agriculture is practised on 80% of the global cropland, while 20% is under irrigated agriculture. In sub-Saharan Africa over 95% is under rainfed agriculture. Strategies to deal with climate change in irrigated agriculture are less evident, and include primarily efficiency improvements and decisions on changes in storage capacity in a scenario of increased variability and/or changes in cumulative water flow. On the other hand, for rainfed agriculture, a much broader set of coping strategies can be adopted and adapted, often based on the transfer of indigenous knowledge between regions. It is interesting to note also that combining coping strategies such as bridging of dry spells with investments in especially integrated soil nutrient management, can result in substantial system improvements, where not only risks are reduced and economic benefits increased (from stabilised growth of yields), but additionally water productivity is enhanced (the amount of biomass output per unit water) (Rockstrom et al., 2001). Overall, this suggests that for risk reduction in rainfed agriculture, in a scenario of climate change, there is already at present, a large space for strategic manoeuvring.

3.3.3 Analysis approaches/strategy design

To determine what the best adaptation and/or coping approach will be for a specific situation will have to be determined based on a thorough analysis of expected conditions, objectives and priorities. Given the complexity of Integrated Water Resources Management it will often be necessary to follow a systems analysis approach that include the following steps:

- formulation of a quantified problem statement
- formulation of objectives and criteria
- description and analysis of the system involved (if needed, using computer models)
- prediction of future conditions (bottleneck analysis)
- formulation and screening of measures
- combination of promising measures into alternative strategies
- impact assessment and evaluation of alternative strategies
- sensitivity and scenario analysis
- decision making

The way climate change will be incorporated in this approach depends on the specific situation involved. If climate change is a minor aspect and has a low priority compared to other aspects involved, it might that climate change is only included in one of the last steps: the scenario analysis. In this scenario analysis the question will be answered how ‘robust’ the recommended strategy will be when the conditions will be different then the ones assumed in the analysis.

In other situations climate change can be taken into account as specific meteorological boundary conditions in screening and strategy evaluation while climate specific measures will be included from the start.

3.4 Examples of coping strategies

…. still to be worked on ….

Make difference between real-world strategies and approaches and ‘academic’ exercises, often from the North. What we are looking for are real-world strategies:

- Netherlands (principles in Policy Note; start of actual policy study on Rhine)
- Lake Ontario-Saint Lawrence study (idem)
- Upper Mississippi (idem)
- Bangladesh, including Ganges-Bramaputra basins (research)
- Aral Sea (UNDP model to analyse changes in climate)

Pavel has examples in Central America – North East Brazil
Community based sand dam construction -
Western Africa TAC (WATAC) should maybe have something
UK institutions: massive awareness campaign to warn them for flooding
Strategies related to coping with El Nino

Tony Allen: don't expect radical changes – good ideas take 50 years; the fact that the Netherlands has made a first step is promising and very good

Table 4.4, Coping strategies derived from: Tom de Bucx????.

Application	Technology	Additional information
Protect		
• Hard structural options	- Dikes, levees, floodwalls - Seawalls, revetments, bulkheads - Groynes - Floodgates and tidal barriers - Saltwater intrusion barriers	
• Soft structural options	- Periodic beach nourishment - Dune restoration and creation - Wetland restoration and creation	
• Indigenous options	- Afforestation - Coconut leaf walls - Coconut fiber stone units - Wooden walls - Stone walls	
Managed Retreat		
• Increasing or establishing set back zones	- Limited technology required	
• Relocating threatened buildings	- Various technologies	
• Phased-out or no-development in susceptible areas	- Limited technology required	
• Presumed mobility, rolling ensements	- limited technology required	
• Managed realignment	- Various technologies, depending on location	
• Creating upland buffers	- Limited technology required	
Accommodate		
• Emergency planning	- Early warning systems - Evacuation systems	
• Hazard insurance	- limited technology required	
• Modification of land use and agricultural practices	- Various technologies (e.g. Aquaculture, saline resistant crops), depending on location and purpose	
• Modification of building styles and codes	- Various technologies	
• Strict regulation of hazard zones	- Limited technology required	
• Improved drainage	- Increased diameter of pipes - Increased pump capacity	
• Desalinisation	- Desalinisation plants	

Box 3.2, Adaptation and coping strategies in the Netherlands.

Introduction:

A distinguishing characteristic of current Dutch water management is that solutions to water problems not only are sought in technical measures but also in spatial measures, in contrary to the past (Commission Waterbeheer 21e Eeuw, 2000; CPB, 2000). Dutch water management policies aim to adapt the current hydrological system in an integrative way in which implications for all stakeholders are considered. Three general concepts are used in water management in order to assess sustainable water management (Commission waterbeheer 21e eeuw, 2000a,b), in order of importance:

- retention of water upstream, in the soil, ditches and small streams
- Increase the discharge and retention capacity of the rivers
- Discharge water into the sea.

Rivers

- *'Space for the river'*: Restriction of human activities in the watershed by development of hydrological criteria within physical planning in order to create more space for the rives. [A5]Increase of the water retention capacity of the rivers by moving the dikes or by deepening the floodplains. Diversion of water from the main stream by creation of branches in areas outside the floodplains (Commission Waterbeheer 21^{e} Eeuw, 2000; Rijkswaterstaat directie Oost-Nederland, 1999; Rijkswaterstaat, 2000).

Lakes

- Water management is optimised to ensure current water levels in the lakes by drainage of water to the sea. Higher water tables in the lakes are accepted as a consequence dikes and dams should be strengthened. Extra pump capacity is necessary in the regional hydrological systems to discharge water in Lake IJssel. Rural areas around the lakes (and river catchments) are used to store surplus of water. This strategy will also create opportunities for a more natural water table management and increase of the freshwater availability (during the dry summer period). However, dams and dikes should also be strengthened.
- *Nature development in the lakes:* Water management adapted to climate change should also consider the habitat and regulation functions (De Groot, 1992, Helmer et al., 1996) of the lakes in the Netherlands. Desiccation of shallow banks in dry summers (more frequently due to climate change) is potentially beneficial for development of wetlands. Wetlands in and around the lakes are not only important habitats for flora and fauna but have also an important 'purification'-function (sedimentation of suspended solids and nutrient uptake by vegetation).
- *Land reclamation in the Marker lake:* Although it seems paradoxically, some stakeholders suggest to reclaim land in lake Marker in order to create space for water to adapt to climate change. In this reclaimed land area physical planning could allocate easy large areas for wetlands, which provide space for water and nature.

The coastal zone

- *Maintenance of the coastline by sand suppletion*: this measure is important for the maintenance of the recreational and natural functions of the coastline.
- *Re-establishment of the natural dynamics of the dunes*: to create more space for natural dune development.
- Compensation of sand losses in the deeper water: Sand suppletion under water
- Development of engineering construction works into the sea: For example, barrages into the sea were constructed at the Northern coast of Texel (Island situated in the Wadden Sea) in order to promote sedimentation processes.
- *Improvement of ecological regulation functions of nature (Helmer et al., 1996)*: Natural areas (like dunes, coastal salt marshes, peatlands and other wetlands) can function like a sink for sediment (mitigation to soil subsidence) and increase also the water retention capacity of the coastal zone (adaptation to reduced freshwater availability caused by sea level rise)
- *Re-establishment of the connection between the riverine estuaries and the sea (Helmer et al., 1996)*: The Rhine-Meusse estuary could be broadened and sluices could be constructed within the present dams in order to create connections with the sea in order to mitigate the impact on natural values of increased freshwater seepage in spring due to climate change (precipitation patterns).

Regional water systems:

- *Minimise the impact of soil subsidence:* (Projectteam Klimaatverandering NW4, 1997)
- Changed drainage and irrigation infrastructure on field scale. These measures make variable water table management possible and minimise the risk of flooding
- *Renaturalisation of the morphological structure of brooks*:
- *Development of (rain)water buffering reservoirs) in urban areas*
- *Flush system with freshwater from the retention reservoirs (lake IJssel, etc):*

Box 3.3, Example of flooding: Bangladesh.

Bangladesh is a low-lying flat country with a dense network of rivers of which the Ganges and Brahmaputra are among the largest streams in the world. Total runoff drains mostly humid areas which are 12 times larger than Bangladesh's territory (Ahmed and Mirza, 2000). Therefore, flooding is a recurring and natural phenomenon occurring practically every year. Since about 60 percent of Bangladesh is flood-prone land (Siddique and Chowdhury, 2000) major parts of the country will be inundated regularly. Like other riverine communities Bangladeshis learned to live with yearly low to moderate floods and to profit from the overall ecological and agricultural benefits of seasonal flooding. The regular improvement of soil fertility by the sedimentation of alluvial sediments by the so-called *barsha* floods is the occasion for traditional festivals of rural communities (Smith and Ward, 1998). Even nowadays, the direct economic losses of moderate floods are often in contrast to indirect and intangible improvements in agricultural food production through improved moisture conditions for intensified cultivation.

However, severe floods emerging once in 6–7 years are causing serious damage to human life, property and crops. High population increases, an extremely high population density of more than 800 inhabitants per km² and urban growth rates in the range of 20–25% (D'Ercole and Pigeon, 1998) expose millions of people to extreme flood risk. Available space in the floodplains is used for food production, which impedes the establishment of flood protection measures. Especially the poorest sections of the population are often pushed to areas with highest susceptibility for inundation (Ahmed and Mirza, 2000). D'Ercole and Pigeon (1998) report that between 1900 and 1971 approximately 460,000 people died and 43 million were affected by hydro-climatic disasters (mainly cyclones and floods) in the territory of today's Bangladesh. These numbers jumped to 200,000, respectively 290 million in the comparatively short period between 1972 and 1996. There were several recent devastating floods in Bangladesh. In 1988, about two-thirds of the country was submerged. In 1991, a storm surge killed 140,000. The destructive 1998 deluge lasted for 2–3 months and seriously affected the economy of the country, mainly by damaging infrastructure and agricultural sectors (Siddique and Chowdhury, 2000). Indeed, D'Ercole and Pigeon (1998) indicate that the number of flood disasters increased during the past century which might be ascribed to human impacts, such as deforestation in the headwaters or increasing direct runoff rates and drainage congestion from the growing urban centres. Climatic variability has been identified as another serious impact factor for flooding in Bangladesh, mainly due to variable snow and glacier melt in the Himalayas or to ENSO effects.

