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Stakeholder Forum
FOR A SUSTAINABLE FUTURE

Water World: Why the global climate challenge is a global water challenge

gppn | global public policy network on water management

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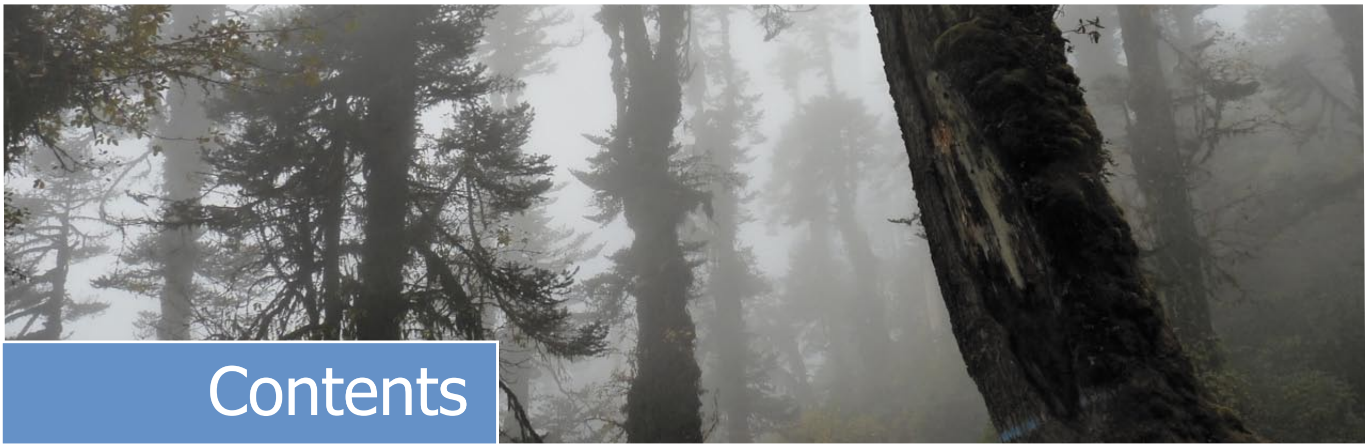
This publication was funded by

Ministry of Foreign Affairs Denmark

Dutch Ministry of Transport, Public Works
and Water Management

UK Department of International Development

German Federal Ministry for the Environment



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About the GPPN

The Global Public Policy Network on Water Management (GPPN) is a joint initiative of Stakeholder Forum and Stockholm International Water Institute, working with global stakeholders to identify priorities for the international water agenda, and communicate those priorities to decision-makers. The GPPN has been working actively to raise the profile of water in the climate change negotiations in the run-up to the 15th Conference of Parties (COP15) of the UNFCCC in Copenhagen in December 2009.

It has co-ordinated the following activities:

- Conducting a global multi-stakeholder consultation on water and climate change adaptation, resulting in a publication outlining major priorities, *Water and Climate Change: Key Messages for COP15*[1]
- Facilitating side events and workshops alongside the negotiations on 'Bridging the Water and Climate Agendas'
- Drafting text amendments on water and adaptation in response to each revision of the negotiating text for the Ad Hoc Working Group on Longterm Co-operative Action under the Convention (AWG LCA)
- Co-ordinating and Chairing an informal government group, 'Friends of Water' to discuss water issues informally as they relate to the negotiations
- Convening with UN Water a 'Water Day' on 3rd November during the UNFCCC negotiations in Barcelona

The GPPN will continue to provide up-to-date responses to the precise text of the climate change negotiations throughout COP15 and beyond.

About this Report

This report has been published to make the case for water as a critical consideration for climate change in the broader context of the UNFCCC, up to and beyond COP15. It has taken the six themes that were covered during the Water Day on 3rd November during the UNFCCC negotiations in Barcelona, addressing water as a cross-cutting consideration in response to climate change: Water and Livelihoods, Water and Land, Water and Transboundary Resource Management, Water and Water and Energy, and Water and Gender.

This report intends to provide a briefing of some of the critical considerations in each of these areas, identifying key messages and why they are relevant to the UNFCCC. It is hoped that it will provide a helpful resource for decision-makers and negotiators as they begin to elaborate details on a shared vision and co-ordinated response to the climate change challenge.

The GPPN was disappointed to see all water references cut from the adaptation text for COP15 ahead of the negotiations in Barcelona in November 2009. Non-Paper 31, which was the adaptation text prepared for that meeting, deleted many of the helpful references to water that had been included until that point. Since then, Non-Paper 41 and Non-Paper 53 have reinserted some limited references to water resources. However, the language could be strengthened considerably, and we hope this report helps to make the case for that, as well as urging for a greater profile for water issues under the UNFCCC beyond COP15.

It seeks to demonstrate that **the global climate challenge is a global water challenge.**

[1] http://gppn.stakeholderforum.org/fileadmin/files/GPPN_2008-9/Papers/GPPN_Key_Messages_Water_and_Climate_Change_Adaptation_COP-15.pdf

Executive Summary

Key Messages

This report demonstrates why water is critical for climate change adaptation and mitigation, and seeks to raise the profile of water in the context of the United Nations Framework Convention on Climate Change. It is divided into six chapters which address the interrelation of water and climate change in the context of: Livelihoods, Land, Ecosystems, Transboundary Management, Energy and Gender.

This report makes the case the **global climate challenge is a global water challenge.**

Any adaptation and mitigation measures committed to, supported or monitored under the UNFCCC should mainstream water considerations and take into account the following points:

Understanding and managing the impacts of climate change on the water cycle is critical for achieving the Millennium Development Goals

Water is the primary medium through which climate change impacts will be felt by populations and the environment. Failure to integrate water management and climate change adaptation will compromise efforts to build resilience and have potentially devastating impacts on people's livelihoods as well as on the achievement of the right to water. Resilience must be built in the water supply and sanitation sector, and effective integrated water resources management must be implemented as an adaptation action prioritised through National Adaptation Programmes of Action (NAPAs).

Integrated Water Resources Management is a fundamental adaptation action

IWRM is critical for managing the many and increasing demands for water globally. As climate change stands to exacerbate existing pressures on water resources, IWRM offers a holistic management arrangement that considers multiple users and sectors, prioritising essential social and environmental needs alongside agricultural and industrial needs. Capacity building for the implementation of IWRM must be enhanced.

Regional and trans-boundary cooperation and co-ordination is required for successful adaptation

Climate change impacts through the water cycle will not respect national and political boundaries. Trans-boundary arrangements for sharing water are not prepared for the additional pressures from climate change which will put considerable strain on regional and global security. Any adaptation plans must recognise the trans-boundary and regional dimensions of climate change adaptation in order to cope with the additional strains that changes in water availability will put on relations between states.

Ecosystem–Based Adaptation builds resilience to climate change

Healthy ecosystems provide natural resilience and 'buffers' against climate change impacts. Freshwater ecosystems have already been hugely degraded by over-abstraction and pollution caused by non-climate pressures. Climate change will only exacerbate degradation, so to build resilience it will be necessary to restore and protect freshwater ecosystems through reducing non-climate pressures and maintaining minimum environmental flows.

Executive Summary

Measures taken in the energy sector to mitigate climate change must take into account water use and availability

The invariable increase in the use of hydropower and biofuels must take into account impacts on water availability. Measures must be taken to reduce ecological impacts of dams and maintain environmental flows, and the additional demand for water presented by biofuels must be managed within a framework that prioritises basic social and environmental needs.

Climate change adaptation through water management must consider the roles of particular groups and users

Women are the primary managers of water in many developing countries, for both domestic and agricultural purposes, and stand to suffer considerably as a result of climate change impacts. Measures to adapt to these impacts through the hydrological cycle must take into account the needs and roles of women, building their resilience through providing them with more resilient water supplies and greater access to decision-making.

Responding to climate change impacts through water management requires additional resources, capacity building and sectoral knowledge-sharing

All the responses outlined in this paper will require institutional arrangements that support their implementation. This includes the availability of finance for adaptive water management and the development of functioning IWRM plans, as well as the provision of capacity building – especially in the most vulnerable developing countries. Resources for knowledge-sharing with a specific focus on adaptation and water management should also be enhanced, including through any successor to the Nairobi Work Programme.

Executive Summary

Key Messages by Chapter

Livelihoods

Build resilient water and sanitation supply systems

Climate change impacts through the water cycle, including water scarcity, floods and droughts, all stand to have impacts on water supply and sanitation infrastructure. If progress is to be sustained towards achieving MDG7 – to halve the number of people without access to water and sanitation by 2015 – and to achieving the right to water building climate resilience in water supply and sanitation must be a major priority of any adaptation plan.

Implement Integrated Water Resources Management to protect vulnerable water users

As demands for water intensify across a range of sectors – agricultural, industrial, domestic – water availability in many parts of the world is decreasing. The exacerbating effect of climate change on this situation may compromise the ability of the poor and vulnerable to access water, and also degrade ecosystems upon which livelihoods rely. Instituting effective IWRM processes will help to manage water resources to protect basic social and environmental needs.

Ensure a strong focus on water management in National Adaptation Programmes of Action (NAPAs)

NAPAs are the main vehicle for defining adaptation needs and responses in Least Developed Countries (LDCs). Integration of NAPAs with water management arrangements, in many cases, remains solely on paper rather than translating into practice, due in part to the limited development and implementation of IWRM plans. NAPAs need to strongly prioritise water management considerations, and identify the implementation of IWRM as an adaptation action.

Land

Support joint land and water management

In many cases governing institutions dealing with land and food are separate entities. It is critical that land and water are co-managed by relevant institutions to ensure a more holistic and multi-dimensional approach to land and water resource management that can take into account climate change impacts.

Invest and develop more water-efficient agricultural practices

Current agricultural practices and strategies mean that a large fraction of rainfall is lost resulting in unproductive evaporation in many parts of the world. In light of climate change, support must be provided for farmers and agricultural producers to improve harvesting technologies and to better capture and use the rainfall to lessen stresses on rivers and groundwater.

Support and evaluate IWRM principles

IWRM is a critical governance framework for managing the many competing uses of water, and helps build flexibility to the uncertainties produced by climate change. Progress towards the development and implementation of IWRM must be accelerated, and countries should be encouraged to monitor and report progress on a regular basis.

Generate and share information

In order for institutions, sectors and communities who depend on the land for their livelihoods to prepare for climate change it is critical that they have access to relevant technologies and current information to enable them to put in place local and national adaptation strategies to protect the land from further degradation.

Transboundary

Invest in institutions

Invest and strengthen the institutions responsible for providing and managing water resources for people, industries, energy and eco-systems. From transparent regulatory frameworks to multi-stakeholder dialogues, stronger institutions can cope with present climate variability and cope with future adaptation. The UNFCCC adaptation framework must recognise the additional financial resources that will need to be committed to support such investments.

Share information and generate data

Assessment is essential for making informed decisions on a shared water resource and it is critical that all parties and bodies have access to the same data as the affects of climate change make themselves felt. A common-basis for decision-making requires harmonised, compatible assessment methods and data management systems as well as uniform reporting procedures. The UNFCCC adaptation framework should support strategies for sharing and generating data that will impact trans-boundary relations as a result of climate change.

Promote Integrated Water Resources Management as a framework for transboundary governance

Trans-boundary agreements should be founded on Integrated Water Resource Management (IWRM) principles to ensure a holistic management of surface and groundwater, which takes into consideration the whole river basin as well as ensuring a multi-sector approach. IWRM should be recognised as one of the core principles for adapting to climate change in the UNFCCC adaptation framework.

Support existing legal tools

Existing and pending legal tools supporting cooperation between states over water resources must be supported and strengthened. In particular, the UN Watercourses Convention represents many of the core principles for ensuring cooperation, including equitable and reasonable utilisation and the no-harm rule.

Ecosystems

Implement Ecosystem-based Adaptation

Managing climate change impacts on ecosystems through water will require strong commitment to and implementation of Ecosystem-based Adaptation (EbA). Ecosystem-based Adaptation, as defined by the Convention on Biological Diversity (CBD) is 'the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change." Achieving EbA requires enhancing ecosystem protection, preservation and rehabilitation to protect watersheds and regulate water flow and water quality.

