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Water, climate change and disasters

Note by the Secretariat*

Summary

The present note is submitted pursuant to General Assembly resolution 64/198, in which the Assembly, inter alia, invited the President of the Assembly to convene a high-level interactive dialogue of the sixty-fourth session of the General Assembly in New York on 22 March 2010, World Water Day, on the implementation of the International Decade for Action, "Water for Life", 2005-2015. The note provides background information for Member States on water, climate change and disasters, selected as the theme of one of the round tables of the interactive dialogue.

Water is the primary medium through which climate change influences the earth's ecosystem and therefore people's livelihoods and well-being. Water-related climate change impacts are already being experienced in the form of more severe and frequent droughts and floods. Higher temperatures and changes in extremes are projected to affect availability and distribution of rainfall, snowmelt, river flows and groundwater and further deteriorate water quality. The poor, who are the most vulnerable, are likely to be adversely affected the most. Adaptation to climate change is mainly about water and sustainable development. Recognizing this and responding appropriately presents development opportunities. Various necessary adaptation measures to deal with climate variability, building upon known land and water management practices, have the potential to create resilience to climate change and enhance water security. Innovative technological practices and implementation of strategies are also needed at the appropriate scales, for adaptation as well as mitigation.

* The present note is based largely on a still unpublished UN-Water policy brief on water and climate change, which was prepared by the Task Force on Water and Climate Change of UN-Water, the inter-agency mechanism designated by the United Nations System Chief Executives Board for Coordination, through its High-level Committee on Programmes, as the coordinating mechanism in the United Nations system for follow-up action in the area of water and sanitation.

The sense of urgency for climate change adaptation and the recognition of the central position of water have not yet permeated the political world and are often not reflected in national plans or international investment portfolios where adaptation measures in water management are underrepresented. Consequently, significant investments and policy shifts are needed. The present note provides some guiding principles for such policy shifts at the country, regional and international levels.

Contents

I. Introduction

1. Water is the lifeblood of the planet and the state of the resource affects all natural, social and economic systems. It serves as the fundamental link between the climate system, human society and the environment. The hydrological cycle and therefore water management is already severely impacted by climate change. This is having significant effects on human development and security.[1]

2. Climate change has large impacts on both water resources availability and demand. It is critical to understand the processes driving these changes, the sequences of the changes and their manifestation at different spatial and temporal scales. It is likely to be an increasingly powerful driver of water availability, acting in combination with other drivers that are already having a serious impact on its quality and availability. Increased water-related risks associated with the changes in frequency and intensity of extreme events, such as droughts, floods, storm surges and landslides, will put further stresses on water resources management and increase uncertainty about quantity and quality of water supplies. This will continue regardless of the mitigation measures employed over the coming decades. Society needs to find ways to adapt to the changes that are expected, and to render its water infrastructure and services more resilient in coping with new conditions and extreme events.

3. Climate change is a complex problem which has brought increased appreciation of the need for an integrated, multisectoral and multidisciplinary collaborative response. Apart from the normal water domain, decision makers in other spheres (finance, trade, energy, housing, regional planning, agriculture, etc.) must utilize water efficiently. Sustainable management and development of water will have a pivotal role in preparing societies to adapt to climate change in order to increase resilience and achieve development goals. It calls for policy shifts, investments and changes in the way water issues are addressed in development strategies and budgets.

4. This policy paper is the product of the joint efforts of the members and partners of UN-Water and is addressed to the practitioners and policymakers of water resources management, the sectoral decision makers as well as the climate change policy shapers. The aim of the paper is to draw attention to the critical importance of better water resources management in adaptation to climate change. Water management should be systematically integrated into national plans and international investment portfolios for adaptation.

II. Climate change impacts

5. Water is the primary medium through which climate change influences the Earth's ecosystems and people's livelihoods and well-being. Global warming is likely to result in an intensification, acceleration or enhancement of the global

[1] M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK, Cambridge University Press, 2007), 976 pp. Available from www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html.

hydrological cycle.[2] The changes in precipitation that higher average temperatures and temperature extremes are projected to cause will affect water resources availability through changes in form, frequency, intensity and distribution of precipitation, soil-moisture, glacier- and ice-snowmelt, and river and groundwater flows, and will lead to further deterioration of water quality. There is already evidence that this is happening in many regions. The global picture is complicated and uneven, however, with different regions, river basins and localities affected to different degrees, and in a variety of ways.