The given circumstances of high population growth rate, scarcity of land, financial difficulties, make the issue of flooding in Bangladesh very difficult. Possible sea level rise and increased river flow due to global climate change as well as further population growth narrows available action strategies to a minimum. A national Flood Action Plan is still under discussion, however its huge financial needs are not affordable and technically and economically problematic. Beside a consequential population policy the reflection on traditions of centuries old proven abilities to cope with floods would be part of the possible options. In addition to this, Islam (2000) proposes the re-excavation of smaller rivers, dead riverbeds and other surface water bodies and the construction of canals to ease the drainage of floodwaters. A side effect might be the establishment of fisheries in order to feed the country. Since most of the reasons for flooding lie outside the control of Bangladesh, the concerns of flooding should be international, thus including the upstream countries into flood mitigation plans. Furthermore, the scientific community is invoked to give any possible research support.

.

3.5 Key-issues

- Prerequisite to adaptation and coping is the application of Integrated Water Resources Management
- from individual households to local communities to catchment to (inter)national
- There are fundamental differences in adaptation and coping strategies between developed and developing countries
- For water managers in many developing countries the impacts of changes in climate are minor compared to the problems they are facing already with the present climate variability
- ‘Coping for present day climate variability’ already takes us a long way down the road towards ‘coping for climate change’
- due to climate change the variability is likely to increase

Other:

- Start by implementing what we have to do anyway to cope with our WRM problems (and know how to do it: IWRM – ‘no regret approach’)
- next: discuss the precautionary principle as option and discuss what the implications for countries like Mozambique will be
- Define the thresholds for what ‘watermanagement’ can do (and where others have to take over)
- There is a limit on resilience of our systems and own capacities to plan and operate based on anticipated climate ‘surprises’
- From the watermanager’s perspective this kind of stuff is something that international fora should discuss at high levels (e.g. 4th IPCC)
- Don’t overreact / overestimate the impacts – stay realistic

4 Conceptual framework for identifying Hot Spots (Acreman et al.)

'Hotspots in relation to climate change and impacts on water resources a global or a regional concern?'

Lead authors:
Dr. Mike Acreman, Centre for Ecology and Hydrology, McLean Building, Crowmarsh Gifford, OX108 BB, Wallingford, United Kingdom, phone: 0044 01491 692443, email: man@ceh.ac.uk, fax: 0044 01491-692424

Prof. Joseph Alcamo, University of Kassel Centre for Environmental Systems Research, Kurt-Wolters-strasse 3, 34109, Kassel, Germany, phone: 0049 561 804 3898, email: alcamo@usf.unikassel.de, fax 0049 561 804 3176

Contributing authors/workshop participants:

Jeroen Aerts	IvM, Free University Amsterdam	jeroen.aerts@ivm.vu.nl
Cees van de Guchte	UN/GPA	c.vandeguchte@unep.nl
Donald Boyd	Int. Ist. For Urban Env.	Boyd@urban.nl
Henk van Schaik	IS-DWC	hvs@ihe.nl
Madeleen Helmer	The Netherlands Red Cross	mhelmer@redcross.nl
Cedo Maksimovic	CUW-UK	c.maksimovic@ic.ac.uk
Tom Kram	RIVM	tom.kram@rivm.nl

Summary[TDM6]

Key statements for the summary key issues up-front

4.1 Introduction

There has been growing interest on behalf of scientists and policymakers about the potential impacts of climate change on water resources. Although it is believed that water resources are vulnerable to climate change, the extent of this vulnerability is far from being established, and there are even different opinions about the definition of vulnerability. In the context of climate change the Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to be the “degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2001).

Despite the lack of consensus about vulnerability, most researchers would agree that the vulnerability of a society or an ecosystem depends on two main factors – the environmental stress it is exposed to, and its susceptibility to this stress. Although there are no strict definitions of these terms, Box 1 gives a typical way to define them.

Environmental Stress. Climate-related environmental stress is a function of “the character, magnitude, and rate of climate change”,[1] In the context of water resources, environmental stress is related to changes in the physical availability and quality of water at a particular location. Hydrological processes, including rainfall, evaporation, groundwater recharge, control this availability, river flows, wetland and Lake Levels. Whilst in some places sufficient quantity of water may be available, it may not be of acceptable quality for the local requirements due to natural factors, such as arsenic in groundwater, or anthropogenic reasons such as effluent pollution. Climate change or variability may directly affect water availability and quality by altering precipitation or evaporation via temperature. Impacts may also be indirect such as a change in the vegetation of a river basin, which changes the flux of materials into a river, or changes to ecosystem functions that influence the hydrological cycle.

Susceptibility. The susceptibility of society and ecosystems is a function of a wide range of factors. For example, the susceptibility of a social group depends on its access to water supply as indicated by the distance to a water source or the time taken to collect water (which will include queuing). Another dimension of susceptibility is the ability of institutions to either respond to the current problems of availability and access, or to cope with future problems, such as reduced water availability or increased variability. But not all countries are equally susceptible. For example, countries such as Saudi Arabia, although subject to a high level of environmental stress, nevertheless have sufficient financial and technical resources to desalinate freshwater from the sea. Thus it has a low level of susceptibility. The susceptibility of ecosystems has an equally complex set of dimensions.

---

[11] The quote is from IPCC (2001), but the IPCC did not use them in connection with the expression “environmental stress”.

Box 4.1. *Example definition of environmental stress and susceptibility (Alcamo, et al. 2001a and b).*

Environmental Stress. The intensity of an environmental change that (i) involves an undesirable departure from long-term or "normal" conditions, (ii) is normally of short duration (iii), is directly or indirectly influenced by society, and not only the result of natural geologic factors (as in the case of volcanoes and most earthquakes). In this context, high levels of environmental stress occur, for example, during coastal and river floods, severe droughts, air pollution episodes, and severe industrial accidents involving toxic and radioactive material.

Susceptibility In the context of environmental studies, the ability of an individual, group, or state to resist and recover from crisis brought on by environmental stress.

4.2 Hot Spots: Regions of High Vulnerability

The question arises, will every ecosystem and every part of society be equally vulnerable to climate change? The IPCC has already concluded that the answer to this is, no. First of all, climate-modelling results indicate that the intensity and pace of climate change will be more intense in some parts of the world than in others, suggesting that the level of environmental stress will also be different. Second, studies of society and ecosystems suggest a great variation in the degree of susceptibility to environmental stress. It follows that some people or ecosystems must be more vulnerable than others. This realisation has led to an interest in "hot spot" areas of climate change, which can be defined as special geographic areas containing human populations or ecosystems highly vulnerable to climate change. The advantage of identifying hot spot areas is that society can devote its sparse scientific and policy resources to this limited area. Hot spot areas could be priority areas in which society tries to avert or mitigate climate-related risks. Other names given to hot spots of climate change are "critical regions" (Alcamo and Henrichs, 2001), or "regions of high vulnerability", or "most vulnerable regions" (Parry, 2001).

4.3 Examples of Estimating Hot Spots of Climate Change and Water Resources

Up to now relatively few studies have attempted to identify hot spot areas of climate change and water resources. An example of a European-scale analysis was carried out as part of the Acacia Project. The aim of the Project was a preliminary assessment of climate change impacts in Europe. As part of its assessment the Project identified the "most vulnerable regions" in Europe "where a change in climate would have a substantial impact". Included in these regions were Southern Europe because of its increased risk to drought, and Northern Europe because of its increased threat of flooding.

An example of a global analysis was conducted by the IPCC who identified "highly vulnerable areas" in their Third Assessment of climate change (IPCC, 2001). However, a consistent framework was not used for this analysis. In some cases they focused on differences between subregions, and in others between sectors. For example, for Asia they identified the relative vulnerability of different subregions (including "highly vulnerable" subregions) with respect to water resources and other categories of climate impacts. They deemed the water resources in Central Asia, "Temperate Asia", South Asia, and Southeast Asia as being "highly vulnerable" to climate change. By contrast, for Australia and New Zealand, they compared sectors rather than subregions. They reported, for example, that irrigation and metropolitan water supply systems had "high vulnerability in some areas".

Alcamo and Henrichs (2001) carried out another example of a global analysis of hot spots of climate change and water resources. In their analysis they focused on water scarcity rather than flooding as a problem. They specified that "critical regions" are regions containing river basins that meet two conditions: First they must currently be under "severe water stress" (defined as where average annual water withdrawals exceed 40% of annual water availability). Second, water stress must be intensifying between 1995 and 2025 because of growing water withdrawals (related to population and economic growth) and/or decreasing water availability (related to climate change). According to this definition, and according to baseline estimates of socio-economic and climate changes up to year 2025, they identified critical regions to include the Caspian Sea region, the Middle East, parts of Argentina and Chile, southern Africa, and southern India (Figure 4.1).