Reduce Non-Climate Pressures on Freshwater Ecosystems

Freshwater ecosystems are under increasing pressures from a range of non-climate influences – including increasing agricultural production, industrial activity, population growth and urbanisation. Excessive demands for water, combined with polluted 'run-off' from industrial and agricultural activities, are decreasing water availability and quality in many parts of the world. Reducing these pressures by instituting improved water management practices, including demand and supply management measures, will help build ecosystem resilience to climate change.

Maintain Environmental Flows

Environmental flows refer to water provided within a river, wetland or coastal zone to maintain ecosystems and the benefits they provide to people. The health and resilience of ecosystems depends upon maintaining these flows to support ecosystem function. Due to the multiple demands on water resources, a critical adaptation response is to use water rights and allocation arrangements to guarantee that a minimum amount of water is utilized to satisfy environmental flow requirements and cannot be diverted for other uses.

Develop and Implement Integrated Water Resources Management (IWRM)

IWRM provides an overarching management and governance arrangement to balance the allocation of water across users and uses. It ensures that ecosystems, as the 'silent users', are considered in decision-making. Whilst the benefit of IWRM has long been recognised in policy-making, implementation is slow in many developing countries, and its full benefits as an adaptation response to climate change must be promoted.

Energy

Mainstream energy efficiency and demand management into sectoral practices

Mitigating climate change will require ambitious global greenhouse gas emission reductions, and increasing energy efficiency in the water sector will be a critical factor in achieving those targets. In turn, managing water demand will be a key component of enhancing energy efficiency in the sector. Where water infrastructure is being planned and built, energy efficiency considerations should be mainstreamed.

Implement Integrated Water Resources Management (IWRM) to promote integration of the water and energy sectors

As the energy sector is a large water user, and as the water sector is a significant energy user, water management

practices are required at national, regional and local levels that consider the needs of multiple sectors and enhance communication arrangements between them. IWRM provides this ability by ensuring that the multiple uses and users of water are considered simultaneously and takes account of competing sectors to manage the water resource sustainably. Enhancing capacity and training for the implementation of IWRM, especially in developing countries, should be a major priority.

Limit ecosystem impacts of energy mitigation measures

Meeting GHG emission reduction targets in developed countries and lowering Business As Usual emission projections in developing countries will require the use of hydropower. Large dams can have devastating impacts on ecosystems and reduce long-term climate resilience if they do not allow for essential environmental flows. The production of biofuels can have similarly unintended consequences on ecosystems and demands significant quantities of water. Tools for identifying ecosystem impacts of alternative energy sources are essential for assessing their suitability.

Base energy mitigation measures on a consideration of future hydrological patterns under climate change

Conventional energy production, as well as alternatives such as hydropower and biofuels, all rely on water availability. Infrastructure and plans to service energy needs that are based on existing hydrological patterns are likely to be highly vulnerable to climate change impacts. Assessments of future water availability based on climate change data will be critical for choosing sustainable energy options that can respond to uncertainty – improved data collection and research will be necessary to achieve this.

Gender

Access to information and decision-making

Small-scale agricultural production plays a critical role in women's livelihoods all over the world. However, for the most part, women are not provided with the necessary access to information on possible climate change affects, or to relevant decision-making forums on water and land resource management. Women must be provided with the relevant information, data and resources on climatic changes in order to put in place local adaptation strategies.

Sustainable agricultural practices

Women make up a large percentage of the world's agricultural labour force and as such must be provided with access to knowledge and resources in order to undertake sustainable agricultural practices such as awareness about crop diversification and adaptive agricultural techniques in order to mitigate and adapt to changes in water resources as a result of climate change.

Understanding the gender-dimension

Climate change adaptation plans and strategies will be developed and implemented at multiple levels: gender-dimensions must be included in all local, regional and international adaptation strategies.

Livelihoods

Water and Livelihoods

Key Messages for the United Nations Framework Convention on Climate Change

Climate change impacts through the water cycle will have potentially devastating impacts on people's livelihoods, especially in developing countries, and pose a serious challenge for the achievement of the Millennium Development Goals. To protect livelihoods that are at risk from climate impacts through the water cycle, it is critical that adaptive water management arrangements are at the heart of adaptation planning. Any adaptation measures committed to, supported and monitored under the UNFCCC must take into account the following considerations:

Build resilient water and sanitation supply systems

Climate change impacts through the water cycle, including water scarcity, floods and droughts, all stand to have impacts on water supply and sanitation infrastructure. If progress is to be sustained towards achieving MDG7 – to halve the number of people without access to water and sanitation by 2015 – and to achieving the right to water building climate resilience in water supply and sanitation must be a major priority of any adaptation plan.

Implement Integrated Water Resources Management to protect vulnerable water users

As demands for water intensify across a range of sectors – agricultural, industrial, domestic – water availability in many parts of the world is decreasing. The exacerbating effect of climate change on this situation may compromise the ability of the poor and vulnerable to access water, and also degrade ecosystems upon which livelihoods rely. Instituting effective IWRM processes will help to manage water resources to protect basic social and environmental needs.

Ensure a strong focus on water management in National Adaptation Programmes of Action (NAPAs)

NAPAs are the main vehicle for defining adaptation needs and responses in Least Developed Countries (LDCs). Integration of NAPAs with water management arrangements, in many cases, remains solely on paper rather than translating into practice, due in part to the limited development and implementation of IWRM plans. NAPAs need to strongly prioritise water management considerations, and identify the implementation of IWRM as an adaptation action.

Climate change, water and the development challenge

The impacts of climate change will present a major challenge for human development, and many of these impacts will be felt through the water cycle. The Intergovernmental Panel on Climate Change states that 'water and its availability and quality, will be the main pressures on, and issues for, societies and the environment under climate change'.

The main challenges for human development and livelihoods relating to water are: having too much, too little, or having polluted sources. Such water security issues stand to arise even without climate change due to a combination of other drivers including population growth, urbanisation, rising living standards and demands for more water-intensive agricultural products e.g. meat, as well as increasing industrial activity. Climate change poses a significant threat as it stands to exacerbate all of these problems in different parts of the world. Rising global temperatures will cause changes in atmospheric moisture due to an increase in evaporation of water from land and sea. This in turn will influence weather patterns, including the amount, location, time and type of precipitation[1], thus having an impact on the availability of water resources for personal and productive uses, especially rain-fed agriculture. Increasing glacial and snow melt will further impact traditional patterns of water availability, and rising sea levels will increase water salinity and reduce productivity.

Climate change impacts through the hydrological cycle will be most severe in many of the least developed and most vulnerable regions of the world, not only because some of the most extreme weather impacts are predicted in those areas which are often hotter and more arid, but also because they lack the institutional governance and economic arrangements to build long-term resilience to climate change.

As 700 million people already face water scarcity, and 900 million lack access to safe drinking water[2], climate change stands to exacerbate an already fragile situation potentially depriving people of access to a reliable source of water for both personal and productive uses, threatening livelihoods and undermining progress towards poverty alleviation. The threat posed by climate change to the achievement of the 7th Millennium Development Goal (MDG7) – to halve the number of people without access to water and sanitation by 2015 – is not only a cause for concern in its own right, but also deserves attention because of the knock-on effects that a failure to meet this target will have on the achievement of all the other MDGs.

Building resilient water and sanitation supply systems and infrastructure

Progress towards the MDG7 is uneven. The drinking water target is currently on track, though this is based on access to a community-level service rather than direct access to the home, and progress in Africa is slower than in other regions. The sanitation target is unfortunately significantly off-track and should be a major cause for international concern due to the socio-economic impacts of inadequate sanitation supplies. In the context of climate change, a recent study conducted by the UK Department for International Development (DFID) and the World Health Organisation (WHO) – *Vision 2030* – suggests that the projected figures for global access to water and sanitation will be significantly reduced if climate change is taken into account, due to increased loss of functioning infrastructure caused by climate impacts, and existing progress towards access may even be reversed unless action is taken.

The impacts of climate change on water and sanitation supply systems will be both direct and indirect. Direct impacts include damage to infrastructure caused by flooding and extreme weather events, as well as contamination and pollution. Indirect impacts are an overall decrease in water availability, which will reduce the functionality of sewerage systems relying on water, whilst also undermining the absorptive capacity of water resources to dilute pollution from sewage.[3]

Until this point there has been limited analysis of the resilience of water and sanitation supply systems to climate change impacts, though the analysis that does exist points to some interesting findings that are helpful in the process of building a clearer picture of vulnerability. Findings by the WHO-UNICEF Joint Monitoring Programme on Water Supply and Sanitation indicates that the water supply technologies most resilient to climate change are utility-piped water systems and tube wells. Piped systems are more vulnerable to contamination through flooding, whereas tube wells prove to be the most resilient overall, though the possibility and options for dense coverage require further consideration. Assessments have shown that the least resilient of all water technologies are dug wells and rainwater harvesting.

In terms of water management arrangements, community-based approaches to water management offer limited potential for resilience and adaptation due to inadequate operation and maintenance of infrastructure. This raises the importance of achieving 'at-house' water supply which also has significant health benefits. Where community-based arrangements persist, capacity for maintenance and effective management must be enhanced. In terms of the resilience of sanitation supply, the conventionally accepted 'gold standard' of sewerage systems for sanitation offer less climate change resilience than pit latrines which are designed for more flexibility. Findings such as these will be important for sanitation supply decisions in the future.[4]

It is clear that whilst there is significant potential to enhance the resilience of water and sanitation supply systems to

1 Global Humanitarian Forum 2009 pp 43-45
2 Tearfund: Separate Streams – Adapting Water Resources Management to Climate Change p 4
3 World Health Organisation (WHO) and UK Department for International Development: Vision 2030 – The Resilience of Water Supply and Sanitation in the Face of Climate Change p 19
4 Vision 2030 p 21

climate change, this is not being translated into actual resilience due to gaps in understanding about the most appropriate technologies and interventions, as well as a lack of certainty as to climate change impacts on water resources and systems, and the consequences of such impacts. For example, where water supply is effectively managed by utilities in urban areas, there is inherent systemic resilience provided by human and financial capital – the knowledge and competence to run the system well, combined with the financial means to make adaptive changes where necessary such as upgrading infrastructure and supply technologies to better cope with climate impacts. However, the ability to use such resources to build actual resilience is limited by a lack of understanding of which technologies would work best, and the absence of established assessment methodologies which would help to identify the appropriate technologies.[5]

Whilst some of the initial findings outlined above will prove useful for water and sanitation supply managers, there is a need for significantly enhanced research into appropriate technologies, and the development of tools which will help identify those technologies. This includes tools to assess the suitability of technologies in relation to varying availabilities of surface and ground water in different locations, as well as research into new technologies where obvious alternatives do not exist e.g. in the case of urban sewerage systems. Scenario-based vulnerability assessment and planning tools, based on credible outcomes from predicted climate change, will play an important role in helping to inform the design of resilient water supply and sanitation systems.[6]

Improving water management arrangements

Building resilience of water and sanitation supply systems will need to occur in the context of wider water resources management arrangements that effectively manage water resources among the ever-intensifying demands of competing users. The impacts of climate change on water and sanitation service and delivery will be both direct - in terms of infrastructure damage and reduced functionality – and indirect – in terms of broader environmental impacts that reduce water availability and ecosystem resilience. In the case of the latter, climate change represents an exacerbating pressure on water resources that will already be under increasing stress, and building resilience requires broader governance arrangements within which adapted physical infrastructure operates.