6. From the supply side, climate change directly affects the water cycle and, through it, the quantity and quality of water resources available to meet societal and ecosystem needs. It can result in higher-intensity precipitation causing greater peak runoffs but less groundwater recharge. Receding glaciers, melting permafrost and changes in precipitation from snow to rain are likely to affect seasonal flows. Longer dry periods are likely to reduce groundwater recharge, lower minimum flows in rivers and affect water availability, irrigated agriculture, drinking water supply, manufacturing and energy production, thermal plant cooling and navigation. Increased intensity of rainfall, the melting glacial ice and large-scale deforestation are increasing soil erosion and depriving top soils of nutrients. Changes to the proper functioning of ecosystems will increase loss of biodiversity and damage ecosystem services.

7. Rising sea levels will have a serious effect on coastal aquifers, which constitute a major source of water supply for many cities and other users.[2] They will have severe impacts on the food production in major delta regions which serve as the food bowl in many countries. This would also have a profound effect on coastal ecosystems, including loss in the productivity of estuaries, changes in barrier islands, wetland loss and increased vulnerability to coastal erosion and flooding.

8. Global warming is expected to have substantial effects on the flow of energy and the recycling of matter through its impact on water temperature. It is likely to result in algal blooms, increases in toxic cyano-bacteria bloom and reductions in biodiversity. The composition of water in rivers and lakes and its quality is likely to be impacted owing to changing precipitation and temperature resulting from climate change. At the same time, changes in precipitation intensity and frequency influence non-point source pollution. Climate change will make the management of waste water and water pollution more demanding and urgent.

9. Climate change will also directly affect demand for water, for instance, through changes in demands from industrial and household use or irrigation. Water demand for irrigation may increase as transpiration increases in response to higher temperatures. Depending on future trends in water use efficiency and the development of new power plants, the demand for water in thermal energy generation could either increase or decrease.

10. Extreme weather events have become more frequent and more extreme in many regions, resulting in an increase in the magnitude of water-related hazards. At the same time, demographic changes are exposing more people to the increased

[2] B. C. Bates, Z. W. Kundzewicz, S. Wu and J. P. Palutikof, eds., *Climate Change and Water*. Technical Paper VI of the Intergovernmental Panel on Climate Change (Geneva, IPCC secretariat, 2008), 210 pp. Available from www.ipcc.ch/publications_and_data/publications_and_data_technical_papers_climate_change_and_water.htm.

risks of flooding, cyclones and droughts. The impacts of recent major flooding, which has resulted in many deaths and has cost billions of dollars in damages, are an indication of what could lie in store from increased climatic variability in future.[3] At the opposite extreme, the more intense droughts seen in the past decade, affecting an increasing number of people, have been linked to trends in higher temperatures and decreased precipitation. In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change has concluded with high confidence (90 per cent probability) that the extent of drought-affected areas will likely increase.[1]

III. Water resources management and climate change

11. Management of water resources impacts almost all aspects of society and the economy including food production and security, domestic water supply and sanitation, health, energy, tourism, industry and functioning of ecosystems. Under present climate variability, water stress is already high, particularly in many developing countries.[1] Managing water has always implied dealing with the natural variability in supplies and its impact on competing uses of water. Climate change threatens to intensify this variability, shifting and intensifying the extremes, and introduces greater uncertainty in the quantity and quality of supply over the long term. Adaptation to the current climate variability, while having direct benefits, can also help society to better prepare itself for the increased variability that is expected in the future.

12. Climate change is one of the basic drivers of change for water resources management, alongside demographic, economic, environmental, social and technological forces.[4] If conceived in isolation, solutions to the major challenges that these drivers create may become self-defeating. Keys to many water management problems are held by decision makers and policymakers in other disciplines. Recognizing water as "the lifeblood" implies that all major decisions, wherever they are taken, should factor in their potential impact on water. Decision makers, while tackling these issues, should think beyond their own sectors and consider the wider ramifications of their decisions on water availability and the forces affecting it. A balanced, integrated and coherent approach would require thinking outside the box.[4]

13. Improved management of water resources, together with land, is critical to sustainable development, especially in the context of worsening food security and malnutrition, increased energy shortages, the spread of diseases, humanitarian emergencies, growing migration, and increased risk of conflict over scarce land and water and escalating ecosystem degradation. Considering the increasing stresses that water scarcity will place on the environment, and the importance of water in development, mitigation of impacts of water management on the environment will become increasingly difficult. Country-specific solutions may include the creation of new decision-making mechanisms incorporating climate change impacts. This

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[3] United Nations Development Programme, *Human Development Report 2007/2008*, Fighting Climate Change: Human Solidarity in a Divided World (New York, UNDP, 2007). Available from http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf.

