Water and adaptation to climate change

Developing countries, as a group, are the ones most threatened by the hydrological impacts of global climate change. Water is a critical resource in development, and it is affected by climate change in multiple, complex ways – through changes in temperature and rising sea levels, changes in precipitation patterns, and melting snowfields and glaciers.

Since 1988, the Intergovernmental Panel on Climate Change (IPCC) has consolidated the work of scientists throughout the world to widen our understanding of the greenhouse gas-induced warming effect, and established a remarkable consensus about the effect and its implications.

Climate change is happening

Global temperature increase, the key primary outcome of global warming, is expected to reach between 1.8 and 2.8° Celsius by the end of the 21st century relative to the 1980 – 1999 average even in rather moderate scenarios of how the global economy would develop. This is on top of the anthropogenic increase of about 0.5° Celsius that has already been measured for the period between 1900 and 1990 (IPCC 2007, *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*). Most ambitious efforts in mitigating greenhouse gas emissions are needed to keep adaptation manageable, but adaptation is already necessary right now. Understanding the impacts of climate change is therefore of utmost importance.

Predictions on precipitation, a second key climatic variable undergoing changes, indicate that mean global precipitation will increase because of the higher moisture holding capacity of a warmer atmosphere and higher evaporation rates from warmer water bodies. However regional effects will differ. Models generally show increases in annual precipitation at higher latitudes and in the tropics, and decreases in the sub-tropics. Importantly, precipitation variability will increase across all regions.

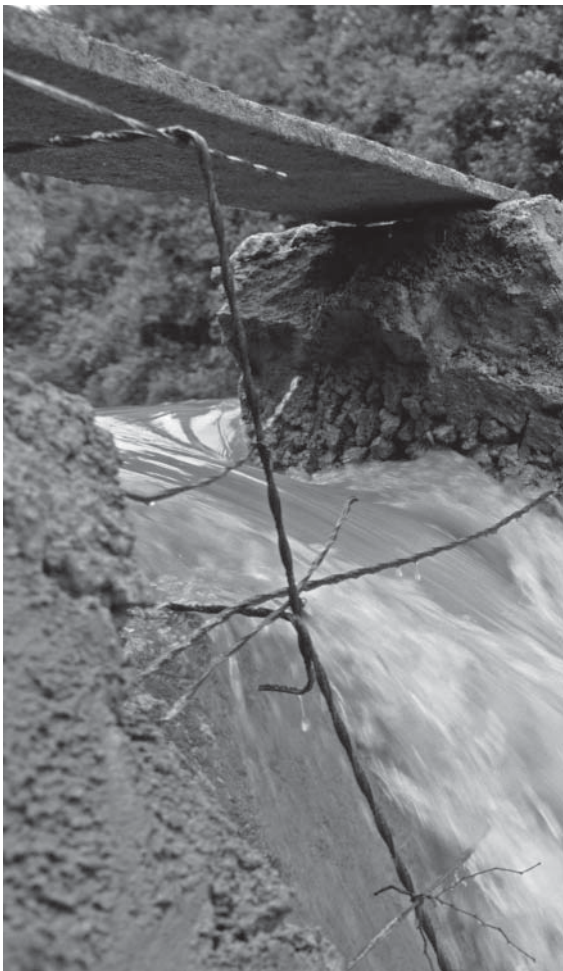
Impacts on the water cycle

These primary effects of climate change critically affect water resources.

One of the earliest and most powerful impacts of rising temperature on water resources is the melting of snowpacks and mountain glaciers which store precipitation as snow and ice in the winter for release during summer months. More than one-sixth of the world's population depend on these glaciers and snowpacks for their water supply.

Another inexorable impact is rising sea levels caused by thermal expansion of seawater and melting of continental glaciers. The overall range of predicted values from the IPCC (ibid) is 0.18 to 0.59 metres by the end of this century. This rise will lead to an inundation of low-lying lands and habitations and increased storm surge damage. It will also increase salinisation of coastal agricultural lands, rivers and coastal aquifers.

Higher temperatures will further increase the rate at which water evaporates from oceans, lakes and reservoirs and from the soil surface. This reduces supplies in storage reservoirs and dries the soil more quickly after rainfall or irrigation. Higher temperatures will also have an effect on water quality and the overall ecology of streams and water bodies.



An irrigation dam on the frontier zone of India's federal states of Andhra Pradesh and Orissa has broken following heavy monsoon rains.

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In regions not dominated by snowpack storage, changes in precipitation patterns are the most important determinant of changes in hydrology resulting from climate change. Higher intensity of precipitation events has already been observed and will lead to increased erosion, landslides and reservoir sedimentation, as well as to more frequent and larger floods. Another important function of precipitation is to recharge groundwater aquifers. Impacts on groundwater recharge are very site-specific, but where precipitation levels decline, groundwater recharge generally decreases more than proportionately.

Despite their importance, however, changes in precipitation resulting from global warming are far more variable spatially than changes in temperature and, at the same time, more difficult to predict. Impacts of climate change on annual and decadal weather cycles may also be significant but are not yet well understood. Examples include the southwest monsoon that waters the South and Southeast Asia, and the El Niño Southern Oscillation which affects weather in many portions of the globe, including sub-Saharan Africa.

