Policy and Planning Review

Paper 2

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Contents

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Acronyms

BCCTF	Bangladesh Climate Change Trust Fund
CAPA	Community Adaptation Plans of Action (Nepal)
CCSAP	Climate Change Strategy and Action Plan (Bangladesh)
COP	Community of Practice
DFAT	Department of Foreign Affairs and Trade (Australia)
DFID	Department for International Development (UK)
ET	Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FO	Farmer organization
GBM	Ganges-Brahmaputra-Meghna river system
Gl	Giga-litre (10^9 cubic meters)
GLOF	Glacial lake outburst flood
GNI	Gross national income
GWP	Global Water Partnership
HKH	Hindu Kush Himalayas
ICIMOD	International Centre for Integrated Mountain Development
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
IWMI	International Water Management Institute
LAPA	Local Adaptation Plan of Action (Nepal)
LDC	Least Developed Countries
MAF	Mean annual flow
MAR	Managed aquifer recharge
MW	Megawatt
MoU	Memorandum of Understanding
NAP	National Adaptation Plan
NAPA	National Adaptation Program of Action
NAPCC	National Action Plan on Climate Change (India)
NAPCCI	National Adaptation Plan for Climate Change Impacts (Sri Lanka)
NCCAS	National Climate Change Adaptation Strategy (Sri Lanka)
NCCSP	Nepal Climate Change Support Program
NGO	Non-governmental organization
NRM	Natural resources management
PRSP	Poverty Reduction Strategy Paper
R&D	Research and Development
SADC	Southern African Development Corporation
SAARC	South Asian Association for Regional Cooperation
UNFCCC	United Nations Framework Convention on Climate Change
WEC	Water and Energy Commission (Nepal)
WECS	Water and Energy Commission Secretariat (Nepal)
WAPDA	Water and Power Development Authority (Pakistan)
WSS	Water Supply and Sanitation
WUA	Water User Association

Executive Summary

This report assesses the suitability of the enabling water and climate related policy instruments (existing policy, legislation, strategies and plans) for adapting to the impacts of climate change on the water sector in South Asia. South Asia will be exposed to a variety of climate-related impacts as a result of climate change ranging from increased frequency and intensity of extreme events - floods, droughts and storms – to longer-term changes in climate and hydrological parameters such as earlier onset of monsoons, reductions in mean annual river flows, and rising sea-levels affecting coastal aquifers and surface waters. Each country of South Asia is exposed to a different suite of climate change impacts – Bangladesh is particularly vulnerable to sea-level rise, while Nepal faces the issue of glacial lake outburst floods (GLOFs). These impacts will have a major effect on the economies and social welfare of the countries of the region. The poor and disadvantaged, in particular, are vulnerable to climate shocks and are likely to be severely impacted by climate change.

Groundwater is already under severe pressure in parts of South Asia. Climate change is likely to place additional pressure on this resource because it is relatively isolated from the effects of increased climate variability and increased evaporation. It is essential that groundwater governance and management be improved as part of the measures to adapt to climate change. More generally, adapting to climate change does not require a new way of managing water resources – with a couple of exceptions, it simply requires better management of existing water resources. If water governance arrangements and water management practices are capable of handling the existing variability in water availability and water demand, then they are well placed to cope with increased variability and changes in availability and demand as a result of climate change.

Integrated Water Resources Management (IWRM) is the accepted paradigm for water management. It is particularly suited for adapting to the impacts of climate change on the water sector because it is intended to help manage competition for increasingly scarce water resources, it emphasizes demand management as much as supply augmentation, it is an adaptive and learning process, and it links management at the local, national and transboundary levels. Its components were grouped into five dimensions in this report – water resources knowledge, water resources governance, water resources infrastructure, planning and management, and communications, education and participation. Twelve criteria were developed from these dimensions. These criteria describe desirable characteristics of water instruments for adapting to climate change.

The water resources instruments[1] of the seven South Asian countries were assessed against these 12 criteria. Generally, the water instruments were found to contain most of the features needed for adapting to climate change. Three of the seven South Asian countries do not have approved water policies. All countries, except Nepal, recognized the potential impacts of climate change in their water instruments. All, except Sri Lanka, explicitly recognize IWRM as the basis for their water resources management. There is a widespread understanding of the importance of monitoring surface water flows and groundwater levels; for coordinating

[1] Only instruments that had been accepted by government were included in this analysis – draft instruments and those that had not been accepted are described in the report but were not included in the analysis.

actions across water dependent sectors; for extending their water storage capacity (although these development plans do not usually incorporate the effects of climate change); for undertaking basin level planning although (with the exception of India and Afghanistan) these plans do not have to include the effects of climate change; for implementing demand management as well as technical measures for improving water use efficiencies; for protecting water quality; for improving public understanding of water management; and for encouraging public participation (including disadvantaged groups) in water management.

These actions are not usually proposed specifically to help prepare a country for the impacts of climate change (although there are exceptions such as India recognizing that there will be a growing need for sediment control because of increased erosion under climate change, and Bangladesh and India advocating participation because it will help adapt to climate change at a local level). Nevertheless, by advocating IWRM principles, these water instruments establish an effective platform for adaptation to climate change as long as intentions spelt out are actually implemented and reflected in actions on the ground.

The climate change instruments of South Asian countries, together with various reports to the UNFCCC, were also examined, against six criteria, for their support for adaptation in the water sector. Overall, there is a widespread understanding of the importance of improving water resources monitoring for surface water and groundwater. Three countries, Bangladesh, Bhutan and India advocate that these data be held in a central repository and be made available when needed. A number of countries recognize the importance of specific disaster monitoring systems, such as monitoring of GLOFs in Bhutan and Nepal. Nepal specifically recognizes the importance of village-level early warning systems for floods (including GLOFs) and landslides. Three countries, Bangladesh, India and Nepal propose establishing specific Centres or Networks for research into the impacts of climate change.

Probably the biggest gap in water instruments is the absence of agreed water policies and legislation in three countries – Nepal, Pakistan and Sri Lanka. Consequently, these countries lack a coherent response to water problems and are reliant on sub-sector instruments or the policies of water-related sectors such as environment, energy and/or agriculture. Three countries – Afghanistan, Bangladesh, and Bhutan –do not have a national climate change instrument, and so lack a guide to implementing their adaptation actions. Four of the seven South Asian countries clearly recognize and incorporate climate change and its impacts in their water instruments. India has a full section on climate change adaptation in its Water Policy while two others acknowledge the importance of climate change.

All countries have established coordinating institutions although the composition and authority of these bodies varies considerably from no inter-Ministerial coordinating body in Sri Lanka to a National Water Resources Council chaired by the Prime Minister in India. However, the climate change documents, while detailing many aspects of water management pay little attention to cross-sectoral coordination of water dependent institutions in spite of its importance to adaptation in the water sector.

While all countries, except possibly Bangladesh, have plans for further developing water storages, this will only provide adaptation if the design and operating rules are cognoscente of climate change. While groundwater provides an alternative water storage option, the links between groundwater and climate change have not been explored in detail in South Asia.

Most South Asian countries with their many large and small transboundary rivers recognize the need to take a regional approach to climate change adaptation, not only to tackle regional issues such as large-scale flooding but also to promote data sharing, research and development and capacity building amongst national institutions.

There is an emphasis on technical methods for improving water use efficiencies, although non-technical methods can be effective and are often cheaper. Conjunctive use and reuse of treated wastewater are also proposed to augment irrigation water supply, although the latter carries considerable health risks unless stringent water quality guidelines are in place and enforced. Bangladesh, Bhutan, India, Pakistan, and Sri Lanka all have special provisions in their water policies to protect groundwater quality, while India has developed a draft model bill for groundwater. India has a clear strategy of rainwater harvesting and artificial recharge using treated wastewater to remediate overdrawn aquifers.

While all countries support community-level participation in adaptation activities in their climate instruments this is often seen as a top-down activity. However, Nepal has now instituted about 90 Local Adaptation Plans of Action while Bangladesh is recognized for its local responses to climate-induced disasters.

This analysis suggested a number of topics that could be developed under phase 2 of this project to assist South Asian countries in the climate change adaptation.

1. Background

This report is one of three commissioned by the World Bank to assess opportunities for adaptation to climate change in the water sector[2] in South Asia. Report 1 describes current scientific understanding of the predicted impacts of climate change on water resources and associated risks in South Asia, while Report 3 assesses the government financial, economic and institutional landscape in South Asian countries for adapting to climate change. This report (Report 2) assesses the suitability of the enabling policy frameworks (existing policy, legislation, strategies and plans) for adapting to the impacts of climate change in Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. The analysis includes surface water and groundwater and the major water using sectors (water supply and sanitation, agriculture, energy, industry and the environment).

1.1 Water Resources in South Asia

The following summary of the water resources of South Asia, the main water uses, and the major climate induced risks is taken from Paper 1 and from FAO[3]. More than half of the surface area of South Asia is drained by three major river basins: the Ganges-Brahmaputra-Meghna (GBM) River System, the Indus River Basin and the Helmand River Basin. The remaining areas comprise the numerous watersheds of peninsula India, the river basins of Sri Lanka, the rivers of northern and western Afghanistan, smaller rivers in Baluchistan, and coastal rivers of Bangladesh.

1.2 The GBM River System

The GBM River System has an annual average flow of 1,310 km^3 which originates primarily during monsoon rains from June to September. The Ganges river basin in India and Nepal has an annual groundwater yield of 108.5 km^3, while the Brahmaputra river basin in Assam (India) has a groundwater yield potential of 10.7 km^3. Groundwater recharge is lower in Bangladesh, estimated at 21 km^3/year. The groundwater resources in Bhutan are estimated to be limited and have yet to be well developed.

Irrigation represents 88% of water usage in the GBM. Other water uses, such as hydropower, recreation, and navigation are rapidly increasing, due largely to changing lifestyles associated with socioeconomic development. Rapid urbanization is affecting water demands and water quality, especially in the Ganges River Basin. Water from the Ganges River is heavily used, compared to the waters of the Brahmaputra and Meghna Rivers, with seven Ganges sub-basins in India using more than 50% of their available water resources.

[2] The water sector encompasses both water resources (i.e. water in nature) and the water using sectors that rely on water resources (agriculture, hydropower, industry, etc.) (see Figure 1).

[3] FAO Aquastat data (http://www.fao.org/nr/water/aquastat/countries_regions/index.stm) may differ from data held by countries because of different definitions of key hydrological variables and the currency of the information.

1.3 The Indus River Basin

River flows in the Indus Basin originate primarily from glacier melt and snowmelt in the Hindu-Kush-Himalaya mountains as well as from rainfall. The glaciers and snow pack provide perennial flows to the Indus River and some of its tributaries. If the Indus was not used for irrigation, the river would discharge about 207 km^3 of water to the sea[4] annually.

The Indus river basin contains an extensive aquifer. Prior to the development of the irrigation system, the water table was well below the surface (>30 m). With the introduction of irrigation, increased percolation to the aquifer has resulted in groundwater level rise and associated waterlogging and salinity issues in the large irrigation schemes. In other areas, such as the lower and central parts of the Bari Doab, there is severe overuse of groundwater with declining water tables (Basharat et al, 2015). The high water table now allows irrigation with dug wells and tube wells in the fresh groundwater zone. Annual recharge for all Pakistan is estimated to be 100 km^3 while annual groundwater abstraction was estimated to be 75 km^3 in 2011 (Associated Consulting Engineers et al 2011).

Irrigation accounts for 93% of the water, withdrawn, the remainder being used in the domestic and industrial sectors. Pakistan is the largest water user in the basin (63% of withdrawals), followed by India (36%), Afghanistan (1%) and China (< 1%). Currently, there is an installed capacity of about 11,000 MW hydropower generation from large dams in the basin with another 19,000 MW of generating capacity under construction[5].

The Indus basin's water resources are under considerable stress, especially in the eastern parts of the basin shared by Pakistan and India, mainly due to extensive water withdrawals to support agricultural production. Within the Indus Basin Irrigation System there are areas of over-abstraction and increasing salinity and water-logging. Nearly 87% of the Indus basin population has access to improved drinking water sources.

1.4 The Helmand River Basin

The Helmand River Basin is an internally draining basin, situated mostly in Afghanistan, although Iran is a key riparian country with significant water use. It receives snowmelt and spring water from the Hindu Kush mountains and has a mean annual flow of about 15 km^3, although this flow is subject to extreme inter-annual variation due to the semi-arid climate. River flows are highly seasonal, with droughts and floods being common.

The latest water use data for the Helmand River basin are from 1998. They show a total surface water and groundwater withdrawal of about 17 km^3, almost all of which was used for agriculture. Groundwater withdrawal is mostly from shallow unconfined aquifers, although deeper confined aquifers are now being developed for domestic and municipal water supply (Rout, 2008).

[4] Associated Consulting Engineers et al (2011) estimate that the mean total annual streamflow of the Indus River is 175 km^3 of which 130 km^3 are diverted for irrigation.
[5] https://sandrp.wordpress.com/2013/07/06/hydropower-performance-in-indus-basin/ 2013.

1.5 Climate-Induced Hazards in South Asia

South Asia is exposed to a variety of climate-related risks due to the geo-climatic characteristics of the region, many of which frequently transcend national boundaries. The three main types of climate-related risks are floods, droughts and storms.

Due to the high intensity of monsoonal rains, the large rivers of the region regularly flood, causing widespread damage and, sometimes, large losses of life. Severe flooding in 2007 along the Ganges and Brahmaputra rivers affected over 13 million people in Bangladesh; flooding in Pakistan in 2010 severely affected 20 million people (Shah and Lele 2011). At the end of 2015, heavy rains caused severe flooding in Chennai. Storms and cyclones are additional climate hazards that cause flooding across coastal regions of Bangladesh, India, Pakistan and Sri Lanka. Excess rainfall can cause local flash flooding, mostly in mountainous areas. Glacial lake outburst floods (GLOF) are a particular type of flash flood that occurs in the HKH mountains when unstable terminal lakes, formed by retreating glaciers, breach their walls.

Droughts cause the greatest number of deaths and the greatest economic losses of all climate-induced hazards in South Asia. Droughts not only reduce surface water availability but also reduce groundwater recharge. In some cases, declining groundwater levels are accompanied by saltwater intrusion into aquifers.

High-intensity precipitation causes erosion and landslides, particularly in the foothills of the HKH. The resulting high riverine sediment loads can cause siltation of dams reservoirs and channels. By the end of 2020, sedimentation is expected to reduce the storage capacity of three of Pakistan's major reservoirs, Tarbela, Chashma and Mangla, by 32%, while sedimentation of the GBM delta impedes navigation during periods of low flow and contributes to flooding (Government of Bangladesh 2001).

Groundwater, too, is under severe threat in parts of the region. Some threats to groundwater, such as saline water intrusion, pollution and land subsidence, are effectively irreversible in the short- to medium-term; others, such as over-abstraction, are technically reversible although it has proven to be extremely difficult to control in practice.

1.6 Impacts of Climate Change on South Asian Water Resources

Across South Asia, average temperatures are predicted to increase (although not uniformly) as a result of climate change with heat waves occurring more frequently. Changes in precipitation will be quite varied, with recent projections based on IPCC5 results (IPCC 2014) showing increases in annual precipitation across the Himalayan region, Nepal and Sri Lanka with smaller increases in Bhutan. There will be a reduction in annual precipitation in lower parts of Afghanistan and across India, Bangladesh and Pakistan. There will be an increase in rainfall extremes (see Paper 1 for details).

Nepal and Shreshta (2015) in their review conclude that there may be little change (or a small increase) in streamflow in the Indus Basin while overall water availability is likely to be maintained in the Ganges Basin to mid-century while, in the Brahmaputra basin, there is likely to be a reduction in upstream water supply. There is likely to be a marked change in seasonal distribution of flows in the Indus Basin because of its relatively high reliance on

snow and ice melt, while the changes in seasonality of flows in the Ganges and Brahmaputra Rivers could lead to increased flooding.

The consequences are increased demand for water for irrigation because of the temperature increases, leading to increasing competition for water even in countries predicted to receive increases in precipitation unless there are significant improvements in water use efficiencies. The increased variability in precipitation is likely to cause increased frequency and intensity of droughts and floods.

Groundwater recharge will be affected by climate change, although it is difficult to predict the direction or magnitude of the change (Clifton et al 2010). However, given that groundwater is more compatible with a hotter and more variable climate than is surface water (because it is protected from evaporation and is buffered against extremes), it is very likely that, even if recharge rates do not change significantly, there will be increased demand for groundwater.

The warming of the oceans and melting ice-caps is causing sea-levels to rise. The rising sea-level, coupled with more severe cyclones and storms, means that saline waters will penetrate further into estuaries and coastal aquifers are at risk of salinization. Bangladesh is highly vulnerable to rising sea-levels, although coastal regions of Pakistan, India and Sri Lanka will also be affected.