Integrated Water Resources Management offers a crucial management framework through which the multi-faceted challenges of climate change and other demands for water resources can be addressed, and agreements on water allocation can be reached. As climate change exacerbates pressures on water resources caused by increasing competition over a scarce resource, it is critical to develop IWRM arrangements that integrate an analysis of climate change impacts to manage and prioritise needs, protecting the livelihoods and wellbeing of the poor and vulnerable. As the recently published UNECE Guidance on Water and Adaptation to Climate Change emphasises:

'The core principles of integrated water resources management (IWRM) include planning at the river basin level, strong intersectoral cooperation, public participation and making the best use of water resources. The same principles also underpin any effective adaptation strategy. So incorporating climate change effects into IWRM and encouraging its wide adoption will also advance adaptation.'[7]

There is widespread recognition by the international community that IWRM is fundamental for ensuring sustainable water supply for personal and productive uses. For example, in 2002 at the Johannesburg World Summit on Sustainable Development some countries committed to developing integrated water resources management and efficiency plans by 2005. However, progress remains slow, and many countries either do not have IWRM plans, or plans remain unimplemented or poorly implemented where they do exist. Studies by UN Water undertaken for the Commission on Sustainable Development (CSD) in 2008 showed that only 4 LDCs had IWRM plans in place, and that 14 were still in preparation.[8] Recent studies show that Least Developed Countries Eritrea, Rwanda, Samoa, Sudan and Zambia have only taken initial steps towards the development of IWRM plans.[9] This makes a holistic approach to water management and climate change adaptation in these countries difficult, as without an IWRM plan the basis for integration does not exist. Specifically, the institutional arrangements required for inter-sectoral

[5] Vision 2030 p 20
[6] Vision 2030 p 42
[7] UN Economic Commission for Europe (UNECE): Guidance on Water and Adaptation to Climate Change p 16
[8] World Water Assessment Programme Dialogue Paper, UNDP: Water Adaptation in National Adaptation Programmes for Action: Freshwater in Climate Adaptation Planning and Climate Adaptation in Freshwater Planning p 5
[9] Op cit. p 11-12

collaboration are absent in many developing countries[10] and **the development of such arrangements** remains an important step in ensuring synergy between sectors in policy planning and implementation for water management in the context of climate change impacts. Furthermore, where IWRM plans exist or are functioning, there continues to be a lack of integration of adaptation requirements into such plans, as they continue to operate in response to traditional climate variability rather than long-term climate change. Progress in these areas will require great leaps forward in the strengthening of water governance institutions in many countries, provided with the capacity and tasked with the authority of implementing equitable IWRM plans that promote collaborative work across sectors, ministries and river basin organisations.

A critical water management response to multiple pressures including climate change is the development of legal and regulatory frameworks and allocation systems that support flexible and adaptive change. Whilst understanding the projected impacts of climate change in any given region is important, and enhancing the data to achieve this must remain a priority, climate predictions by their nature will always involve margins of error. This means that impacts through the water cycle will be hard to predict, and so developing water management systems that can flexibly respond to uncertainty and altered water availability will be a fundamental component of any adaptive water management plans. Water rights and allocation arrangements govern who is allowed to take water from a system, when and in what quantities[11]. Currently most water allocation arrangements bestow water rights upon a particular subset of users rather than following frameworks or mechanisms for prioritising water users. At times of reduced availability or in response to increasing scarcity, systems that give preference to and protect higher priority users are critical for averting the most serious social and environmental impacts of climate change as expressed through the hydrological cycle. Prioritising human usage, and securing minimum 'environmental flows' to maintain healthy ecosystems, helps to build social and environmental resilience, and any 'surplus' can then be allocated to priority economic uses. Few water allocation systems function in this way at the moment, and developing flexible arrangements in this regard will be a critical and pro-poor adaptation response. This also applies to the transboundary context – existing treaties between states often allocate fixed water allowances based on assumptions of water availability drawn from data that does not take into account climate change impacts. Without flexibility in the water allocation arrangements in response to climate change, this may result in over-withdrawals which will have knock-on social and environmental impacts, and could potentially lead to conflict. The challenge of transboundary water management in face of climate change is addressed in more detail in the chapter on 'Water and Transboundary Resource Management'.

In the context of enhancing water resources management, a strong focus on agricultural productivity and efficiency will be critical. Agriculture uses up to 70% of water resources, and demands for water for agricultural production only stand to increase due to a number of drivers, including population growth and urbanisation. Climate change impacts include altered rainfall and increased temperatures which will reduce potential yields and overall food production in the tropics and sub-tropics. IPCC scenarios predict that potential yields in rain-fed systems in Africa may reduce by up to 50% by 2020.[12] As up to 75% of agriculture in large parts of Africa is rain-fed[13], and small-scale farmers rely on good yields for their livelihoods, innovative responses will be required as part of broader water management arrangements across sectors that enhance productivity and efficiency. This includes crop diversification, drainage systems that direct water back into ponds and dams, wider use of permaculture techniques and drip irrigation technologies.

Whilst the challenges to developing functioning IWRM arrangements are significant, climate change presents an opportunity to address water resources management as an integral and overarching approach to national and regional water policies. As climate change stands to exacerbate other pressures, and demands a long-term strategy of being able to respond to changing water availability, it will no longer suffice to take a narrow-minded approach to water supply and sanitation that focuses primarily on delivery rather than integrated management. As the Vision 2030 report makes clear:

'A focus on adaptation to climate change puts greater emphasis on the need to address water source sustainability from the outset of new programmes and not simply as an afterthought.' [14]

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10 Tearfund: Separate Streams, p 5
11 WWF: Adapting Water Management: A primer for coping with climate change p 30
12 Stockholm International Water Institute: Saving Water From Field to Fork - Curbing losses and wastage in the food chain p 13
13 Comprehensive Assessment of Water Management in Agriculture (2007)
14 Vision 2030 p 7

Ensuring a strong focus on water management in National Adaptation Programmes of Action (NAPAs)

National Adaptation Programmes of Action (NAPAs) were agreed in 2001 under the United Nations Framework Convention on Climate Change, with the objective of building capacity in Least Developed Countries (LDCs) to adapt to climate change. The NAPAs communicate the 'urgent and immediate adaptation needs' of LDCs, and an LDC Expert Group (LEG) under the UNFCCC provides guidance on how to develop a NAPA.

It has been demonstrated and is widely accepted that integrated water resources management (IWRM) that takes into account climate change impacts is a fundamental component of adaptation. Planning for adaptation should include water resources planning and conversely water resources planning should take into account the impacts of climate change on the water resources sector. As this appears to be a generally obvious point, there is simultaneously an overriding assumption that this is implicit in adaptation, and that countries will take it into account by default. However, an assessment by UNDP of the 38 LDCs that have produced NAPAs has shown that very few LDCs have developed or adopted formal plans for the water resource sector, let alone any IWRM plans which would be an essential vehicle for climate change adaptation[15]. There is also a clear disconnect in many cases between existing water reform work, and water-related adaptation that is set out in the NAPAs.

Though the majority of NAPAs recognise that water access and management are crucial, the technical, analytical and institutional capacity to integrate climate risks into national development planning and water management strategies is missing. This is often because such plans and governance arrangements do not exist meaning that references to integration or links to water management often merely represent a recognition of the significance of water resources management for adaptation, rather than a comprehensive plan on how to make this happen.[16] Furthermore, the limitations inherent in inadequate water governance arrangements mean that many NAPAs place more focus on the impact of climate change on drinking water supply, rather than identifying the need for broader integration from a river-basin perspective.[17]

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15 World Water Assessment Programme Dialogue Paper, UNDP: Water Adaptation in National Adaptation Programmes for Action: Freshwater in Climate Adaptation Planning and Climate Adaptation in Freshwater Planning p 4

16 Op cit p 6

17 Op Cit p 14

Water and Land

Key Messages for the United Nations Framework Convention on Climate Change

40% of the world's agricultural land is already seriously degraded. Failure to recognise the interrelatedness of land resources, water resources and climate change risks undermining all adaptation efforts. Adaptation to climate change will necessitate holistic land and water management practices in line with the principles outlined in the Nairobi Statement. The following measures should be integral to any adaptation efforts that are committed to, supported and monitored under the UNFCCC:

Support joint land and water management

In many cases governing institutions dealing with land and food are separate entities. It is critical that land and water are co-managed by relevant institutions to ensure a more holistic and multi-dimensional approach to land and water resource management that can take into account climate change impacts.

Invest and develop more water-efficient agricultural practices

Current agricultural practices and strategies mean that a large fraction of rainfall is lost resulting in unproductive evaporation in many parts of the world. In light of climate change, support must be provided for farmers and agricultural producers to improve harvesting technologies and to better capture and use the rainfall to lessen stresses on rivers and groundwater.

Support and evaluate IWRM principles

IWRM is a critical governance framework for managing the many competing uses of water, and helps build flexibility to the uncertainties produced by climate change. Progress towards the development and implementation of IWRM must be accelerated, and countries should be encouraged to monitor and report progress on a regular basis.

Generate and share information

In order for institutions, sectors and communities who depend on the land for their livelihoods to prepare for climate change it is critical that they have access to relevant technologies and current information to enable them to put in place local and national adaptation strategies to protect the land from further degradation.

Land, water and climate change

"Man - despite his artistic pretensions, his sophistication, and his many accomplishments - owes his existence to a six inch layer of topsoil and the fact that it rains."

This quotation, cited by one of the participants at Water Day held at the UNFCCC negotiations in Barcelona in November 2009, reminds us not only that humans depend on natural resources for their survival and development, but that water and land resources are inextricably linked; land devoid of water cannot retain nutrients, cannot effectively support ecosystems, cannot maintain biodiversity, and as such cannot support humans. Climate change presents a new challenge that will further exacerbate and multiply the effects of human activities; and most climate-induced land degradation will occur as a result of changes in the hydrological cycle due to a recurrence of droughts, floods and other extreme climatic events, changes in precipitation and water resource availability and, changes in the lengths of days and seasons.

The efficient use of our land resources and water resources provide the backbone of poverty reduction, food security and development. In order to prepare ourselves for the

coming decades it is imperative that all adaptation policy frameworks, strategies and legal tools recognise the interrelatedness of land and water resources in adapting to climate change. The UNFCCC provides a critical opportunity to generate a framework addressing climate change adaptation in the context of land and water resource management. The following section explores the interrelatedness of water and land in the context of climate change and goes on to set out the key priorities in the context of climate change adaptation.

Pressures, demands, and losses

From highlands to lowlands, from forestlands to wetlands, from agricultural pastures to conserved parklands, our global land resources are already under severe strain as a result of human activities. Population growth, industrialisation, urbanisation, agricultural practices and our insatiable consumption patterns are all putting strains on land availability and land quality the world-over. Climate change presents a new set of challenges that will multiply and exacerbate those pressures, many of which will be felt through changes in the hydrological cycle.

Recent projections suggest that global population will increase by 34% by 2050, an additional 2.3 billion people compared to today's figures[18]. In simple terms, more people means that more food will need to be produced. Agriculture is by far the main user of water across all sectors; irrigated agriculture accounts for 70% of water withdrawals world wide. Food supply directly translates into consumptive water use, that is, how much water is transpired and evaporated from the field during the production of a specific amount of food. Yearly some 7000 km^3 of water are evaporated and transpired in con-nection with the production of crops to meet global food demand, and current population projections mean that those figures will increase dramatically over the coming decades[19].

Furthermore, consumer tastes are changing towards more nutritious and more diversified diets, which tend to boost the consumptive use of water. In the last twenty years we have witnessed a shift in dietary patterns among cereal crops and away from cereals toward animal products. For example, in South East Asia, rice supply peaked at 120kg/capita/year during the 1980's, while wheat demand per capita tripled between 1961 and 2002 and is still increasing[20]. Higher value crops, such as sugar and vegetables, typically require more water per calorie than staple cereal crops, and meat and dairy production is also more water-intensive than crop production. For example, 500–4000 litres of water are evaporated in producing one kilogram of wheat, whilst to produce one kilogram of meat takes 5000–20,000 litres, mainly to grow animal feed.[21]

Moreover, to meet growing food demand agricultural practices have begun to rely on fertilisers and pesticides to increase their yields, which is putting an additional pressure on already degraded land and water resources. Current projections suggest that in the next 35 years we can expect to see a further 3-fold increase in nitrogen and phosphorous fertilisation rates used in agricultural practices, a doubling of irrigated land area, and an 18% increase in cropland. Such changes would have dramatic impacts on the diversity, composition, and functioning our land resources The largest impacts are expected to be felt by freshwater and marine ecosystems which would suffer from such high rates of nitrogen and phosphorus release from agricultural fields.