[4] World Water Assessment Programme, *The United Nations World Water Development Report*, third edition: *Water in a Changing World* (Paris, UNESCO, and London, Earthscan, 2009). Available from www.unesco.org/water/wwap/wwdr/wwdr3/.

may call for the establishment of new institutions and networks and for better coordination and exchange of information.

14. The world needs to adapt to climate change in water resources management. If improvements in water resources management are not addressed urgently and adequately, the progress towards poverty reduction targets, the Millennium Development Goals and sustainable development in all its economic, social and environmental dimensions will be jeopardized.

IV. Adapting to climate change

15. Policy in response to climate change has so far been dominated by the need for mitigation. Though these measures can slow climate change, they will not halt or reverse it within the foreseeable future. Since effects of climate change are inevitable in the short and medium term, adaptation needs to be addressed with the same urgency as mitigation. Adaptation, as embodied in the Nairobi Work Programme of the United Nations Framework Convention on Climate Change, relies on a better understanding of the impacts of climate change and making informed decisions on measures to cope with it. Water management, based on integrated and system-wide approaches, is key to climate change adaptation.

16. Adaptation planning and practices need to be comprehensive and flexible with cross-sectoral national climate change adaptation plans developed with water management as a pivotal consideration. At the same time, adaptation needs have to be considered in the context of a climate risk management framework to ensure sustainability of interventions.[5] Water-related disaster risk reduction should be considered as a tool in climate change adaptation with greater integration of water-related adaptation and disaster risk reduction strategies.

17. Long-term, sustainable adaptation to climate change will require integration of infrastructure, policy and economic instruments, as well as behavioural changes. Adaptation programmes should consider both structural and non-structural measures, the potential offered by both natural and physical infrastructure and "soft" programmes: positive inducements and negative sanctions. They should also be evaluated from the mitigation perspective. Efforts must be made to evaluate adaptation strategies for their likely impacts on the ecosystems services and health consequences. Adaptation measures should be built on learning-by-doing principles, particularly those being introduced locally that draw on traditional and indigenous knowledge, and could enrich the scientific knowledge base for application more widely.

18. Adaptation measures can be categorized in essentially five ways that water managers have of adapting to contemporary climate variability, and which ultimately will serve as the foundation to adapting to climate change:[6]

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[5] M. E. Hellmuth et al., eds., *Climate Risk Management in Africa: Learning from Practice* (New York, International Research Institute for Climate and Society, Columbia University, 2007).

[6] Eugene Stakhiv and Bruce Stewart, "White Paper: Needs for climate information in support of decision-making in the water sector". Paper produced for the Third World Climate Conference, 31 August-4 September 2009. Available from www.waterandclimate.org/UserFiles/File/WWW2009_Water Sector Needs-White Paper Ver 3_Numbered.doc.

- Planning and applying new investments, and capacity expansion (reservoirs, irrigation systems, levees, water supply, wastewater treatment, ecosystem restoration)
- Adjusting operation practices, monitoring and regulation of existing systems to accommodate new uses or conditions (e.g., ecology, pollution control, climate change, population growth)
- Maintenance and major rehabilitation of existing systems (e.g. dams, barrages, irrigation systems, canals, pumps, rivers, wetlands, etc.)
- Modifications in processes and demands (rainwater harvesting, water conservation, pricing, regulation, legislation, basin planning, payments for ecosystem services, stakeholder participation, consumer education and awareness) for existing systems and water users
- Introducing new efficient technologies (desalination, biotechnology, drip irrigation, wastewater reuse, recycling, solar panels).

Managing uncertainty

19. Uncertainty should not be allowed to be a reason for inaction. Adaptive management overcomes the challenges presented by uncertainties in various inputs to water management decision-making, including long-term climate projections. It allows adjustments to be made as more and better information is available. A pragmatic and "proactive adaptive management" approach, similar to the "no regrets" philosophy of climate change adaptation,[7] should be based on risk-based planning and design of infrastructure that accounts for climate uncertainties, and on the development of a new generation of risk-based design standards for infrastructure. Many non-structural measures are flexible and therefore more suitable for adapting to large uncertainty in both supply and demand and should therefore be integrated in every adaptation strategy. Adopting alternatives that perform well over a wider range of future scenarios could improve system flexibility. Adaptive management requires continuous feedback and adjustments based on the information provided by monitoring networks.

Managing increasing variability

20. Greater climatic variability and short-term uncertainty is likely to be superimposed on any long-term trend, thereby increasing the frequency of extreme events. This will call for comprehensive risk management, including disaster risk reduction at various levels, and adopting new technologies to develop improved early warning systems for improved reservoir and emergency operations. Water operators will need to take account of climate change predictions and uncertainties and prepare for the risks of more intense droughts and floods. Communities will need contingency plans for rapid and coordinated responses to floods and droughts. Demand management in the major user sectors can also improve resilience.