1.7 Methodology

The report assesses the extent to which the policy instruments of South Asian countries are prepared to adapt these likely effects of climate change. The assessment is based on a desk study of water resources and climate change documents available on government websites and the websites of international agencies and NGOs, together with analyses and critiques of policy environments published in academic literature. In some cases, these documents were not available in English and could not be included in this analysis.

Being a desk study, the analysis did not include information from interviews with government officials or other in-country sources. In particular, it does not examine the success with which the various policy instruments have been implemented. The draft report was circulated to experts in four of the seven countries (Bangladesh, India, Pakistan, and Sri Lanka) for comment before being finalized.

Table 1 illustrates the range of adaptation options for responding to the different risks arising from climate change. The primary risks arise from changes in climate and marine parameters, whereas the secondary risks arise from the consequences of those primary changes. Thus floods and droughts both arise as a result of changes in precipitation, while some coastal aquifers will experience decreases in water quality because of sea-level rise.

Table 1. Climate related risks to water resources and potential adaptation actions

Climate Risks	**Knowledge**	**Governance**[6]	**Infrastructure**	**Planning/Management**	**Communications / Education / Participation**
1. Primary risks					
a) Changes in precipitation (especially monsoon)	Research; weather monitoring	Coordination between meteorological, water and agriculture agencies	Dams; inter-basin transfers; groundwater recharge (including artificial options)	Flexible irrigation management systems; inter-sector responses to assist adaptation	WUAs and FOs involvement; capacity development; communication to farmers and other stakeholders
b) Sea-level rise[7]	Monitoring; research	Coordination between water agencies, agriculture and other water using sectors, and coastal authorities	Embankments; sub-surface groundwater barriers, maintaining and restoring natural shorelines	Groundwater use plans; controls over groundwater use;	Involvement of coastal communities; capacity development
c) Temperature extremes	Research; monitoring	Coordination between water, energy and productive sectors	Soil and water conservation; improved water supply infrastructure	Mapping trends and designing for peak demands	Prevention of risk through public information and information sharing
2. Secondary risks					
a) Floods	Monitoring and early warning systems	Coordination (inter-agency, government-public)	Embankments; Dams; flood refuges	Flood management plans; restrict development on floodplains; flood mapping; flood insurance	Public awareness of flood risk areas; capacity strengthening
b) Droughts	Weather prediction and early warning communications;	Allocation priorities and planning mechanisms;	Dams; inter-basin transfers; groundwater development	Water allocation plans; conjunctive use; demand management including	Involvement and sharing local solutions; capacity development

[6] Note that some governance actions transcend specific threats – separation of regulation and operations leads to good governance
[7] Includes only water resources threats from sea-level rise (principally contamination of coastal aquifers)

	research; monitoring	coordination between agriculture / power / water resources / water supply; local institutional capacities to manage scarce water resources and improvise		pricing; water efficiency technologies; irrigation and urban water management; recycling and reuse	
c) Reduction in groundwater recharge	Monitoring and characterization of aquifers; research into groundwater; database on groundwater-related information,	Coordination between agriculture, domestic water supply, industrial water use, water resources; public ownership of groundwater	Check dams, recharge ponds, managed aquifer recharge development	Groundwater use plans; controls over groundwater use including indirect regulation; artificial recharge; conjunctive use	Awareness of groundwater limitations; capacity development
c) Increased erosion, landslides and sedimentation	Research into soil management and protection	Coordination between land, water, energy and other agencies	Sedimentation dams	Land management; riparian management; soil conservation	Awareness of soil loss; participation and local solutions; capacity development
d) Reduced water quality (surface water and groundwater)	Monitoring; research into water quality treatment	Coordination between water resource and industry / water supply and sanitation agencies	Wastewater treatment and pollution treatment plants	Water quality standards and enforcement; wastewater and pollution treatment including through incentives and disincentives; recycling and reuse	Awareness on pollution risks and prevention measures, polluter pays principle
e) Glacial Lake Outburst Floods (GLOF)	Research; monitoring and early-warning systems	Coordination between departments working on disaster management, geology, hydro-meteorology	Artificial lowering of lake levels	Hazard and risk management protocols, planning for natural disaster management	Public awareness of flood risk areas; opportunities to effectively participate in local infrastructure development and their O&M; capacity strengthening

These options fall within five groups of Integrated Water Resources Management (IWRM) attributes – knowledge, governance structure, infrastructure, planning and management activities, and communications/participation/education. These groups were taken and extended from an earlier analysis of climate change adaptation for the Zimbabwean government that had been adapted from a report to the Southern African Development Community on climate change adaptation in the water sector (SADC 2011).

1.8 Report Outline

The report consists of five chapters. The next chapter (Chapter 2) introduces IWRM and explains why it provides many of the features needed for adapting to the impacts of climate change. Chapter 3 analyses the water resources policy environment in each South Asian country against 12 criteria (defined in the chapter) that describe the adequacy of these instruments for adapting to climate change. Chapter 4 analyses each country's climate change instruments for their inclusion of water resources adaptation measures. Chapter 5 summarizes the findings on the extent to which each country's water and climate change policy environments are compatible with each other and provides the tools for adapting to changes in water availability and water demand as a result of climate change. It also contains possible topics for Phase II of this work. Appendix 1 contains a detailed description of the contents of the various water resources instruments.

2. Integrated Water Resources Management and Climate Change Adaptation

Integrated Water Resources Management (IWRM) is an approach that seeks to improve the efficiency, equity and flexibility with which a country's water resources are managed. These are the attributes required for adapting to climate change. It is a framework that is widely embedded in water and climate policy instruments in South Asian nations.

2.1 Integrated Water Resources Management

IWRM is defined as "a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership, 2000 p22). This definition makes it clear that IWRM incorporates both development as well as management of water resources. It also states that IWRM is a process rather than an end result, with benefits arising from the cycles of learning that arise as water management practices are improved.

The "integration" idea in IWRM carries a number of meanings. Most importantly, it refers to integration of water-dependent sectors (including irrigation, hydropower, and domestic water supply) in decisions about water use; but it also includes integration of decisions by those upstream on a river with those who are affected downstream; integration of the management of water quantity and quality; integrated management of connected surface water and groundwater systems; integrated management of water bodies and connected catchments; and the integration of freshwater and connected estuarine and marine systems. Essentially, IWRM is advocating the management of the complete water cycle at a watershed scale as far as possible, with input from the water user community. However, IWRM also recognizes that some tasks can only be undertaken at state or national scale such as managing transboundary water and establishing the rules by which water management is to occur.

Some of the key features of IWRM are (Global Water Partnership 2000):

- Taking an *inter-sectoral approach* to water resources management and development. Coordination across sectors is essential because links between activities within a watershed are not always understood within sectoral Ministries. It is common to find Ministries with nearly impermeable barriers between them, and with technically competent staff who pursue narrow sectoral objectives (see Paper 3). Establishing a genuinely inter-sectoral approach is probably the most contentious feature of IWRM because it often upsets established power relationships.
- As far as possible, management should be devolved to a *basin level* because this is the natural area within which many water-related decisions are inter-dependent and need to be managed. Decentralization has proven contentious partly because it challenges the authority of centralized water management

agencies and partly because river basins do not match existing institutional boundaries (see Paper 3). It can also be difficult to recruit trained staff to regional areas.

- Managing water as *efficiently* and cost effectively as possible. This includes assessments of surface water and groundwater resources, reuse and recycling of water, and evaluation of environmental and social impacts of all distribution and water use decisions.
- Strengthening *demand management* through establishing prices for surface water and groundwater use that reflect its full value, introduction of water efficient technologies and a sense of responsibility amongst water using groups, and establishment of decentralized water management authorities.
- Ensure *equitable access* to water by establishing water user associations that provide a voice for individual and community water users, including marginalized groups. It is also important to consider equity considerations within policies, strategies and plans for infrastructure investments and management activities by, for example, extending water supply to poor communities.
- *Establishing policies* so that government intentions are clear regarding over-arching principles such as state ownership of water, ensuring polluters pay, establishing water quality standards, and introducing market-based regulatory mechanisms. This should be backed by legislation that provides institutions with the authority to implement these policies.

IWRM means using different management instruments in a coherent and collective manner under systems of resource governance that engage stakeholders (as users) alongside planners in resource allocation and management decisions.

Water resources are commonly depicted in the IWRM framework as constituting the handle of a comb (Figure 1) where the teeth of the comb are the various sectors that use or depend on these water resources. The environment is included as a water-using sector along with irrigation, energy and water supply because the environmental requires water to provide beneficial ecosystem services such as mangroves that provide storm surge protection and trap sediment; floodplains that attenuate peak flood events and allow the recharge of alluvial aquifers; and removal of nutrients and other contaminants to make water more potable for downstream domestic consumption. In this report, the combination of the water resources sector and the water using sectors (i.e. the whole comb) are referred to as the water sector.

IWRM can be used to protect water quantity and quality in the natural environment (surface water and groundwater) and to plan and manage the access of the various water using sectors to the resource. Figure 1 shows that provision of infrastructure is an essential element of IWRM, along with the policy/institutional framework needed to implement integrated management, the use of a range of management instruments (described below), and attention to the political economy of water management including the norms and issues of each jurisdiction within which IWRM is to be applied.

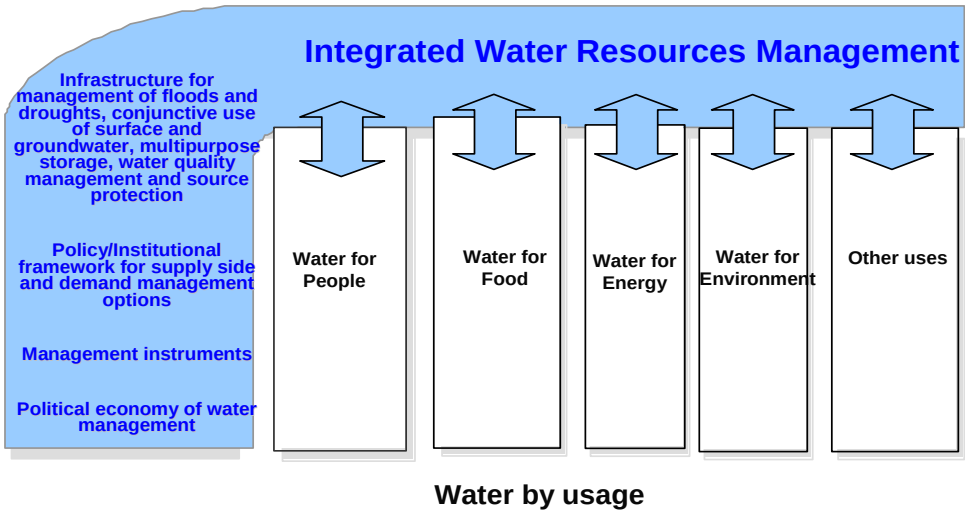

Figure 1. Conceptual framework of Integrated Water Resources Management (*source:* adapted from Global Water Partnership 2000).

There is no universal model for implementing IWRM. Different features will be needed, depending on specific issues faced by each country including water management norms and priorities as well as the state of knowledge about water resources. Twenty years of experience shows that implementing IWRM is almost always slow and incremental. It is worth agreeing on an implementation strategy with agreed milestones and timetables but, at the same time, these should be open for review and modification as experience is gained with what works and what doesn't.

2.2 Limitations

A number of commentators have criticized IWRM on both conceptual and practical grounds (e.g. Gain et al 2013). The principal conceptual objection is that there are so many different interpretations of IWRM that it is not possible to know what the concept means in practice (Biswas 2008). In this report we will use the above widely-accepted GWP definition. The practical objections revolve largely around the difficulty of bringing about changes that challenge existing power structures in water management. Some of the IWRM principles are certainly difficult to introduce. For example, introducing a mechanism for coordinating decisions about water development and management will always be challenging when sectoral Ministries are used to acting independently. Similarly, agencies responsible for managing water quantity and water quality do not always work together efficiently. However, it is difficult to see how progress can be made in sharing scarce and uncertain water resources without challenging some traditional relationships. Snellen and Schrevel

(2004), in their comprehensive review of IWRM, conclude that, in spite of the difficulties of implementation, "It is generally accepted that to manage water resources there is no alternative to IWRM" (p14).

Consequently, we have structured this paper around IWRM concepts because they remain the best blueprint for improving water management. They are widely accepted amongst South Asian governments as reflected in most water and climate policies, even though policy implementation may face obstacles.

2.3 IWRM and Climate Change

Climate change affects many sectors (irrigation, water supply and sanitation, hydropower generation, industry and tourism) through changes to water availability, changes in water demand and increases in the risk of extreme events. Consequently, a number of reports conclude that water is the medium through which most early climate change impacts will be felt (Alavian et al 2009, World Water Council 2009, Sadoff and Muller 2009a, Global Water Partnership 2007) through changes to the water cycle. Water also multiplies some of the impacts of climate change. For example, a 1% change in annual average precipitation often translates into a 4-5% change in runoff and streamflow. Thus, adapting to the effects of climate change means, to a large part, adapting to changes in water availability, water demand and water-related risk.

An important point is that adaptation to climate change is fundamentally about improving existing water management rather than undertaking any fundamentally new approach. Shah and Lele (2011), in their report from an IWMI/GWP workshop on adapting to climate change in the water sector in South Asia, concluded that "climate change adaptation does not call for a *different* way of managing water resources; we need to simply do a far better job of planning and managing our water resources than we have done so far" (p14). Having said this, there are two additional topics that need to be added to the suite of existing water management activities – the effects of non-stationarity of climate parameters (see Paper 1) now need to be accounted for (in, for example, monitoring, modeling and establishing infrastructure design standards), and the impacts of sea-level rise on coastal surface water and groundwater systems need to be added to existing coastal water quality concerns.

Adoption of IWRM principles means that water users and water managers can adapt to climate change by using water more efficiently and equitably where there is increasing pressure on water availability, and managers can respond more flexibly in the face of increasing variability. Consequently, IWRM is well placed to be the basis for adapting to the effects of climate change for a number of reasons:

1. If countries follow a strictly sectoral approach to adaptation then they risk exacerbating competition for water resources. For example, a pursuit of food security to respond to reduced water availability or increased variability because of climate change may cause problems in hydropower generation and provision of water for water supply and sanitation. Also some mitigation strategies (such as a shift to hydropower generation or increased reliance on biofuels) can have water resources implications. In reality, trade-offs will be

needed between competing water demands. IWRM, with its emphasis on collaboration and consultation, provides tools for dealing with these conflicts (Sadoff and Muller 2009a, b).

2. IWRMs emphasis on water use efficiency and demand management is also important, especially where water shortages are likely to increase because of shifts in demand or reductions in water availability. Similarly, coping with existing climate variability through IWRM helps adapt to increases in water variability from climate change (CAPNET 2009). IWRM includes infrastructure and institutional responses, demand management and supply augmentation, as well as structural and non-structural approaches to efficiency (Box 1).

3. IWRM is a reflexive learning process intended to allow for modifications as circumstances unfold. As Slootweg (2009) points out, developments in society such as population growth or economic development are already strong drivers of change in water demand – climate change adds yet another layer of complexity. IWRM can cope with this, by providing robustness and flexibility in solutions

4. Adaptation will require better information and more responsive institutions together with both infrastructure investments and structural and non-structural responses at all levels. IWRM offers a coherent way to implement these responses (Global Water Partnership 2007).

5. IWRM provides the tools to promote adaptation at all levels in a coherent way (Sadoff and Muller 2009a, p16). "The impacts of variability, aggravated by climate change, will have to be addressed at different levels. Individual farmers, commercial organizations, urban residents and national governments will all have to engage with the issues and take difficult decisions. Because decisions at all levels can affect the holistic resource, they will have to be coherent with one another if they are to be effective."

Box 1. Possible IWRM activities to respond to climate change.

In areas of water stress: Adaptation interventions could consist of:

- Water pricing;
- Seasonal water rationing during times of shortage;
- Adapt industrial and agricultural production to reduce water wastage;
- Increase capture and storage of surface run-off;
- Reuse or recycle wastewater after treatment;
- Desalination of salty or brackish water;
- Better use of groundwater resources; and
- Rainwater harvesting.

In areas where water quality is affected, possible measures are:

- Improvements to drainage systems;
- Upgrading or standardizing of water treatment;
- Better monitoring; and
- Special measures during high precipitation seasons

Source: CAPNET 2009

There are also shortcomings with using an IWRM approach to climate change adaptation. The World Water Council (2009) cautions that even though IWRM advocates a multi-sectoral approach, its implementation is inevitably limited by sector boundaries. "Sectors outside the water sector may be totally ignorant of the principles of IWRM. For example, energy supply, tourism, or agriculture all have to adapt to potential water stress or water-related hazards as a result of climate change. Yet, there are few mechanisms to get a foothold for IWRM in these sectors". Gain et al (2013) assessed six principles of IWRM against four desirable characteristics of adaptive approaches. While they conclude that, overall, IWRM does enhance adaptive responses to climate change, they see a need for IWRM to be more flexible if it was to be used to respond to the effects of climate change.