Pressure on the world's land and water resources have also been exacerbated by efforts to mitigate climate change. The global biofuels market is currently small, they provide only 1.8% of transport fuels but it is also one that is growing quickly. World ethanol production for transport fuels tripled between 2000 and 2007 from 17 billion litres to more than 52 billion litres[22]. Biofuel production rates again have a direct impact on water resources. Current biofuel production accounts for approximately 1% of all water withdrawn for irrigation[23]. According to projections, by 2017 the amount of water to be withdrawn for biofuel production would increase by 74% if agricultural practices remain the same[24].

In line with the increasing demand for food and biofuels there is now increasing pressure for agricultural land expansion. Stratified random sampling of 10% of the world's tropical forests reveals that direct conversion by large-scale agriculture may be the main source of deforestation, accounting for around 32% of total forest cover change, followed by conversion to small-scale agriculture, which accounts for 26%[25]. As well as having a detrimental impact

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18 World Resource Institute http://earthtrends.wri.org/searchable_db/index.php?step=countries&ccID[]=0&theme=4&variable_ID=363&action=select_years

19 Saving Water: From Field to Fork. Paper 13. (SIWI, 2008) http://www.siwi.org/documents/Resources/Papers/Paper_13_Field_to_Fork.pdf

20 ibid.

21 ibid.

22 Towards sustainable production and use of resources: Assessing Biofuels, (UNEP, 2009) http://www.unep.fr/scp/rpanel/pdf/Assessing_Biofuels_Full_Report.pdf

23 http://www.fao.org/nr/water/docs/wwf5/water_for_food/Hoogeveen-et-al_Biofuel.pdf

24 ibid.

25 United Nations, Food and Agricultural Organization (FAO, 2001). Forest Resources Assessment 2000: Main Report. FAO Forestry Paper 140. Rome, 2001.

on biodiversity levels, the conversion of land resources to agricultural lands has significant implications for mitigating climate change. It is estimated that deforestation contributed globally to approximately 20 per cent of annual greenhouse gas emissions in the 1990s[26]. As such, forestland that is converted to agricultural lands undermines attempts to mitigate climate change.

The United Nations Convention to Combat Drought and Desertification (UNCCD) estimates that up to 40% of the world's agricultural land is already degraded to the point that yields are greatly reduced, and a further 9% is degraded to the point that it cannot be reclaimed for productive use by farm measures. Desertification and land degradation are already threatening a significant portion of Africa's currently fertile land and food production in the face of water scarcity. The most vulnerable areas are along desert margins, home to some 22 million people and mountain ecosystems. Degraded land is far more sensitive to climate change and large areas of croplands, in particular in semi-arid zones, will need to adapt to new conditions with lower precipitation. Thus it is critical that adaptation strategies include policy frameworks to improve water resources management to reduce poverty and enhance food security, improve the effectiveness of legislation and facilitate transparent allocation of water.

Dealing with climate change through land and water management

As has been demonstrated, the nexus between water, land and climate change is complex and multifaceted. Rising temperatures, shifting rainfall patterns and extreme weather events will have both direct and indirect impacts on land and water resources; and increased rates of land degradation will further undermine efforts to mitigate climate change. Indeed, if we fail to recognise the role of land and water resources in adapting to climate change we will undermine progress towards achieving many of the Millennium Development Goals (MDGs) and sustainable development commitments.

In light of climate change projections, a number of new policy frameworks have underscored the critical role of land and water resources in the context of climate change. In 2008 the Danish Ministry of Foreign Affairs collaborated with international and national partners to conduct a Dialogue on land and water resources, which resulted in the Nairobi Statement. The Nairobi statement recognises five key principles that will need to guide all international frameworks on land and water policy frameworks;

1) Sustainable development; adaptation must be addressed in a broader development context, recognising climate change as an added challenge to reducing poverty, hunger, diseases and environmental degradation.
2) Resilience; building resilience to ongoing and future climate change calls for adaptation to start now by addressing existing problems in land and water management.
3) Governance; strengthening institutions for land and water management is crucial for effective adaptation and should build on the principles of participation of civil society, gender equality, subsidarity and decentralisation.
4) Information; information and knowledge for local adaptation must be improved, and must be considered a public good to be shared at all levels.
5) Economics and Financing; the cost of inaction, and the economic and social benefits of adaptation actions, calls for increased and innovative investment and financing.

The Nairobi principles provide a core understanding of the linkages between land and water resources that must help to guide a response to climate change adaptation. Whilst the precise and local affects of climate change cannot be predicted, it is now clear that we are already seeing evidence of those changes and it is it is critical that we ensure that the necessary actions are taken in order to prepare communities, sectors and regions for a much more unpredictable future. The underlying adaptive capacity of both the ecosystem and communities will determine the extent and direction of climate change impacts. The UNFCCC provides a vital opportunity to integrate the international response to land and water adaptation strategies and should consider the following priorities.

First, an integrated approach to land and water management is critical at the local, regional and international level. Erratic and rapid rainfall, droughts and flooding will undermine livelihoods that depend on agricultural production and urban populations will experience reduced supply of food at higher prices. Responding to those changes will require a cross-sectoral understanding of land and water resources in order to respond to the changing environmental, economic and social impacts. As noted by the Nairobi statement, building on existing and accepted approaches to integrated land

[26] Fact sheet: Reducing emissions from deforestation in developing countries: approaches to stimulate action (UNFCCC, 2009) http://unfccc.int/files/press/backgrounders/application/pdf/fact_sheet_reducing_emissions_from_deforestation.pdf

and water management is an effective way of addressing socio-economic and environmental development objectives in the context of current climate variability, while improving the overall resilience to the more uncertain future. For example, Integrated Water Resource Management (IWRM) principles should be incorporated into all national adaptation strategies in order to protect land and ecosystems from further degradation. Governing bodies should also be supported to implement and evaluate the extent to which IWRM principles have been integrated into their national adaptation strategies and to benefit from the instances of good practice and lessons learned from countries who have already put such strategies in place.

Second, and relatedly, strategies to promote sustainable agricultural practices and sustainable uses of water must be supported to ensure that biodiversity and land quality are protected from further degradation and agricultural conversion in the light of pressures such as urbanisation, population growth and rapid industrialisation. In Africa, of all the renewable water available each year, only 4% is used given the shortage of infrastructure such as wells, canals, pumps, reservoirs and other irrigation systems that are needed to make use of the potential water supply[27]. Efforts to ensure sustainable agricultural practices such as promoting crop variability and rainwater harvesting will also help to protect lands against further land and water resource mismanagement. This will be particularly important in those areas of the world already experiencing water scarcity, or climate change 'hotspots' such as the world's drylands which cover 41% of the earth's surface and are home to about 38% of the world's population

Third, effective adaptation planning and implementation in land and water management systems will require improved information and more knowledge-sharing of good practice. Adaptation should be knowledge-based including and integrating both scientific and local knowledge. Observational networks and linkages between meteorological services and end-users should be improved.

Finally, the issue of water wastage and misallocation of water in the production of food remains a critical problem. Current agricultural practices and strategies mean that a large percentage of rainfall is lost in terms of unproductive evaporation in many parts of the world. In light of climate change, support must be provided for farmers and agricultural producers to improve harvesting technologies and to better capture and use the rainfall to lessen stresses on rivers and groundwater. This will require additional investment, resources and research.

[27] Securing water resources in water scarce ecosystems in the face of desertification, land degradation and drought (DLDD) imperatives. (UNCCD, 2009) http://www.unccd.int/publicinfo/pagi/docs/EnhancingwaterresourcesprotectionDraftpolicydocument.pd

Ecosystems

Water and Ecosystems

Key Messages on Water and Ecosystems for the UNFCCC

The following measures must be integral to any adaptation efforts that are committed to, supported by and monitored under the UNFCCC:

Implement Ecosystem-based Adaptation

Managing climate change impacts on ecosystems through water will require strong commitment to and implementation of Ecosystem-based Adaptation (EbA). Ecosystem-based Adaptation, as defined by the Convention on Biological Diversity (CBD) is 'the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change." Achieving EbA requires enhancing ecosystem protection, preservation and rehabilitation to protect watersheds and regulate water flow and water quality.

Reduce Non-Climate Pressures on Freshwater Ecosystems

Freshwater ecosystems are under increasing pressures from a range of non-climate influences – including increasing agricultural production, industrial activity, population growth and urbanisation. Excessive demands for water, combined with polluted 'run-off' from industrial and agricultural activities, are decreasing water availability and quality in many parts of the world. Reducing these pressures by instituting improved water management practices, including demand and supply management measures, will help build ecosystem resilience to climate change.

Maintain Environmental Flows

Environmental flows refer to water provided within a river, wetland or coastal zone to maintain ecosystems and the benefits they provide to people. The health and resilience of ecosystems depends upon maintaining these flows to support ecosystem function. Due to the multiple demands on water resources, a critical adaptation response is to use water rights and allocation arrangements to guarantee that a minimum amount of water is utilized to satisfy environmental flow requirements and cannot be diverted for other uses

Develop and Implement Integrated Water Resources Management (IWRM)

IWRM provides an overarching management and governance arrangement to balance the allocation of water across users and uses. It ensures that ecosystems, as the 'silent users', are considered in decision-making. Whilst the benefit of IWRM has long been recognised in policy-making, implementation is slow in many developing countries, and its full benefits as an adaptation response to climate change must be promoted.

Climate Change Impacts on Global Freshwater Ecosystems

The quality of global freshwater and its ecosystems is fundamental to human well-being. The ecosystem services provided by freshwater resources are vast and significant – from provisioning services such as inland fisheries, and water for domestic, agricultural and industrial usage; to supporting services such as soil formation and nutrient recycling – all of which are fundamental to sustainable agricultural production. The global stability of freshwater ecosystems is, however, under increasing threat from human activity, unsustainable patterns of development and production, and climate change. The Millennium Ecosystem Assessment states that the 'primary indirect drivers of degradation and loss of inland [and coastal] wetlands

have been population growth and increasing economic development'.[28] As human, agricultural and industrial pressures on water resources mount, little consideration is often given to the harmful trade-offs made with the other services provided by wetlands that are fundamental to human well-being. Diversion of water for irrigation is, often irreversibly, changing the environmental flows of freshwater upon which ecosystems depend. 'Environmental Flows describes the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems'.[29]

The degradation and loss of ecosystems is advancing rapidly, further exacerbated by climate change. Climate induced water scarcity in many regions will increase pressure on water resources, and reduce environmental flows further. Sea-level rise, flooding, changes in hydrology, and temperature of water bodies will further destabilize fragile ecosystems. The construction of large dams and increased demand for irrigation to deal with, and regulate, water availability in the face of these climate change impacts will in turn have potentially adverse affects on the integrity of freshwater ecosystems due to dramatically altered environmental flows[30]. These degrading effects on ecosystems further weaken human resilience to climate change by compromising the essential services provided by ecosystems for human livelihoods and wellbeing and reducing the capacity of human populations to respond to climate challenges.