21. Creating the infrastructure for water resource development and distribution has been shown to have considerable human and macroeconomic benefits; conversely,

[7] Rasmus Heltberg, Paul Bennett Siegel and Steen Lau Jorgensen, "Addressing human vulnerability to climate change: toward a 'no regrets' approach", *Global Environmental Change*, vol. 19, issue 1 (February 2009), pp. 89-99.

countries lacking this capability suffer damaging shocks from droughts and floods.[4] More water storage is required to manage increased variability of water resources. Some of this can be natural — enhancing groundwater recharge through rainwater harvesting, sustainably managing aquifers and nourishing wetlands. Others can be man-made in terms of small, medium or large reservoirs, subject to safeguards for the environment and disrupted communities. Storage of both kinds will be required in many regions to insure against droughts and flooding, as well as to provide regular multi-purpose benefits.

Domestic water supply and sanitation

22. The world is on track to meet the Millennium Development Goal drinking water targets, but this is not the case for sanitation.[8] At the same time, water is increasingly under stress from competing demands and climate change, affecting both water quality and quantity. Adaptation calls for coherent measures to address water security for all major users with priority given to the basic needs of human hygiene, consumption and subsistence, which are uses defined as a human right.[9,10]. Increasing population, migration and rising living standards will put increased demand on water services. The existing water supply and sanitation infrastructure was historically designed for different resource availability and water use patterns. Such heritage infrastructure is likely to come under greater pressure owing to hydraulic changes and to warmer temperatures. Overcoming this deficit is an urgent issue that will facilitate adaptation to climate change. Storm-water and wastewater infrastructure would have to include climate change effects in their design and evaluation to improve performance under changing water availability, water demand and water quality conditions. A recent study of water supply and sanitation services shows that many are not resilient to climate change impacts.[11]

Agriculture

23. Climate change is expected to impact both rainfed and irrigated agriculture. Climate change will alter the distribution of agriculture across the globe, shifting potential to high latitude areas, while more frequent and severe droughts and floods will hurt subsistence agriculture in semi-arid zones at low latitudes, thereby worsening the living conditions of rural people who depend on agriculture for their livelihoods. Rural communities, particularly those living in already fragile environments, face an immediate and ever-growing risk of increased crop failure or loss of livestock and loss of fertile topsoil owing to increased erosion. The challenge

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[8] World Health Organization and United Nations Children's Fund, Joint Monitoring Programme for Water Supply and Sanitation, *Progress on Drinking Water and Sanitation: Special Focus on Sanitation* (New York, UNICEF, and Geneva, WHO). Available from www.who.int/water_sanitation_health/monitoring/jmp2008/en/index.html.

[9] United Nations, Committee on Economic, Social and Cultural Rights, "General Comment No. 15 (2002), The right to water (arts. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights"), 20 January 2003 (E/C.12/2002/11). Available from: www.unhcr.org/refworld/docid/4538838d11.html.

[10] Office of the United Nations High Commissioner for Human Rights, Position Paper, "Climate Change and the Human Right to Water and Sanitation", 2009. Available from: www2.ohchr.org/english/issues/water/Iexpert/docs/ClimateChange_HRtWS.pdf.

[11] World Health Organization and the Department for International Development, *Vision 2030: The Resilience of Water Supply and Sanitation in the Face of Climate Change* (Geneva, WHO, 2009). Available from www.who.int/water_sanitation_health/vision_2030_9789241598422.pdf.

is to increase the ability of the rural population to cope with climate change impacts through enhanced resilience and preparedness.

24. Several densely populated farming systems in developing countries are at risk from the impacts of climate change. Severe reductions in river runoff and aquifer recharge are expected in the Mediterranean basin and in the semi-arid areas of Southern Africa, Australia and the Americas, affecting water availability in already stressed regions. The large contiguous areas of irrigated land associated with river deltas are at risk from a combination of reduced inflows, change in annual flood cycles, increased salinity and sea-level rise. In irrigation systems that rely on high mountain glaciers for water, high runoff periods will advance to earlier spring, when irrigation water demand is still low. In addition, rising temperatures will increase crop water demand. Much more needs to be done to address water shortages with an integrated supply and demand-side management, including increased water storage infrastructure (surface water and groundwater), watershed development, rainwater harvesting, water conservation and a host of community initiatives, with a much better integration of land and water management.[12]