This report place emphasis on groundwater management because groundwater is likely to become more important as a source of water as climate change advances because, unlike surface water, it is shielded from evaporative losses and better buffered against increased climate variability. Surface water and groundwater are closely linked and should be managed together. At the same time, groundwater balances will be affected by climate change although there is considerably more uncertainty about the effects than there is with surface water (Box 2).

Box 2. Regional groundwater vulnerability under climate change.

Clifton et al (2014) have constructed an index expressing the vulnerability of the World Bank's six regions to the likely effects of climate change. The index incorporates four criteria:

- sensitivity: current level of exploitation of groundwater resources relative to average annual recharge (after IGRAC, 2004);
- exposure (recharge): the magnitude and trend in changes in rates of groundwater recharge under 2050 climate change projections (after Doll and Florke, 2005);
- exposure (sea level rise): the exposure of regional water resources to sea level rise and contamination due to storm surge; and
- adaptive capacity: wealth, as measured by per capita gross national income, as a proxy for capacity to adapt (GNI).

Region	Sensitivity	Exposure (recharge)	Exposure (sea-level rise)	Adaptive Capacity	Vulnerability
East Asia & Pacific	Moderate	Increase	Medium	Moderate	Moderate
Europe and Central Asia	Low	Increase	Low	High	Low
Latin America & Caribbean	Moderate	Reduction	Medium	Moderate	Moderate
Middle East & North Africa	High	Uncertain	Low	Moderate	Moderate
South Asia	Moderate	Negligible	High	Low	High
Africa	Moderate	Reduction	Low	Low	High

The assessment suggested that Europe and Central Asia is the least vulnerable region to the effects of climate change on groundwater resources, while South Asia and Africa are the most vulnerable.

Source: Clifton et al (2014)

3. Water Instruments and Adaptive Capacity

3.1 The Five Dimensions of IWRM

For convenience IWRM can be divided into five dimensions relevant to discussion of climate change adaptation – water resources knowledge, water resources governance, water resources planning and management, water resources infrastructure, and education/participation/communications. These dimensions are based on an earlier study of climate change adaptation in the water sector in Zimbabwe (SADC 2011, Davis and Hirji 2014). If a country has established an effective water information system, a good governance framework, has plans for water infrastructure investments to provide flexibility, has instituted efficient and equitable water management practices, and has established good education, communications, and participation strategies then it is well positioned to adapt to the impacts of climate change.

Twelve key criteria were developed from these dimensions. These criteria do not cover all possible actions, based on the author's judgement of the most requirements for adapting to the impacts of climate change. These criteria are used in the next section to assess the status of IWRM in each South Asian country, and hence its preparedness to adapt to climate change in the water sector.

3.2 Water Resources Knowledge

Staff in water resources and water-related institutions need to be properly trained in IWRM as well as in the management of impacts that result from climate change. This may require developing training courses and establishing centres of excellence in water resources and climate change and/or establishing guidelines on how to effectively implement these provisions.

They need access to the best available information from monitoring networks as well as from scientific models of surface water and groundwater quantity and quality and how these are affected by climate change. These monitoring and modelling requirements apply to surface water and especially to groundwater where there is usually much less information and growing demand. Where water information is collected by institutions other than departments of water resources (e.g. Ministries of Health or Environment), then the information needs to be freely shared so that it is available for decision making.

> *Criterion 1. Undertake surface water and groundwater monitoring of change in state so that there is a factual basis on which to base strategies of adaption to climate change.*

3.3 Water Governance

Water needs to be treated as a common pool resource, managed by the state on behalf of the people, rather than as an individually owned resource (Schluter and Pahl-Wostl 2007). Water users are licensed to use the water for various purposes including abstractions for consumptive uses such as irrigation, flow-through for non-

consumptive uses such as hydropower, and as a sink for discharging wastes. State management helps institute equitable access to water, particularly when it is scarce – to prevent, for example, upstream users abstracting water regardless of downstream impacts. Of course, this upstream-downstream conflict remains with transboundary waters where water should be treated as a shared resource to be used for mutual benefit under agreements that provide rules for water sharing.

Criterion 2. Agreement that water (surface water and groundwater) is held in trust by the State rather than owned by individuals.

Establishing an effective water governance framework that promotes clear responsibilities with coordination between institutions with an interest in water resources is essential for adaptation to climate change. Coordination between water resources managers and water-using sectors of all decisions that affect a number of sectors is probably the most important governance action, in order to improve allocative and technical efficiency with which water is used and help prevent inter-sectoral and upstream-downstream disputes over access to water. Often a Water Department or Water Ministry is established to have overall responsibility for water resources management and to undertake coordination with water dependent sectors. Good governance can also include establishing the right of the environment as a water using sector, separation of regulatory institutions from water operations to avoid conflicts of interest, instituting independent bodies to establish water prices to avoid political interference, ensuring that policies and practices in some sectors do not have perverse influences on water availability and quality elsewhere.

Criterion 3. A policy framework that provides a common set of objectives across all water relevant sectors and a means for these sectors to work effectively together

IWRM advocates that river basins be designated as the primary unit of management and that this is most efficiently implemented by establishing river basin authorities with responsibility for establishing and implementing water plans. Good governance also includes establishing means for community involvement in water management through WUAs or other such groups. Governance requires that cooperative mechanisms be implemented for managing transboundary surface waters and groundwater.

Water governance also includes establishing clear policies and strategies that are widely agreed and understood, coupled with legislation and regulations to implement these policies. Recognizing climate change as an important influence on future water management in these policies and strategies, supports a country's ability to respond and implement adaptive actions.

Criterion 4. Recognition of climate change impacts in the water instruments and inclusion of adaptation actions

3.4 Water Resources Infrastructure

Dams help manage variability. Having sufficient water storage will become increasingly important as greater rainfall variability and reduction of ice and snow as a result of climate change, result in increased streamflow variability (see Paper 1 for details). Dams provide water for irrigation, hydropower, industry and domestic consumption, so contributing to both climate adaptation and mitigation efforts. An important caveat is that additional infrastructure can only provide a buffer against increasing variability if it is constructed and operated according to design rules that take account of climate change. Thus, new infrastructure, such as hydropower dams, needs to be accompanied by a review of design criteria and operational rules to ensure that it is adaptive to climate change – including coping with future extremes.

Aquifers provides a source of water that helps meet increased variability and existing groundwater supply can be augmented through artificial recharge (managed aquifer recharge (MAR)). Smaller scale infrastructure such as household and community water tanks and rainwater harvesting can also help provide water during droughts. But dams can also alter the patterns of river flow so that they provide too little or too much water to downstream ecosystems and communities, thereby lessening their ability to adapt to climate change. Infrastructure developments that interrupt flows (dams, weirs, barrages) need to be operated according to environmental flow plans that minimize downstream disruptions.

> *Criterion 5. Implement an investment program to develop sustainable water storage infrastructure to help smooth out peaks and troughs in water availability while aiming to preserve environmental flows*.

Water treatment plants make a major contribution to public health while wastewater treatment plants help maintain water quality for users downstream. Recycling of storm water and wastewater for non-potable uses also reduces pressure on water supplies in areas subject to reduced water availability as a result of climate change.

Dams can also reduce downstream flooding, while embankments and levees can protect critical areas from floods (although they may simply divert floodwater to other areas), while canals and pipelines can move water from areas of abundance to those of shortage.

> *Criterion 6. Implement an investment program to provide protective infrastructure against floods and water transfer to address areas of scarcity*

Not all investments need be directed towards new infrastructure. Rehabilitating and improving existing infrastructure can often be more cost effective than constructing new infrastructure.

3.5 Water Resources Planning and Management

There are numerous actions involved in good water resources planning and management that help adapt to the impacts of climate change. They include undertaking assessments to establish the size and dynamics of the water resource; and

producing basin level water use plans for allocating surface water and groundwater amongst competing users.

Criterion 7. Institute water allocation plans at basin level that are developed collaboratively with all water users to establish principles of equitable use

IWRM advocates that demand management methods be used to enhance efficiencies and reduce wastages where there is increasing competition for the resource, as a result of reduced water availability and increased evaporative water losses from climate change. Demand management includes establishing realistic prices for water, public education and participation, and technical measures such as reducing leaks and illegal connections, and water saving technologies in domestic water supply. Recycling and reusing water, and conjunctive use of surface water and groundwater makes more efficient use of existing resources.

Water quality guidelines and regulations are essential for water recycling and reuse, especially where treated wastewater is the water source. Technical guidelines and coordination between surface water and groundwater managers are also important for conjunctive use.

Criterion 8. Introduce demand management methods, reuse and recycling, and conjunctive use to make most efficient use of water resources

There are many other techniques to use water more efficiently. Irrigation technologies such as drip and sprinkler irrigation can be employed where practical; irrigation operating procedures can be optimized; and industrial production procedures can be modified to reduce water use and reduce contamination (and therefore expensive need for treatment). MAR requires scientifically established standards to ensure that groundwater is not contaminated with chemicals, salt or pathogens from the source water and that recharge does not preclude important usages downstream, including environmental flows.

Criterion 9. Apply technical efficiency measures in the main water using sectors

Protecting surface water and groundwater quality is also an important part of water resources management. Not only does this provide more useable water for irrigation and water supply in the face of increased evaporation and, in some places, reduced water availability as a result of climate change. Water quality protection measures include catchment/watershed protection to reduce erosion and sediment loads; protecting riverine vegetation that intercepts sediments and contaminants; and controlling industrial, domestic and irrigation discharges to surface water and groundwater. Aquatic environments should also be protected so that important environmental services are maintained.

Regulations on land use and land clearance and zoning schemes can be used to help protect watersheds, while water quality discharge standards are important regulatory devices for controlling discharges to waterways and protecting aquatic environments. Discharges to groundwater systems should normally be banned because of the

difficulty of policing water quality and the great difficulty of remediating groundwater once it is contaminated.

Criterion 10. Protect water quality in rivers and aquifers and prevent erosion in watersheds to make available water more useable

3.6 Education, Participation and Communications

Many of the actions necessary to improve water management are unpopular amongst sectoral interest groups as well as the general public. Vesting ownership of water in the state can challenge traditional beliefs amongst individual landowners; an integrated collaborative approach to decisions about access to water can threaten the rights of dominant sectors to make independent decisions about water use; and instituting basin level planning and management can undermine the authority of central water resources ministries. The delays in water reforms in Sri Lanka, Pakistan and Nepal can be partly traced to a lack of public and other stakeholder understanding and acceptance of misinformation about proposed changes. It is essential that the general public, as well as key water-dependent sectors (and key states/provinces in federal systems) and senior decision makers and politicians, are educated about the long term benefits of reforming water management, despite any changes in long-held beliefs and authorities. In federated systems such as India and Pakistan, it is essential to establish support from state and provincial governments. Without widespread public support, IWRM approaches are vulnerable to partisan attack.

Criterion 11. Educate the public, officials and decision makers so that there is widespread support for efficient and equitable water management

One of the important principles of IWRM is the inclusion of water users in decision making. This includes educating the general public, as well as administrative and political decision makers, in collaborative water management. It specifically includes helping organize user groups such as farmers' organizations and water-user associations so that they can participate in – help to shape – water management decisions. In many cases, governments have devolved responsibility to such groups for management of irrigation areas.

Criterion 12. Ensure participation by water user groups so that local knowledge is incorporated into decisions and there is support for those decisions

3.7 Water Resources Instruments

South Asian countries have instituted a framework of policies, legislation, regulations, plans and strategies to manage their water resources. These instruments, which vary from nation to nation, have been developed in the water sector as well as in water using- and water-dependent sectors, especially in the major water-using sectors of agriculture, industry, power and water supply/sanitation (WSS). There are also regional instruments such as international water agreements that are briefly described but not analysed here (see Paper 3 for fuller description of transboundary

instruments). For example, the Indus Waters Treaty governs transboundary water management between India and Pakistan.

Policies are central to water resource management because they describe the intentions of governments concerning water management. In some cases these policies are backed up with implementation legislation, strategies and plans that provide details on how policy provisions are to be implemented. The policies and other instruments of water-related sectors – WSS, industry, irrigation or agriculture, power and environment – can also contain elements of IWRM approaches that contribute to adaptability to climate change. For example, it is common to find irrigation policies and strategies that empower local water-user associations (WUAs) to manage their irrigation districts and so potentially enable greater flexibility in adapting to changing local conditions.

Table 2 provides the full list of water-related instruments, drafted and approved, that were analysed for this paper. Appendix 1 describes the content of these instruments for each South Asian country organized under the four dimensions of IWRM.

3.8 Analytical Framework

The water resources and water-related instruments of each South Asian country are analysed in the following section against the 12 key criteria that measure whether water management is sufficiently equitable, informed, flexible and efficient for responding to the impacts of climate change. All water-related instruments are described in Appendix 1. However, only those instruments that have been accepted by government were included in the following analysis. Some policies and strategies had been drafted but have either not been supported or are so recent that they have yet to be considered by government. The government-approved instruments analysed in the next section are shown in bold in Table 2.

Table 2. Water resources and water-related instruments. Instruments in bold were used for the analysis in this section.

	Policy	Legislation	Strategy/Plan	Other
Afghanistan	• **Strategic Policy Framework for Water sector 2005** • **Agriculture and Natural Resources Policy and Strategy 2005** • Groundwater	• **Water law 2009** • **Environment law 2007**	• **Water sector Strategy 2008**	• **National Development Framework 2002**

	Development Policy			
Bangladesh	• **National Water Policy 1999** • **National Agriculture Policy 1999** • National Agriculture Policy 2010 (draft) • **Coastal Zone Policy 2005** • **National Policy for Safe Water Supply and Sanitation 1998** • National Agricultural Extension Policy (draft) 2012	• **Water Act 2013** • **Environment Conservation Act 1995** • **Environment Conservation Amendment Act 2010** • **Water Development Board Act 2000**	• **National Water Management Plan 2001**	• Guidelines for Participatory Water management 2001 • Water Rules (draft) 2015
Bhutan	• **National Irrigation Policy 2011** • **Bhutan Water Policy 2003**	• **Water Act 2011** • **National Environment Protection Act 2007**	• National Integrated Water Resources Management Plan (draft) 2016 • **National Environment Strategy (The Middle Path) 1998**	• **Water regulations 2012**
India	• **National Water Policy 2012** • **National Urban Sanitation Policy 2008** • **New Agriculture Policy 2000**	• **Water (Prevention and Control of Pollution) Cess Amendment Act 2003** • **Water Prevention and Control of Pollution Act**	• **Ministry of Water Resources Strategic Plan 2011**	

		1974 • National Water framework law (draft) 2013 • Model Bill for the Conservation, Protection and Regulation of Groundwater (Draft) 2011 • **Interstate Rivers Dispute Act 1956** • **River Boards Act 1956**		
Nepal	• **Irrigation Policy 2003** • National Water Supply and Sanitation Sector Policy 2014 (draft) • **National Rural Water Supply and Sanitation Policy 2004** • **National Urban Water Supply and Sanitation Sector Policy 2009** • **Water Induced Disaster Management Policy 2006** • **Hydropower Development Policy 2001**	• **Water Resources Act 1992**	• **Water Resources Strategy 2002** • **National Water Plan 2005** • **Renewable Energy Investment Program Plan 2011x**	
Pakistan	• National Water Policy (draft) 2006 • National		• **Water Sector Strategy 2002**	• **Pakistan 2025 One Nation-One Vision 2014**

	Water Policy (draft) 2015 • **National Sanitation Policy 2006** • **National Drinking Water Policy 2009** • **National Environment Policy 2005** • National Wetlands Policy 2009 (Draft still in draft in 2015 according to Ramsar)			
Sri Lanka	• National Drinking Water Policy • **National Rural Water Supply and Sanitation Policy 2001** • **National Disaster Management Policy 2013** • **National Environmental Policy and Strategies 2003** • **National Wetland Policy and Strategy 2006** • National Policy on Protection and Conservation of Water Sources,	• **Water Resources Board Act 1999** • **Irrigation Amendment Act 1994** • **Disaster Management Act 2005** • **Agrarian Development Act 2000** • **Mahaweli Authority Act 1979** • **National Environmental Amendment Act 1988** • **Irrigation Amendment Act 1994**		

	Catchments and Reservations in Sri Lanka 2014 (draft)			

3.9 Analysis of Water Resources Instruments

1.1 Criterion 1. Monitoring surface water and groundwater.

The need for monitoring surface water and groundwater volumes and quality is widely recognized in water sector and sub-sector instruments, except for those of Sri Lanka where monitoring is not included in the Wetlands, Rural Water Supply, or Drinking Water Policies. However, the Environment Strategy and Policy both advocate monitoring of industrial discharges while the Disaster Management Programme calls for an improved rainfall monitoring system. Nepal particularly emphasizes that groundwater monitoring needs to be expanded to provide information on both water levels and water quality in irrigation districts, while exploration is needed to locate further groundwater resources for development.