Human and environmental impacts

The immediate impacts of climate change pose a threat to a large share of the world population, not so much because of the higher or lower levels of temperature and rainfall that they yield, but rather because global warming alters these levels rapidly and strongly.

The changes in hydrology resulting from global warming and consequent climate change have profound implications for human well-being. Because of the large volumes of water involved, among the most important of these is supporting sources of human livelihood. Water-dependent livelihoods include rainfed and irrigated crop agriculture, livestock raising, and fishing, while many other income-generating activities are indirectly affected.

Photo: J. Boethling

Vulnerability is the degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

IPCC

Agricultural capacity has been estimated in recent studies to fall by 10 to 25 percent by the 2080s, and damages will be particularly strong in Africa and Latin America (Cline, William 2007: *Global warming and agriculture: impact estimates by country.* Center for Global Development, Washington D.C.). Studies on specific crops have found that reductions in the production of highly hunger-important crops of South Asian wheat, Southeast Asian rice, and Southern Africa maize are expected in the absence of adaptation measures (Lobell, D. et al. [2008]: *Prioritizing climate change adaptation needs for food security in 2030.* Science 319).

Both water availability and water quality will be threatened in many locations affecting availability of drinking water and water availability for sanitation. The impact on women is especially concerning, since women usually bear primary responsibility for carrying water to the home, and are often the primary cultivators, particularly in Africa.

Who is hit worst?

Although climate change will have impacts that can be positive for some areas and groups of people, the most significant impacts are expected to be negative. Positive impacts for agriculture, in the form of increased rainfall and longer growing seasons, will mostly be experienced in the northern hemisphere, particularly the higher latitudes of North America and Eurasia. The question of who is hit worst is closely linked to the question of vulnerability (see Box).

Photo: J. Boethling

Changing precipitation patterns and global warming will have very damaging effects on agricultural capacity in Africa and Latin America.

Related to water resources, impacts affect the following systems:

- **Drought-prone areas:** Some semi-arid and sub-humid regions of the globe such as the Sahel are already suffering from more intense and multi-annual droughts, highlighting the vulnerability of these regions to the increased drought occurrence that is expected in the future due to climate change (IPCC, 2007). By 2020, yields from rainfed agriculture could be reduced by 50 percent (ibid), partly due to droughts, in some African countries.

- **River systems fed by snow and ice melt:** Measurable reductions in snowpacks and ice and shifts in spring runoff hydrographs are already evident in the Western United States and Australia, and are likely to occur in India, Pakistan, China, river basins fed by the Andes, and elsewhere, too. IPCC (ibid) reports that in Asia, by the 2050s, freshwater availability in Central, South, and East Asia, will decrease.

- **Areas with lower precipitation plus elevated temperatures:** Negative changes in water availability, in general, and harmful affects on agriculture, in particular, are expected to worsen in the Mediterranean region, Southern Africa, the Western United States and Northern Mexico, and Brazil. In Africa, by 2020, between 75 and 250 million people will be exposed to increased water stress, partly due to climate change (ibid).

- **Lowland delta regions:** IPCC (ibid) mentions heavily-populated megadeltas in Asia as particularly vulnerable systems. Higher intensity storms and earlier spring runoff in snow-fed rivers will lead to increased flooding.

Responses

These changes and impacts have led to action in developed and developing countries. First experiences with responses to climate change by developed and developing countries are:

- Study and assessment of climate change implications are often the first steps undertaken. In developing countries where this first involves building capacity, pairing arrangements with established research organisations is a common practice.
- Most countries, regardless of income levels, are not yet at the stage of making large infrastructure investments solely to adapt to the impacts of climate change.
- Climate change issues are often integrated with or subsumed under more general issues of water supply and water scarcity. Where climate change impacts are still invisible and unrecognised, they will often still benefit from adaptations to general water scarcity problems.
- Countries are willing and able to separate mitigation and adaptation responses to climate change. Thus adaptation is relevant even in countries that do not recognise a near-

The adaptation strategy in Tunisia

In Tunisia, climate change has already had a strong impact: After a period of extreme drought between 1999 and 2001, which raised social conflicts, especially regarding water availability, and which contributed to the Tunisian economy shrinking by 20 percent, the Tunisian Government decided to develop an adaptation strategy for the agricultural and water sector.

The first Tunisian climate model was developed and expected impacts on the agricultural and water sectors were analysed. Areas of concern include: a 50 percent loss of the olive harvest by 2050 and a 20 percent decrease of grain production.

Based on this analysis, priorities for action were identified involving all relevant stakeholders leading to a national cross-sectoral adaptation strategy. The strategy marks a shift from short-term crisis management to long-term orientation and risk-management.

GTZ (German technical assistance) has supported this process. A concrete step at the national level is that the strategy now guides a screening of the legal framework for agriculture, water and infrastructure – an effective way to minimise climate risks.

term responsibility to help mitigate the problem.
- Developed countries, in particular, often establish multi-agency frameworks to house and govern institutions working on climate change assessment and adaptation.

