Environment as infrastructure – Resilience to climate change impacts on water through investments in nature

This Perspective Document is part of a series of 16 papers on «Water and Climate Change Adaptation»

'Climate change and adaptation' is a central topic on the 5th World Water Forum. It is the lead theme for the political and thematic processes, the topic of a High Level Panel session, and a focus in several documents and sessions of the regional processes.

To provide background and depth to the political process, thematic sessions and the regions, and to ensure that viewpoints of a variety of stakeholders are shared, dozens of experts were invited on a voluntary basis to provide their perspective on critical issues relating to climate change and water in the form of a Perspective Document.

Led by a consortium comprising the Co-operative Programme on Water and Climate (CPWC), the International Water Association (IWA), IUCN and the World Water Council, the initiative resulted in this series comprising 16 perspectives on water, climate change and adaptation.

Participants were invited to contribute perspectives from three categories:

1 **Hot spots** – These papers are mainly concerned with specific locations where climate change effects are felt or will be felt within the next years and where urgent action is needed within the water sector. The hotspots selected are: Mountains (number 1), Small islands (3), Arid regions (9) and 'Deltas and coastal cities' (13).

2 **Sub-sectoral perspectives** – Specific papers were prepared from a water-user perspective taking into account the impacts on the sub-sector and describing how the sub-sector can deal with the issues. The sectors selected are: Environment (2), Food (5),

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Impacts of climate change, in combination with other drivers of global change, are compromising our ability to address global economic, security and social priorities. As floods, drought and other impacts of climate change on water become more frequent or intense, economies and livelihood security will weaken. Adapting to such impacts by building resilience is integral to addressing these global priorities. As water is at the centre of climate change impacts, this demands a focus on resilience to impacts on water. The environment has a critical role in building resilience to climate change and reducing vulnerabilities in communities and economies. Well-functioning watersheds and intact floodplains and coasts provide water storage, flood control and coastal defence. They are 'natural infrastructure' for adaptation.

Reducing vulnerability to climate change requires a combination of reduced exposure to hazards, reduced sensitivity to their effects and increased adaptive capacity. In each case, the environment, its natural infrastructure and related institutions and governance have key roles to play. Experience from river basins around the world shows that exposure to hazards can be reduced through environmental means. Risk of flooding, for example, can be lessened by restoring floodplains; risk of drought can be minimized by preserving wetlands and groundwater recharge areas; and risk of coastal erosion can be reduced by protecting mangroves. Sensitivity is reduced by using sustainable river basin management to expand livelihood assets and enterprise opportunities. Critically, adaptive capacity is built through water and natural resource governance that builds flexible and coordinated institutions and dissemination of knowledge needed to empower people in planning and decision-making about adaptation. Investing in natural infrastructure and adaptive institutions provides water storage, flood control and coastal defence, while building self-organisation and learning that are characteristics of resilience needed to deal with uncertain future events.

Any rush to invest in engineered infrastructure needs to be reconsidered. The danger of maladaptation – for example infrastructure that weakens resilience – needs to be assessed. All infrastructure options must be on the table, whether engineered or natural. Policymakers need to consider portfolios of approaches that support local actions, development of engineered infrastructure where appropriate and investments in natural infrastructure. Resilience increases where the natural infrastructure of river basins is in place and where basin institutions empower self-organisation and learning. To ensure effective action on global economic, security and social priorities, resilience to climate change impacts on water is vital. With resilience as a goal, natural infrastructure must be central to effective strategies for climate change adaptation.

1 Impacts of Climate Change on Water: Why Does the Environment Matter?

Economic, security and social issues dominate the global political agenda and dictate the parameters of global policy dialogue. At a time of extreme volatility in food and energy prices, concerns over food security and energy security bring demands for rapid response and structural change from world leaders. Governments are scrambling to relieve severe strains in a world financial system increasingly shaped by globalisation and the rapid industrialisation of emerging economies. For the nearly 3 billion people worldwide living on less than $2 per day, above all, the Millennium Development Goals (MDGs) and escaping poverty are the priority (WRI, 2008). Societies are trying to respond and build progress – but doing so in the face of myriad competing and conflicting interests, and in an era of unprecedented global change driven by population growth, urbanisation, deforestation and climate change.