India establishes the link between climate change and monitoring. Its Water Policy says that because of climate change, more information is needed on snow and glacial dynamics, evaporation losses, tidal hydrology and hydraulics, river geometry, and erosion and sedimentation.

A number of countries point out that merely collecting data is not enough. The information is sometimes closely held by the collecting agency and not made available to other institutions. Bangladesh wants to establish a central database of ground water and surface information while India, through its Water Policy, proposes a national informatics centre to hold data (Box 3). Bhutan specifies that there should be open access to its monitoring data, as do India and Pakistan.

Box 3. India.

The Water Policy advocates improved information, including flood forecasting, flood mapping, community action plans and disaster preparedness. Also climate and hydrological data, surface water and groundwater use data, and surface water and groundwater quality data should also be monitored in each river basin. A national water informatics centre should be established and all possible data put into public domain. Because of climate change, more data is needed on snow and glacial dynamics, evaporation losses, tidal hydrology and hydraulics, river geometry, and erosion and sedimentation. Both the National Water Policy and the Framework Bill propose that forecasting systems be developed.

Sources: India National Water Policy; India Draft National Water Framework Bill

2.1 Criterion 2. Water – both surface water and groundwater – is held in trust by the nation.

All South Asian countries, except Pakistan and Sri Lanka, have clarified in their water instruments that water is owned by the people with the State adopting the role of trustee or custodian. All water extractions require a permit, although most countries provide exemptions for basic human needs and sometimes other traditional uses, such as navigation in Afghanistan. Permits are also required for discharge of pollutants to waterways and, in cases such as Bangladesh's Water Act, for diverting or impeding flows thus asserting government authority over embankments and other structures erected by land owners for flood control.

This clarification about authority over water resources applies to both surface water and groundwater in Afghanistan, Bangladesh, Bhutan, India and Nepal. This is important because in some countries there has been a traditional belief that groundwater is the property of the owner of the overlying land, sometimes supported by colonial era common law principles. This contributes to overuse of what is, in reality, a common pool resource.

Of course, all countries, including Pakistan and Sri Lanka, have long established mechanisms for assigning water rights and for sharing water but this assertion of public ownership clarifies the right of governments to implement actions to help adapt to climate change, such as controlling over-abstraction and introducing artificial recharge and conjunctive use (Box 4).

Box 4. India's Model Groundwater Bill 2011.

The 2011draft Model Bill for the Conservation, Protection and Regulation of Groundwater marks a distinct change from the previous groundwater model bills in 1970, 1992, 1996, and 2005. It clearly states that the state is the public trustee for groundwater and that everyone, not just landowners, has a right to access water for basic needs. The Bill breaks with the long-held belief that groundwater is linked to land ownership. The Bill assigns management responsibility to the lowest possible level of elected organization that encompasses the boundaries of an aquifer. These Groundwater Committees will be supported by technical expertise residing in State agencies. The Bill allows for protection zones and groundwater security plans for areas of high groundwater stress. The former allow State water authorities to control water extraction, overlying land uses and to manage potential pollution of aquifers. The latter provide priorities for access to groundwater and encourage conjunctive use. The Bill also encourages replenishment and recharge of aquifers.

Source: Cullet 2012

Criterion 3. Integrative Policy framework.

All countries, except Sri Lanka, have formally adopted IWRM principles in their water instruments. Thus, Afghanistan built its Water Policy 2008 and Water Law 2009 around IWRM; Bangladesh incorporated IWRM principles into its 1999 National Water Policy (Gupta et al 2005); India's National Water Policy requires IWRM to be the main principle for planning, development and management of water resources; and Pakistan's 2002 Water Sector Strategy states that "Pakistan's water

resources need to be developed and managed in an integrated and holistic manner in keeping with the principles of integrated water resources management (IWRM)" (p25). Bhutan has institutionalized IWRM to the point of making it a cross-cutting objective within the environment sector of the Tenth Five-Year Plan, 2008–2013 and in the draft Eleventh Five-Year Plan, 2014–2019 (Asian Development Bank, 2014).

All countries have some institutional mechanism for coordinating across water dependent sectors, although the structure and effectiveness of these mechanisms varies greatly. This is examined in more detail in Paper 3. Approaches vary from Afghanistan's Supreme Council on Water Affairs Management, chaired by the First Vice-President and containing all relevant Ministers, to India's long-established (since 1983) National Water Resources Council, chaired by the Prime Minister, to Nepal's Water and Energy Commission which has limited authority and whose role is not well recognized by some sectoral ministries (Suhardiman et al, 2015).

3.1 Criterion 4. Recognition of climate change.

Afghanistan, Bangladesh, Bhutan, India, to a lesser extent Pakistan and Sri Lanka, explicitly recognize the impact of climate change in their water sector instruments. In Bhutan, climate change is recognized as being important enough to be one of the drivers for the 2011 Water Act. In fact, an IWRM approach was adopted in the Water Act specifically to help respond to the threat of climate change (Bhutan National Environment Commission, 2016). The 2012 Indian Water Policy clearly recognizes climate change as being one of three key pressures on water availability along with population growth and increasing demand. Climate change figures prominently throughout this Policy including a detailed section on adapting to climate change.

At the other extreme, Nepal does not mention climate change in its 2002 Water Strategy or 2005 Water Plan apart from the need to study this issue by establishing a Himalayan Climate Change Study Centre. Nepal's 2006 Water Induced Disaster Management Policy surprisingly does not mention the potential of climate change to exacerbate disasters. Because Pakistan and Sri Lanka have not approved water policies, their recognition occurs through sub-sectoral policies. Pakistan's Drinking Water Policy states that climate change will affect planning and development of water supply but does not propose adaptive actions. On the other hand, Pakistan's Vision 2025 sees climate change as having a major influence on water availability and that adaptive actions need to commence soon including the construction of new storage facilities.

The Environment Policy in Sri Lanka says that management needs to be flexible to respond to changing circumstances such as the effects of climate change, while the Disaster Management Policy requires that the impact of climate change on the risk of disasters needs to be assessed. The Disaster Management Programme is quite explicit: "Climate Change impacts are likely to cause increased spatial and temporal variability in weather patterns leading to increased incidence of floods, droughts and epidemics. This would require integrating potential Climate Change impacts into Disaster Management planning and implementation including the Climate Change Adaptation practices and related local disaster preparedness capacities (Ministry of Disaster Management 2014, p21)."

4.1 Criterion 5. Water storage investment.

All South Asian countries, except Bangladesh, have plans for water storage expansion. Bangladesh, in its Water Management Plan, calls for a limited number of new irrigation schemes but does not specifically mention new storage facilities. However, the Bangladesh Water Development Board, proposed in the National Water Policy, is mandated to undertake large water-related infrastructure projects. The main water infrastructure issues in Bangladesh concern protection from floods, cyclones and storm surges described in the next section.

The Afghanistan Water Sector Strategy proposes that a National Water Resource Development Plan be prepared identifying options for dams and other storage facilities for multipurpose use (Mahmoodi 2008). The strategy already lists 31 surface water and groundwater infrastructure projects for irrigation, water supply, flood control hydropower and groundwater recharge purposes, while the National Development Framework identified urban water supply and sewage treatment infrastructure as an urgent need. Irrigation infrastructure, damaged during conflict, will also be rehabilitated under the Agriculture and Natural Resources Policy.

Pakistan, in their Water Sector Strategy, make it clear that improved water use efficiencies will not be sufficient to meet future water needs and that additional large storage will be required.

The Indian NWP requires that all projects, including hydropower projects, should be planned as multi-purpose projects. This will increase their flexibility in terms of adaptation responses to climate change. The Policy also requires all storages to be designed to take account of climate change. Nepal and Bhutan have ambitious plans to develop hydropower plants to generate export revenue by selling the electricity. Nepal's Renewable Energy Investment Plan 2011 contains details about proposed mini hydropower schemes. Hydropower development has been included in both five- and three-year plans since the 1980s.

Finally, Sri Lanka has developed a Water Use Master Plan 2013 that details possible new water infrastructure for irrigation, hydropower and WSS. This includes 10 dams in the short term for a total investment of LKR 94,000 million (USD 640 million) with a further 16 infrastructure projects in the medium-term. Inter-basin transfers are a further option for the longer term but resettlement issues are likely to arise. It is apparent that Sri Lanka has a number of surface water infrastructure options available for coping with increased precipitation variability and changes in monsoonal rainfall, if funding is available. However, no groundwater development options were examined in the Master Plan.

Expansion of groundwater use is proposed in some water instruments. Thus, the Afghanistan Water Sector Strategy's Infrastructure Report argues for the installation of more wells and extraction equipment for both municipal and rural water supply, and the artificial recharge of depleted groundwater systems. In its 2012 Water Policy India also advocated artificial recharge of groundwater, more to replenish overdrawn aquifers than to open up new groundwater systems. Nepal actively looked to

groundwater as an untapped source that would allow year-round irrigation in the terai. Pakistan recognizes that storing water in carry-over storages as well as in aquifers (because of minimal evaporative losses) constitutes a response to climate change. However, in all cases groundwater development must be accompanied by stringent regulation, monitoring and oversight together with support for strong farmer-led management groups if the problems now present in both India's and Pakistan's groundwater systems are to be avoided.

5.1 Criterion 6. Flood protection.

Floods are one of the major climate-induced water risks in South Asia as described in Paper 1. The source of the floodwaters varies from glacial lake outbursts in HKH countries to monsoonal rains in India, Pakistan, Bangladesh and Sri Lanka, to tidal surges and contamination of surface water and groundwater in low lying and estuarine areas (Bangladesh and Pakistan). Consequently, all countries include infrastructure protection against floods in their water instruments, although the extent and detail of coverage varies considerably.

Afghanistan, Bhutan and Sri Lanka make little mention of infrastructure for flood protection in their water instruments, apart from a passing reference to flood protection systems in all river basins in Afghanistan's Water Sector Strategy, although these countries report serious local flooding issues.

On the other hand, Nepal has a specific Water Induced Disaster Management Policy 2006, focused on floods and landslides to provide direction for disaster response, prevention and preparation. It includes the need for detention basins and river training works (embankments), although it does not mention the potential for climate change to exacerbate water-induced disasters in Nepal. On the other hand, Bangladesh's Coastal Zone Policy 2005 specifically links the need for flood protection infrastructure to the expected impacts of climate change, and India's National Water Policy and Water Framework Bill require that embankments and other flood infrastructure be designed to take account of climate change.

Most of the water instruments across South Asia advocate a mix of structural (i.e. infrastructure such as embankments) and non-structural measures. In the case of India, the National Water Policy 2012 advocates an integrated approach ranging from early warning systems and flood forecasting to flood preparedness and flood protection to disaster recovery. Non-structural measures include rehabilitation of natural drainage systems, changes in reservoir operating procedures and community flood planning.

6.1 Criterion 7. Basin-level water management.

All countries, except Bangladesh, Pakistan and Sri Lanka, have adopted basin-level water planning and management in their water policies or other instruments. The functions of these Basin authorities are generally similar across countries – developing water allocation plans with participation from water users (sometimes devolving responsibility to sub-basin level), issuing water use permits taking account

of water availability, monitoring water use and enforcing action if there are breaches of water use permits.

Bangladesh, in its Water Policy 1999, has opted to develop a national water management plan (developed in 2001) that recognizes different geographic areas of the country, rather than basin-level plans. However, the Water Policy makes it clear that Bangladesh is primarily interested in developing a basin plan for the whole Ganges basin and that would require greater levels of transboundary cooperation with India than have been achieved to date. Although Pakistan has adopted most of the principles of IWRM it has not included basin-level management in its 2002 Water Sector Strategy. This may be because of the dominant position of the Indus basin to water management in Pakistan – consequently, water management in Pakistan is intrinsically basin-centred and heavily influenced by the Indus Waters Treaty and relations between provinces. Sri Lanka had included basin-level water planning and management in its draft water policy of 2006 but this was not approved by government. There are agencies (primarily the Irrigation Department and the Mahaweli Authority) responsible for river basin management in Sri Lanka, but these do not undertake the planning and management functions of river basin agencies envisaged in the IWRM model and there are clear conflicts of interest with the Irrigation Ministry being both the river basin manager and the major water user in most basins.

India is the only country that specifically requires that basin-level plans take account of climate change in its water instruments. Afghanistan, while it does not require that climate change be incorporated into basin plans, does require that climate change be included in the national water resources development plan with which the basin plans need to be consistent.

Nepal points out in its National Water Plan that the correct enabling environment - policies and legislation, institutions, and management instruments - has to be in place before river basin management can be implemented. Even when this enabling environment has been established, the experience of other countries shows that it has been difficult to establish effective basin-level management agencies (e.g. South African experience). The extent to which these institutions have been established in South Asia will be examined in Paper 3.

7.1 Criterion 8. Demand management, reuse/recycling and conjunctive use.

Demand management is generally endorsed in water instruments across South Asia although the specific mechanisms by which demand will be controlled are not always spelt out. This is the case in Afghanistan's Water Sector Strategy, which has the explicit intention of elevating demand-side management to an equal status with supply augmentation to meet increasing demand, but does not provide details.

India, in its National Water Policy, has probably the most complete description of demand management and water reuse. Its National Water Policy wants to treat water as an economic good and proposes that States should introduce water regulators who can set water tariffs. It also encourages water recycling and reuse and conjunctive use of canal seepage water for irrigation. It sees demand management as a mechanism to

help combat the impacts of climate change and calls for alignment with compatible agricultural strategies. The National Agriculture Policy 2000 also promotes optimal water use through water conservation, conjunctive use, and control over receding groundwater levels.

A number of countries – Bangladesh, India, Nepal, Pakistan, and Sri Lanka – support economically realistic water prices as a mechanism to help manage demand. Nepal is already moving towards full cost recovery for groundwater irrigation, while Sri Lanka's Drinking Water Policy and its Irrigation Amendment Act 1994 both advocate establishing a water tariff that covers operating costs and promotes water conservation (although not to control demand for water).

Conjunctive use is included in the Water Plan of Nepal and in its Irrigation Policy and also in its Irrigation Policy, while Bangladesh's National Water Policy 1999 and Water Management Plan 2001 encourages conjunctive use generally. The former instrument makes special mention of its potential to help combat drought.

8.1 Criterion 9. Technical efficiency measures.

Technical measures to improve the efficiency of irrigation, urban and other water uses are widely included in water instruments. Irrigation techniques such as drip and sprinkler irrigation and better crop management are called for in the water resources and irrigation instruments of all South Asian countries except Sri Lanka. In Pakistan, there is considerable scope for improving water use efficiencies, not only to reduce demand on water sources but also to halt salinization and loss of useable groundwater. The Pakistan Water Sector Strategy estimates that there is the potential to save 5,800 Gl annually through increasing irrigation efficiency from the current estimate of 40% to 45% by 2025.

There is also considerable scope for water-efficient technologies in urban water supply systems. Two countries, Pakistan through its Drinking Water Policy 2009 and Sri Lanka through its National Drinking Water Policy, propose a number of technical means to reduce urban water wastage such as replacing old pipes, detecting illegal connections, using water saving plumbing, and replacing common outlets with individual connections (Fan 2015).

9.1 Criterion 10. Protecting water quality.

Protecting water quality from irrigation, industrial and human contaminants is often required under both water resources and environmental policies and legislation. Bangladesh seeks to control pollution through three policies – the 1999 National Water Policy, the 1998 Safe Water Supply and Sanitation Policy, and the 1995 Environmental Conservation Act and its 2010 Amendment.

Although the policies and legislation focus primarily on protecting surface water quality, there are also protections for groundwater quality in the instruments of Bangladesh, Bhutan, India, Pakistan, and Sri Lanka. The Indian Water Policy points out that groundwater quality requires special attention because of the difficulty of remediating polluted groundwater. Not surprisingly, one of the objectives of the

Indian Model Bill for the Conservation, Protection and Regulation of Groundwater is the prevention of groundwater pollution and degradation.

There is also considerable concern about preventing contamination of surface waters from erosion, landslides and consequent sedimentation across the South Asian water and environmental policies and legislation. Not surprisingly, Bhutan and Nepal have detailed prescriptions for controlling erosion and landslides in their instruments. In Bhutan the National Environment Council can declare threatened water sources as Water Management Areas where special controls can be applied, while the National Environment Strategy advocates maintenance of watersheds to reduce erosion and sediment loads. In Nepal the Water-Induced Disasters Management Policy calls for catchment conservation works to prevent landslides, and river corridor tree plantings and inclusion of environmental conservation as part of watershed conservation, while the National Water Plan proposes an environmental action plan to rehabilitate degraded watersheds to reduce erosion and the danger of landslides.