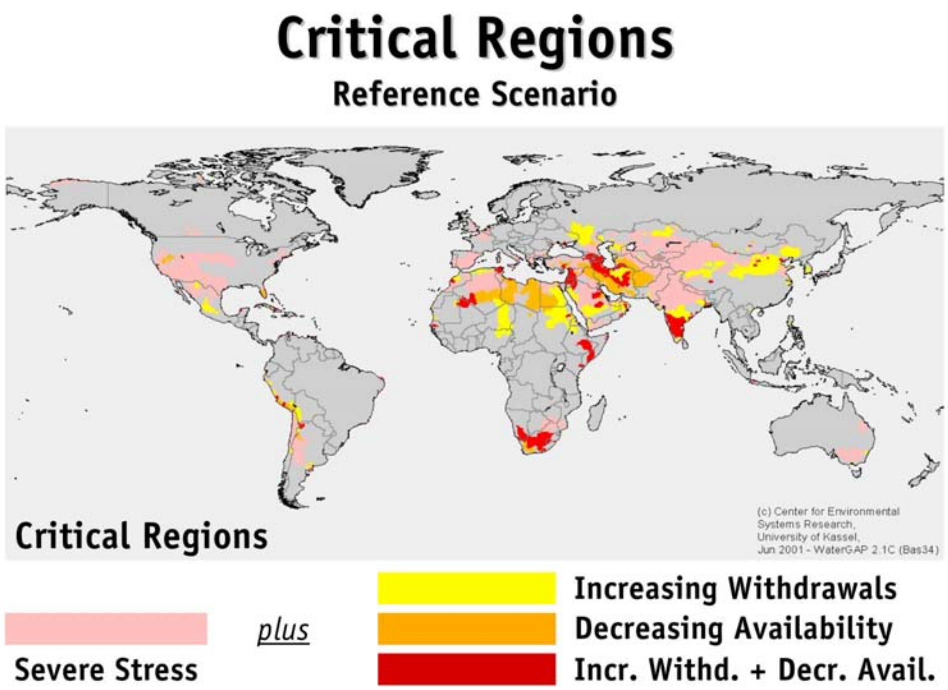


Figure 4.1, Critical regions of water resources in 2025 according to a baseline scenario of socio-economic and climate changes. "Critical regions" are river basins that fulfil the following conditions: (1) they are river basins under "severe water stress" in 1995, (2) water availability decreases under a reference climate scenario up to 2025, and/or (3) water withdrawals increase up to 2025 because of economic or population growth. Source: Alcamo and Henrichs (2001).

Their analysis pointed out the importance of setting thresholds for vulnerability in order to identify hot spot areas. It also illustrated the need to specify future climate and other conditions. In other words, whether or not a "hot spot area" is hot depends on the selected climate change and socio-economic scenario.

An example of a global analysis that compared nations rather than regions is the vulnerability mapping of Lonergan (1998). Lonergan quantified the "vulnerability" of nations to environmentally related migration and conflict using 12 factors including child mortality, income per capita and "degree of democratisation". Each country was then assigned a vulnerability rating based on its average score for these indicators. Lonergan presented his results on a global map that portrays the relative vulnerability of one country versus another (Lonergan, 1998).

A similar global analysis is contained in the World Vulnerability Report being prepared by the United Nations Development Programme (UNDP). According to UNDP, the report will "highlight the evolution of patterns of risk and vulnerability and promote the adoption of policies, legislation and governance structures for managing and mitigating disasters." At the core of the Report is the estimation of a country-level Global Risk-Vulnerability Index, which assesses countries according to their relative disaster risk levels over time. The index will be presented on global maps.

Related Work That Can Contribute to Hot Spot Assessment

There is also work going on in the social sciences that could be very relevant for assessing susceptibility of society to changes in climate and water resources. The political scientists Organski and Kugler (1980) introduced the idea of "political capacity of states" which is intended to capture "the ability of political systems to carry out the tasks chosen by the nation's governments in the face of domestic and international groups with competing priorities". In one application Organski and Kugler (1980) showed that political capacity was related to the capability of nations to sustain and recover from war. These national capabilities may bear a close relationship to the idea of susceptibility of a nation to climate change.

The disciplines of sociology and psychology have also developed ideas relevant to assessing susceptibility. Here susceptibility is related to the concept of "coping capacity". More specifically, susceptibility is taken as the absence of suitable coping capacities of social groups. Coping capacities are high if people are able to undertake actions that are appropriate to prevent harm from environmental stressors. Although this concept is oriented towards the susceptibility of individuals or social groups, the state also plays a major role in this concept by providing alternatives for an individual to respond to stressful events. A representative example of work is "Protection Motivation Theory" developed by Rippetoe and Rogers (1987). This theory has been found to be useful in describing coping capacities of social groups facing environmental stress (e.g. Gardner and Stern, 1996).

Development Needed

Up to now few attempts have been made to assess hot spot areas of vulnerability of society and ecosystems to changes in climate and water resources; even less work has been devoted to developing a consistent methodology to carry out these assessments. To develop this methodology we need to address the main deficits of the work already carried out. First of all the meaning of "hot spot area" needs to be clarified. Are hot spot areas, truly *areas,* i.e. geographic areas where populations or ecosystems are most vulnerable, or are they the populations or ecosystems themselves? In other words, are refugees as a social group a "hot spot", or is a region containing a large numbers of refugees a "hot spot area"? Furthermore, must we focus on populations or ecosystems, or can sectors such as "municipal water supply" also be deemed hot spots?

Second, the identification of hot spot areas requires progress in specifying the thresholds of vulnerability. Indeed, hot spot areas cannot be specified without first specifying these thresholds. Sometimes they are explicit as in the analysis of Alcamo and Henrichs (2001) where it was required that a region had to meet two quantitative conditions to be a "critical region". But more often thresholds are implicit and not explicitly stated as in the case of the assessments by IPCC or Acacia.

Third, the identification of hot spot areas requires, as a pre-condition, a consistent framework for vulnerability assessment. Such a framework is needed so that one region's vulnerability can be compared in a scientifically credible way with another's. Such a comparison of regions would also provide new insights into general factors affecting vulnerability. Also, a transparent assessment framework would link new studies with ongoing vulnerability assessment studies.

4.4 Elements of a New Framework

Here we take the first few steps in designing a consistent framework for vulnerability assessment and the identification of hot spot areas. The idea of the framework is to evaluate the level of environmental stress and susceptibility of a region according to a standard set of criteria (Box 4.2.) These criteria are chosen such that they represent many important aspects of vulnerability with respect to impacts of climate change and variability. Criteria for environmental stress is subdivided into indicators related to the quantity of water (i.e. too much or too little) and its quality. Susceptibility is broken down into indicators of "access" to actions and infrastructure that can help individuals or ecosystems to cope with climate change and indicators related to their ability to manage water resources in the face of increased climate change. "Ability" is a function of financial resources, strong management institutions, and other factors. In the following paragraphs we present two examples of applying the framework.

Box 4.2, Framework for identifying highly vulnerable areas.

Environmental stress								
Quantity							**Quality**	
Magnitude	Variation	Temporal aspects	Domestic	Food production	Natural resource	Protection	Human health	Eco-system health
Susceptibility								
Access				**Ability**				
Distance	Legal rights	Price	Infrastructure	Technical	Financial	Social	Institutional	Demographic

4.5 Examples of Applying the Framework

4.5.1 The Ganges Brahmaputra Meghna Basin

*[*An example of a hot spot river basin is the Ganges Brahmaputra Meghna (GBM) basin in South Asia. The vulnerability of the GBM basin can be described following the criteria shown in Figure ***. In terms of water quantity, it is projected by the IPCC that the magnitude of the monsoon discharges will increase in 2050, with possible increased effects on flood magnitude and duration in the downstream parts. In the dry period, however, less water will be available according to IPCC scenarios causing drought and possible decreased food production. The quality of ecosystems is affected by decreased fresh water discharges in the dry period, such as the mangrove areas at the border of Bangladesh and India --they will suffer from increased salt water.

With respect to susceptibility, the institutional framework between the riparian countries in the GBM basin is yet to be developed, and currently unable to cope with excessive population increases in the area. For instance, the building of the Ganges barrage at the border between India and Bangladesh has generated political friction for more than twenty years, and therefore prohibits further basin wide institutional development.

[Is it a hot spot area? If yes, why?]

4.5.2 Over-Abstracted aquifers in the Mediterranean

In Mediterranean Europe, irrigated agriculture is the heaviest user of abstracted water and accounts for 80% of total demand in Greece, 50% in Italy and 65% in Spain (EEA, 1996). Much of the resource comes from groundwater since surface runoff is insufficient to meet irrigation demand. For example, in Spain, of the 5500 Mm^3 abstracted annually from aquifers, 4000 Mm^3 is used for irrigation (Ministerio de Medio Ambiente, 1999). An imbalance between supply and demand occurs occasionally due to reduced recharge as a result of droughts and other climatic variability, which may be accentuated by future climate change. For example, it is predicted that by 2050 average temperatures in southern England will be 1.6ºC higher, with increased evaporative losses, but rainfall will be 10% higher (with wetter winters and drier summers. In contrast, a slight decrease (5%) in annual rainfall change is predicted for central Spain with no change in seasonal pattern, whereas early wet season rainfall is expected to decrease significantly in Greece, with annual totals 25% less.

In 51 or the 442 hydrogeological units in Spain the abstraction/recharge ratio greater than 1. The Mancha Occidental aquifer abstraction has increased from 200-million $m^3\ yr^{-1}$ in 1974 to 600 million $m^3\ yr^{-1}$ in 1987. This latter figure is greater than the estimated average recharge to the aquifer from the catchment of 200-300 million $m^3\ yr^{-1}$. This resulted in degradation of large areas of internationally important wetlands, including the Tablas de Damiel. A Water Law was passed in 1985 to limited abstraction in 15 hydrogeological units declared over-exploited in 1994

The Water Law could *theoretically* solve the situation following the regulations to be applied in aquifers declared as “over-exploited”. For these aquifers, the Water Authority should prepare a Water Plan indicating the maximum amount of water available to each groundwater-licensed user. In practice, the situation has become much more complicated. Since the aquifer was legally declared “over-exploited”, and the Authority’s attempt to impose abstraction restrictions, farmers have probably drilled about 8000 or 9000 new illegal water wells. Before this declaration, about 16 000 wells had been drilled (Acreman, 2000).

This case study shows a region where water availability is finely balance and where the Authorities are trying to implement sound management measures, but where collaboration with water users is proving the obstacle to sustainable use.

[Is it a hot spot area? If yes, why?]