Water and health

25. Climate change will influence human health through water-related impacts of various kinds.[13] Changes in the composition of aquatic ecosystems will impact the nutritional status, and exposure to health risk and access to health services for communities whose livelihoods are closely tied to such ecosystems. The occurrence of opportunistic invaders in particular, such as cyanobacteria in lakes and reservoirs, will pose new challenges for water service companies. There has been a resurgence of water-related vector-borne diseases in areas where eradication programmes historically have been successful, and the emergence of new vector-born diseases in areas where they were previously unknown (e.g., chikungunya virus transmission in Italy and the continuing spread of dengue). While it is difficult to identify different driving forces, the role of climate change cannot be excluded. Reduced nutrition and access to safe water for human consumption and personal hygiene may compromise basic human health, and in particular affect the health burden owing to diarrhoeal diseases. Malnutrition because of water shortages, and in availability of safe drinking water during flooding caused by extreme rainfall events, may induce outbreaks of water-related diseases. New breeding places for mosquitoes and other disease-transmitting insects may develop. Groundwater resources may also need improved protection against contamination from extreme rainfall events and floods.

26. Nevertheless, climate change also brings opportunities to improve community health. These health benefits could offset some of the costs of climate change mitigation and adaptation. It is important to raise awareness among stakeholders of the nature and scope of these health benefits.[14]

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[12] Danish Ministry of Foreign Affairs and Partners, "Nairobi Principles in the 'Dialogue on Land and Water Management for Adaptation to Climate Change'", 2009. Available from www.landwaterdialogue.um.dk.

[13] Bettina Menne, Franklin Apfel, Sari Kovats and Francesca Racioppi, eds., *Protecting Health in Europe from Climate Change* (WHO Regional Office for Europe, 2008). Available from www.euro.who.int/Document/E91865.pdf.

[14] *The Lancet*, Executive Summary for the Lancet Series on Health and Climate Change (London, 2009). See http://press.thelancet.com/ccexec.pdf and http://www.wellcome.ac.uk/climatechange.

Ecosystems

27. The services provided by ecosystems underpin livelihoods and economic development. Impacts of climate change on water will aggravate drivers of ecosystem degradation, reducing the benefits people obtain from them, such as supply of clean water, fisheries and coastal defences. The impacts of climate change on ecosystems will increase the vulnerability of people. Thus, actions to reduce and restore ecosystems and their services will help to reduce community vulnerability and build community and national-level resilience. Such actions include upper watershed management to maintain water storage, allocation of water to ecosystems through application of environmental flows, and restoration of floodplains and mangroves. To maximize benefits for resilience, these should be complemented by effective, participatory water governance implemented through adaptive institutions.

Water-related hazards

28. Society needs to adapt to the full range of water-related hazards that will accompany climate change. These can result from too much water (causing floods, erosion, land- and mud-slides, etc., in land-degraded areas) or too little (droughts, forest fires, loss of wetlands or other habitats, saline encroachment, etc.) and from the effects of chemical and biological pollution on water quality and in-stream ecosystems. Approaches, such as Integrated Flood Management,[15] which are robust and adaptive should be adopted to manage floods. Flood risk assessment, which forms an essential element in such approaches should incorporate climate change impacts on the magnitudes and vulnerability of floods.[16] Early warning for droughts is essential, especially for the large regions of rainfed agriculture. The Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters[17] provides the internationally agreed framework for reducing disaster risks and is widely acknowledged as an important tool for adaptation to climate change.

29. Agreed at the World Conference on Disaster Reduction in January 2005, in Kobe, Japan, by 168 Governments, the expected outcome of the Hyogo Framework for Action is “the substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries”.[18] The Framework specifically identifies the need to “promote the integration of risk reduction associated with existing climate variability and future climate change into strategies for the reduction of disaster risk and adaptation to climate change”.[19]

30. The Hyogo Framework sets out five priorities for action,[20] each elaborated into a number of specific areas of attention. These offer a strong basis for developing concrete risk-reducing adaptation measures, as follows:

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[15] Associated Programme on Flood Management, *Integrated Flood Management Concept Paper* No. 1047 (WMO, 2009). Available from www.apfm.info/pdf/concept_paper_e.pdf.

[16] European Commission White Paper, “Adapting to Climate Change: towards a European framework for action” (Brussels, 2009). Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:EN:PDF.

[17] A/CONF.206/6 and Corr.1, chap. I, resolution 2. Available from http://www.unisdr.org/eng/hfa.htm.

[18] Ibid., para. 11.

[19] Ibid., para. 19 (i) (c).

[20] Ibid., para. 14.