The Indian National Water Policy recognizes that climate change is likely to make erosion worse because of increased rainfall intensity. Water and land conservation should be practiced to protect river corridors, wetlands and floodplains. The Agriculture Policy 2000 also advocates watershed development programs to protect water quality.

10.1 Criterion 11. Education of the public and government officials.

In spite of the importance of building public support for water reforms, it is uncommon to find much attention paid to this criterion in the instruments analysed. However, Bangladesh recognizes in their National Water Management Plan 2001 that there is a need to improve water knowledge, and raise public awareness of sustainability, while the Nepal Water Plan 2005 recognizes the need to raise awareness of the advantages of IWRM among all stakeholders, general public, legislators, political activists, civil societies and professional societies. Sri Lanka does not recognize the need for educating the public or specific groups about water management generally, although the sub-sectoral policies on Wetlands and Drinking Water both propose awareness campaigns on the importance of wetlands conservation and watershed protection, respectively.

Pakistan has perhaps the most comprehensive requirement for public and interest group education. Its 2002 Water Sector Strategy is quite clear that public awareness is lacking on water management issues. It says that it will be necessary to improve awareness to build public support for the changes that will be necessary in water management in the short- to medium-term. In addition, the 2009 Wetlands Policy argues for a broad communications strategy to develop public awareness of wetlands and to sensitize environmental magistrates towards wetland issues and regulations, as well as designing an education campaign targeted at wetland stakeholders and users. The 2009 Drinking Water Strategy also seeks to build public awareness about water conservation to help maintain domestic water supplies.

11.1 Criterion 12. Participation by water users.

Participation by water users is widely advocated in water instruments. Irrigation and agriculture policies for some decades have pursued the establishment of Water User Associations (WUAs) and Farmer Organizations (FOs) as a means to transfer responsibility for managing irrigation infrastructure to the irrigators within irrigation districts. These organizations are often given the authority to charge water use fees and to use the funds for maintenance of their irrigation infrastructure. Although WUAs have enjoyed some success in Afghanistan, it has proven difficult to fully develop them largely because they lack a formal institutional status (Centre for Policy and Human Development 2011). The success of this devolution of responsibility varies and the factors underlying successful WUAs are often difficult to establish (Small 2011).

More generally, user participation in water resources decisions is widely endorsed in the water instruments of the seven South Asian countries examined here. Most advocate the establishment of mechanisms by which water user representatives can participate in water allocation and development decisions at basin and local levels. In most countries participation of irrigators in their districts is endorsed in agriculture or irrigation policies too. In the cases of Bangladesh, Nepal, Pakistan and Sri Lanka, the relevant drinking water policies and legislation encourage participation by water users in the development and management of water supply and sanitation systems.
The Bangladesh Agriculture Extension Policy and the Indian Water Policy make it clear that one of the reasons for advocating stakeholder participation is to advance adaptation to climate change at the local level. The Bangladesh policy says "Climate change adaptation in agricultural extension may include … documenting and promoting indigenous farmer practices against disasters and vulnerabilities" (Ministry of Agriculture 2012 p10). The Sri Lankan Disaster Management Policy also proposes that indigenous knowledge should be drawn on when responding to disasters, including those arising from climate change.

3.10 Summary

The water instruments generally contain most of the features needed for adapting to climate change. In fact, all countries, except Nepal, recognize the potential impacts of climate change on their water sectors in their water instruments. All countries, except Sri Lanka, have designed their water instruments around IWRM principles and, consequently, the 12 IWRM criteria used here are generally incorporated in these instruments. Thus, there is a widespread understanding of the importance of monitoring surface water flows and groundwater levels; for coordinating actions across water dependent sectors; for extending their water storage capacity (although these development plans do not usually incorporate the effects of climate change); for undertaking basin-level planning although (with the exception of India and Afghanistan) these plans do not have to include the effects of climate change; for implementing demand management as well as technical measures for improving water use efficiencies; for protecting water quality; for improving public understanding of water management; and for encouraging public participation (including disadvantaged groups) in water management.

These actions are not usually proposed specifically to help prepare a country for the impacts of climate change (although there are exceptions such as India recognizing that there will be a growing need for sediment control because of increased erosion under climate change, and Bangladesh and India advocating participation because it will help adapt to climate change at a local level). Nevertheless, by advocating IWRM principles, these water instruments establish an effective platform for adaptation to climate change as long as intentions spelt out are actually implemented and reflected in actions on the ground.

4. Climate Change Instruments and Water Sector

4.1 Climate Change Documents

All South Asian governments are signatories to the UN Framework Convention on Climate Change and are committed to reducing carbon emissions and undertaking adaptive actions to respond to the risks arising from climate change. As Non-Annex I parties to the Convention, South Asian countries provide Communications reports to the UNFCCC on progress with both mitigation and adaptation actions every four years. They are also required to submit Biennial Update Reports every intervening two years, although these updates are focused on mitigation actions and need not include adaptation. Not all developing countries provide these updates. In addition, all signatory countries were required to provide an Intended Nationally Determined Contributions (INDC) report to the 2015 COP21 meeting in Paris. This report focused on mitigation activities but countries were invited to include their adaptation activities if they wished.

The UNFCCC provides funding to help Least Developed Countries (LDCs) develop National Adaptation Programmes of Action (NAPAs) that focus on selecting short term, urgent adaptation projects usually using a multi-criteria decision analysis method. Once NAPAs are accepted by the UNFCCC, the LDC can apply to the GEF for funding to implement the priority projects. There are four LDCs in South Asia – Afghanistan, Bangladesh, Bhutan and Nepal – and each has prepared a NAPA.

In addition, the UNFCCC has established National Adaptation Plans (NAPs) that, in contrast to the NAPAs, describe medium- to long-term adaptation needs. NAPs can include activities that mainstream climate adaptation, into national and sub-national development and sectoral planning. No South Asian countries have submitted NAPs to date, although Afghanistan and Nepal have stated they intend to develop National Adaptation Plans and Sri Lanka has completed its NAP.

These reports to the UNFCCC constitute one group of documents that describe a government's intentions for climate change mitigation and adaptation. The South Asian Governments' own policy instruments – policies, legislation, strategies and plans – constitute a separate group. Unlike the reports to the UNFCCC, these instruments are subject to internal review and debate by all sectors of government and consequently describe the agreed position of government in dealing with climate change. Table 3 summarizes the various reports and instruments analysed in this chapter.

Table 3. Climate Change Instruments in South Asian countries.

	Policy	Legislation	Strategy/Plan	Other
Afghanistan			• National Adaptation Programme of Action 2009 • National Climate Change Strategy Action Plan (draft) • National Adaptation Plan (draft)	• INDC 2015 • First National Communication UNFCCC 2013
Bangladesh		• Climate Change Trust Fund Act 2010	• National Adaptation Programme of Action 2009 • Climate Change Strategy and Action Plan 2009	• Second National Communication UNFCCC 2012 • INDC 2015
Bhutan			• National Adaptation programme of Action 2006	• Second National Communication UNFCCC 2011 • INDC 2015
India			• National Action Plan on Climate Change 2008 • National Water Mission (under Action Plan on Climate Change) 2008	• Second National Communication UNFCCC 2012 • INDC 2015 • First Biennial Update Report 2016
Nepal	• Climate Change Policy 2011		• National Adaptation Programme of Action 2010	• Second National Communication UNFCCC 2014 • INDC 2016
Pakistan	• National Climate Change Policy 2012		• National Framework for Implementing Climate Change Policy 2013	• First National Communication UNFCCC 2003 • INDC 2015

Sri Lanka	• National Climate Change Policy 2012		• National Climate Change Adaptation Strategy 2011-2016 (2010) • Information, Education and Communications Strategy for Climate Change Adaptation 2010 • National Adaptation Plan for Climate Change Impacts 2015	• Second National Communication UNFCCC 2011 • Water Sector Vulnerability Profile 2010 • Technology Needs Assessment and Action Plans 2011 • INDC 2015

4.2 Analytical Structure

These climate change instruments will be examined to assess the extent to which they respond to six criteria described below that describe important aspects of adaptation in the water sector.

Do the climate change documents recognize adaptation opportunities in the water sector?

The IPCC recognizes that many of the climate change's impacts will be mediated, directly and indirectly, through changes in water availability and water demand. Each country's climate change documents should recognize this and explain clearly how changes in water are expected to affect the water-dependent sectors in that country as well as opportunities for adaptation in water development, planning and management. These opportunities should include both surface water and groundwater and coastal/estuarine waters, to the extent relevant in each country.

Do the documents propose strengthening the elements of IWRM as an adaptation response?

Chapter 3 analyses the extent to which the various documents incorporate good water management practices as advocated through IWRM and that would strengthen a country's ability to adapt to climate change. The major adaptation opportunities - coordination across water-dependent sectors, improving the efficiency with which water is used, controlling demand, etc., - should be reflected in the adaptation sections of the climate change documents. The water resources instruments would provide the detail of management practices but the climate change documents should be consistent with the broad outlines of the former.

Do the documents address the major water-related risks from climate change?
Each country identifies the major risks faced from climate change in its climate change documents. The documents can be expected to describe adaptation options for the water-related risks.

Do the documents recognize the importance of both top-down and bottom-up adaptation?
Many adaptation activities are best carried out at the community level and even individual level. This may be because local impacts vary, in order to take advantage of different local experiences of dealing with variability in water availability, and/or to build ownership amongst water users (see Paper 3 for more detailed discussion). However, other adaptation activities are best undertaken on a river basin or aquifer level, because they affect users of a whole water resource, while other activities need to be conducted nationally. A comprehensive climate change adaptation document should incorporate all such levels of activity.

Do the documents include regional opportunities for responding to climate change?
Water resource risks are usually best managed across a whole connected water body, including transboundary river basins and aquifers. Thus large regional floods as well as water sharing during droughts require transboundary management if they are to be dealt with effectively. Climate change documents should recognize that regional cooperation is an essential component of adaptation for countries with transboundary water bodies (see Paper 3 for more detailed discussion). Information and data-sharing, R&D and training can also be undertaken regionally to help build capacity to respond to climate change.

Do the documents recognize the importance of mainstreaming climate change into the water sector?
Climate change adaptation is usually treated as a separate government activity with its own suite of activities, separate sources of funding and management structures, usually centred round Environment Departments. However, it is most effectively carried out when adaptation is accepted and undertaken as part of the routine activities of affected Ministries. This is most apparent with water resources adaptation where, to a large extent, good water resources management also constitutes good adaptation. Mainstreaming adaptation requires education and training for staff of water dependent Ministries while still retaining coordination with central climate change authorities. One downside of mainstreaming is that it is more difficult to account for adaptation activities once they are integrated into normal Ministry activities especially from a financing perspective (see Paper 3),

4.3 Water Resources Adaptation in Climate Change documents

4.3.1 Afghanistan

Afghanistan has three UNFCCC documents describing its climate change adaptation actions – the 2009 NAPA, the 2013 First Communication to the UNFCCC, and the 2015 INDC. It does not have any government approved climate change instruments, although it is preparing a National Climate Change Strategy and Action Plan, a

National Adaptation Plan, and Nationally Appropriate Mitigation Actions (Amiri, undated).

According to the NAPA, the first three of the seven major climate-related threats[8] facing Afghanistan are water-related. They are (in decreasing order of priority):

- Periodic drought
- Floods from heavy rainfall
- Floods from snow/ice thawing

Recognition of adaptation opportunities in water sector

The NAPA assessed 51 project proposals for addressing the above threats across a range of sectors. Eleven projects emerged from the multi-criteria decision analysis as being important, with the highest priority project being *Improved Water Management and Use Efficiency and Land and Water Management at the Watershed Level*. Two others, dealing with climate-related research and early warning, and improved water management and water use efficiency were also included in this priority group.

The 2013 First National Communication to the UNFCCC explicitly recognizes that strengthening water resources management contributes directly to adapting to the impacts from climate change. Thus, externally funded projects such as the ADB USD 300 m Water Resources Development Program and the EU-funded Multiannual Program that includes a river basin management component, are expected to help build a water sector that can respond to the changes arising from global warming. It also states that the 2009 Water Law which authorizes IWRM and river basin management with multi-stakeholder participation, and the Water Sector Policy that endorses a river basin and sub-basin approach to management are contributing to adaptation in the face of changes brought on by global warming.

Strengthening IWRM elements

Given the design and objectives of NAPAs, it is not surprising that the priority projects focus on technical requirements for adapting to climate change such as improving irrigation water efficiency. Nevertheless, the above water efficiency and watershed management project also includes other elements of IWRM such as establishing fully-functioning Water Management Associations and building public awareness about the importance of demand side management.

The INDC includes a USD 24 billion program for adapting to climate change. This includes three water projects:

- Development of water resources through rehabilitation and reconstruction of infrastructure USD 0.75 billion
- Planning watershed management and community based natural resources management USD 2.5 billion

[8] The remaining four threats are rising temperatures (which will increase evapotranspiration rates); frosts and cold spells; hail, thunder and lightning; and monsoon and 120-day winds.

- Increase irrigation to 3.14 million ha through restoration of irrigation systems USD 4.5 billion

The First National Communication recognizes the importance of IWRM to adaptation in the water sector and especially the 2009 Water Law which required the establishment of river basin organizations. However, none of these climate change documents includes mechanisms to improve coordination between water-dependent sectors. In fact, the NAPA states that "Inter-institutional coordination mechanisms addressing critical themes related to the implementation of the Rio Conventions are either ineffective or non-existent" (UNEP 2009 p55).

All three documents call for improvements in climate and water resources monitoring and knowledge. The First Communication calls for forecasting climate-induced disasters, including the ability to communicate information to people in advance. It also says that the government will attempt to rehabilitate damaged weather and meteorological stations and add a few new facilities at high altitudes to monitor glacier lakes, while the INDC says that the draft NAP includes a proposal to strengthen and expand hydro-meteorological monitoring networks and develop a national database at a cost of USD 100 million.

The 11 priority projects in the NAPA contain components aimed at improving understanding of water efficiency. The top-ranked project – Improved Water Management and Use Efficiency – includes funding for public awareness, while other projects include participation and community training in land conservation techniques. However, the NAPA did not develop a dedicated project aimed at increasing local decision making capacity or education about the impacts of climate change on water resources. The 1st National Communication concludes that more attention is needed to educate the public about climate change and its potential impacts.

Addressing water risks

The 1st National Communication says that the 51 projects in the NAPA were reduced to 11 specifically to address the two major water-related climate change risks - drought and flooding. These are mainly technical interventions intended to help adapt in the short term but do not address some of the major structural issues, such as coordination across water dependent sectors, that are also important.

Enhancing local community capacity for adaptation

None of the three documents recognize that some climate change adaptation activities are best implemented by local communities. They describe the need for stakeholder involvement in higher-level decision making but do not include the possibility of supporting local communities who undertake adaptation actions. The only passing mention is the call for better support for community-based NRM programs in the 1st Communication, although this call is not linked to adaptation to climate change.

Regional approach

The 1st National Communication says that Afghanistan proposes to engage in the South Asian Association for Regional Cooperation (SAARC) Thimpu Declaration program for regional education and awareness. This involves the development of

regional educational material on climate change for use in schools and the establishment of information sharing and capacity building amongst national institutions.

There is no mention of possible engagement with neighbouring countries on topics such as joint management or even information sharing on transboundary rivers where climate change may exacerbate management issues. The Afghanistan Human Development Report (Centre for Policy and Human Development, 2011) points out that most of Afghanistan's neighbours depend on surface resources originating from within Afghanistan and so Afghanistan must address these transboundary water management issues in its plans for infrastructure development.

Mainstreaming adaptation in the water sector

All three documents recognize the importance of mainstreaming climate change adaptation into sectoral instruments, with the INDC report stating that the overall objectives include "mainstreaming climate change considerations into national development policies, strategies, and plans" (p4). The 1st National Communication says that the government is committed to mainstreaming climate adaptation into national and sectoral development strategies and to perform climate risk screening to make adaption programs and projects produce beneficial outcomes "Climate mainstreaming and developing national and sectoral policies is vital" (pxii). The draft NAP (not cited) is reported in the INDC to include the identification and mainstreaming of climate change adaptation into sectoral policies, strategies, and plans.

The INDC says that some policies and plans already integrate climate change such as the National Water and Natural Resources Management Priority Program. It says that other policies, such as the Strategic Policy Framework for Water Sector, do not currently include climate change but have entry points which allow climate change adaptation to be mainstreamed into the policies. Even the priority NAPA project to improve irrigation efficiency and watershed management contains a component to mainstream climate change adaptation at national level.