4.6 Conclusions and recommendations

While our knowledge continues to increase about climate, water and vulnerability, we are still far from being able to reliably identify “hot spot areas”. Here we have defined hot spot areas as special geographic areas containing human populations or ecosystems highly vulnerable to climate change. The advantage of identifying hot spot areas is that society can devote its sparse scientific and policy resources to this limited area. Hot spot areas could serve as priority areas where society tries to avert or mitigate climate-related risks.

But to make progress in estimating these areas we have several tasks – including clarifying the definition of hot spot areas, specifying the thresholds of vulnerability, and developing a consistent framework for vulnerability assessment. These and related tasks need to be added to the agenda of climate and water research.

5 The Knowledge base, information network and communication

'XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX'

XXXX, XXXX

Lead authors:
Dr. R. Connor, IS-DWC, P.O. Box 3015, 2601 DA Delft, phone: 0031 15 2151 882, email: rco@ihe.nl, fax 0031 15 262 4873

Dr. Caroline Figueres, NEDECO, P.O.Box 90413, 2509 LK, The Hague, The Netherlands, phone: 0031 70 314 3632, email: cFigueres@nedeco.nl

Contributing authors/workshop participants:

Marcel van den Heuvel		
Albert Tuinhof	Royal Haskoning	a.tuinhof@royalhaskoning.com
Andreja Sonoski	Unesco-IHE	jon@ihe.nl
Raimond Hafkenscheid	NWP	r.hafkenscheid@nwp.nl
Wakako Matsuda	WWF3	matsuda@water-forum3.com
Gunter Konnen	KNMI	konnen@knmi.nl

Summary[TDM7][TDM8]

Key statements for the summary key issues up-front

5.1 Introduction

Background

The overall communication objective of the Dialogue on Water and Climate is to prepare an interactive set of activities to communicate the Dialogue between stakeholders and partners, to raise awareness about the Dialogue and it's activities, and to communicate the outcomes. The Dialogue activities facilitate and support knowledge build up on case studies and partner activities to serve the central synthesis process and to offer target audiences access to a comprehensive information network.

The aim is to inform the largest possible cross-section of society about the Dialogue, to increase public awareness, and to mobilise social and political will to promote more effective strategies that reduce vulnerabilities associated with climate variability and change.

Target audiences, objectives and communication instruments will be identified and described in a separate communications plan. It will focus on the desired impact, output, activities, tasks and budget of the Dialogue's communications strategy. The plan will be interlinked with the communications strategies of the Dialogue with associated organisations and initiatives, such as the Dialogue on Water and Food; 3rd World Water Forum; World Bank Institute; GWP; UNEP etc. These organisations and their initiatives share common objectives, actions and means. Integration and co-operation will contribute to optimal efficiency and effectiveness.

Key target audiences

The communications strategy of the Dialogue on Water and Climate will emphasise on the widest possible, active participation of the key target audiences. Prime target audiences are (1) water experts; (2) water professionals; (3) other (water) stakeholders e.g. in private government, non-governmental and knowledge institutes. In addition, we identify (4) politicians and policy makers and (5) the public at large.

The Dialogue is a temporary project-like organisation that will be guided by an International Steering Committee (ISC) consisting of representatives of a selected group of international organisations. The Dialogue's International Secretariat, based in the Netherlands, will encourage co-ordinate and report on the activities of the central and partner dialogues.

5.2 Methodology

The Dialogue on Water and Climate should communicate a clear message. A range of instruments and tools will be developed for this purpose. Since the wider objective of the Dialogue is to bridge the gap between water experts, professionals and science by promoting dialogue and exchange of know how and strategies that reduce vulnerabilities associated with climate variability and change, it will be necessary to give priority to these identified audiences. However, this can not be an objective of its own. In order to succeed it is vital to increase public awareness and mobilise social and political will to act. Media attention to inform the public at large will have an effect on the perception of politicians, policymakers and other stakeholders.

The proposed communications strategy will have a top down approach, aiming at the prime target audiences 1 and 2, as well as a bottom up approach reaching out to target audience 3, 4 and 5. Given the limited resources, The latter approach will be executed in close co-operation with other strategic partners, such as the Dialogue on Water and Food; 3rd World Water Forum; World Bank Institute; GWP; UNEP etc.

The strategy will be implemented by raising (1) *Awareness*; providing (2*) Information*; generating a (3) *Desire* process among its targeted audiences; and stimulating (4) *Action*.

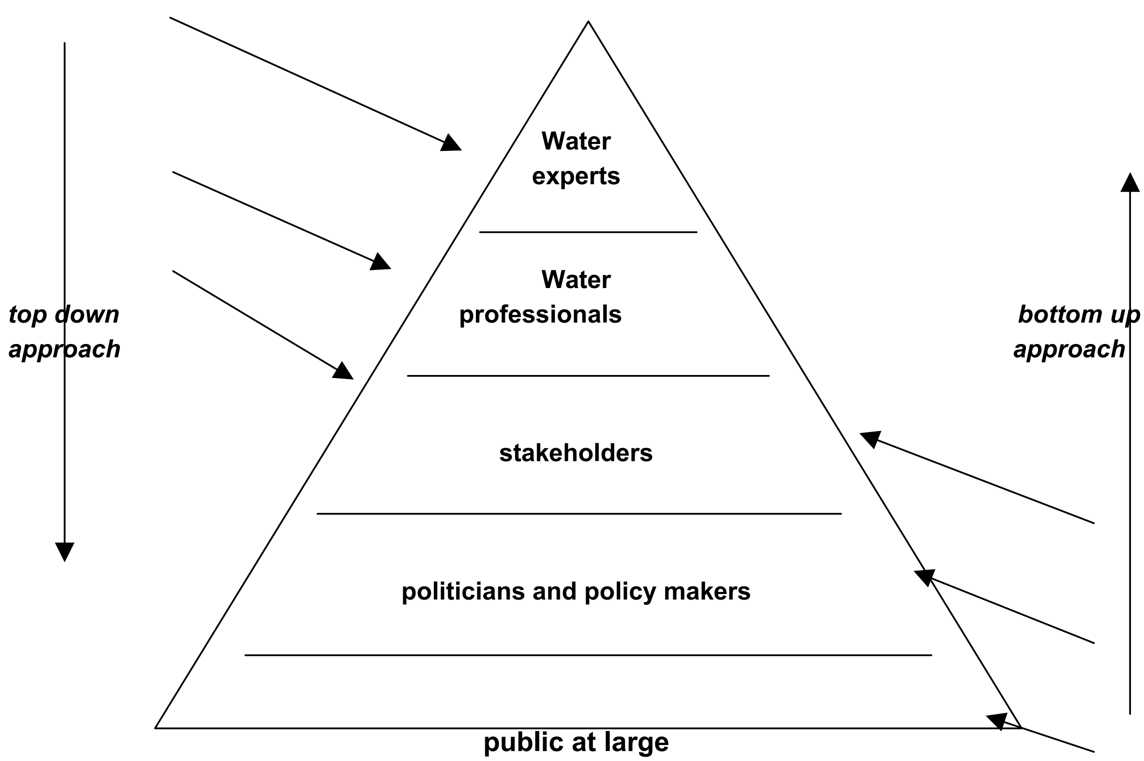


Figure 5.1, stakeholders and methodology.

5.2.1 Organisation of the communication

The Dialogue's International Secretariat will work closely with a part-time (in-house) communication expert and were necessary will commission several communications and/or public relations agencies at national and international level. These experts will be commission to develop and execute elements described in the communications plan. The plan will be the basis of all activities undertaken such as the to be outsource activities. The management and co-ordination of the communications strategy will remain under the responsibility of the international secretariat.

5.2.2 Instruments and tools

A variety of instruments and tools will be developed to communicate the objectives and outcome of the Dialogue on Water and Climate to its key target audiences.

a) attractive brochure
b) fact sheets on specific themes or events
c) liaison with related journalist networks
d) press announcements and press releases
e) media briefings
f) video news releases (VNR's)
g) public service announcements (PSA's)
h) platform of 'eminent persons'
i) electronic newsletter
j) theme-info-packages (to be developed)
k) network co-ordination tool (to be developed)
l) coalition building program (to be developed)

A. Basic brochure

OBJECTIVE

The brochure is to provide basic information to a broader public on the Dialogue on Water and Climate. The brochure is a printed format. Content on electronic media, such as internet site(s), is also included under this heading.

➢ *TARGET AUDIENCE*

A wider audience and in particular stakeholders who are involved in activities related to the Dialogue on Water and Climate.

➢ *DESCRIPTION*

An attractive and concise brochure explaining in clear language the main objectives and the working method of the Dialogue. This brochure will not be a fact-finding report. It will exclusively focus on the procedural merits of the Dialogue, its objectives and actions. The brochure will be published in several languages and will include graphics, maps and pictures explaining the ratio behind the Dialogue and will be appealing to the reader.

➢ *INTERRELATION TO OTHER COMMUNICATION TOOLS*

The brochure is meant as a basic and independent communication tool and will therefore be the starting point upon other instruments will be developed.

B. FACT SHEETS ON SPECIFIC THEMES OR EVENTS

➢ *OBJECTIVE*
Information tool on a specific cases and/or activities of the Dialogue.

➢ *TARGET AUDIENCE*
Several audiences require specific information, which goes beyond the basic information provided by in the brochure. These groups e.g. gender, youth etc. will be targeted by this tool, providing additional information on the merits of the Dialogue affecting their sector or group.

➢ *DESCRIPTION*
Fact sheets consist of concise information on a specific theme or event. In most cases not more than one page (size A4) per fact sheet is needed. Subject examples for fact sheets are for instance the introduction of case studies, scientific information or linked to an important event, such as the World Summit. The fact sheets can be written in an additional language for a special purpose. They will be used independently or enclosed with the (basic) brochure.

➢ *INTERRELATION TO OTHER COMMUNICATION TOOLS*
Fact sheets are meant as a basic and independent communication tools. However, it should be linked to themes and/or should address the information needs of specific audiences. This means that the fact sheets should touch familiar themes or campaigns. This tool is to be used to underline the message(s) of the Dialogue in this field.