1. **Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation**. This need is critical to both adaptation and risk reduction. Suggested actions towards achieving this priority include: encouraging a core ministry with a broad mandate including finance, economics or planning, to be responsible for mainstreaming climate change adaptation policies and activities; organizing a national high-level policy dialogue to prepare a national adaptation strategy that links with disaster risk reduction strategies; formalizing collaboration and the coordination of climate-related risk reduction activities through a multisector mechanism such as a national platform for disaster risk reduction; and developing mechanisms to actively engage and empower women, communities and local governments in the assessment of vulnerability and impacts and the formulation of local adaptation activities.

2. **Identify, assess and monitor disaster risks and enhance early warning**. Important steps under this priority include developing and disseminating high-quality information about climate hazards and their likely future changes; conducting assessments of vulnerability and specially vulnerable groups; preparing briefings for policymakers and sector leaders; reviewing the effectiveness of early warning systems; implementing procedures to ensure that warnings reach vulnerable groups; and undertaking public information programmes to help people to understand the risks they face and how to respond to warnings.

3. **Use knowledge, innovation and education to build a culture of safety and resilience at all levels**. This principle applies equally to adaptation and disaster risk reduction. Specific steps should include collating and disseminating good practices; undertaking public information programmes on local and personal actions that contribute to safety and resilience; publicizing community successes; training the media on climate-related issues; developing education curricula on climate adaptation and risk reduction; supporting research programmes on resilience; and improving mechanisms for knowledge transfer from science to application for risk management in climate-sensitive sectors.

4. **Reduce the underlying risk factors**. This covers the many environmental and societal factors that create or exacerbate the risks from natural hazards. Measures can include incorporating climate risk-related considerations in development planning processes, macroeconomic projections and sector plans; requiring the use of climate risk-related information in city planning, land-use planning, water management, and environmental and natural resource management; strengthening and maintaining protective works such as coastal wave barriers, river levees, floodways and flood ponds; requiring routine assessment and reporting of climate risks in infrastructure projects, building designs and other engineering practices; developing risk transfer mechanisms and social safety nets; supporting programmes for diversification of livelihoods; and instituting adaptation activities in plans for recovery from specific disasters.

5. **Strengthen disaster preparedness for effective response at all levels**. Actions include revising preparedness plans and contingency plans to account for the projected changes in existing hazards and new hazards not experienced before; building evacuation mechanisms and shelter facilities; developing specific preparedness plans for areas where settlements and livelihoods are under threat of permanent change; and supporting community-based preparedness initiatives. Resilience-building and early warning systems also contribute to this priority.

V. Guiding principles

A. Mainstreaming adaptation within the broader development context

31. Adaptation must be addressed in a broad development context, recognizing climate change as an added challenge to reducing poverty, hunger and diseases and reversing environmental degradation. For adaptation measures to be effective they must be integrated into national development plans, promoting synergies as the poor and marginalized groups are most vulnerable to the impacts of climate change, and suffer the most from accelerating water scarcity, water quality degradation, floods and droughts, and sea-level rise. Policy changes for promoting synergies between adaptation and existing development challenges such as food security, poverty reduction, disaster risk reduction and environmental protection that are closely linked with effective water management need to be identified and implemented.

32. Effective adaptation not only requires that water is at the heart of national climate change adaptation strategies, but also that existing national water policies, plans and funds mainstream climate change adaptation.

33. Managing the competing demands for water from various sectors will become more onerous in conditions of water scarcity and drought. Different interests (water supply, sanitation, agriculture, irrigation, hydropower, navigation/transportation and environment) fashion their own set of management principles, rules and incentives that are often in conflict with one another. Cross-sectoral, integrated and system-wide approaches to climate change adaptation must be developed, with water management recognized as central to any development plans.

B. Strengthening water governance and the integration of land and water management

34. Effective adaptation for water requires different approaches within a comprehensive, integrated framework, where bottom-up meets top-down — from community-based adaptation in the villages to the basin, national and regional/transboundary levels. Water and climate do not respect borders and many adaptation measures will have impacts on neighbouring countries. This calls for cooperative solutions that help to prevent negative effects of unilaterally taken adaptation measures and identify more holistic solutions. Many countries have embarked on water sector reforms based on Integrated Water Resources Management approaches,[21] employing a variety of tools based on multidisciplinary

[21] Global Water Partnership, “Strategy 2009-2013”, 2009.

inputs, public participation and regulatory, financial and policy incentives. Well-functioning institutions are needed to effectively administer this broad array of fairly complex combinations of management measures.

35. In order to incorporate climate change adaptation within the governance of water resources, mandates and management functions may need to be clarified and institutions strengthened at various levels. Adaptive water governance will call for more intersectoral planning and linkages between institutions responsible for agriculture, forestry, energy, the environment and water.[22] The role of water in climate change adaptation should be mainstreamed into the work of all ministries.[12] All development projects need to be resilient, and all adaptation measures need to be assessed for inadvertent adverse effects on the environment and on human health, to avoid maladaptation.