The Intergovernmental Panel on Climate Change (IPCC), in its technical paper on Climate Change and Water suggests that climate change impacts on the hydrological cycle will range from alterations in timings and volume of streamflow; to the lowering of water levels in many wetlands; the expansion of thermokarst lakes in the Arctic; and to a decline in mist water availability in tropical mountain forests. Observed trends in patterns of precipitation over the past century give an indication of what can be expected in the future, and these changes may have devastating impacts on ecosystems and biodiversity:

"Although changes in precipitation during the last century indicate considerable regional variation, they also reveal some important and highly significant trends. Precipitation increased generally in the Northern Hemisphere from 1900 to 2005, but the tendency towards more widespread drought increased concomitantly for many large regions of the tropics and the Southern Hemisphere, notably the African Sahel and southern Africa, Central America, south Asia and eastern Australia." [31]

The observed decreasing rainfall in the Sahel, combined with devastating droughts, are recognised as some of the most significant climate changes since the 1970s[32]. This stands to affect ecosystem health and species migration patterns as well as the human livelihoods that depend on rain-fed agriculture. Changes in hydrology brought about by climate change stand to have wide-ranging impacts on a diversity of ecosystem types. For lakes and streams, climate change will alter inflows to lakes, and under climatic conditions which reduce precipitation and increase evaporation, lakes may disappear entirely[33]. The devastation of the Aral Sea, influenced by a range of pressures including climate change, provides an example of the kinds of impact that can be expected in the future. Wetlands are also highly vulnerable to climate change impacts due to altered precipitation or more frequent or intense disturbance events (droughts, storms, floods). In general, atmospheric warming stands to have a drying effect on wetlands. In mountain ecosystems and snow-melt dominated watersheds, temperature increases will shift the magnitude and timing of hydrological events, altering peak stream-flows and changing patterns of water availability, leading to potentially devastating impacts on small-watershed streams that are sustained by glacial melt. Forests, savannahs and grasslands are also vulnerable - many forest ecosystems in the tropics, high latitudes and high altitudes are becoming increasingly susceptible to drought and associated changes in fire, pests and diseases as a result of increasing temperatures and altered moisture availability caused by climate change. The IPCC estimates that up to 40% of Amazonian forests could be affected by even slight decreases in precipitation.[34]

[28] Millennium Ecosystem Assessment: Ecosystems and Human Well-being – Wetlands and Water: Key Messages p 4 Year?
[29] The Brisbane Declaration – agreed at the 10th International River Symposium and International Environmental Flows Conference, Brisbane, Australia, September 2007
[30] WWF: Freshwater Facts and Figures
[31] Intergovernmental Panel on Climate Change (IPCC): Technical Paper on Climate Change and Water p 67
[32] UNEP: Fourth Global Environment Outlook Report: Water p 12
[33] IPCC, op cit, p 55
[34] IPCC op cit p 70 op cit??

Reducing Non-Climate Pressures on Freshwater Ecosystems

It is clear that freshwater ecosystems will be significantly impacted by climate change, and that altered and degraded freshwater ecosystems will have knock-on effects on other ecosystem types which are critical for mitigating climate change. More critically, climate change represents an additional stress among a suite of existing drivers of freshwater ecosystem degradation. Excessive withdrawal of both surface and groundwater over the past 50 years for agriculture, energy, industry and urban growth has led to a situation in many parts of the world where water abstraction exceeds the threshold of water renewability in the river basin resulting in widespread damage to ecosystems[35]. In West Asia, the Indo-Gangetic Plain in South Asia, the North China Plain and the High Plains in North America, human water use exceeds annual average water replenishment[36]. Global water withdrawals stand to increase by 50% by 2025 in developing countries, critically enhancing pressure on freshwater ecosystems and lowering resilience to the projected climate change impacts on the hydrological cycle. Where trends of decreased rainfall and increasing temperatures are predicted that will result in water scarcity, these added pressures may trigger 'tipping points' in freshwater ecosystems beyond which rehabilitation will be either impossible or a huge challenge.

Freshwater ecosystem degradation is both driven by, and can exacerbate, climate change impacts. Where climate-induced water scarcity leads to the drying of wetlands, land degradation and desertification, the capacity for absorption of carbon is reduced resulting in increased GHG levels in the atmosphere. In addition, global resilience to climate change is dramatically impacted as healthy ecosystems provide 'buffers' against climate impacts, including flood resilience through wetlands, water storage through lakes and upland soils, and groundwater recharge where stream-flow is affected by glacial melt[37].

Ecosystem Resilience

Protecting, preserving and rehabilitating freshwater ecosystems to build climate resilience, therefore, requires reducing non-climatic pressures on water resources. As the world is already committed to a certain degree of climate change which is beyond our control, and which will have subsequent impacts on freshwater ecosystems, it would be wise to focus on reducing those pressures on freshwater ecosystems that we do still have control over. WWF points out that 'the presence of so many non-climate pressures is one of the most novel components of this era of climate change'[38] – this multitude of pressures reduces the capacity of freshwater ecosystems to adapt to climate change.

Impact	Infrastructure	Services
Drought	Lakes and Upland Soils	Storage
Flood	Floodplains	Supply
Storms	Wetlands	Flood Control
Melting Ice	Groundwater	Disaster protection
Sea-level Rise	Mangroves and sediments	Coastal Defence

Source: IUCN

Agriculture is the main user of water resources globally – using up to 70% of available freshwater. Not only does the current demand for water from the agricultural sector place ever-increasing pressure on available water resources, but the agricultural water run-off laced with fertilizer and pesticide leeches into rivers and streams and can cause devastating impacts through 'eutrophication'. This is the process whereby the excessive growth of algae and plants chokes other organisms, alters the balance of the water body and, reduces the ecosystem services provided. Regulation of pesticide and fertilizer usage, and clear incentives to minimize run-off, could help to restore freshwater ecosystems impacted by agricultural practices and increase their resilience to other pressures such as climate change. Furthermore, instituting water demand and supply management practices for agricultural usage could help to enhance efficiency and reduce levels of extraction – drip irrigation technologies, rainwater harvesting, improved local storage and, tariff structures that reduce wastage, are all options for reducing the impact of agriculture on freshwater ecosystems. Similar regulatory frameworks should be instituted to limit industrial impacts on freshwater ecosystems, through mandatory efficiency requirements, appropriate tariffs that penalize excessive usage, and strictly imposed standards on industrial effluent that can seriously degrade water quality and damage sensitive freshwater

[35] World Water Development Report 2008: Chapter 9 – Managing Competition for Water and the Pressure on Ecosystems p 2
[36] UNEP Fourth Global Environment Outlook Report: Chapter 4 – Water year
[37] IUCN – presentation to 'Water Day', 3rd November 2009 in Barcelona, by Mark Smith, Head of Water Programme
[38] WWF – Adapting Water Management: A Primer for Coping with Climate Change p 31

ecosystems. Domestic usage can also be reduced through packages of regulation and incentives.

Maintaining Environmental Flows

In the context of reducing non-climate pressures, a major objective should be to maintain critical environmental flows which are often impacted by overabstraction, changes in land use and redirection of rivers and streams for a variety of water uses. Environmental Flows (eFlows) refer to water provided within a river, wetland or coastal zone to maintain ecosystems and the benefits they provide to people[39]. Some of the vast benefits provided by environmental flows include freshwater supply for human populations; the supply of nutrients, organic matter and moisture conditions in soils; and groundwater replenishment. However, as countries develop, water resources are increasingly diverted for other uses, and this is leading to the 'closing' of some river basins as flows decrease to such an extent as to preclude the delivery of services further downstream such as flushing-out sediments, diluting polluted water, controlling salinity intrusion and sustaining estuarine and coastal ecosystems. In many areas this has significant transboundary impacts; for example, 83% of the flow of the lower Jordan River is consumed before it reaches the Dead Sea because of diversions into Israel and Syria[40]. Dams can also have a significant impact on environmental flows by impeding the natural flows of rivers and restricting the delivery of sediments downstream that support critical ecosystem functions.

To avoid increasing freshwater and broader ecosystem degradation, minimum environmental flows must be guaranteed to maintain ecosystem function upon which critical ecosystem services depend. Situations such as the 'closed' river basin in Jordan occur due to the lack of consideration of the importance of maintaining environmental flows in water management arrangements; as well water allocation systems that do not assess how much water should be allocated to meet flow requirements – as a prioroty above and beyond other uses. As climate change variability and uncertainty enhances the need for resilience of freshwater ecosystems, environmental flow requirements need to be recognized as a prior allocation, behind basic social needs but ahead of alternative and competing economic uses. This means that water rights for other uses must be allocated alongside 'hands-off' supply to meet minimum environmental flow requirements which provide a buffer against climate change impacts. Impacts of dams on environmental flows and ecosystems can be reduced through changing the way in which water is released from dams, and identifying the appropriate volume and timing of those releases which will best mimic natural environmental flows. Though dams will have impacts on downstream areas which cannot be mitigated by the environmental flow management, effective planning in this area can mitigate some of the worst effects. Environmental flows assessments and modeling should be undertaken as early as possible during construction to inform engineering design and financial requirements, and any resulting flow requirements must be closely monitored. Lessons learned from the development of an Instream Flow Requirement policy as part of the Lesotho Highlands Water Project in 2003 further highlight the importance of such conditions[41].

The Role of Integrated Water Resources Management

Reducing non-climate pressures, maintaining environmental flows and building resilience of freshwater ecosystems to climate change all require a water management arrangement that recognizes the role of ecosystems as water-users, and allocates rights to the environment in terms of water allocation. The benefits of IWRM have been clearly outlined in the chapter on Water and Livelihoods, but should be reemphasized here as a holistic framework for dealing with the multiple pressures on water at a local, regional, national and international level, taking into account climate impacts to create a system that can respond flexibly to future variability and uncertainty.

IWRM is not a silver bullet, and the challenges for protecting ecosystems are many – it is clear that a certain degree of degradation will occur due to irreversible climate changes that are beyond human control. However, the level of degradation can be managed, and the worst impacts mitigated, with the appropriate institutions, frameworks and mechanisms – as well as the capacity to develop such systems – which seek to ensure that the needs of one particular user for water do not compromise the ability to meet essential social and environmental needs. IWRM provides that overarching framework, and the development and implementation of it as an integrating concept should be considered a core priority in building resilience and adapting to climate change.

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39 EFlows Network – definition of environmental flows as found at www.eflownet.org

40 World Water Development Report 2008: Chapter 9 – Managing Competition for Water and the Pressure on Ecosystems p 2 http://www.unesco.org/water/wwap/wwdr/wwdr3/pdf/20_WWDR3_ch_9.pdf

41 International Rivers: Let it Flow – Lessons from Lesotho http://www.internationalrivers.org/en/africa/lesotho-water-project/let-it-flow-lessons-lesotho

Energy

Water and Energy

Key Messages for the United Nations Framework Convention on Climate Change

The Water and Energy nexus will be a critical consideration for adaptation, mitigation, technology transfer and climate change finance – the four pillars of the Bali Action Plan. The following considerations should be integrated into any adaptation and mitigation measures committed to, financed and monitored under the UNFCCC:

Mainstream energy efficiency and demand management into sectoral practices

Mitigating climate change will require ambitious global greenhouse gas emission reductions, and increasing energy efficiency in the water sector will be a critical factor in achieving those targets. In turn, managing water demand will be a key component of enhancing energy efficiency in the sector. Where water infrastructure is being planned and built, energy efficiency considerations should be mainstreamed.

Implement Integrated Water Resources Management (IWRM) to promote integration of the water and energy sectors

As the energy sector is a large water user, and as the water sector is a significant energy user, water management practices are required at national, regional and local levels that consider the needs of multiple sectors and enhance communication arrangements between them. IWRM provides this ability by ensuring that the multiple uses and users of water are considered simultaneously and takes account of competing sectors to manage the water resource sustainably. Enhancing capacity and training for the implementation of IWRM, especially in developing countries, should be a major priority.

Limit ecosystem impacts of energy mitigation measures

Meeting GHG emission reduction targets in developed countries and lowering Business As Usual emission projections in developing countries will require the use of hydropower. Large dams can have devastating impacts on ecosystems and reduce long-term climate resilience if they do not allow for essential environmental flows. The production of biofuels can have similarly unintended consequences on ecosystems and demands significant quantities of water. Tools for identifying ecosystem impacts of alternative energy sources are essential for assessing their suitability.

Base energy mitigation measures on a consideration of future hydrological patterns under climate change

Conventional energy production, as well as alternatives such as hydropower and biofuels, all rely on water availability. Infrastructure and plans to service energy needs that are based on existing hydrological patterns are likely to be highly vulnerable to climate change impacts. Assessments of future water availability based on climate change data will be critical for choosing sustainable energy options that can respond to uncertainty – improved data collection and research will be necessary to achieve this.

The Water-Energy Nexus

Water management, and energy production and usage, are deeply interrelated, and the impact that climate change will have on both raises a number of complex issues. Water is the primary medium through which climate change impacts will be felt by human populations and the environment, whilst energy production is one of the most significant

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emission of Greenhouse Gases (GHGs) into the atmosphere through the burning of fossil fuels. It is of vital importance that the water and energy nexus is included within any intergovernmental agreement which tackles climate change because any carbon reduction agreement will mean a move towards greater efficiency standards and renewable technologies, which in turn will have impacts on the use of water.