C. Liaison with related journalist networks

- *OBJECTIVE*

To maintain, initiate or develop relations with journalist's networks of related organisations and initiatives.

- *TARGET AUDIENCE*

Existing journalists and/or media networks, such as the 3rd World Water Forum and Forum of Environmental Journalists (FEJ) and the Journalist training programme of the World Bank Institute.

- *DESCRIPTION*

This tool is primarily meant to involve existing journalist's networks in the activities of the Dialogue. As example we mention the training program for journalists from developing countries of the *World Bank Institute* (WBI). Through the active involvement of journalists messages can easily be broadcasted to specific groups and/or regions, which normally, are not covered by the communications strategy of the Dialogue because of language, region or sector.

- *INTERRELATION TO OTHER COMMUNICATION TOOLS*

Messages broadcasted through existing network are linked to the overall communications strategy of the Dialogue on Water and Climate. By using other Fora, like that of the 3rd World Water Forum, WBI and FEJ, an effort must be made not to have the Dialogues massage(s) be overshadowed or interfered with communications objectives of other Fora. This requires tactical planning and active co-ordination. This can be realised by having appointed spokespersons and/or organising press conferences during special events. By using such networks substantial saving on the communications budget of the Dialogue can be realised.

D. Press releases

- *OBJECTIVE*

To inform media representatives on the actions of the Dialogue on Water and Climate on a particular theme, case study or event.

- *TARGET AUDIENCE*

Media representatives at national (one country), regional (more countries or continents) and international level (global).

- *DESCRIPTION*

Press announcements or press releases are meant to communicate a specific actual news item to the media. Three types of press announcements can be considered:

a.) National press releases (for instance focussing on the Dialogue's donor countries, such as the Netherlands, Japan etc.)
b.) Regional announcements (with a focus on the Dialogue's priority region's, such as Sub-Sahara Africa)
c.) International press releases (with a focus to emphasis world-wide themes covered by the actions of the Dialogue)

Besides these geographical divisions, press announcements could be used to inform 'special interest' media. As a basic rule however, press announcements should only be used if they contain good stories and actual news facts.

It is perceived that in the run up to the 3rd World water Forum, two major press releases will be made. The first is scheduled for August / September, prior to the World Summit in Johannesburg. This press release will emphasise the negative aspects of water and climate. The next press release is scheduled for December, to be released during the Dialogue's conference in Bangladesh. It will have a positive undertone.

- *INTERRELATION TO OTHER COMMUNICATION TOOLS*

Press announcements and press releases are focussed on a specific subject or theme which gives this tool a direct relation to other communications tools and instruments such as fact sheets, PSA's / VNR's etc. produced for a specific group, sector, region or event (see also other instruments and tools described under 2, 6 etc.)

E. Media briefings

- *OBJECTIVE*

To build a respectable and credible source of information to media networks by representatives of the Dialogue on policies, and mid- and long-term strategies. Establishing the International Secretariat and the experts involved in the Dialogue on Water and Climate as a credible resource and network.

- *TARGET AUDIENCE*

Media networks, media representatives, free lance journalists, editors etc.

- *DESCRIPTION*

Media briefings are primarily aimed to explain and elaborate on short-term policies and strategies. The aim is to provide credible background information, link media representatives to eminent persons or scientist and to become a respectable resource organisation. Media representatives seek persons and/or organisation to provide feedback on policies, statements etc. They are not in the first case meant to communicate actual news activities (press announcements and press releases) but used in feature articles or productions.

This instrument will have an internal and external side. The internal media briefing will be a seminar or workshop for experts involved in the Dialogue to brief them on the communications strategy, the identified topics and how to deal with the media in order to bring across a comprehensive an solid message concerning the Dialogue. During the course of time, these experts will regularly be briefed through email and documents on media related matters.

The external briefing will be aimed to inform media representatives of the availability of the resource network and the activities of the International Secretariat. The organisation of the external media briefings could best be linked with events such as seminars or workshops, making use of the presence of a group of journalists.

- *INTERRELATION TO OTHER COMMUNICATION TOOLS*

  Media briefings are reflecting an organisation's or person's professional opinion. These opinions must be interlinked with the wider objective of the communications strategy. When testimonials are used, the professional opinion of a spokesperson must be known in advance. Opinions can be stimulated and promoted or can be counterattacked. PSA's and VNR's should be used to channel such opinions to favour the wider objective.

F. Video News Releases (VNR's)

- *OBJECTIVE*

  To inform broadcasting media and networks on specific theme or news item of the Dialogue on water and Climate.

- *TARGET AUDIENCE*

  Primarily broadcasting media and through them the public at large, including a range of target audiences. A VNR offered by a newswire will be exclusively available for subscribers to this service.

- *DESCRIPTION*

  Video News Releases are considered 'ready to use' material, which are submitted to a 5 – 10 minutes slot on the video transponder of one ore more major Newswires/agencies. The format is based on a script, describing a story plus (video) footage of event such as flooding, draught etc. and commentary in the form of statements, one-liners by eminent persons or scientists. A VNR plugged by ‘buying’ customer is not different then material offered by a Newswire/agency on their video transponder.

- *INTERRELATION TO OTHER COMMUNICATION TOOLS*

VNR’s and PSA’s are focussed on a specific subject or theme which gives this tool a direct relation to other communications tools and instruments such as fact sheets, press announcements, press releases etc. produced for a specific group, sector, region or event.

G. public service announcements (PSA’s)

- *OBJECTIVE*

To inform media broadcasters on the actions of the Dialogue on Water and Climate on a particular theme, case study or event through an in-house produced (non-profit) television commercial.

- *TARGET AUDIENCE*

Public Service Announcements are meant to communicate a specific actual news item to the broadcasting media, specifically to the viewers of international media networks, such as BBC World, CNN, Star-TV, MBC, EuroNews etc.

- *DESCRIPTION*

Public Service Announcements are considered commercials from the non-profit sector which are submitted to international broadcast agencies (CNN, BBC World, National Geographic, MBC, etc.) to be broadcasted free-of-charge. Topics are identified in the same way as press announcements or press releases. They provide video footage produced on the basis of a script, broadcasting a well-defined message. PSA’s run for short period of time, several times per day, on these networks.

- *INTERRELATION TO OTHER COMMUNICATION TOOLS*

A PSA is an effective tool to communicate a message. It should be used not on its own, but linked with other tools, such as a press releases and VNR’s together these tools form an important instrument to influence public opinion.

H. Platform of 'eminent persons'

➢ *OBJECTIVE*

Eminent persons are used to communicate the overall or specific message of the Dialogue on water and Climate. Their identification with the objectives of the Dialogue will decrease barriers and make communication with specific target audiences easier and more effective.

➢ *TARGET AUDIENCE*

Media networks and representatives.

➢ *DESCRIPTION*

Creating a small platform of opinion leaders and known persons who believe in the Dialogue's basic philosophy and are willing to promote it on their personal capacity. They will be asked to cooperate through testimonials at events, PSA's, VNR's and through public performances.

The involvement of such persons to create a platform to promote the Dialogue is an enduring and costly instrument. It is perceived that by using, existing video footage, produced for the SWYNK television production ("Water, the drop of life"), easy access will be created to 10 – 20 of such persons (Gorbachov, Queen Noor, Isabelle Allende etc.). In addition, a handful of persons should be approached for active participation. This will eventually create a platform of eminent persons without huge expenses and with limited input.

➢ *INTERRELATION TO OTHER COMMUNICATION TOOLS*

A platform of eminent persons is an effective tool to communicate the overall message of the Dialogue. It should be used not on its own, but linked with other tools, such as a PSA's, VNR's press releases. Identification with these people will prove to be an effective instrument to influence public opinion.

I. Electronic newsletter

➢ *OBJECTIVE*

To generate regular spot news which will be spread actively among the network of the Dialogue, politicians and the network(s) of journalists.

➢ *TARGET AUDIENCE*

In first instance the known and identified participants in the Dialogue and group and/or network of identified journalists.

- *DESCRIPTION*

The electronic newsletter is a regular updated service communicating the activities and findings of the Dialogue on Water and Climate. All participants of the Dialogue should be contributors of the newsletter. Regularly the electronic newsletter is sent as an email document to an ever-increasing amount of subscribers and target audiences. This network will be increased by a snowball mechanism and will be edited at the Dialogues International Secretariat.

- *INTERRELATION TO OTHER COMMUNICATION TOOLS*

The electronic newsletter is meant as a basic and independent communication tool. It will not refrain from controversy and debate. When well managed, it will be an effective a tool to manage debate and for the provision of selective information.

J. Theme-info-packages

- *DESCRIPTION*

These packages are made to inform specific groups, such as gender, youth etc. Based on the activities and outcome of the Dialogue, materials will be collected for these specific groups. The aim is to inform these groups on the activities and relevance of the Dialogue on Water and Climate. The packages will be limited in number and developed by the International Secretariat. It is perceived that they will go hand-in-hand with the development of a fact sheet for such a group or sector.

The identification of groups and sectors is pending

K. Network co-ordination

- *DESCRIPTION*

Given the limited resources of the Dialogue, it is necessary to co-ordinate the execution of (existing) communications strategies of strategic partners such as the Dialogue on Water and Food; 3rd World Water Forum; World Bank Institute; GWP; UNEP etc. By co-ordinating these strategies and plugging actions related to Water and Climate precious capacity and means can be saved. The co-ordination activity and liaison with these partners is the responsibility of the International Secretariat.

The identification of partners and relevant strategies is pending.

L. Coalition building

- *DESCRIPTION*

The Dialogue is constantly developing coalitions with other sectors, non-profit organisation and the private sectors. It is perceived that such coalitions itself will open the possibility to develop a common communications strategy to reach out to new audiences. Strong partners can be organisations like WWF, IUCN, Greenpeace, but also WBCSD and private sector organisations.

The identification of coalition partners is pending.