36. Strengthening institutions and building capacities for land and water management is crucial for effective adaptation, building on the principles of participation of civil society, equality and decentralization.[22,12] Creation of authorities based on hydrological rather than political boundaries and more effective regional water institutions and improved transboundary cooperation will be required.[23] Stronger, accountable institutions will be able to plan and adjust to changes in water availability and extreme water events.

37. Despite the considerable uncertainty and large potential range in local climate change predictions, deliberate and constructive decisions can still be taken. Lessons can be learned from drought and flood experiences of the past to reduce the vulnerability of newly affected areas in the future. Strengthening resilience and capacity to manage today's climate is often an appropriate response to future climate change threats.

C. Improving and sharing knowledge and information

38. Sound water management is built upon long-term hydrological and climate information gathered through monitoring networks that provide accurate, timely and consistent data. Meeting the challenge of climate change is made more daunting as information about the status of availability and use of water and the potential impact of climate change is often very limited for informed decision-making. Hydrological monitoring networks are on the decline.[24] Hydrological information is often partial, unreliable, inaccessible or simply lacking at relevant levels — global, regional, national and sub-national. Even the data that exists is not efficiently used. There is little sharing of hydrologic data, owing largely to limited physical access, policy and security issues, lack of accepted protocols for sharing and, often, commercial considerations.

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[22] Mannava V. K. Sivakumar and Robert Stefanski, "Climate and land Degradation — an Overview", in Mannava V. K. Sivakumar and Ndegwa Ndiang'ui, eds., *Climate and Land Degradation* (chap. 6) (Hamburg, Springer-Verlag, 2007).

[23] United Nations Economic Commission for Europe, Convention on the Protection and Use of Transboundary Watercourses and International Lakes: *Guidance on Water and Adaptation to Climate Change* (Geneva, UNECE, 2009). Available from www.unece.org/env/water/publications/documents/Guidance_water_climate.pdf.

[24] World Water Assessment Programme, The Second United Nations World Water Development Report: *Water: a shared responsibility*, 2006. Available from www.unesco.org/water/wwap/wwdr/wwdr2/.

39. Transboundary cooperation in the development of adaptation strategies can bring mutual benefit for all riparian parties — for example, by reduced uncertainty through exchange of data and information. Transboundary cooperation can widen the knowledge/information base, enlarge the set of available options for prevention, preparedness and recovery and thereby help to find better and more cost-effective solutions.[23]

40. No individual water management agency and affiliated research institute can deal with the problem of developing a suite of new principles and tools that water managers and design engineers can use effectively to adapt to climate change. An internationally coordinated, collaborative applied research and development effort needs to be undertaken that routinely deals with practical implementation issues for water management.[6]

41. Better access to information promotes more rational decision-making. As most decisions on adaptations in the water domain would have to be made at basin and local level, accurate, consistent, timely and relevant information about water and climate should be widely available. Information and knowledge for local adaptation must be improved, and must be considered as a public good to be shared at all levels. Better information, communication and public awareness, reinforced by the right incentives and sanctions, are required to produce changes in the behaviour of water users to complement other measures.

D. Building long-term resilience

42. Owing to future uncertainties, the keystone for adaptation must be resilience — managing risks and building the capacity to deal with unpredictable events. Building resilience to ongoing and future climate change calls for adaptation to start now by addressing existing problems in land and water management. Climate change impacts are already beginning to be felt and we need to act today, through context-specific adaptation measures, to be prepared for an increasingly uncertain future.

43. Water management options, including operational changes, demand management and infrastructure changes, facilitate adaptation to climate change. Decision-making frameworks using robust solutions should be encouraged. Multidisciplinarity, multisectoral collaborations and adaptive management require building capacity, both institutional and human, at various levels. The planning and design of new hydraulic infrastructure in addition to new hydrologic tools also calls for a new socio-economic decision framework.

44. Climate change is widely perceived as a threat rather than an opportunity, yet there may be overall benefits to health and development in adapting to climate change. There is a potentially high adaptive capacity in many water and sanitation services, but this potential is rarely fully achieved. Systematic assessments of the climate change resilience of all utilities and of rural water and sanitation programmes are needed.[11] Urgent action is required to turn the potential adaptive capacity of many utility-managed water supplies to actual resilience to climate change.