Water and Energy share a number of the same drivers on usage: demographic, economic, social and technological. Water demand is expected to increase into the next century: demand for energy is expected to increase by over 40% by 2030[42] while demand for available freshwater resources is expected to rise from 54% of available resources in 2001 to 70% in 2025, and 90% in 2025 if per capita consumption is at developed country levels[43]. This increasing demand constitutes competing pressures from a number of sectors – including agriculture, energy and domestic use. Climate change, which is predicted to alter precipitation patterns, accelerate glacial melt and change moisture availability, will exacerbate pressure on water resources further. Both demand for energy and demand for water will also be influenced by climate change pressures. Within a resource constrained environment, competition and, potentially conflict, will arise between these sectors, and mechanisms need to be in place to address these competing demands.

Water has an important role to play in both mitigation and adaptation to climate change especially in regards to energy. Water is needed in the production of energy – after agriculture, energy is the most water-intensive sector with 20% of total water withdrawals used for energy and industry globally[44]. There are some significant differences between developing and developed countries; in Africa 90% of water use is agricultural while in the majority of the developed world the majority of water is used in industry. In the energy sector specifically, water is used in a number of ways – from the production of the materials used to build energy power stations (embedded water), to the production of the fuels used in generating energy (e.g. mining), to the actual generation of the power itself from thermo-cooling and hydropower generation.

In the United States, the water withdrawn for cooling for power generation in 2003 equated to 39% of freshwater withdrawals[45]. The current trend towards increased use of thermal power plants, e.g. coal powered stations, stands to increase competition for water resources – to produce one kilowatt-hour of electricity requires 140 litres of water for fossil fuels and 205 litres for nuclear power plants[46]. IEA projections up to 2030 expect energy generation from fossil fuels to continue to be the dominate source of supply[47]. Low-carbon energy technologies will also play a crucial role with projections that by 2030 around 60% of global electricity production will come from non-fossil fuel sources – with renewables at 37%, nuclear at 18% and plants fitted with carbon capture and storage at 5%. All these forms of production will draw on water resources. Different energy scenarios will have different water extraction costs and it is important that these are managed effectively.

In addition to water being required to produce energy, conversely energy also essential for the delivery, treatment and transportation of water. Energy is required for pumping water for domestic, industrial and agricultural purposes. In California, 19% of energy used is for water supply and delivery, and it is the single largest user of energy in the state[48]. Energy is also used in the treatment of waste water and sewerage, and demand for energy in this sector also looks set to increase globally by 44% between 2006 and 2030, with the largest rise in non-OECD countries of 73%[49] due to changing social and economic conditions. Energy can account for between 60% and 80% of water transportation and treatment costs, and 14% of total utility costs[50]. 7% of all energy produced globally is used to lift groundwater, pump it through pipes and treat both groundwater and wastewater[51].

The water and energy nexus also has important implications for the achievement of the 7th Millennium Development Goal which commits to halve the number of people without access to safe drinking water and sanitation by 2015. Globally 884 million people still lack access to safe drinking water. Energy access is still more elusive, with 1.5 billion people lacking access to electricity, 80% of which live in Least Developed Countries in South Asia and Sub-Saharan

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42 International Energy Agency (2009), World Energy Outlook 2009.
43 United Nations Population Fund (2001) State of the World 2001
44 United Nations (2009) World Development Report Chapter7: Evolution of Water Use
45 National Renewable Energy Laboratory (2003) Consumptive Water Use for US power Production
46 Thirlwell G, Madramootoo C, Heathcote I (2007) Energy-water Nexus: Energy Use in the Municipal, Industrial, and Agricultural Water Sectors
47 International Energy Agency (2009) World Energy Outlook 2009
48 National Resource Defence Council (2009) Water Facts: Water Saving Solutions
49 International Energy Agency (2009) World Energy Outlook 2009
50 Global Water Intelligence. 2007. Global Water Market 2008: Opportunities in Scarcity and Environmental Regulation.Oxford: Global Water Intelligence.
51 http://waterindustry.org/Water-Facts/world-water-6.htm

Africa[52]. Demand for more energy will mean an increase in demand for water to service energy systems; demand for more water will see an increase in demand for energy to deliver safe water supply, which in turn will contribute to climate change whose impacts are largely felt through the water cycle.

Water and Energy Efficiency

Energy will be required for responses to climate change impacts through the hydrological cycle – for example the delivery of potable water into a water-stressed environment will require pumping, transport and infrastructure, all of which have a carbon footprint due to energy requirements, which in turn has a water footprint. Enhanced efficiency will be critical in managing water and energy use, and lead to significant co-benefits for each sector. For example, agricultural useage accounts for 70% of freshwater withdrawals, but as the sector becomes more efficient due to changing agricultural practices, less energy will be used for the pumping and transportation of water. Obstacles to enhanced water efficiency in agriculture include 'perverse subsidies' within the water sector which do not internalise the cost of transporting water for agricultural production and do not incentivise efficient water usage.

Although water withdrawals are on the rise, mainly for hydropower and thermo-cooling, 95% of the water used for energy production is returned to the water system. However, this water may be of a degraded quality[53] – water discharged from coal-fired power stations is likely to be more acidic unless it is treated, thus influencing the acidity of ecosystems and potentially affecting their ability to function. Power generation which relies on water cooling will also be affected by the quality and resilience of the riparian ecosystem – for example in the summer of 2003 and 2006 production of energy on the river Rhine was curtailed because increased water temperatures and low flows made the cooling capacity of the water ineffective[54]. Future projection scenarios of flow and temperature will be vital in the management of water and energy. It is essential that the water returned to the ecosystem is treated to the highest standards and that water which is too degraded is stored securely rather than returned to ensure that ecosystem services are not put at risk by the discharge of polluted water. The removal of freshwater should be kept at a minimum. The reuse of treated wastewater within energy systems, therefore, is a clear example of how to minimise freshwater extraction.

Efficiency within the energy sector can occur at the start point of energy generation such as through the re-use of water for cooling or the use of waste water recycling in and between the industrial and municipal sectors. An example includes a factory in the Netherlands that re-uses 3 million tonnes of waste water from a nearby housing development for industrial purposes and cooling, which uses 90% less energy. In addition to substantial reduction in costs, it has also resulted in a reduction in CO_2 emissions of 1,850 tons/year[55]. Generating the largest possible amount of energy from the minimum available water is a clear priority.

Energy efficiency at the end point of energy use can also lead to carbon and water reduction measures. For instance, industrial energy demand accounts for just under 30% of global greenhouse gases and this energy demand is 40% of all energy produced globally[56]. Although energy efficiency has improved each year - the 2005 IEA report stated that the energy efficiency of most industrial processes is at least 50% higher than the theoretical minimum"[57] – clear gains in efficiency can still clearly be made. Changing consumer behaviour in relation to the use of energy can also reduce energy demand which will significantly impact water use and can be achieved through education campaigns and the production of more energy efficient products through incentives and national regulation.

Knowledge and technological transfer will increase the efficiency in both the water and energy sectors. It is important that when ensuring the delivery of energy into, and access to energy in, developing countries they have the best available technology for the particular context, and that the communities have the knowledge to use the technology effectively. It is of vital importance that the infrastructure built is as energy efficient as possible and resilient enough to deal with potential change. Technological transfers relate directly to the Bali Action Plan, and technological transfer in relation to water management is key to allowing communities to adapt effectively to differing climate change scenarios.

52 United Nations Development Programme (2009) The Energy Access Situation in Developing Countries, A Review Focusing on the Least Developed Countries and Sub-Saharan Africa

53 Environmental Protection Agency http://www.epa.gov/RDEE/energy-and-you/affect/water-discharge.html

54 Rutten M, van de Giesen N, Baptist M ,Icke J, Uijttewaal W (2008) Seasonal forecast of cooling water problems in the River Rhine Hydrological Process 22 (7) 1037-1045

55 World Business Council for Sustainable Development (2006) Water Energy and Climate Change

56 Worrell E ,Bernstein L, Roy J, Price L, Harnisch J (2009) Industrial energy efficiency and climate change mitigation Energy Efficiency (2) 109-123

57 International Energy Agency (2005) World Energy Report 2005

Integration of water and energy management through Integrated Water Resources Management (IWRM)

Another important component is the integration of the water and energy sectors. In many cases, these sectors do not communicate effectively with one another due to the absence of intersectoral institutional arrangements or a 'common language' that would facilitate engagement. An important step towards integration is the development and implementation of Integrated Water Resource Management (IWRM). IWRM allows for the incorporation of the multiple uses of water across different areas, sectoral and geographical. This also allows for the management of water at the watershed level and takes into account the transboundary context. According to a number of reports and studies, the simultaneous analysis of all the sectors that use water at the policy level can enable significant increases in productivity and the sustainable use of the resource, as well as having a positive impact on development and growth[58]. The move toward demand management within water management, as is currently the trend within the power sector, will also mean that there is commonality of language. An area where this would be particularly important is in relation to hydropower production within the energy sector.

Hydropower currently accounts for over 15% of all energy production worldwide and for 89% of the world's renewable energy[59]. In some countries, for example Brazil, it constitutes as much as 90% of energy production. The production of energy from dams is projected to increase in the future due to rising demands for renewable energy, driven partly by increases in fossil fuel prices and the move to a low carbon economy. Hydropower is the most important and economic source of renewable energy worldwide.

Dams, when built in at suitable location and in an appropriate way, can have substantial net benefits – they can guarantee downstream flows, whilst also delivering low carbon energy in a constant way. However, the World Commission on Dams in 2001 concluded that while dams have delivered many benefits and made a significant contribution to human development, the price paid to secure those benefits, especially in social and environmental terms, in many cases has been too high and, more importantly, could have been avoided[60].

Where dams are not built in a suitable location or appropriately managed they can cause a large amount of social, economic and, as aforementioned, environmental damage. The impact of each dam will be unique and will depend on dam structure, the attributes of local biota, and the climatic and geomorphic conditions of a particular area. The primary effect dams have is their interference with the rivers "continuity"[61] and can disrupt exchanges occurring along the river system. This has both upstream and downstream impacts, for example, the Hadejia-Nguru wetlands in Nigeria experienced annual natural flooding of 3,000 km^2 prior to dam building which was reduced to 1,000 km^2 after construction[62], leading to a knock on effect on the wetland ecosystem. Large dams also invariably lead to the displacement of communities that live in areas that will be flooded. With hydrodams expected to increase, especially on the African continent, it is important that there is a large amount of community consultation and that these local community benefits from the production of the resource[63]. Dams will have an increasing role to play in the move to a low carbon future and the delivery of renewable energy, and so the criteria drawn up by the World Commission on Dams[64] must be adhered to when constructing any new dams, not just those which are built for the generation of electricity.

Furthermore, large dams, particularly those built in tropical areas, can be net contributors of global greenhouse gases due to the decomposition of vegetation and the release of methane into the atmosphere from the reservoir and in the through-flow of water. A study of the Curuá-Una dam in Brazil in 2004 found that over its 13 year lifespan it had emitted 3.6 times more greenhouse gas than the same amount of electricity generated by using oil[65]. Emissions released from dams depend on a range of factors including depth, temperature, influx of organic matter, and operation regime of the dam, with the greatest emissions occurring in shallow tropical reservoirs. When the power generated

58 United Nations (2006) Water a shared responsibility: The United Nations World Water Development Report 2
59 World Business Council on Sustainable Development (2006) Water Energy and Climate Change
60 World Commission on Dams (2001) Dams for Development
61 McCarthney M (2008) Living with dams: managing the environmental impacts Water Policy 11 (1) 121-139
62 McCarthney M (2008) Living with dams: managing the environmental impacts Water Policy 11 (1) 121-139
63 International Institute for Environment and Development (2009) Sharing the benefits of large dams in West Africa
64 World Commission on Dams (2001) Dams for Development http://www.unep.org/dams/WCD/report/WCD_DAMS%20report.pdf
65 Fearnside P (2005) Do hydroelectric dams mitigate global warming? The case of the Curua-Una Dam Brazil Mitigation and Adaptation Strategies for Global Change 10 (4)1573-1596

by hydropower is less than 0.1W per m^2 of reservoir area connected to the generator, there is the chance that such emissions may exceed those that would be produced by an equivalent thermal power station.[66]

Large dams can also be incredibly water inefficient as evaporation from a large standing body of water is significant. If not managed properly, they can cause rivers downstream to run dry, increase water stress across regions, and lead to conflicts within transboundary watersheds. While the energy benefits are clear, it is important that rigorous sustainability standards are set and adhered too. Hydropower dams must be managed for multiple-uses and not solely for the delivery of energy. The use of small dams and decentralised energy systems should be investigated.