5.3 Budget

It is difficult to make an estimation of the required budget to execute the above mentioned communications strategy. Since resources are limited, the communications strategy of the Dialogue on Water and Climate is very much depending on co-operation with other strategic partners. It is therefore necessary to liase with the partners and their communications advisors at a professional level. Nevertheless, a rough estimation of costs is listed below. The proposed activities as well as the costs for a part-time communications expert at the International Secretariat are budgeted.

Budget line		***Amount***
01. attractive brochure	€	30.000
02. fact sheets on specific themes or events (6x)	-	30.000
03. liaison with related journalist networks	-	pm
04. press announcements and press releases	-	20.000
05. media briefings	-	pm
06. video news releases (VNR's)	-	20.000
07. public service announcements (PSA's)	-	pm
08. platform of 'eminent persons'	-	25.000
09. electronic newsletter	-	pm
10. theme-info-packages (to be developed)	-	10.000
11. network co-ordination tool (to be developed)	-	pm
12. coalition building program (to be developed)	-	pm
13. (part time) communications experts	-	45.000
Total	**€**	**180.000**

The budget lines marked pm are not yet defined and/or will have to fund through co-operation schemes. It is perceived that additional costs will emerge, which are not yet budgeted.

6 Discussion & Conclusions

7 References

Agarwal and Narain, 1997. Dying wisdom. Rise, fall and potential of India's traditional water harvesting systems. State of India's environment 4, A Citizens' Report, Centre for Science and Environment, CSE, New Delhi, India. p 398.

Alcamo, J. and Endejan, M. 2001b. The security diagram: An approach to quantifying global environmental security, in: Petzold-Bradley, *et. al*. (eds). Responding to Environmental Conflicts: Implications for Theory and Practice. NATO ASI Series. Kluwer: Dordrecht. 133-147.

Alcamo, J. 2001a. Environment, security and the question of quantification. *International Journal of Sustainable Development*. **4**(2). 139 - 156.

Alcamo, J. and Henrichs, T. 2001. Critical regions: preliminary estimates of water resources sensitive to global changes. Invited paper to International Conference "Challenges of a Changing Earth", Amsterdam, July, 2001.

Allan, J. A., 2001, The Middle East water question: hydropolitics and the gllobal economy, London: I. B. Tauris.

Arbetman, M., Kugler, J. (eds). 1997. Political capacity & economic behavior.Westwiew Press:Boulder, 338 pp

Falkenmark, M., Rockström, J., 1993. Curbing rural exodus from tropical drylands. *Ambio*, vol 22 (7) : 427 – 437

Gardner, G. T., & Stern, P. C. 1996. *Environmental problems and human behavior*. Boston: Allyn & Bacon.

Gleick, P.H. et al., 2000. Water: the potential consequences of climate variability and change for the water resources of the United States. Report for the US. Global Change Research Program, September 2000

IPPC, 1996, Climate change 1995; economic and social dimensions of climate change: contribution of working group III to The Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

IPCC, 2001. Climate Change 2001, Impacts, Adapation and Vulnerability, Section, Hydrology and Water Resources, Report of Working Group II of the Intergovernmental Panel on Climate Change

Kasperson, J.X., Kasperson, R.E., Turner, B.L. 1995. Regions at risk: comparisons of threatened environments. U.N. University Press: Tokyo. 588 pp.

Laswell, H. D., 1958, Politics: who gets what, when and how, New York: The World Publishing Company.

Lonergan, S. 1998. The role of environmental degradation in population displacement. Global environmental change and human security project, International Human Dimensions Programme on Global Environmental Change, Research Report 1. 84pp.

Nicholsson, S.E., and Flohn, H., 1980. African environmental and climatic changes in late Pleistocene and Holocene. Climate Change, 2(4) : 313 - 349

Ohlsson, L. and Turton, A., 1999, The turning of the screw: social resources scarcity as a bottle-neck in adaptation to water scarcity. Occasional Paper No 19, SOAS Water Issues Group. www.soas.ac.uk/geaography/waterissues/

Organski, A. and Kugler, J. 1980. The war ledger. University of Chicago Press: Chicago.

Oweis, T ., Prinz, D., and Hachum, A., 2001. Water Harvesting. Indigenous knowledge for the future of the drier environments. International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. p 40.

Parry, M. (ed.). 2001. The Europe Acacia Project: assessment of potential effects and adaptation for climate change in Europe.

Reisner, M, 1984, Cadillac desert, New York: Penguin Books.

Rippetoe, A. P., & Rogers, R. W. 1987. Effects of Components of Protection-Motivation Theory on Adaptive and Maladaptive Coping With a Health Threat. *Journal of Personality and Social Psychology, 52*(3), 596-604.

Rockstrom, J., Barron, J., and Fox, P., 2001. Rainwater management for increased productivity among small-holder farmers in drought prone environments. Proceedings from 2nd Waternet/Warfsa Symposium, Integrated Water Resources Management, Theory, Practice, Cases, pp 319 – 330. Cape Town, South Africa, 30 – 31 October 2001.

Stakhiv, E. Z., 1998, Policy implications of climate change impacts on water resource management, Water Policy, Vol 1, pp 159-175.

SIWI, 2001. Water harvesting for upgrading of rainfed agriculture. Problem analysis and research needs. By: Rockström, J., Fox, P., Persson, G., and Falkenmark, M.. SIWI Report No 11, Stockholm, Sweden.

Schulze, R.E., 2002. Modelling as a Tool for Integrated Water Resources Management: Conceptual Issues and Case Study Applications. Water Research Commission, Pretoria, RSA, Report No. 749/01/01.

Appendix A Summary IPCC reports, thema Water& Climate

Jeroen Aerts, IvM
Version: date: 29-1-02
Institute for Environmental Studies
Vrije Universiteit
De Boelelaan 1115
1081 HV AMSTERDAM
The Netherlands
Tel. ++31-20-4449 528
Fax. ++31-20-4449 553
E-mail: Jeroen.Aerts@ivm.vu.nl

About this Memo

This memo summarizes the main findings of the Intergovernmental Panel on Climate Change (IPCC), on the influence of climate change on hydrology and water resources. These findings are described in the Third Assessment Report (TAR), which was issued in spring 2001. Most of the descriptions below are taken from Chapter 4 of Working Group 2 ("Hydrology and Water Resources"), and from the summaries of Working Group 1. The IPCC reports can be found on the website http://www.ipcc.ch.

Introduction

It has been widely recognized that changes in the cycling of water between land, sea and air could have significant impacts across many sectors of the economy, society and environment. Consequently, there are many studies that focus on the effects of Climate Change (CC) on hydrology (cycling of water) and water resources (human and environmental use of water). The majority of these studies have focused on changes in the water balance. Other, but fewer, studies focused on impacts of CC on water resources (reliability of water supply or risk of flooding) and exploring possible adaptation strategies.

It is important to realize that CC is only one of the pressures facing the hydrological system and water resources. Other global changes, such as land use changes and land management, similarly threaten the hydrological system. In general, there is an increasing move towards sustainable water management and increasing concern for the impacts of global change on the water resources system. Recent initiatives to address these issues are, for example, the 'Dublin Statement' in 1992, which urges the sustainable use of water, reports on freshwater resources by the UN Commission on Sustainable development (WMO, 1997) and activities by the World Water Council, which led to a vision for a 'water secure world' (Cosgrove and Rijsberman 2000).

The IPCC has published its Third Assessment Report (TAR), prepared by three working groups. Here, one of the main themes of IPCCs Working group II (Impacts, Adaptation and Vulnerability) was to assess the impacts of Climate Change on he global hydrology and water resources. Since the hydrological system also affects climate, its impacts are described by Working group I of the TAR, called the 'Scientific basis'.

Current state of CC and water research since IPCCs Second Assessment Report

Since the Second Assessment Report (SAR 1995), there have been made considerable advances in field measurements, coordinated research programs (e.g. IGBP) and improved hydrological modeling. More studies explored and emphasized the role of climatic variability and hydrological behavior. The hydrological changes over time are acknowledged as extremely important, and knowledge on these changes helps to efficiently develop adaptation strategies. Therefore, The TAR emphasizes that the hydrologic baseline cannot be assumed to be constant.

Planned adaptation to changing climate circumstances is based on minimizing risk and reducing vulnerability. Here one can distinguish supply side strategies (e.g. building reservoirs) and demand side strategies (e.g. changes rules for existing structures).

Climate scenarios

For the TAR, the IPCC has prepared a total of 40 emission scenarios. These scenarios are based on the emission driving forces of demographic, economic and technological evolution, which produce greenhouse gas and sulphur emissions. On the basis of these emissions, possible future pathways of temperature, precipitation and sea level changes have been modeled. Note that none of these scenarios assumes explicitly the implementation of the UNFCCC or the Kyoto Protocol targets.

The four scenario “storylines” are (list adapted from IPCC TAR WGI Box 9.1, p. 532):

A1. The A1 story line describes a future world of very rapid economic growth, global population that peaks in mid-century 2100 and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. This family is divided into three groups that are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil sources (A1T), and balance(A1B).

A2. The A2 scenario describes a very heterogeneous world --the underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented than in other storylines.

B1. The B1 scenario describes a convergent world with the same global population as the A1 scenario (population that peaks in mid-century and declines thereafter) but with rapid change in economic structures towards a service and information oriented economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than the A2 scenario, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the B2 scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

The computed resulting emissions of CO2 and SO2 according to the above-mentioned scenarios are shown below in Figure 1.