Climate change holds many dangers – and water is at the centre of its impacts. Climate change is expected to bring more frequent drought and floods, and alongside them, more frequent severe storms. The retreat of mountain glaciers, in the Andes and Himalayas most critically, is expected to increase risk of disaster because of flooding and mudslides, and to reduce availability of freshwater in mountain rivers in the long term. Sea-level rise will bring a higher risk of coastal inundation and erosion. Expected impacts among regions vary, but globally the numbers of people living with water scarcity is expected to climb from 1.7 billion to 3.2 billion by 2080 (IPCC, 2008).

These impacts of climate change, in combination with other drivers of global change, are compromising our ability to address global economic, security

longer a viable guide to the future, because of damage caused to livelihoods and the environment (Palmer et al., 2008). Indeed, the environment has a critical role to play. Well-functioning watersheds and intact floodplains and coasts, likewise, provide water storage, flood control and coastal defence. Thus, the environment itself is infrastructure for adaptation – it is 'natural infrastructure'. Furthermore, when based on principles of good governance, sound investment

stream flood peaks by giving rivers the space needed to dissipate peak flows. Such use of floodplains as flood control infrastructure, recognised, for example, in the Dutch policy of 'making room for the river' (V&W, 2006), has the benefit of reducing the extent and height of flood control infrastructure that must be engineered downstream. At the coast, mangroves, barrier reefs and islands protect against erosion and storm damage, but also attenuate tidal or storm surges, as witnessed in the Asian tsunami of 2004, where damage from coastal inundation was reduced where mangroves were intact (UNEP-WCMC, 2006).

Natural infrastructure has been fundamental to water resources management, and thus to management of climate variability and extremes, throughout history. As such, natural infrastructure has been a critical instrument of development, just as has engineered infrastructure, though usually unseen and uncosted, and therefore receiving much less investment. The focus on reducing water-related vulnerabilities brought by climate change requires, however, that there is new, explicit recognition given to the role of natural infrastructure.

2.2 Reducing Vulnerability

Vulnerability to climate change combines exposure to hazards that resul005 Tc9outy 5/,Vulne3 fun2how-

3 Building Resilience to Climate Change Using Natural Infrastructure

3.1 Case Story: The Komadugu Yobe Basin, Nigeria

The Komadugu Yobe River is part of the natural infrastructure of northern Nigeria. Part of the Lake Chad basin, it can be counted among the dryland hot spots of vulnerability. With a semi-arid climate, rainfall variability is high and severe drought a frequent hazard. Deep poverty characterises the basin, where population has doubled in three decades to more than 23 million. Over this same time, flow in the Komadugu Yobe has fallen by 35%, due to the combined effects of the construction of two dams since the 1970s, abstraction of water for large-scale irrigation and regional drying of the climate. A society already under social and economic crisis has thus been facing ever-increasing water stress. The river itself has been severely degraded, as the natural cycle of seasonal flows has been replaced by perennial low flows, causing loss of the services from riparian and wetland ecosystems that communities have historically relied on. Fishing, farming and herding livelihoods have been devastated as a result, because fish habitats are choked with invasive weeds, floods used by farmers to fill their soils with water are small or absent, and scarcity of water has led to conflict. The natural infrastructure of the river has been damaged, and as a result communities living with drought hazards are less able to cope. With further climate change looming, the adaptive capacity of ecosystems and communities of the Komadugu Yobe have become brittle, just when resilience is most needed.