The largest user of freshwater is the agricultural sector at over 70%. International pressure to lower carbon emissions, combined with rising oil prices in recent years, has led to a surge of interest in bioenergy within the agricultural sector. Globally around 10% of the total energy supply comes from biomass with 80% of this related to 'traditional' sources of biomass such as, wood and crop residues. The rise in the use of bio energy crops is driven by demand in OECD countries fuelled in part by increased crude oil prices and also through legislative pressures such as the EU Biofuels Directive.

By 2017, global ethanol and biodiesel production are expected to increase to 127 billion litres and 24 billion litres respectively[67]. The affects on food security of this production has been noted elsewhere , but in relation to water there has been little research on its impact globally. Independently, biofuels production represents an additional demand for water, and if projected increases in production are additional to rather than a substitute for other forms of production, this could result in decreased water availability for other uses. Currently 2% ($44km^3$) of irrigated land is allocated for biofuel production – implementation of all current national biofuels policies and plans would require an additional 180 km^3 of irrigated water. This water delivery will divert water from other services or deplete the groundwater resources and, as such, it is clear that water and energy considerations are deeply interrelated when it comes to implementing policies on biofuels production that are ostensibly designed to mitigate climate change. Agricultural subsidies which distort the market for biofuels should be reappraised in light of ecosystem and freshwater impacts which may weaken resilience to climate change in the long-term.

To minimise the negative impact that biofuels may have, sustainability indicators must be implemented and adhered too. While the 'Water Footprint' concept has been suggested as a possible way of gathering data and ensuring sustainability, this should be greeted with some caution. Although the water footprint metric can be used across a range of different areas, its relevance remains highly contextualised. The water footprint of a good produced in a semi-arid area is not equal to the water footprint of a good produced in a temperate environment with a large amount of water availability and access. The Water Footprint is context specific and whilst it is a useful tool, it is not a panacea.

Institutional capacity building

Capacity building within the water and energy sectors can have a positive impact in the context of both climate change mitigation and adaptation. International climate finance must prioritise building institutional capacity within these sectors[68], as this can help to enhance efficiency measures and promote their integration into Integrated Water Resource Management (IWRM) plans. Essential to this capacity building is increased access to reliable data and information. This information must be up–to-date and freely available to all stakeholders. Information on the amount of energy used in the water sector can lead to the implementation of better management practices and also target management approaches. Knowledge of the use of water in energy production is vital to ensure the delivery of this water and to ensure water efficiency within the energy sector.

Reliable climate change risk data and models must incorporate water and energy into their analysis tools. This will enable long term planning in relation to the competing uses of water. Climate Change models which will help predict future precipitation scenarios and hydrological flows will be vital in the prioritisation, placement and use of future renewable energy technologies and increasing their resilience to changing weather patterns and long term viability[69].

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66 Fearnside P (2004) Greenhouse gas emissions from hydroelectric dams: controversies provide a springboard for rethinking as supposedly "clean" energy source. Editorial comment Climatic Change 66 (1-2) 1-2

67 Food and Agriculture Organisation (2008) The State of Food and Agriculture 2008 Biofuels: Prospects risks and opportunities

68 World Wildlife Fund (2009) Adapting Water Management Water Security Series

69 World Business Council for Sustainable Development (2006) Water Energy and Climate Change

Transboundary

Water and trans-boundary water management

Key Messages for the United Nations Framework Convention on Climate Change

Trans-boundary arrangements for sharing water are not prepared for the additional pressures of the effects of climate change, which will put considerable strain on regional and global security. Adaptation plans must recognise the trans-boundary and regional dimensions of climate change in order to cope with the additional strains that changes in water availability will put on relations between states. Any adaptation measures committed to, supported and monitored under the UNFCCC must take into account the following considerations:

Invest in institutions

Invest and strengthen the institutions responsible for providing and managing water resources for people, industries, energy and eco-systems. From transparent regulatory frameworks to multi-stakeholder dialogues, stronger institutions can cope with present climate variability and cope with future adaptation[70]. The UNFCCC adaptation framework must recognise the additional financial resources that will need to be committed to support such investments.

Share information and generate data

Assessment is essential for making informed decisions on a shared water resource and it is critical that all parties and bodies have access to the same date as the impacts of climate change make themselves felt. A common-basis for decision-making requires harmonised, compatible assessment methods and data management systems as well as uniform reporting procedures. The UNFCCC adaptation framework should support strategies for sharing and generating data that will impact trans-boundary relations as a result of climate change.

Promote Integrated Water Resources Management as a framework for transboundary governance

Trans-boundary agreements should be founded on Integrated Water Resource Management (IWRM) principles to ensure a holistic management of surface and groundwater, which takes into consideration the whole river basin as well as ensuring a multi-sector approach. IWRM should be recognised as one of the core principles for adapting to climate change in the UNFCCC adaptation framework.

Support existing legal tools

Existing and pending legal tools supporting cooperation between states over water resources must be supported and strengthened. In particular, the UN Watercourses Convention represents many of the core principles for ensuring cooperation, including equitable and reasonable utilisation and the no-harm rule.

Climate Change Impacts on Transboundary Waters

Water is not contained by political borders. An estimated 145 states have international basins within their territory, and 30 countries lie entirely within them. In addition, about 2 billion people worldwide depend on groundwater supplies, which include approximately 300 trans-boundary aquifer systems[71]. In short, the majority of the world's freshwater

70 How can we adapt? Global Water Partnership Briefing Note (GWP, 2009) http://www.gwpforum.org/gwp/library/GWP_Briefingnote_climatechange.pdf
71 Transboundary Waters: Sharing Benefits, Sharing Responsibilities (UN Water, 2008) http://www.unwater.org/downloads/UNW_TRANSBOUNDARY.pdf

supply, essential for all human life, is contained in river basins and groundwater systems that are shared by two or more countries.

History suggests that, for the most part, neighbouring states have managed to cooperate across borders and share common water resources. Climate change introduces a new dimension. Rivers that have normally relied on annual glacier melt and regular rainfall patterns are likely to experience dramatic shifts in flow and a one time 'dividend' of water release to downstream regions. For example, the Mekong River that flows through China, Burma, Thailand, Laos, Cambodia and Vietnam, providing the key water supply to the entire regional population, relies on the Himalayan glaciers for regular snowmelt. Similarly, the vast Amazon river basin which covers more than 350,000 square kilometres and is home to the largest rainforest on Earth, derives half of its water from the glaciers in the Andes. Since the 1960s, snow cover has decreased in most regions, particularly in the spring and summer, and increasing rates of mass loss have occurred on the majority of glaciers and ice caps. The decrease in water storage in glaciers and snow cover, together with shifts in the amplitude and timing of runoff in glacier and snowmelt fed rivers, affect more than one-sixth of the world's population living in the impacted river basins. In the short term, glacier melting would lead to increased river flows, but then the contribution would gradually fall. As a consequence, the hundreds of millions of people who depend on glacial melt water from the Andes, Hindu Kush and Himalayas for their dry season water supply will face increased water scarcity and water insecurity. If left unchecked, shared water resources are likely to become a fierce battlefield between competing states and users.

When coupled with population growth, industrialisation development, and growing consumption and production patterns, climate change poses a significant threat to the future of international relations. If we fail to address the pressures that climate change will put on already strained trans-boundary resources it is likely that new disputes will emerge, existing tensions will intensify and old controversies will be re-ignited. If water is to remain a source of cooperation, rather than conflict, it is critical that the necessary legal, institutional and economic frameworks are put in place. The following section explores the interrelatedness of trans-boundary water management and climate change and identifies some key issues, challenges and recommendations for policy-makers.

Limitations of existing arrangements

Formal agreements over shared water resources are by no means a new development. The Food and Agriculture Organisation (FAO) has identified more than 3,600 treaties relating to international water resources dating as far back as AD 805, and in the last century over 300 agreements on international waters have been signed[72]. There are numerous examples of existing bilateral and regional water agreements including the Great Lakes Water Quality Agreement (1978), the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (1995), the Nile Water Treaty and the Indus Water Treaty, which are all cited as instances of cooperation between neighbouring states over shared water resources. In particular, the Indus Water Treaty, signed between Pakistan and India in 1960, which divides the three Eastern Rivers and the Western Rivers between the two neighbouring states, has survived three major conflicts and remains intact today.

However, while there are a number of examples of cooperation between neighbouring states over a common water resource, the emerging effects of climate change requires us to subject existing and historical water agreements to further scrutiny. First, despite the proliferation of agreements on trans-boundary water management, there are still numerous watercourses and river basins without adequate legal frameworks for cooperation. According to UN Water, 158 of the world's 263 international river basins lack any type of cooperative management framework[73].

Second, existing and historical water treaties have tended to cover only technical management aspects, such as the use of transport or the use of a river section for navigational purposes. Only a small fraction of existing and historical water treaties tackle how to share a common water resource and almost none were conceived with the impact of climate change in mind. For example, treaties such as the Ganges water-sharing treaty, signed between Bangladesh and India in 1996 which share the dry season discharge of the Ganges River at Farakka, West Bengal, India, are relatively new developments in terms of trans-boundary water management agreements and are not well equipped for sharing resources under more extreme situations. Evidence suggests that since 1975 the dry season discharge of the Ganges at Farakka has declined due to increased upstream uses of agriculture and other human activities[74],

72 (FAO, UNWATER, 2000) http://www.unwater.org/worldwaterday/faqs.html

73 Transboundary Waters: Sharing Benefits, Sharing Responsibilities, (UN Water, 2008) http://www.unwater.org/downloads/UNW_TRANSBOUNDARY.pdf

74 Adverse Effects on Agriculture in the Ganges Basin in Bangladesh, The Ganges Water Diversion: Environmental Effects and Implications. M. Monirul Qader Mirza (Netherlands, 2005)

which has a direct implication for the values that were agreed as part of the initial agreement. The effects of climate change will change annual flows on rivers such as the Ganges and will thus put a further pressure on already tenuous agreements for sharing water supplies.

Moreover, few existing treaties are founded on integrated water resources management principles due to problems at the national and local levels such as inadequate water management structures and weak capacity in countries to implement the agreements as well as shortcomings in the agreements themselves, including the lack of enforcement mechanisms, limited sectoral scope and non-inclusion of important riparian States (UN Water).

A third major area for concern is the power-discrepancies between states sharing a water resource. States with greater economic and political positions than their neighbours, 'hydro-hegemons', are able to dictate the rules of engagement and the terms of the so-called cooperation. Ongoing Turkish or Chinese dam building projects on the Tigris and the Mekong rivers demonstrate the advantage an upstream state has over its down-stream neighbours.[75] Equally, the same highland position enjoyed by Ethiopia on the Eastern Nile or by Nepal on the Ganges has not translated into the same mega-projects, suggesting that economic and political prowess will determine upstream river activities[76]. In some cases, more powerful states have used 'soft power' instruments to ensure cooperation. For example, China's financial assistance to Cambodia in sectors unrelated to the Mekong has been credited for ensuring official Cambodian acquiescence to China's building of upstream dams. Thus the failure to take into consideration current and future power discrepancies between states in any trans-boundary water arrangement has much wider implications for the wider ecosystem and states dependent on a shared resource.

As yet, we have no international convention in force that regulates international waters. The UN Convention on the Law of the Non-navigational Uses of International Watercourses was adopted in 1997 after 27 years of development. The convention establishes the rights and obligations between Member States relating to the management of international watercourses. However, to date, only 18 nations have ratified the Convention and a further 17 are required for it to enter into force. Since its original inception not only have several factors such as population growth, increases in water demand, growing levels of pollution, aggravated the problems that motivated the convention's adoption (SIWI), but climate change had not yet been fully understood. As such, the International Watercourses Convention alone will not be sufficient for preventing interstate conflict in the context of climate change.