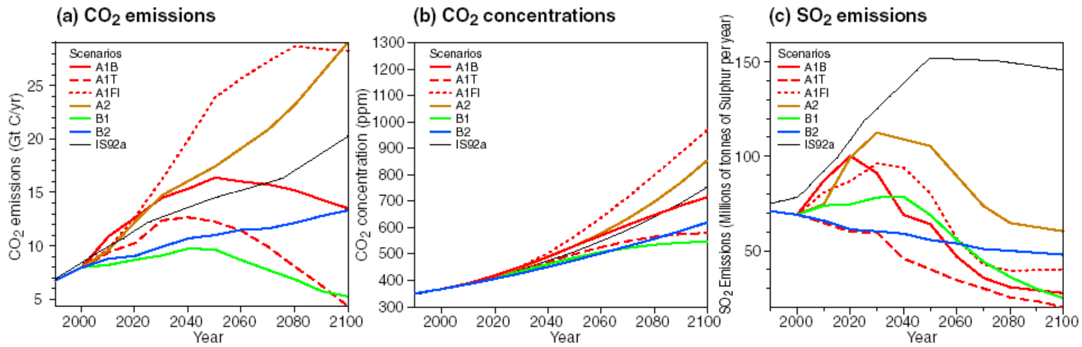


Figure 1. Green House Gas emissions according to different scenarios.

Climate modeling

For climate projections, both simple climate models and coupled Atmosphere Ocean General Circulation Models (AOGCMs) were used for the TAR. Due to computing limitations, only the so-called ‘draft marker scenarios’ A2 and B2 were used for AOGCM model runs. The results from the simple climate models for all ‘marker’ scenarios (which are considered most illustrative) are shown below in Figure 2. The globally average surface temperature is projected to increase by 1.4 to 5.8 ºC over the period 1990 to 2100. Global mean sea-level is projected to rise between 0.09 and 0.88 m for 1990 to 2100 for the six emission scenarios.

In the figures 2 and 3, for six marker scenarios both temperature increase and sea-level rise are shown for the period 1990 to 2100. The bars at the right of figure 2 indicate ranges.

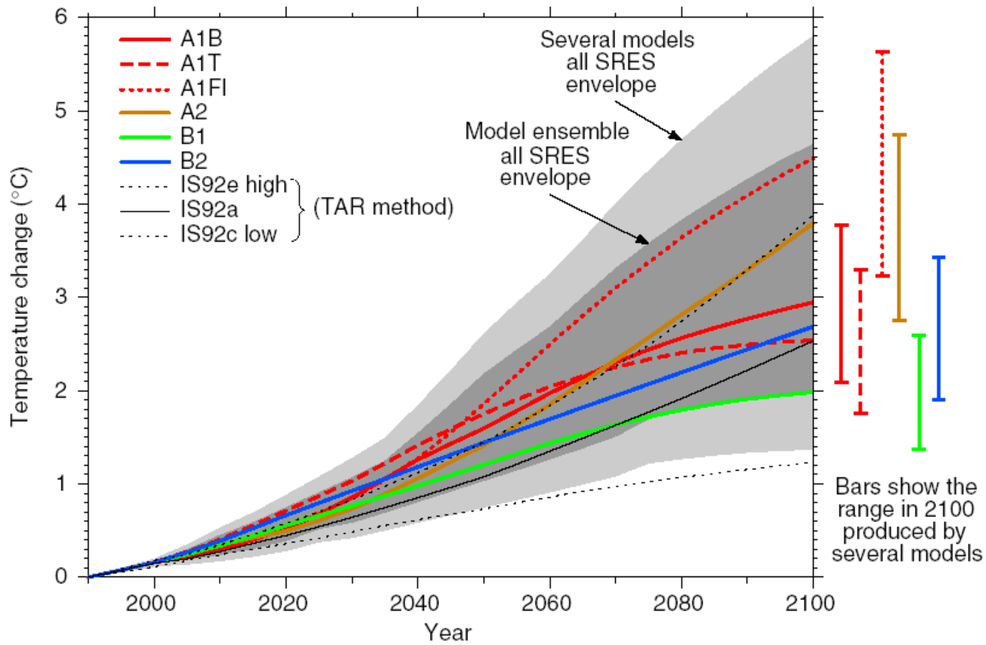


Figure 2. Global temperature projections, according to different scenarios.

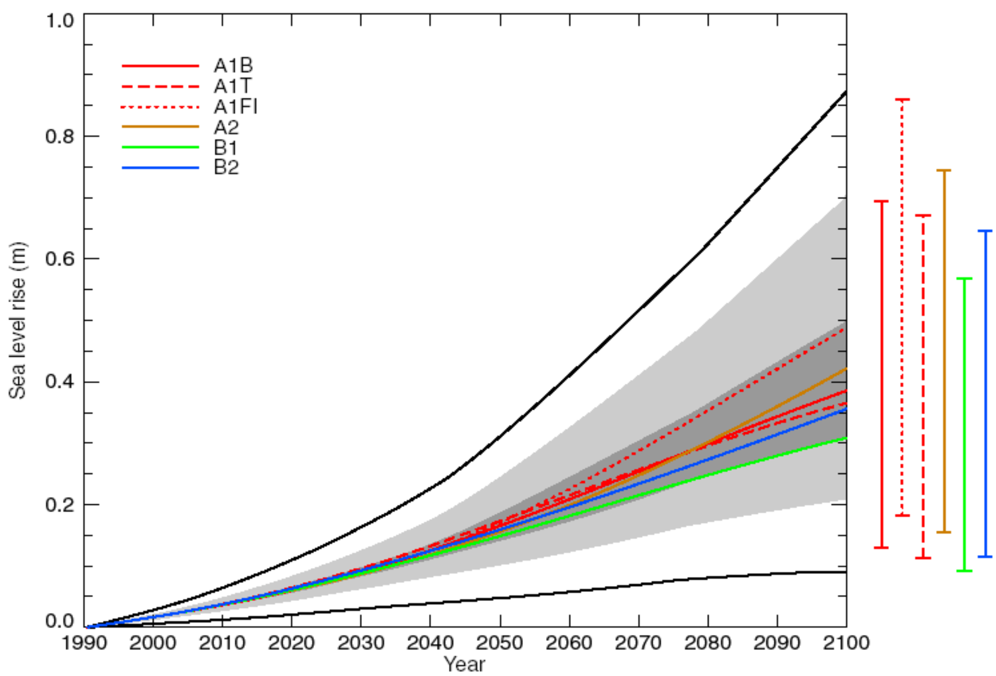


Figure 3. Global sea level rise projections according to different scenarios.

Also, regional precipitation patterns have been modeled by AOGCMs, under the A2 and B2 scenarios. The results and the analysis of inter-model consistency in regional precipitation change is shown in Figure 4. Regions are classified as showing either agreement or disagreement on precipitation change. A consistent result from at least seven of the nine models used here is deemed necessary for agreement. Where there is agreement, large increases means more than 20% change in regional precipitation. Small increases lie between 5 and 20% and no changes between –5 to +5%. A small decrease lies between –5 and –20%, and a large decrease is defined as less than –20%. For results where there is no agreement, the Figure shows the inconsistent sign.

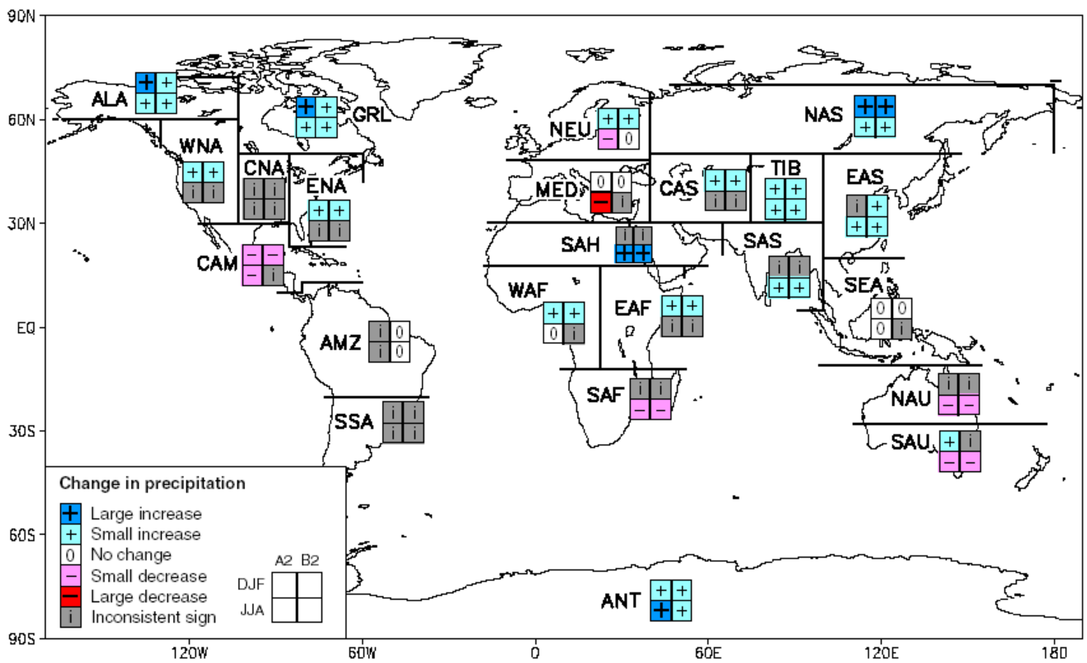


Figure 4. Projected future changes in precipitation patterns, according to different models. The gray boxes 'i', show inconsistent results across the different models.

Effects on the hydrological cycle

The impacts of CC on hydrology are usually estimated by defining scenarios for changes in climatic inputs to a hydrological model. These scenarios are derived from the output of general circulation models (GCMs). Problems arise, however, when downscaling GCM results to basin scale model inputs. In effect, the greatest uncertainties in the streamflow results from hydrological models using CC scenarios, are caused by the fact that the precipitation patterns from the coarse gridded GCMs are uncertain.

Precipitation

The TAR summarizes precipitation trends as a general increase in mean annual precipitation in the Northern Hemisphere (autumn & winter) and a decrease in the (sub-) tropics in both hemispheres (see also Figure 4). The frequency of extreme rainfall is likely to increase with global warming although the spatial resolution of global climate models is too course to provide details. Higher temperatures mean that a smaller proportion of precipitation may fall as snow.