Summary

Afghanistan does not have a climate change instrument to provide a coherent all-government response to climate change mitigation and adaptation. Nevertheless, its reports to the UNFCCC clearly recognize that water resources will be central to adaptation and that implementing IWRM contributes directly to adaptation in the water dependent sectors. The list of priority projects in the NAPA were deliberately selected to address the major issues of drought and flood facing Afghanistan. These projects provide short-term technical responses to floods and droughts rather than a coherent strategy. They do not address non-technical issues such as coordination between water-using sectors, implementation of river basin management, or the use of demand management to enhance water efficiency.

4.3.2 Bangladesh

As well as the three UNFCCC reports – NAPA 2009, Second National Communication to UNFCCC 2012, and the INDC 2015 - the Bangladesh Government has approved a Climate Change Strategy and Action Plan (CCSAP). The INDC

describes two recently-established Trust Funds – the Climate Change Trust Fund for government-budgeted activities and the Climate Change Resilient Fund for donor funded activities, the first of which is authorized through legislation. The government is also preparing a National Adaptation Plan (NAP) to facilitate the coherent integration of adaptation into policies, programs and activities across all sectors. The Government of Bangladesh has made climate change an integral part of its Poverty Reduction Strategy Paper (PRSP). The INDC confirms that the CCSAP, together with other sectoral policies, remains the guiding document for adaptation actions.

The CCSAP identifies the threats to Bangladesh from climate change as

- greater monsoonal rains leading to flooding,
- sea-level rise causing coastal flooding and aquifer contamination,
- increased droughts,
- erosion of stream banks, and
- increased sedimentation

Bangladesh's NAPA points out that the country has long experience in adapting to climate extremes. However, even though awareness of climate change and its potential impacts is growing, there are still barriers to large-scale adaptive actions. First, the extent and severity of the climate change impacts may be leading to inertia whereby the issues seem too large to deal with; secondly, adaptation activities are not integrated into on-going programs and policies in key sectors such as water (although the CCSAP is a step towards such integration); and thirdly Bangladesh still lacks the tools and knowledge at both an institutional as well as individual level. Consequently knowledge generation and dissemination are vital for effective adaptation.

Recognition of adaptation opportunities in water sector

Bangladesh sees climate change through the lens of water resources. There is very high recognition of the potential impacts on the country and, not surprisingly, its climate change documents contain extensive discussion of adaptation measures. Thus, the CCSAP identifies 44 programs and actions, most of which are adaptation activities and many of which are water-related, while the NAPA identifies water related impacts from climate change as likely to be the most critical issues facing Bangladesh, especially coastal and riverine flooding and drought. In addition changes of the riverbed level due to sedimentation and changes in morphological processes due to seasonal variation of water level and flow are also critical for Bangladesh.

The PRSP identifies climate change as a major threat to Bangladesh along with a number of water related threats such as flooding, droughts and cyclones. The NAPA points out that climate change is likely to exacerbate these existing threats and so the NAPA adaptation actions complement the activities in the PRSP.

The INDC's discussion of adaptation is almost entirely focused on water-related hazards. However, the adaptation activities described, largely revolve around infrastructure, such as embankments, polders, and cyclone shelters.

Strengthening IWRM elements

The various documents recommend a number of activities and programs that are included in the IWRM approach to water management. The CCSP programs include infrastructure development (such as flood protection and drainage schemes, coastal embankments and coastal greenbelts), prioritizing drinking water and sanitation programs in risk areas, strengthening information systems (such as cyclone and storm and flood warning systems, modelling hydrological impacts of climate change, and establishing a new Centre for Research and Knowledge), building capacity, and encouraging community-based adaptation actions.

The INDC report also describes maintenance and expansion of infrastructure (including embankments and dykes, as well as cyclone and flood shelters) as a key measure in climate change adaptation.

The INDC report includes research and improved knowledge such as hydrological modelling and the formation of a new Centre for Research and Knowledge Management on Climate Change, and the development of early warning systems for floods and other water-related disasters.

Addressing water risks

The documents pay most attention to flood adaptation as a result of more intense monsoonal rains. Considerable infrastructure (including embankments, coastal polders, and flood shelters) has already been constructed and the NAPA and the Climate Change Strategy and Action Plan call for maintenance of this infrastructure and the construction of new protection works. Since 2015, the BCCTF has funded over 236 projects many of which are for flood control and flood shelter. The documents also call for early warning systems for floods, droughts and cyclones, as well as better urban drainage and river draining. Drinking water and sanitation projects should be implemented in areas at risk from both floods and droughts. Importantly, the 2nd Communications report and the NAPA say that the design standards for flood protection embankments should be modified to take climate change effects into account. While the 2nd Communication calls for community-based flood management, the adaptive responses are biased towards infrastructure.

There are limited options for preventing seawater contamination of coastal aquifers as a result of sea-level rise. However, the 2nd Communication report suggests that improvements in the Ganges flow regime and a barrage across the Ganges with linking canals will limit seawater intrusion up the river. Rainwater harvesting is included in the NAPA as an adaptive option if coastal aquifers become too contaminated to be useable.

The CCSAP does not propose many drought adaptation options apart from changing cropping strategies, and implementing drinking water and sanitation programmes in drought-prone areas. However, the NAPA and the 2nd Communication suggest that more tube wells, re-excavation of canals and ponds and improvements in water use efficiency together with supplementary irrigation, could help respond to drought.

The reports call for new erosion control infrastructure to control erosion of stream-banks to meet the changing conditions expected with climate change.

The increased risk of growing sedimentation as a result of climate change, receives little attention, apart from proposals for river draining and increased dredging.

Enhancing local community capacity for adaptation

Bangladesh is renowned for its community response program to floods and cyclonic storms. Communities have learnt to adapt to floods and cyclones often using local solutions such as planting short-duration crops and artificial temperature controls in poultry sheds (Ministry of Environment and Forests, 2009). The Bangladesh government fully recognizes the value of building on this local adaptation and disseminating the solutions more widely (Ahmed 2010). In the NAPA, the government also recognizes that local adaptation often needs to be supplemented by government action, such as the construction of cyclone and flood shelters. While the NAPA contains a good appreciation of community level adaptation, the CCSAP is focused on top-down approaches.

The Bangladesh Agriculture Extension Policy makes it clear that one of the reasons for advocating stakeholder participation is to advance adaptation to climate change at the local level (Box 5): "Climate change adaptation may include … documenting and promoting indigenous farmer practices against disasters and vulnerabilities" (Ministry of Agriculture 2012 p10).

Box 5. Community action to reduce vulnerability in Bangladesh.

Bangladesh has pioneered community-based approaches to reducing vulnerability to climate change. The village of Sona Mollar Dangi illustrates typical local action to respond to increased flooding risk. Flooding became more frequent in the village with major floods in 1988 and 1998, being followed by devastating floods in 2004 and again in 2007. With the assistance of an NGO, the villagers decided to lift all houses and farm buildings above the 1998 flood level. They intend to lift all tube wells above this flood level too.

Source: Bangladesh Climate Change Strategy and Action Plan 2008.

Regional approach

While many adaptation activities are best carried out locally, some activities such as management of scarce water during droughts and management of floodwaters will require government leadership in regional negotiations. As the 2nd National Communication says "85-86% of the river surface water flow originates outside the international border in the neighbouring countries and without a regional framework for sharing and caring for water, some of the efforts now or in the future, may not bear much fruit" (Ministry of Environment and Forests, 2012 p133) The CCSAP states that the government is trying to work with neighbouring countries to manage climate change impacts through regional action plans. The government also wants to enhance cooperation with neighbours on key issues, including water security.

There are also a number of regional organizations that Bangladesh has joined for exchanging environmental information and helping develop scientific expertise.

Mainstreaming adaptation in the water sector

Bangladesh has recognized the importance of moving climate change adaptation from being a separate set of activities, to activities that are integrated into sectoral policies, strategies and programs. The National Adaptation Plan is being developed specifically to help integrate climate change adaptation into all policies, programs and activities.

The CCSAP, the NAPA and the INDC propose that all sectoral policies be reviewed for inclusion of climate change and the possibility of incorporating adaptation activities. There is also a need to mainstream climate change into development plans at all levels, from national to community scale, and that climate change impacts be included in all sectoral planning. The NAPA says "A key feature of any adaptation action to climate change proposed to be undertaken (either through the NAPA or other programmes) is that they need to be well integrated with other ongoing activities so that they can build upon the synergy among them to be cost effective rather than standalone activities at higher cost" (p36).

The BCCTF has funded 41 projects so far, all for infrastructure and hardware, and most of which are water related. While these projects are not part of the main sectoral programs, the INDC report points out that Sectoral Ministries and agencies, such as Water Development Board, have also funded mainstream adaptation projects although it is difficult to account for the extent of this (see discussion in Paper 3).

Summary

Bangladesh has put adaptation in the water sector at the centre of its adaptation activities with strong emphasis on infrastructure and knowledge development in the water sector. There is little in the climate change documents about the importance of ensuring coordination across water-related sectors or water saving through demand management and water efficiency approaches. It is not surprising that the NAPA does not deal with these issues since it is focused on discrete short-term projects, but more surprising that the CCSAP does not raise them as important to improved water resources management. Building cooperation with India and other upstream countries is clearly also important for adapting to climate change, but transboundary issues receive little attention in these documents. There are no groundwater considerations in these documents. The reports focus on adapting to increased flood risk, not surprisingly given the damage caused by historic floods, and pays much less attention to other risks including increased erosion and sedimentation. Most of the responses to these risks are focused on engineering solutions.

4.3.3 Bhutan

Bhutan has not developed a Climate Change Policy or Strategy, although it clearly acknowledges the potential impact of climate change on water, land and energy sectors in its water instruments. Bhutan completed a NAPA in 2006. It submitted its 2nd Communication to the UNFCCC in 2011 and the INDC in 2015. The 2nd Communication is the most detailed document on Bhutan's adaptation plans and the 2015 INDC report confirms that this Communication still provides the best summary of the country's adaptation plans.

The NAPA lists the country's major climate change vulnerabilities as:

- Moraine dam lakes leading to GLOFs (regarded as most likely adverse impact of climate change)
- Landslides due to high rain intensity
- Flash floods from GLOF or rain intensity
- Drought due to temperature rise and changing weather patterns

All are water resources issues.

One of the major barriers to implementing adaptation activities is simply raising awareness of climate change – it is still a new concept given the previous focus on development. Other barriers include lack of national capacity, lack of physical access to many regions of the country, and limited technical skills.

Recognition of adaptation opportunities in water sector

The above list of climate vulnerabilities shows that water-related issues are seen to be central to responding to climate change impacts and the three documents examined here have a major focus on adaptation in the water sector. Of the 45 potential adaptation projects identified in the NAPA, 15 were water resources projects. These projects were reduced to nine priority adaptation projects, six of which are concerned with improving water resources management. Examples include artificial lowering of Thorthormi Lake, GLOF hazard zoning in Chamkhar Chu Basin, and flood protection of a vulnerable industrial and agricultural areas in the Taklai river basin.

The 2nd Communication and the INDC report also recognize the importance of water resources to climate change adaptation.

Strengthening IWRM elements

The 2nd Communication report identifies some structural water resources governance issues that need improving if the water sector is to be able to adapt to climate change impacts. It states that there needs to be institutional restructuring, as well as better collaboration between agencies and local government and WUAs. It also calls for the Independent Water Authority to be established as described in the Water Act.

This report confirms that IWRM is the approved approach to water management and that river basin planning and management is needed for adaptation. The report proposes one element of infrastructure – impoundments to provide water during the dry season – as well as watershed management to control erosion and sedimentation. There is a need for capacity building in the water sector. Importantly, surveys had shown that there was a need to develop better awareness among the public, to mount education campaigns in schools, and provide decision-makers with better technical information on climate change.

The INDC report confirms the 2nd Communications report, again stating that IWRM is the approach to provide water security in the face of climate change. The recommended actions to adapt to climate change include water harvesting and water use efficiency measures, integrated watershed management and monitoring GLOFs

and climate extremes. Mounting a public awareness and education campaign is important and capacity building and institutional strengthening will be essential.

The 2006 NAPA report proposes six priority projects to address immediate hazards. These are not intended to be considered a comprehensive program to address adaptation. Nevertheless, they contain some IWRM elements such as climate and river-flow monitoring, infrastructure for lowering hazardous lake levels, and building capacity in local communities for watershed management. But they do not include any of the institutional and governance activities described in the 2nd Communications report.

The 2nd Communications report identifies a baseline water resources assessment as a high priority since one has never been undertaken in the Kingdom. This would provide the information on how much water is available in different river valleys so that factual decisions could be made as climate change and development progressively affect the resource. The report also calls for the development of a GLOF early warning system and the strengthening of the climate observation network.

The latter recommendation is reinforced in the INDC report. Strengthening the hydro-meteorological network and introducing flood and weather forecasting is a priority for adapting to climate change.

Addressing water risks

GLOFs from moraine dam lakes are regarded as the most likely adverse impact of climate change on Bhutan's water resources. The NAPA lists a number of adaptation options including artificial lowering of glacier lake levels, as well as protective measures such as installation of early warning systems with associated awareness raising, implementation of a Hazard Zonation Plan in the Pho Chu River Basin and assessment of GLOF threats for hydropower projects.

To combat landslides due to high rain intensity, the second risk from climate change, the NAPA proposes a number of remedial measures such as soil conservation activities, river bank protection and small stream catchment protection, and slope stabilization of major landslide- and flash flood-prone areas. It also assesses landslide risk areas, while the INDC report suggests that a monitoring and warning system for landslides could be introduced.

The risk from flash floods can be reduced through a mix of preventative measures and early warning systems. The NAPA proposes that watershed catchment management integrated with land management and soil conservation and community-based forest management and afforestation projects can help reduce the runoff that contributes to flash floods. There is also a need for a monitoring and early warning systems for flash floods.

Bhutan proposes to adapt to increased droughts by first studying the likely impacts on hydropower generation, drinking water and irrigation supplies and installing a weather- and climate-forecasting system. It also proposes to build impoundments to store water for use during lean seasons.

Enhancing local community capacity for adaptation
The Bhutan reports to the UNFCCC describe the importance of education and awareness of climate change amongst decision makers as well as the public. While there are a number of community-level programs proposed, none of the documents makes explicit the importance of empowering communities to respond to climate change impacts at a local level and support to these activities.

Regional approach
None of the reports makes reference to Bhutan undertaking regional consultations with its neighbours on adapting to climate change. All the actions described in the NAPA, 2nd Communications report and the INDC are internally focused, except for reference to the use of the regional climate model and the use of an ICIMOD regional flood-warning system.

Mainstreaming adaptation in the water sector
The 2006 NAPA was developed to be consistent with Bhutan's development goals, including the PRSP, which has several cross-cutting issues that are supported by projects in the NAPA.

The 2nd Communications report is even more explicit, identifying mainstreaming climate change and water resources into plans and programs as one of the five water resources adaptation measures.

The INDC says that Bhutan wants to prepare NAPs as a way to mainstream adaptation activities but needs external support before it can implement them. However, it regards mainstreaming as important enough to be included in the 12th 5-Year Plan (2018-2023).

Summary
The Bhutan climate change documents show a high level of awareness of the need to improve water resources management as part of adapting to climate change. Importantly, these improvements include institutional and governance changes as well as improved water and catchment management activities and the development of increased storage to provide water during drier periods. None of the documents mention groundwater management, but this is not a major source of water in Bhutan. Public education, capacity building, resource assessment and hydro-meteorological monitoring are all recognized as important activities to improve Bhutan's adaptive capacity.

4.3.4 India

India's 2008 National Action Plan on Climate Change (NAPCC) identifies eight priority areas (Missions) under which climate change will be tackled. One is the National Water Mission (2008), which is currently being redesigned according to the INDC report. The National Mission on Strategic Knowledge for Climate Change is also relevant to adaptation in the water sector.

India also submitted a 2nd National Communication to the UNFCCC in 2012 followed by a Biennial Update in 2016, and their INDC report in 2015. In addition, the government has implemented a series of schemes to improve the adaptive capacities of vulnerable communities through poverty alleviation, health improvements and disease control, as well as other water resources programs such as the National Mission for Clean Ganga. The Biennial Update report confirms that the National Water Mission remains the definitive document describing adaptation in the water sector with the five goals:

- development of a water database in the public domain, particularly regarding the assessment of the impact of climate change on water resources,
- promoting water conservation, augmentation and preservation, focusing attention on over-exploited areas from a water use perspective,
- increasing water use efficiency by 20% through regulatory mechanisms
- promoting basin-level IWRM

Each State has also put in place a State Action Plan on Climate Change. These sub-national climate plans focus on adaptation (Box 6). However, the analysis here assesses only the central government documents.