The Role of Cooperation

As has been demonstrated, existing trans-boundary water treaties lack the resilience, flexibility and foresight to cope with the affects of climate change and the majority of international water basins lack any cooperative management framework at all. As such, trans-boundary arrangements for sharing water are not prepared for the additional pressures of the affects of climate change, which will put considerable strain on regional and global security. In light of the added pressures of climate change, it is clear that we will not only require increased levels of technical cooperation between states but will also need renewed political will and commitment from all Governments at all levels. Whilst there are no clear blueprints for ensuring high quality cooperation across borders, the relevant legal frameworks, institutional structures and preparatory measures will help to protect relations across borders.

Firstly, a well grounded legal framework is critical for ensuring long-lasting and accountable levels of cooperation. At the global level, the International Watercourses Convention, though still not in force, represents many of the core principles for ensuring cooperation, including equitable and reasonable utilisation and the no-harm rule. In Europe, the UNECE Convention on the Protection and Use of Trans-boundary Watercourses and International Lakes has also been used as the basis for adoption of many bilateral and multilateral agreements in other parts of the world. The framework document developed under the Convention, Guidance on Water and Adaptation to Climate Change, provides advice to decision-makers and water managers on the steps needed to develop an adaptation strategy[77]. The EU Water Framework Directive, negotiated by the EU member states, has also proven an effective tool for generating cooperation and requires intra-national, multi-level institutional structures, including legal systems

[75] http://www.worldwaterweek.org/documents/Resources/Events/ZeitounJagerskog_Challenging_Power_Asymmetry_June_2009.pdf
[76] ibid.
[77] http://www.unece.org/env/documents/2009/Wat/mp_wat/ECE_MP.WAT_30_E.pdf

to ensure implementation of the directive. Any adaptation framework under the UNFCCC must also recognise the trans-boundary and regional dimensions of climate change.

Secondly, power asymmetry between states sharing common resources is unavoidable, however neighbouring states can benefit from their different geographical advantages when sharing a common water resource. For example, payments for benefits for the use of the joint ecosystem could be explored in policy development, whereby downstream countries can be compensated for the creation and operation of additional storage capacity by upstream countries; whilst upstream might be financially compensated for benefits accrued by its downstream neighbours. The concept of 'benefit-sharing' will need to be more fully explored in light of the additional pressure of climate change[78].

Thirdly, trans-boundary water management is not solely the domain of governments and Member States. Effective, flexible and well-rooted cooperation between neighbours will require close collaboration between municipalities, local authorities, local water providers, as well as NGOs, community groups, business and industry, and other stakeholders. Common obstacles can include conflicting mandates, fragmented authority and limited capacity of national institutions. Adaptation strategies will need to be developed together with all partners and stakeholder groups. Such multi-stakeholder processes will require much more investment, resources and capacity building for the myriad of institutions and bodies that play a part in managing national and regional water resources which will be put under new pressures as a result of climate change. At the trans-boundary level, the formation of joint bodies with strong enforcement capacity, such as river, lake and aquifer commissions, is fundamental to ensuring cooperation between the various governmental entities and good management of shared resources. Enforcement can only be achieved if these bodies possess strong mandates and political support from the various Governments[79].

Finally, the management of the world's trans-boundary water resources requires reliable information about the current state of the resource and how it is currently changing in response to drivers such as climate change. To date, there has been little sharing of hydrological data across national and regional boundaries, which is largely due to the limited physical access to data and lack of agreed protocols for sharing data and information[80]. In light of climate change, the sharing of data will be critical for ensuring integrated and timely adaptation strategies.

[78] Getting Transboundary Water Right: Theory and Practice for Effective Cooperation (SIWI, 2009) http://www.siwi.org/documents/Resources/Reports/Report25_Transboundary_Waters_with_WWW.pdf

[79] Transboundary Waters: Sharing Benefits, Sharing Responsibilities (UN Water, 2008) http://www.unwater.org/downloads/UNW_TRANSBOUNDARY.pdf

[80] ibid.

Gender

Water and Gender

Key Messages on Water and Gender

Climate change is likely to be felt more acutely by those with the least adaptive capacity. Women make up a disproportionate share of the world's poorest, and commonly lack access to information, decision-making and resources that enable them to prepare for changes in their local climate. As such, women are likely to be particularly vulnerable to the impact of climate change. Any adaptation measures committed to, supported by and monitored under the UNFCCC must take into account the following considerations:

Access to information and decision-making

Small-scale agricultural produce plays a critical role in women's livelihoods all over the world. However, for the most part, women are not provided with the necessary access to information on possible climate change effects or to relevant decision-making forums on water and land resource management. Women must be provided with the relevant information, data and resources on climatic changes in order to put in place local adaptation strategies.

Sustainable agricultural practices

Women make up a large percentage of the world's agricultural labour force and as such must be provided with access to knowledge and resources in order to undertake sustainable agricultural practices such as awareness about crop diversification and adaptive agricultural techniques in order to mitigate and adapt to changes in water resources as a result of climate change.

Understanding the gender-dimension

Climate change adaptation plans and strategies will be developed and implemented at multiple levels: gender-dimensions must be included in all local, regional and international adaptation strategies.

The vulnerability of women to climate change

Water is the main medium through which climate change impacts are felt by human populations and the environment. Climate change impacts through the hydrological cycle include increasing water scarcity, more widespread desertification, more and heavier floods, and water-borne diseases. It is estimated that by 2025, almost two thirds of the world's population are likely to experience some kind of water stress, and for one billion of them the shortage will be severe and socially disruptive.[81]

Women form a disproportionate share of the poor. Seventy per cent of the human beings worldwide that are living below the poverty line are women[82]. In the developing nations of the global South, women constitute a large share of the natural resource dependent communities. Water resources for personal and productive uses are, therefore, critical to women's survival and their livelihoods. Women in the rural areas of these developing countries shoulder the main responsibility for household water supply, as well as being dependent on available water for small-scale farming and agricultural production.

As these rural women are the major users and managers of water and so changes in water availability induced by

[81] Gender and Climate Change: Mapping the Linkages (IDS, 2008) http://www.bridge.ids.ac.uk/reports/Climate_Change_DFID.pdf
[82] Investing in Women: Solving the poverty puzzle (UNIFEM, 2007) http://www.womenfightpoverty.org/docs/WorldPovertyDay2007_FactsAndFigures.pdf

climate change could have potentially devastating impacts on their wellbeing. Climate change often impacts the areas that are the basis of their livelihood responsibilities, for example, nutrition and water and energy supplies. This, combined with the many unrelated disadvantages that women suffer in many countries including; poverty, limited access to resources, and decision-making processes, make them highly vulnerable to climate change.

Rural Livelihoods and Agriculture

As suggested by the Food and Agriculture Organisation[83] (FAO), women's livelihoods are often dependent on growing, processing and managing small-scale agricultural produce as well as raising livestock and collecting food and fuel. As climate change effects will result in increased rates of land degradation, soil erosion and water scarcity it is likely that it will be increasingly difficult for women to sustain productive and secure livelihoods in the face of an unpredictable climate. Yet, despite the critical role of such small-scale agricultural produce as a source of income and security, women often lack access to information and data that will help them prepare them for changes in weather and climatic conditions, which makes them less equipped to adapt. Research suggests that the effects of climate change are already making themselves felt for women around the world. For example, women in rural communities in the Ganga river basin in Bangladesh, India and Nepal are already adapting their practices in order to secure their livelihoods in the face of climate change and such strategies would be enhanced by more access to information on what to expect[84]. Moreover, as a result of more time being spent collecting resources from further afield, it is likely that they will have few opportunities to engage in non-traditional activities. The danger, therefore, is that the unequal gender-relations and stereotypes will become further entrenched.

Furthermore, it is important not to fall into gender-biased assumptions about the different roles of men and women in agricultural production. Women not only play a critical role in collecting fuel, water and producing small-scale agricultural produce, but in many parts of the world they are also responsible for providing huge swathes of the agricultural labour force. For example, in Southeast Asia, women provide up to 90 percent of labour for rice cultivation and in Sub-Saharan Africa they are responsible for 80 percent of food production[85]. As climate change will likely increase food insecurity as a result of land degradation, drought and desertification, women's livelihoods and incomes will be put under additional pressures.

Access to Water for Domestic Use

Where climate change, combined with other pressures stands to enhance water scarcity, women who do not have access to a community based or at-home piped water supply will have to go further to collect water. Walking long distances to fetch water and fuel can expose women and girls to harassment or sexual assault, especially in areas of conflict - there are many accounts of women and girls being attacked when searching for water and kindling in refugee camps around Darfur[86].

In regions where drought is a persistent trend, women are forced to walk miles and often return empty handed. Unfortunately, at present there are limited gender-related statistics on the impacts of drought or flood stricken areas. By nature of the locations where women must walk longer distances for water, there are no records kept by regulatory bodies, so exact numbers of violence towards women are unavailable. However, there is a clear imperative for providing safe environments where women can access a reliable water supply, and priority should be placed on providing climate resilient water access which will reduce the vulnerability of women and free up time otherwise spent collecting water for other domestic and productive uses – in the case of girls and younger women, this could also increase the time available to attend school. In Morocco, a World Bank Rural Water Supply and Sanitation Project succeeded in increasing girls' school attendance by 20 percent over four years, in part by reducing the traditional burden on them to fetch water.[87]

Access to information

Women's limited access to information and decision-making processes in many countries increases their vulnerability to climate change. Following the cyclone and flood of 1991 in Bangladesh the death rate was almost five times as high for women as for men.[88] Warning information was transmitted by men to men in public spaces, but rarely communicated to

83 Quoted in Gender and climate change: Mapping the linkages (IDS, 2008) http://www.bridge.ids.ac.uk/reports/Climate_Change_DFID.pdf
84 ibid.
85 ibid.
86 ibid.
87 ibid.
88 http://www.gdrc.org/gender/gender-and-envi.html S. Baden, A.M. Goetz, C. Green and M. Guhathakurta, commissioned by ODA, August 1994

the rest of the family and, as many women are not allowed to leave the house without a male relative, they ultimately perished waiting for their relatives to return home and take them to a safe place.

Women as Agents to Adaptation

The goal of adaptation strategies is to reduce vulnerabilities to climate induced change in order to protect and enhance the livelihoods of impoverished people. Experience shows that vulnerability is differentiated by gender and thus adaptation to climate change will be dependent on issues such as wealth, technological power, access to information, all of which are major problem areas for women. Nevertheless, implementation of this knowledge in practical action is lacking.

To support the integration of gender knowledge into adaptation policy and planning, it is necessary to train planners and raise their awareness of gender issues. Women can be key agents of adaptation and mitigation to climate change in their role as stewards of natural resources 68% of the population active in agriculture are women.[89] For example, it is estimated that 59% of the world's food production – or as high as 80% in some parts of Africa – rests squarely on the shoulders of women. As such, women are perfectly situated to form the front line in increasing the sustainability of agricultural water use. However, to do this they must have access to relevant information and education about climate change, complimented by necessary means and resources. Many countries are developing national adaptation plans, and/or adaptation measures and projects. Coping with water scarcity, heavy rainfalls and floods are important issues in the adaptation debate. Equal participation of women and men is indispensable for successful planning. Additionally, gender experts should be consulted during the planning process. Overall, the integration of gender into the whole development and adaptation procedures is critical: research, consultation, planning, implementation, monitoring must be achieved supported by appropriate tools.

Therefore, it is imperative that the differentiated gendered roles of men and women in relation to water access, use and delivery are integrally considered in any discussions and policy making concerning climate change and development. Without an in depth and thorough understanding of the contextual differences affecting each sex, adaptation plans will lack the relevance and long-term vision to be sustainable.

[89] Gendered Impacts of Climate Change: A Human Security Dimension (Energia, 2000) http://www.energia.org/resources/newsletter/pdf/EN102000_denton.pdf

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This publication was funded by

Ministry of Foreign Affairs Denmark

Dutch Ministry of Transport, Public Works
and Water Management

UK Department of International Development

German Federal Ministry for the Environment