Crisis in the Komadugu Yobe basin has led to change. Restoring the river basin's natural infrastructure has become a source of adaptive capacity and renewed resilience. With the six federal Nigerian riparian states unable to coordinate development of water resources in the basin, and with the number of cases of conflicts over land and water resources reaching court running into the hundreds each year, the dysfunctional state of the river had become a barrier to pursuing the Millennium Development Goals in the basin. Beginning in 2006, the federal and state governments and stakeholders, including dam operators and farming, fishing and herding communities, came together to negotiate a plan for coordinating and investing in restoration and management of the basin. In addition to agreeing on a Catchment Management Plan, they drafted a 'Water Charter', spelling out the agreed principles for sustainable development of the basin and the roles and responsibilities of governments and stakeholders. Reform of water governance is enabling transparent coordination of water resources development, including remediation of degraded ecosystems and, eventually, restoration of the river's flow regime. Dialogue has reduced the number of cases of conflict to just a handful per year and governments have pledged millions of dollars in new investment for basin restoration (KYB Project, 2008).

Change achieved in the Komadugu Yobe basin has increased capacity to address critical constraints in development, such as water scarcity, conflict and degradation of natural resources. Under the agreed management plan for the basin, actions are underway to restore ecosystem services and rebuild the natural infrastructure used to cope with drought and sustain the livelihoods and enterprise development needed to reduce poverty. The new institutions and empowerment of stakeholders to participate in planning and management of water resources provide flexible capacity to respond to stresses and shocks that was missing in the past.

Where resilience in the Komadugu Yobe was weakening, it is now strengthening. Ability to adapt in the basin was spiralling downward as the structure and function of the basin – in terms of hydrology, ecology, and social development – degraded. There is promise that the spiral is now slowing and reversing, with much greater capacity for self-organisation than there was previously. Myriad problems remain and barriers to reduced poverty and increased food and water security are profound. These include lack of financial resources, access to technology, skills and knowledge including hydrological and climate information. However, with the changes underway in the basin, governments and communities are acquiring capacities to both learn9ills ang,

flexible institutions and investment that underpin effective management and restoration of a river basin's natural infrastructure provide vital adaptive capacity that is based on resilience (Nelson et al., 2007).

3.2 Integrating River Basin Management into Adaptation Decisions

The experience of the Komadugu Yobe is repeated in other river basins globally. The Worldwide Fund for Nature reported in 2008 how investment in the natural infrastructure of river basins and adaptive governance is reducing vulnerability to climate change (Pittock, 2008), including in:

- the Lower Danube, Eastern Europe – where increases in flooding are projected, restoration of floodplains has increased flood storage, diversified livelihood options and reconnected habitats;
- the Great Ruaha River, Tanzania – where greater water scarcity is expected, strengthening of local Water User Associations and basin management institutions has increased water use efficiency by communities, diversified livelihoods and enabled use of hydrological and climate information in decision making;
- the Yangtze Lakes, China – where likely climate change impacts include increased flooding, restoration and reconnection of 450 km^2 of lakes has enabled retention of 285 Mm^3 of floodwaters while increasing fisheries production by 15 %;
- the Rio Conchos, Mexico – where a drying climate is projected, establishment of a multi-stakeholder institution for adaptive management of the basin has led to reduced demand for water and development of conjunctive management for surface and ground waters that expand options for coping with drought;
- the Rio São João, Brazil – where climate change is expected to exacerbate pollution of coastal

resilience. Maladaptation thus includes actions that cause natural infrastructure to degrade and weaken ecosystem services needed to lower exposure and sensitivities to climatic variability and change.

The story of the Komadugu Yobe river provides a warning of the dangers of maladaptation associated with infrastructure development that damages resilience. Capacity of communities to cope with stresses, shocks and future change fell after dams and irrigation development caused damage to the river and loss of ecosystem services. Such mistakes are liable to be repeated if the benefits of ecosystem services are not recognized in strategies for climate change adaptation. Any rush to engineer infrastructure for adaptation such as dams, levees, dikes and sea-walls needs to be reconsidered. Instead, comprehensive and resilience-based strategies for infrastructure development are needed which combine sustainable and appropriate investment in portfolios of both engineered and natural infrastructure.

4 Conclusions

World Bank (2006). Ethiopia: Managing Water Resources to Maximize Sustainable Growth. World Bank, Washington, DC.

World Resources Institute (WRI) in collaboration with United Nations Development Programme, United Nations Environment Programme and World Bank (2008). World Resources 2008: Roots of Resilience—Growing the Wealth of the Poor. World Resources Institute, Washington, DC.