Indicative priorities for adaptation

Water is a core development sector, relating both to many climate change impacts and to many development objectives. Current adaptive capacities in developing countries are often low. Adaptive action is needed, and some indicative priorities may be identified, even though a clear understanding of climate change impact pathways and priorities for action will be needed in each country and region. Adaptation priorities should be derived from a cross-sectoral perspective to find the most effective entry points.

One important dimension of priority setting is related to geographic considerations. Certain regions will be more strongly affected by negative hydrological effects than others. However, the expected water-related impacts of global warming are not unique and will often simply build on and exacerbate current trends and emerging problems. Recommended priorities with widespread applicability are therefore described below (Svendsen, M., Künkel, N., 2008: *Water and Adaptation to Climate Change. Consequences for developing countries.* GTZ. Eschborn).

Water scarcity. The first strong priority is to develop measures to deal with growing water scarcity and increased variability of supply. In many of the most vulnerable regions, this is already a problem which climate change impacts are very likely to exacerbate. Measures to alleviate existing or impending water scarcity could also be beneficial to ameliorating similar climate change impacts. Such measures include steps to both manage demand for water and to enhance sup-

Zusammenfassung

Die Entwicklungsländer sind von den hydrologischen Folgen des Klimawandels am stärksten betroffen. Die Verfügbarkeit der Ressource Wasser, die für die Entwicklung eine entscheidende Rolle spielt, wird durch den Klimawandel in vielfältiger und komplexer Form beeinträchtigt – durch Temperaturveränderungen und steigende Meeresspiegel, Veränderungen der Niederschlagsmengen und das Schmelzen von Eis und Gletschern. In den dürregefährdeten Gebieten beispielsweise erwartet der Weltklimarat – Intergovernmental Panel on Climate Change, IPCC – bis 2020 einen Rückgang der Agrarproduktion um bis zu 50 Prozent. Strategien für die Anpassung an den Klimawandel müssen sorgfältig auf die regionalen Bedingungen abgestimmt sein. Im Vordergrund müssen Maßnahmen für den Umgang mit der zunehmenden Wasserknappheit stehen. Für die Umsetzung dieser Anpassungsstrategien benötigen die Entwicklungsländer starke internationale Unterstützung.

Resumen

Los países en desarrollo como conjunto son los más amenazados por los impactos hidrológicos del cambio climático global. El agua es un recurso crítico para el desarrollo y está siendo afectado por el cambio climático de maneras múltiples y complejas – a través de cambios en la temperatura y el alza en el nivel del mar, cambios en los patrones de precipitación y el derretimiento de campos nevados y glaciares. Por ejemplo, en lo que respecta a las áreas susceptibles a las sequías, el IPCC (Grupo Intergubernamental de Expertos sobre el Cambio Climático) espera una reducción del 50 por ciento en la producción agrícola para el año 2020. Las estrategias de adaptación deben adecuarse eficiente y cuidadosamente a las condiciones regionales. Debería darse prioridad absoluta al desarrollo de medidas para hacer frente a la creciente escasez de agua. A fin de implementar estas estrategias de adaptación, los países en desarrollo requieren mucho apoyo internacional.

ply. It means that we need not wait for ex post evidence of change and precise estimates of its magnitude before beginning to act, since action will be beneficial even in the absence of climate change impacts.

Knowledge base and analytic capacity. Another important priority is to expand the knowledge base on water resources, climate change exposure and impacts, and to strengthen national analytic capacity. Such knowledge is useful and important regardless of the exact magnitude of the hydrological impacts to come. Important knowledge gaps often include quantification of the elements of the hydrologic system, including inflows, outflows, storage, and use of both surface and groundwater. The capacity to adapt and use regional climate and hydrologic models is also a critically important adaptive skill for a country to have.

Integrated planning and management. A further strong priority is strengthening capacity for integrated water resource planning and management. Such capacity will be beneficial under a wide range of climate impact scenarios. Integrated planning to deal with shrinking water availability and expanding demand for water is the bridge that translates knowledge into action. Emphasis should be both on strengthening planning and management tools and on developing mechanisms for broad stakeholder participation in the planning process.

Photo: J. Boethling

The Sahel region is already suffering from severe, multi-annual droughts.

International support

Developing countries' demand for financial and technical support for adaptation in water resources is expected to rise considerably. The most comprehensive assessment of financial flows needed for adaptation, conducted by the United Nations Framework Convention on Climate Change – UNFCCC – (United Nations Framework Convention on Climate Change, 2007: *Investment and financial flows to address climate change*. Bonn), estimates that an additional 9 billion US dollars will be needed by 2030 to adapt the water sector in developing countries to the effects of climate change. In Least Developed Countries, water-related issues were identified among the most important priorities in many National Adaptation Programmes for Action prepared under the UNFCCC.

Addressing hydrological impacts of climate change is also an important issue for international co-operation, water being a critical development sector. Climate change-related international development co-operation can assist countries in building the necessary capacity and making needed adjustments, but will be most effective if adaptation efforts are integrated into the overall planning and investment processes.