Box 6. Andhra Pradesh Climate Change Action Plan 2012

Andhra Pradesh has developed its Action Plan to complement the NAPCC. It identifies adaptation and mitigation actions in the State's key sectors. Water resources is not identified as a key sector although water-related concerns arise in a number of water dependent sectors, such as Irrigation and Water Supply, and Manufacturing.

Adaptation actions in agriculture include improving water-use efficiency and increased recycling of domestic wastewater, strict regulation of groundwater abstraction, and engineering solutions to recharge groundwater. Andhra Pradesh is concerned about coastal zone issues but the adaptation actions are focused on disaster warning and response and do not include protection of coastal surface water and groundwater. The industrial sectoral responses include infrastructure (seawalls, alternative water sources) to protect industrial production from disasters, while existing urban and rural WSS facilities will be remodelled to reduce vulnerability to climate change. Watershed degradation will be reversed. The State also proposes to undertake agro-climatic vulnerability studies in major river basins. There is little attention to supporting household and community adaptation actions.

Source: Environment Protection Training and Research Institute, 2012.

According to Shah and Lele (2011), the climate change will mean:

- Kharif (monsoon) season crops will be subject to heightened risk of floods and droughts
- Rabi (winter) and especially summer crops will experience increased evapotranspiration and thus will need larger, more frequent doses of irrigation

- Surface water storage – large and small – will benefit from increased runoff but will also suffer increased evaporation from large open surfaces of reservoirs and open canal networks as a result of higher mean temperature

The Water Mission, following the discussion in the First National Communication to the UNFCCC, identified India's water resources issues as:

- increased droughts
- increased floods
- groundwater quality decline
- changes in recharge, and,
- saline intrusion into coastal aquifers.

Recognition of adaptation opportunities in the water sector

The government of India's recognition of the importance of the water sector in adapting to climate change is very clear. Four of the eight national missions identified in the 2008 NAPCC are intended to build the capacity for adaptation[9] – water is one of these four missions. While the Water Mission is currently being revised, recent reports, such as the INDC and Biennial Update reports, make it clear that the water mission remains central to India's adaptation response. The NAPCC points out that the National Water Policy stresses non-conventional methods for utilizing water such as inter-basin transfers, artificial groundwater recharge, and desalinization along with water conservation through rainwater harvesting. However, many of these procedures are based on supply augmentation and not on demand management.

Strengthening IWRM elements

The Water Mission relies on an IWRM approach; basin-level management through IWRM is one of the five goals of the Water Mission. The Mission identifies inter-sectoral coordination, capacity building and an awareness program as its three most important actions. Most of the elements of IWRM are included in the Water Mission. Storage needs to be augmented and drainage improved to address droughts and floods, watersheds need to be protected, old water tanks should be restored, and there should be enhanced storage in multi-purpose hydropower dams.

It identifies a number of governance improvements including legislation for groundwater regulation and clarity over surface water and groundwater ownership, more use of market mechanisms, establishment of water regulators, and reducing electricity subsidies for groundwater pumping. The Mission also calls for the water policy to be revised and incorporation of climate change considerations when new projects are being considered. Improving regulatory and institutional measures for groundwater are seen as some of the most important measures. Some of these proposals, including a new Water Policy and groundwater legislation, have now been implemented.

The document calls for basin and sub-basin level authorities to be established with stakeholder representation so that river basin management can be introduced. It also

[9] Three missions are to undertake mitigation activities and one is to build the strategic knowledge to support the other seven missions.

calls for technical improvements to help meet the water-use efficiency targets, including evaporation management and wastewater reuse. Other management actions include better flood management, greater emphasis on estuarine management, and better data collection.

To improve groundwater over-exploitation, the Water Mission proposes water harvesting and artificial recharge in relevant urban areas; enhancing recharge of deeper groundwater aquifers; ensuring proper disposal of industrial wastes; and regulation of power tariffs for irrigation.

Finally, one of the goals of the Water Mission is a national, publicly-available and comprehensive database. The water monitoring network will be strengthened, particularly in the Himalayan region, and the groundwater monitoring network expanded. The database will hold coastal and estuarine data, hydrological and climatic data in low rainfall areas, hydrological and climatic data in the Himalayan region, groundwater level data, and surface water and groundwater quality data. The INDC report says the Indian Network on Climate Change Assessment, called for in the Water Mission, has now been established.

Addressing water risks

The Water Mission incorporates actions to respond to the above five water resources risks from climate change.

- Responses to increased risk of drought include economic studies into the effects of drought, production of drought management plans (unspecified) and a number of technical improvements including groundwater recharge, pollution abatement, reuse of effluent on crops, irrigation efficiency improvements, reducing evaporation, and modelling the effectiveness of conjunctive use.
- Adaptive actions for increased flood risk include embankments for flood protection and development of multi-purpose dams, modelling flood risk areas, using flood water for productive uses, conjunctive use of groundwater and flood waters, and prevention of reservoir siltation. The INDC report points out that there are also various state/national flood management programs.
- The Water Mission has little to say on protecting groundwater quality, other than the need to model the effects of sea-level rise on salinity of coastal aquifers.
- The Water Mission specifically recognises that groundwater recharge may decrease as a result of climate change. The major response is to implement rainwater harvesting in areas where groundwater is at risk and to use the water for recharge. The 2nd Communication to the UNFCCC confirms that rainwater harvesting and recycled water are to be used for groundwater recharge.
- Responses to increased seawater intrusion into coastal aquifers include models of saline intrusion, better monitoring of coastal aquifers and modelling the implementation of seawater intrusion barriers.

Enhancing local community capacity for adaptation

While the National Water Policy states that local adaptation is needed to combat climate change, there is little detail evident in the reports examined. There is

considerable detail about various community climate change awareness initiatives, but no clear acknowledgement that communities need to be supported to undertake water adaptation activities that take advantage of local knowledge and initiative. The 2nd Communication report describes some community-based disaster preparedness initiatives and an NGO project to support community-based models for mangrove restoration and rehabilitation.

Regional approach

India recognizes that regional conflicts over water could become more acute with climate change, and supports a common approach to resolving this issue. The Water Mission instrument proposes to engage in cooperative regional flood forecasting and modelling, possibly under the auspices of SAARC, with China and Pakistan for the Indus Basin, with Nepal and Bangladesh for the Ganges/Brahmaputra Basin and with Bangladesh for the Meghna basin and the Teesta and Lower Brahmaputra rivers. It points out that the Ganges Water Treaty was not drawn up with climate change in mind, and that any claims to maintain the river's water regime (as contained in the Treaty) need to be revisited. It also looks forward to a more integrated solution for Indus water management.

India also recognizes the need for a regional approach to climate modelling, particularly for the Himalayan region where snow melt models need to be developed for general use at a regional level.

Mainstreaming adaptation in the water sector

The Water Mission document is designed around the assumption that responding to the impacts of climate change requires improved water resources management primarily through departmental programs. The First Biennial Update makes this clearer, saying that significant efforts are being made to mainstream policies and acts relating to climate change. Twenty-one of the government's 66 Central Government Schemes have been identified as being directly related to climate change adaptation. Total spending on developing adapting capacity and adaptation was around USD 91.8 billion in 2013-14. This mainstreaming lies behind the government's claim that expenditure on climate change adaptation has been growing rapidly, primarily through departmental programs with critical adaptation components[10].

Summary

India's Climate Change Action Plan is very closely aligned with its water resources instruments. In fact, the National Water Policy 2012 and the new Groundwater Bill were both called for in the Action Plan. The Water Mission is predicated on the idea that improving water resources management through IWRM will improve adaptation to climate change. The document includes a wide range of IWRM features. It includes governance changes, many of which have now been implemented, improvements in water use efficiency and water demand, some infrastructure expansion for flood control and drought management, and a major investment in water information.

[10] Oxfam challenge the accuracy of this claim

Groundwater management figures strongly in the adaptation program with attention being paid to both groundwater quality and quantity management. The major water resources risks from climate change are all included in the Water Mission goals.

Dealing with the increased pressure on transboundary water, both upstream and downstream of India, is not included in any of these climate change documents. Regional floods would best be dealt with on regional basis, while changes in water availability and increased pressure on transboundary aquifers because of climate change are likely to require modification to existing treaties. The INDC document states that transboundary and regional issues need to be factored in but does not elaborate.

4.3.5 Nepal

Nepal approved a Climate Change Policy in 2011. It had completed its NAPA the previous year. Nepal's 2nd Communication was submitted to the UNFCCC in 2014 and the INDC was completed in 2016.

The water-related climate change risks facing Nepal, according to the vulnerability mapping (Ministry of Environment, 2010) carried out for the NAPA, are:

- Temperature and rainfall trends
- Landslide and floods in Mountain and Hill Ecological Zones
- Floods in Terai Ecological Zone
- GLOFs

The NAPA notes that changes in flow patterns will also affect hydropower operations but does not include this as a separate risk.

Nepal is also formulating a National Adaptation Plan (NAP) to help integrate adaptation activities into sectoral policies and strategies, although it is not clear whether this is a UNFCCC NAP or a separate national effort.

Recognition of adaptation opportunities in water sector

The Climate Change Policy and other government documents recognize that climate change will have major impacts on Nepal's water resources, and that the water resources sector needs to adapt to the risks arising from climate change. Nepal's NAPA puts this succinctly: "water is both root cause of climate change risks as well as mainspring of solutions" (Ministry of Environment 2010 p25). The NAPA recognizes that climate change impacts on water resources will stress agricultural productivity, cause malnutrition and other health issues, and affect settlements, infrastructure, agriculture, micro- and main hydro, solar power, prevalence of forest fires, siltation, and landslips. The 2nd Communication to the UNFCCC contains considerable detail on the modelled impacts on river flows and glaciers and GLOFs. It also suggests a number of adaptation actions.

Neither the policy nor other government climate change documents mention IWRM as the blueprint for organizing the water sector to adapt to climate change. However, the NAPA says that the 2005 Water Plan remains the basis for adaptation action and

the 2002 Water Resources Strategy and 2005 National Water Plan are based on IWRM.

Strengthening IWRM elements

The NAPA identifies multipurpose use of water resources, conservation of watersheds, and an expanded hydromet network as being the most urgent adaptation requirements.

The Climate Change Policy proposes that the network of climate observation centres should be expanded and a real time data acquisition system developed. A Climate Change Centre will be established to formulate climate change-related programmes and research. Village-level early warning systems will be developed for floods and landslides according to the 2nd Communication to the UNFCCC, together with an early warning system for GLOFs. One of the more important research initiatives is the Optimum Sediment Exclusion project to develop methods to protect hydropower plants from the increased sedimentation risk arising from climate change.

The NAPA proposes the construction of additional water storage infrastructure consistent with plans to expand the country's hydropower generation capacity. However, there is no indication that these will be designed to take account of climate change.

Conserving soil and water through measures such as source protection, rain water harvesting, and environmental sanitation are included in the Climate Change Policy, together with adopting a basin approach for water management through regular monitoring of water resource availability. Protecting mountain watersheds from degradation is clearly a government priority and is included in the Climate Change Policy, the INDC and the 2nd Communication to the UNFCCC.

The 2nd Communication also describes sprinkler and drip irrigation and rainwater harvesting as water saving measures and a "reorientation of supply-driven approaches" (p109) implying a shift towards demand management. The GLOF threat from Tsho Rolpa Glacial Lake has been reduced by lowering the lake water level.

The Climate Change Policy emphasizes the participation of NGOs and user groups in the formulation and implementation of programmes related to climate adaptation, as well as the need for public awareness and capacity-building programmes. The capacities of WUAs are also being improved.

Addressing water risks

GLOFs are being tackled by lowering the levels of the most threatening lakes and installing early warning systems for downstream populations. Micro-hydropower plants are also being developed to reduce the exposure of the power sector to GLOFs.

The 2nd Communication explains that various structural and non-structural adaptation measures have been adopted to reduce the impacts of floods including construction of embankments, check dams and spurs, emergency protection measures, development of a flood early-warning system and piloting of a flood forecasting system, awareness

raising programs, flood hazard and risk mapping, and the provision of insurance schemes.

Watershed conservation programs have been initiated to help reduce the incidence of landslides together with zoning to regulate development in landslide-prone areas. Nepal is investing in the Optimum Sediment Exclusion research project to develop methods for protecting hydropower plants from increased sediment loads as a result of climate change.

Apart from various cropping and agronomic practices that are being introduced to help combat increased incidents of drought, the 2nd Communications report proposes that more efficient irrigation techniques and rainwater harvesting should be expanded.

Enhancing local community capacity for adaptation

Nepal is strongly committed to empowering local communities to respond to the impacts of climate change. It has developed Local Adaptation Plans of Action (LAPAs) to implement adaptation at the community level. According to the INDC report these are meant to ensure a bottom-up contribution to the national adaptation process as well as educating and engaging local people in adaptation activities and implementing adaptation plans. The LAPA process provides opportunities for either stand-alone local plans or plans that are integrated into regular planning and implementation processes. Nepal is currently implementing LAPAs in 90 Village Development Committees and 7 Municipalities and about 375 local adaptation plans and nearly 2,200 Community Adaptation Plans of Action (CAPAs) for community forests.

Localising climate adaptation actions is also deeply rooted in the planning and implementation of the Nepal Climate Change Support Program (NCCSP) target areas.

Regional approach

The Climate Change Policy recognizes the need for regional cooperation, particularly between upstream and downstream areas. However, it does not propose any actions to advance regional approaches apart from expanding cooperation for risk reduction in transboundary areas.

Nepal also engages in regional research collaborations through ICIMOD and other institutions.

Mainstreaming adaptation in the water sector

Nepal is committed to mainstreaming climate change adaptation into national and local planning processes. This includes mainstreaming disaster prevention and mitigation efforts for floods, landslides and GLOFs. The Environment-Friendly Local Governance Framework is specifically designed to help incorporate climate change adaptation and environmental activities into local planning processes.

Summary

Both the NAPA and the Climate Change Policy contain adaptation components. Although the Government of Nepal has not included IWRM in its adaptation

responses in the water sector, it has identified three priority adaptation actions – multipurpose use of water resources, conservation of watersheds, and an expanded hydromet network. There are a larger number of less urgent adaptation actions it intends to take in the water sector. Nepal is probably the most advanced country in South Asia for engaging local communities in adaptation actions. These are formalized in a number of LAPAs under a national framework. On the other hand, the climate change documents make little mention of engaging in regional water management initiatives as part of water resources adaptation.

4.3.6 Pakistan

Pakistan approved a National Climate Change Policy in 2012, followed by a Framework for implementing the policy in 2013. It had submitted its First National Communication to the UNFCCC in 2003 but has not provided further Communications or Updates. Although it provided an INDC to UNFCCC in 2015, the document is very brief and provides no information on adaptation activities.

Pakistan is heavily dependent on flows in the Indus River which are fed from both snow and glacier meltwaters as well as from rainfall. Once the glaciers have finished melting in the coming three decades or so, no country in the region will suffer as much water stress from the Himalayan impact of climate change as Pakistan (Ghazanfar Ali quoted in Shah and Lele 2011).

Important water-related climate change threats to Pakistan according to the Framework for Policy Implementation are:

- decrease in the glacier volume and snow cover leading to alterations in the seasonal flow pattern of the Indus river;
- increase in the formation and burst of glacial lakes;
- higher frequency and intensity of extreme climate events coupled with irregular monsoon rains causing frequent floods and droughts (Gilani in Shah and Lele (2011) argues that increasing intensity of flood events is Pakistan's major threat); and
- greater demand for water due to increased evapotranspiration rates at elevated temperatures.

Recognition of adaptation opportunities in water sector

The National Climate Change Policy and its Implementation Framework start by acknowledging that water resources are inextricably linked with climate, because "freshwater resources in Pakistan are based on snow and glacier-melt and monsoon rains, both being highly sensitive to climate change" (p10).

Strengthening IWRM elements

The Policy and the Implementation Framework both state that IWRM plays an important role in addressing climate change impacts in the water sector. Both instruments want IWRM to be implemented on a river basin level "by involving downstream and upstream stakeholders in planning and decision-making processes and by integrating their issues of water quality and quantity, for achieving long-term social, economic and environmental benefits" (Government of Pakistan 2103 p11).

The Framework briefly comments that the draft National Water Policy needs to be approved and implemented.

There is little mention in the Policy or the Framework about the need for water relevant sectors to be coordinated through an apex institution. A number of legislative changes are proposed including harmonizing all legislation, policies and plans in the water sector to ensure that they include climate change adaptation measures.

The Framework devotes considerable attention to irrigation water efficiency measures, most through technical means although pricing reform is mentioned as a means to generate resources for sustainability. Demand management is not mentioned. Rainwater harvesting can be used to provide irrigation and domestic water. Farmers should participate in decisions about their irrigation areas. Groundwater needs protection through regulatory frameworks, licencing water users, and by introducing artificial recharge using treated wastewater. Catchment areas should be protected from erosion, and environmental flows should be provided to help repel saltwater intrusion into the Indus delta.