Evapotranspiration

Increased temperatures generally result in an increase in potential evapotranspiration. In dry regions, potential evapotranspiration is driven by energy and is not constrained by atmospheric moisture contents. In humid regions though, atmospheric moisture content is a major limitation to evapotranspiration. Studies show increases in evapotranspiration with increased temperatures. However, models using equations that do not consider all meteorological controls may be very misleading.

Vegetation plays an important role in evaporation, by intercepting precipitation and by determining the rate of transpiration. Higher CO2 concentrations may lead to increased Water Use Efficiency (WUE, or water use per unit biomass), implying a reduction in transpiration. However, higher CO2 concentrations also may be associated with increased plant growth, compensating for increased WUE – thus, plants may acclimatize to higher CO2 concentrations.
The actual rate of evaporation is constrained by water availability.

Soil moisture

Runs with the HadCM2 climate model show that increases in green house gasses (GHGs) are associated with reduced soil moisture in the Northern Hemisphere summers. This is the result of higher winter and spring evaporation, caused by higher temperatures and reduced snow cover, and lower rainfall during the summer. The lower the water holding capacity of the soil, the greater the sensitivity to CC.

Ground water recharge

Increased winter rainfall may result in increased groundwater recharge in the northern hemisphere (NH). However, increased temperatures may increase the evaporation, which leads to longer periods of soil water deficits.

Shallow unconfined aquifers along floodplains in (semi-) arid regions, are recharged by seasonal streamflow and can be depleted directly by evaporation. Changes in the duration of flow in those streams may lead to lower groundwater recharge. Sea level rise will cause saline intrusion to coastal aquifers, especially in shallow aquifers. An overlying bed that is impermeable, on the other hand, characterizes a confined aquifer and local rainfall does not influence the aquifer.

River flows

Most hydrological studies on the effects of CC have concentrated on streamflow and runoff. Streamflow is water within a river channel, whereas runoff is the amount of precipitation that does not evaporate. In general, changing patterns in runoff are consistent with those identified for precipitation. However, in large parts of (Eastern-) and NW- Europe, Canada and California, a major shift in streamflow from spring to winter has been associated with a change in precipitation but more particularly with a rise in temperature: Precipitation has fallen as rain, rather than snow in winter periods. In colder regions, no significant changes have been observed.

It is difficult to identify trends in hydrological data. Records are short, and monitoring stations are continuing to be closed in many countries. However, there are many hydrological models, which simulate river flows, using climate change scenarios derived from GCMs. Relatively a few studies have been published in Africa, Latin America and South East Asia.

Cold and cool temperate climates: The streamflow in these areas is largely dependent on melting snow in springtime. The most important effect of CC is the timing of streamflow: there will be more runoff during winter because less precipitation falls as snow.

Mild temperate climates: These regions are dominated by rainfall and evaporation. The magnitude of the flows is largely determined by rainfall changes. Trends show a decrease in summer runoff and an increase in winter runoffs.

(semi-) Arid regions. Here a small percentage of change in rainfall causes considerable effects in runoff.

Tropical regions: Runoff figures are largely dependent on rainfall. The number of extreme events such as flooding may increase due to increased intensity in precipitation.

Lakes: Especially closed (endorheic) lakes, with no outflow, are vulnerable to changes in climate conditions. These lakes are considered as indicators for CC (e.g. Aral sea). Exorheic lakes may also be sensitive. For instance, lake levels of lake Victoria in East Africa have increased for several years following increases in precipitation levels.

Flood frequency: relatively few studied have studied CC effects on flooding frequencies. Reasons can be found by the facts that GCMs produce (1) relatively course scenarios, which are monthly averages --the spatial and temporal resolution may be not representative to study short-duration rainfall. An example of a flood frequency studie is conducted by Mirza (1997) in South Asia. Here, according to 4 GCM scenarios, the flood discharges in the Ganges Brahmaputra Meghna (GBM) basin could increase with 6-19%.

Drought frequency: Droughts are more difficult to define in quantitative terms as compared to floods (rainfall deficits, soil moisture deficits, lack of flow in the river, etc). Not only climatic and hydrological inputs, but also changes in water resources management may effect drought.

Water quality: Agriculture practices may change through CC, hence agricultural chemical loads in surface and groundwater may change accordingly. Furthermore, higher temperatures may decrease the concentrations of oxygen and thus increase eutrophication.

Glaciers and ice caps: At the global scale, small valley glaciers will decline through higher temperatures. Also, some simulations show increases in mass exchange in valley glaciers through increased winter accumulation. Especially tropical glaciers will be largely affected by small increases in temperature.

Effects on water withdrawals

Water demand is a synonym for human and environmental ‘water requirements’. There are instream demands (no withdrawals, e.g.hydropower generation) and offstream demands (withdrawals). These demands can be consumptive (e.g. irrigation) or non-consumptive (water is returned to the river).

Agricultural use is the largest consumer of water around the world (67% of all withdrawals, and 79% of all water consumed). Municipal, or domestic use, account for 9% of withdrawals. Global water withdrawals would increase with 23-49% by 2025 over 1995 values. The greatest rates are projected in developing countries, e.g. in Africa and the Middle East (without taking CC into account). Water withdrawals are expected to fall in developed countries because of e.g. water pricing. Industrial water withdrawals accounts for 20% of all withdrawals. Without CC, these withdrawals will increase, and is concentrated largely in Asia and Latin America.

The amount of Agricultural water use is largely dependent on irrigation. Factors that influence these developments are: the expansion of irrigated land, agricultural demands, water pricing and population growth. Agricultural use is relatively sensitive to CC as compared to domestic and industrial use of water. The effects on agricultural use are: (1) a change in field level climate may alter the need for and timing of irrigation: Increased dryness may lead to increased demands, but demands could be reduced if soil moisture content rises at critical times. And (2) Higher CO2 concentrations would lower plant stomatal conductance, hence increase the WUA, but this maybe offset to a large extent by increased plant growth.

Impacts on Water resources and Hazards.

Water resources stress indicators include: amount of water available per person and ratio of volume withdrawn to volume available. Projections show that 0.5 billion people could see increased water resources stress by 2020 as a result of CC. Case studies show that the impacts of different demands and operational assumptions by 2050 are greater than, or of similar magnitude to, the potential impacts of CC.

Estimates of the cost of CC must consider measures used to adapt to that change, and the economic costs of CC will depend on the adaptation strategies adopted.

It is difficult to quantitatively estimate impacts of CC on the water resources system. Some general implications, however, are:

- In systems with large reservoirs, changes in resource capacity may be proportionally smaller than changes in riverflows.
- Potential effects of CC must be considered in the context of changes in water management – CC changes may have little effect on the water resources as compared to changes in water management over a period of 20 years.

- The implications of CC are likely to be the greatest in systems that currently are highly stressed.

Also, the IPCC report urges the importance to assess the effects of CC in the context of the water management system that would exist by then in the absence of CC – considering, for example, changes in demands.

Adaptation Options and Management Implications

Most studies have focused on the impacts of CC in the absence of planned adaptation. CC is just one of the pressures that face a water manager. Other stresses are protection against hazards, changing water management objectives and technologies.

The optimum level of adaptation minimizes the combined costs of adaptation and residual negative effects, with the most cost-effective steps taken first. Factors that affect adaptive capacity itself include: institutional capacity, wealth, planning time, scale, etc.

Water management options include smart combinations of supply- and demand side approaches. Techniques for assessing alternatives include scenario analysis and risk analysis. Important is the role of uncertainty in these alternatives and making decisions on the basis of this assessment.

Scenario analysis involves simulation of scenarios including e.g. CC. Non-linearities in impacts and the uncertain nature of CC may lead to the necessity of evaluating a large number of scenarios. Risk analysis involves the assessment of the risk of certain thresholds being crossed under different possible futures. It generally involves stochastic simulation of hydrological data.

Integrated Water Resources Management (IWRM) is regarded as the most effective way to manage water resources. It involves three components: consideration of all supply-side and demand side actions; inclusion of all stakeholders and continual monitoring and review of water resources situation.

Final points:

- Upstream adaptation may have implications for downstream uses: this emphasizes the need for basin-scale management
- There is a need to look at the effects of CC for water systems that are only managed at the household level, particularly in developing countries.

References

Cosgrove, W.J. and F.R. Rijsberman, 2000: World Water Vision: Making Water Everybody's Business. World Water Council, Earthscan Publications Ltd., London, United Kingdom, 108 pp.

The Dublin Statement, 1992. International Conference on Water and the Environment. World Meteorological Organisation, Geneva.

Mirza, M.Q., 1997. The runoff sensitivity of the Ganges river basin to climate change and its implications. Journal of Environmental Hydrology, 5, 1–13.

SAR (1995). "Climate Change 1995: The Science of Climate Change". J T Houghton, L G Meira Filho, B A Callender, N Harris, A Kattenberg and K Maskell (Eds.). Cambridge University Press, UK. 572pp. (ISBN: 0-521-56433-6). Available from: Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, UK.

TAR (2001). Climate Change 2001. 'Impacts, Adaptation and Vulnerability'. Third Assesment Report IPCC. http://www.ipcc.ch/pub/tar/wg1/.

WMO, 1997: Comprehensive Assessment of the Freshwater Resources of the World. World Meteorological Organisation, Geneva, Switzerland, 34 pp.

Apendix B glossary

term	meaning
drought	???? meteorological definition? hydrological definition?
climate variability	Variations in the mean state and other statistics of the climate on all temporal and spatial scales beyond that of individual weather events.
adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (IPCC TAR WG2)
vulnerability	The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. (IPCC TAR WG2)

Page: 10

Page: 10
[TDM2]Tim Mitchell to write this section.
Page: 39
[TDM3]Tim Mitchell to write this section.
Page: 56
[TDM4]Tim Mitchell to write this section.
Page: 73
[A5]
Page: 76
[TDM6]Tim Mitchell to write this section.
Page: 85
[TDM7]Tim Mitchell to write this section.
Page: 85
[TDM8]Tim Mitchell to write this section.