45. Focusing on the adaptive capacity for livelihoods and ecosystem maintenance, and building on integrated land and water resources management approaches, “no regrets” investments are needed for both hard and soft adaptation measures. These

include increased water use efficiency and water storage capacity, intensification and diversification in agriculture, and sustainable ecosystems.[25,26]

E. Cost-effective adaptive water management and technology transfer

46. Infrastructure must be designed to cope with climate uncertainty. Climate adaptation is value for money in terms of economic cost benefits (in terms of damages avoided). Furthermore, "soft" infrastructure such as watershed and wetlands should be assessed as viable alternatives to "hard" infrastructure such as dams or canals.

47. Cost-benefit analysis of adaptation actions should take note of all potential benefits, especially health-related ones. Experience in the area of drinking-water supply and human health has shown that a narrow perspective, such as that adopted in the early 1980s for so-called selective primary health care, fails to support a long-term goal. Recent studies by the World Health Organization have demonstrated that by taking all co-benefits into account (through a social cost-benefit analysis), returns of up to US$ 34 can be achieved for every US dollar invested in drinking-water supply. Analyses of a similar scope, including health co-benefits, should be carried out on adaptation measures aimed at strengthening the resilience of hydraulic infrastructure.

48. Technological advances for improving irrigation efficiency, use of lower quality water (including reclaimed wastewater), reduction of system losses from water systems, and other developments indicate considerable potential for conserving existing water supplies and making better use of what is available. These technologies, appropriately adapted to local conditions, must be facilitated and the capacity to implement and operate them supported.

F. Additional and innovative funding

49. The costs of inaction are high. The economic and social benefits of adaptation, require increased and innovative investment and financing. Improving adaptive capacity calls for more intelligent use of existing financing, targeted towards the most exposed groups. The full range of financing options needs to be utilized, including innovative financing mechanisms, private sources and public funding from developed countries.

50. Developing countries currently lack effective funding mechanisms to support adaptation to climate change. More funding must be made available if adaptation strategies are to become sustainable. There is a need for increased support for adaptation actions through targeted financing and improved aid effectiveness. As such, any adaptation funds must be new and additional to existing official development assistance in recognition of the compensatory nature of such funds.[27]

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[25] John H. Matthews and Tom Le Quesne, *Adapting Water Management: A Primer on Coping with Climate Change*, World Wildlife Fund, Water Security Series 3, 2009. Available from www.worldwildlife.org/climate/Publications/WWFBinaryitem12534.pdf.

[26] International Union for Conservation of Nature, "Environment as Infrastructure — resilience to climate change impacts on water through investments in nature", 2009.

[27] Commission on Climate Change and Development, *Closing the Gaps: Disaster risk reduction and adaptation to climate change in developing countries* (Ministry of Foreign Affairs, Stockholm, 2009). Available from www.ccdcommission.org/Filer/report/CCD_REPORT.pdf.

Access to existing adaptation funds should provide funding for adaptation across the board for all sectors concerned. Sound land and water management practices that provide mitigation and/or adaptation benefits should be eligible for such financial support. There is a need to prioritize the water-related projects in adaptation funding. Climate change adaptation should be integrated into existing funding streams for water management, and adaptive water management should be considered as a funding priority for other water-reliant sectors.

51. Development budgets are already under high pressure from the global financial and economic crisis. There is a need to influence and ensure the development of financing mechanisms capable of generating sufficient resources and delivering them in a manner that minimizes complexity and supports the integration of adaptation concerns into the broader development agenda.

VI. Conclusions and recommendations

52. **Climate change manifests itself through water resources. Its management impacts almost all aspects of society and the economy. Water-related climate change adaptation has a pivotal role in achieving sustainable development.**

53. **The sense of urgency for climate change adaptation and the recognition of the central position of water have not yet permeated the political world and are often not reflected in national plans. Significant investments and policy shifts are needed. These should be guided by the following principles:**

(a) **Mainstreaming adaptations within the broader development context;**

(b) **Strengthening water governance and improving water management;**

(c) **Improving and sharing knowledge and information on climate and adaptation measures, and investing in data collection;**

(d) **Building long-term resilience through stronger institutions, and investment in infrastructure and well-functioning ecosystems;**

(e) **Investing in cost-effective and adaptive water management as well as technology transfer;**

(f) **Leveraging additional funds through both increased national budgetary allocations and innovative funding mechanisms for adaptation in water management.**

54. **Application of these principles would require concerted efforts and global to local-level collaborations among various sectoral, multisectoral as well as multidisciplinary institutions.**

55. **Responding to the challenges of climate change impacts on water resources requires regional, national and local-level adaptation strategies. Countries are urged to improve and consolidate their water resources management systems and to identify and implement "no regrets" strategies which have positive development outcomes that are resilient to climate change.**