Other elements of IWRM are also advocated in the Climate Change Policy including raising the awareness of the general public about the effects of climate change on water resources and the need for conservation and sustainable use of water. There is a need to train government officials about climate change impacts on water resources and the Indus River System Authority needs to be trained to implement the IWRM approach to water allocation.

The Policy recognizes that the hydrological network needs improvement, along with seasonal hydrological forecasts, and a comprehensive inventory of surface water and groundwater resources.

Overall, the Policy and its Implementation Framework emphasize that adaptation in the water sector rests on improving all aspects of water management, consistent with an IWRM approach.

Addressing water risks

The Climate Change Policy's emphasis on improving water efficiency and protecting groundwater resources is a response to the likelihood of increased droughts under climate change. The Policy also proposes contingency plans to help adapt to water shortages caused by drought.

Apart from a proposal to use floodwaters for irrigation in Baluchistan, the policy has little to propose about flood responses aside from studies to identify flood-prone areas, developing floodplain regulations and laws, and mapping flood areas.

There is little mention of responding to GLOFs in the Policy or the Implementation framework, apart from the establishment of an early warning system and conducting research.

Although the Policy makes no mention of adaptation responses to higher temps and increased ET, many of the water efficiency measures together with some of the agricultural responses (e.g. drought tolerant species) would help adapt to this threat.

Saltwater contamination of coastal aquifers is not recognized as a risk from climate change in the Policy, although there is a brief mention of this impact later in the Policy.

Enhancing local community capacity for adaptation

Although Pakistan recognizes, in its 1st Communication report, that autonomous adaptation (i.e. adjustments made within the system, initiated by the stakeholders themselves) can occur alongside planned, top-down adaptation measures, it does not explicitly encourage autonomous actions in the water sections of its climate change instruments.

There are a number of initiatives involving local groups, although the program design and organization comes from the national level. These include rainwater harvesting, watershed management and, in the Indus delta, mobilization of local communities for irrigation.

Regional approach

The Government of Pakistan says that it will explore the possibility of joint watershed management of transboundary catchment areas with neighbouring countries (presumably referring to the Indus catchment), although it will also safeguard Pakistan's rights on trans-boundary water inflows. It will also look at developing a water treaty with Afghanistan and entering into an agreement with neighbouring countries to protect the HKH glaciers. It is difficult to imagine how the latter could be achieved apart from relying on international efforts to mitigate greenhouse gases.

It is also committed, through the Policy, to engage in scientific exchanges with neighbouring countries including the sharing of real time hydrological data for flood forecasting and early warning.

Mainstreaming adaptation in the water sector

The policy does not discuss the benefits of mainstreaming adaptation responses into the normal business of sectoral Ministries. However, the Framework for Implementation says that it has been developed as a catalyst for mainstreaming climate change concerns into decision making and national planning.

Summary

The policy is only partially responsive to the nominated water-related threats from climate change. It contains many proposals to improve water use efficiency as a mechanism to combat increased incidence of drought under climate change, but fewer recommendations for dealing with floods apart from studies into flood extent and very little on combating the threats of GLOFs and effects of higher temperatures on agriculture.

Overall, the Policy sees IWRM as the desired approach and incorporates a wide range of methods to improve water management, including non-technical approaches such

as pricing reform, river basin management (even though this is absent from the water instruments), integrated water flow and water quality management, and provision of environmental flows to limit seawater intrusion into the Indus delta. It calls for a National Water Policy to be approved quickly and implemented, although it says little about coordination across water-dependent sectors. It also recognizes the need for raising public awareness and improved hydrological monitoring.

There is little evidence that the government recognizes the need to mainstream climate change into their regular water management activities. The section on international cooperation to deal with regional climate change issues, such as large-scale floods, is an encouraging recognition that some of the impacts of climate change cannot be dealt with on a national basis.

4.3.7 Sri Lanka

Sri Lanka produced a National Climate Change Adaptation Strategy (NCCAS) in 2010, followed by a National Adaptation Plan for Climate Change Impacts (NAPCCI) in 2015. The latter document was designed following the UNFCCC guidelines for NAP reports. These two documents constitute the definitive instruments for adaptation in Sri Lanka. The Climate Change Policy 2012, includes adaptation but is also concerned with mitigation and other issues. An Information, Education and Communications Strategy for Climate Change Adaptation and a Water Sector Vulnerability Profile were produced in 2010 to support the preparation of the Strategy.

Sri Lanka has also produced two Communications reports to the UNFCCC (2000 and 2011) and submitted its INDC report in 2015. The 2nd Communication to the UNFCCC identifies the risks to water resources as:

- Reduced river flows because of increased rainfall variability
- Increased rainfall intensity causing floods and landslides
- Reduced groundwater recharge, especially in north and northeast regions
- Soil erosion causing sedimentation and loss of reservoir capacity

Recognition of adaptation opportunities in water sector

According to Sri Lanka's INDC "(the) water sector is the most crucial sector where immediate adaptation measures are required that cut across all the other sectors including health, food security and renewable energy generation (hydropower)" (Ministry of Mahaweli Development and Environment, 2015 p6). The Policy and the NCCAS both recognize the potential impacts and needs for adaptation across the sectors dependent on water. The Strategy recognizes that it will affect not only water availability and the risk of disasters, but also the demand for water due to errant precipitation patterns and increased temperatures.

The NAPCCI provides an additional reason for focusing on water adaptation. It quotes the Water Development Report (2010) as noting that there is no policy, plan or programme in the water sector, and consequently the NAPCCI provides an opportunity to state the adaptation needs in the water sector.

Strengthening IWRM elements

The NCCAS states that Sri Lanka currently has poor management of watersheds and water sources and that the principles of IWRM are rarely implemented. However, both the Strategy and the Climate Change Policy promote integrated watershed and water resources management. None of the climate change instruments mentions the need for a water policy for Sri Lanka to guide adaptation actions, although the proposed review of all sectoral policies will undoubtedly highlight the country's lack of a water policy.

More water storage is needed along with inter-basin transfers according to the NCCAS, although the National Water Use Master Plan has concluded that inter-basin transfers are a long-term option and could be contentious because of resettlement issues.

Better watershed planning and management is widely advocated in the instruments because of the currently degraded state of watersheds and the likelihood that climate change will lead to more intense storms and sedimentation. Development projects should be required to take the effects of climate change into account.

Improvements in water use efficiency through technology and changed behaviors are advocated for irrigation water use. These include micro irrigation and drip irrigation as well as more efficient use of groundwater and reuse of drainage water. For urban water use, the instruments advocate rain-water harvesting systems (e.g. ferro-cement tanks and roof top systems). Wastewater can also be recycled for industrial and aquaculture use.

The instruments propose research into the impacts of climate change on water availability. They advocate a long-term monitoring programme into the effects of climate change on water resources. There is a need to improve the existing system for timely issuance of short-term weather forecasts and strengthening early warning systems. Although the instruments advocate monitoring sea-levels, there is no proposal to check the intrusion of saltwater into coastal aquifers as a result of sea-level rise.

The Information, Education and Communications Strategy recommends working through small groups and selected on-ground implementation agencies rather than mass media campaigns to raise awareness of climate change and the need to adapt.

Addressing water risks

The instruments do not have specific discussions of the specific threats or risks. Nevertheless, the NCCAS anticipates an increased frequency and severity of droughts, combined with increased soil erosion and siltation due to high intensity rains. These risks will be ameliorated through improved water-use efficiency, augmentation of water storage and rainwater harvesting. Areas vulnerable to floods and drought will be mapped and disaster risk management plans and early warning systems developed. Drainage will be improved in flood prone areas.

Increases in salinity as a result of sea-level rise are seen as a problem for surface waters and coastal lands. There is no mention of contamination of coastal aquifers in the NAPCCI nor is there any mention of combating reductions in groundwater recharge.

The NAPCCI points out that the risk of soil erosion will be managed through the National Action Programme for Combating the Degradation of Lands, which incorporates a range of identification, assessment, and remediation actions for soil erosion. The Plan will complement these activities through the development of a Climate Information Centre.

Enhancing local community capacity for adaptation

The climate change instruments endorse the need for community-level adaptation activities. The NCCAS suggests that existing mechanisms, such as District Coordinating Committees and local government and the extensive grassroots networks of the NGO sector could be mobilized towards climate change adaptation. However, regulations and incentives are lacking. The NAP has a section on building the adaptive capacities of local communities through provision of a small grants program for community adaptation, identifying traditional knowledge for adaptation to climate variability, and identifying indigenous assets that are vulnerable to climate change. The NAP also suggests that climate-resilient indigenous practices of water management should be explored and ways found to integrate them into modern practices. Although seeking to assist local communities, these activities are still directed from the top down.

Regional approach

Being an island, Sri Lanka does not have transboundary water management issues to resolve. However, it supports regional and international cooperation and networking to promote climate change research.

Mainstreaming adaptation in the water sector

Mainstreaming adaptation activities into national planning and development is one of the five key features of the NCCAS. The National Adaptation Plan says that sectoral and macro policies and other instruments will be assessed to identify options for mainstreaming adaptation. No other details are provided of how the mainstreaming will be implemented.

Summary

Sri Lanka has developed a specific adaptation strategy and, separately, an adaptation plan. They fully recognize the centrality of water resources to adaptation activities, and particularly recognize the importance of identifying adaptation in the water sector because of the absence of a national water policy. The climate change instruments propose a range of adaptation activities from constructing more water storage facilities, to improving water use efficiencies in irrigation and urban areas, to watershed management and promoting IWRM. Sri Lanka has developed a specific Information, Education and Communications Strategy for climate change adaptation. Although the instruments endorse the concept of community-level adaptation, their approach is largely driven from the national level. The importance of mainstreaming is clearly spelt out although details on how it is to occur are not provided.

5. Findings and Possible Topics for Phase 2

5.1 Findings

There is generally both a high level of appreciation of the impacts of climate change within the water sector instruments together with a clear understanding that the water sector is key to climate change adaptation within climate change documents.

IWRM is formally adopted as guiding principles in all countries, except Sri Lanka, in water resources instruments. Nevertheless, Sri Lanka had designed its 2006 draft Water Policy around IWRM although this was not approved by government. Similarly, the climate change documents recognize the importance of adaptation in the water resources sector and accept that improved water governance and management practices are at the core of adaptation. Like the water instruments, the climate change documents see IWRM as the appropriate way to improve water management. While there is no argument about IWRM being the correct approach to water management, there are often doubts about its applicability. However, implementation need not be a problem if IWRM is regarded as a process and not a plan according to Arriens (in Shah and Lele 2011). The Asian Development Bank (ADB) has found that IWRM is accepted at basin level if it meets economic, social and environmental aspirations of stakeholders.

5.1.1 Water Resources Knowledge

The need for improved monitoring networks for surface water and groundwater volume and quality is one of the most consistently-voiced actions across South Asian water resources and climate change documents. Three countries, Bangladesh, Bhutan and India advocate that these data be held in a central repository and be made available when needed. Coastal countries also propose monitoring of sea-levels although it is not clear how this information would be used.

A number of countries recognize the importance of specific disaster monitoring systems, such as monitoring of GLOFs in Bhutan and Nepal. Nepal specifically recognizes the importance of village-level early warning systems for floods (including GLOFs) and landslides.

There is also a wide acceptance of the need to invest in research, including modelling the hydrological effects of climate change. Three countries, Bangladesh, India and Nepal propose establishing specific Centres or Networks for research into the impacts of climate change.

5.1.2 Water Resources Governance

Probably the biggest gap in water instruments is the absence of agreed water policies and legislation in three countries – Nepal, Pakistan and Sri Lanka. Consequently, these countries lack a coherent response to water problems and are reliant on sub-sector instruments or the policies of water-related sectors such as environment, energy and/or agriculture. There is also a shortage of national climate change strategies

(Ahmed and Suphachalasai, 2014). Three countries – Afghanistan, Bangladesh, and Bhutan – that do not have a national climate change instrument, and so lack a guide to implementing their adaptation actions.

Four of the seven South Asian countries clearly recognize and incorporate climate change and its impacts in their water instruments. India has a full section on climate change adaptation in its Water Policy. Two others acknowledge climate change. On the other hand, Nepal, likely to be heavily impacted does not address climate change in its 2002 Water Strategy or 2005 Water Plan, beyond a commitment to study the phenomenon.

The four LDCs in South Asia – Afghanistan, Bhutan, Nepal and Bangladesh – have produced NAPAs but do not have agreed policies or strategies for dealing with climate change. However, the NAPAs are a mixed blessing. While they provide LDCs with a vehicle for developing adaptation options, they also focus attention on short-term (usually technical) priority projects at the expense of coherent programs of adaptation. This shortcoming is recognized by the UNFCCC who have proposed NAPs be developed to help countries mainstream medium- long-term adaptation actions into their regular management activities. The IPCC also emphasize the need to integrate adaptation into government processes, thereby creating synergies with development simply because people who are socially and economically marginalized are also highly vulnerable to climate change (IPCC 2014). Only Sri Lanka has developed a NAP, although Afghanistan, Bhutan and Nepal have all indicated that they are developing these instruments. In the meantime, most countries recognize the importance of mainstreaming adaptation. India already includes mainstreamed activities in their accounting for adaptation (Ganguly and Panda 2010).

The key institutional feature of IWRM, coordination across water dependent sectors, is recognized as important in the water instruments of all South Asian countries. All countries have established coordinating institutions although the composition and authority of these bodies varies considerably from no inter-Ministerial coordinating body in Sri Lanka to a National Water Resources Council chaired by the Prime Minister in India. However, the climate change documents, while detailing many aspects of water management pay little attention to cross-sectoral coordination of water dependent institutions in spite of its importance to adaptation in the water sector.

Climate change policies also need to be coordinated across central and sectoral ministries (including finance, economics, environment, energy, transport, water and health) (Asian Development Bank, 2009). This could lead to conflicts over which ministry is taking the lead role in implementing adaptation in the water sector – the apex water organization or the apex climate change organization (usually the Ministry of Environment). The effectiveness of these coordinating arrangements in South Asian countries is examined in depth in Paper 3.

Managing groundwater will assume an even greater significance than it already does because of climate change. Climate change will not only affect groundwater supply in diverse and hard to predict ways but will also lead to an increase in demand for

groundwater. Yet the links between groundwater and climate change have not been explored in detail in South Asia.

5.1.3 Water Resources Infrastructure

All countries, except possibly Bangladesh, have plans to develop additional water storage – both small and large. This will only provide additional flexibility to respond to increased climate variability if such storage is not fully committed to new production (e.g. hydropower plants and/or irrigation expansion). Pakistan, in particular, has not built enough dams according to Pervaiz Amir (in Shah and Lele 2011) and now needs to rapidly develop dams as a defense against climate change. In India, on the other hand, the available water resources may have already been developed according to Mihir Shah in Shah and Lele (2011), especially in light of revisions of the country's available water resources, and that the focus should be strongly on improved management rather than new infrastructure development.

Managing groundwater storage will acquire greater significance than ever before under climate change. In addition to affecting groundwater demand, climate change is expected to have an impact on groundwater supply in direct and myriad ways, although the actual impacts are complex and hard to determine. Yet links between climate change and groundwater have received little attention in the literature or policy compared to surface water, and those attempts to raise the profile of groundwater management (e.g. India's draft Groundwater Bill) have had little impact in practice. Given that the region has come to depend heavily on groundwater irrigation, greater analysis and sound policy on groundwater are critical for South Asia's agricultural future.

5.1.4 Water Resources Planning and Management

Afghanistan, Bhutan, India, and Nepal have adopted basin-level water planning and management. Bangladesh agrees in principle with this approach but points out that it means greater cooperative management of the Ganges River basin. Pakistan does not include basin-level water management in its water instruments, presumably because the Indus River is already the focus of its management attention. South Asian countries with their many large and small transboundary rivers need to take a regional approach to climate change adaptation, not only to tackle regional issues such as large-scale flooding but also to promote data sharing, research and development and capacity building amongst national institutions. Many countries recognize this in their climate change documents. For example, the Pakistan government in its Climate Policy offers to explore joint watershed management of transboundary basins with neighbouring countries.

Given the low water-use efficiencies in irrigation across South Asian countries, most countries see improved water-use efficiencies through technical methods as providing the primary response to the threat of increased frequency and severity of droughts because of climate change. However, technical solutions, such as lining canals, are popular although they often do not achieve any real water savings (Facon and Mukherji in Shah and Lele 2011). Non-technical methods, including demand management, can be just as effective and are often cheaper. Facon and Mukherji

found that the greatest scope for delivering better service in South Asian public irrigation systems lies in improving the management of the main canal system. Tightly run irrigation agencies that focus on better employee management through incentives, empowerment, supervision and capacity building play a big role in improving irrigation service to farmers.

Conjunctive use and reuse of treated wastewater are also proposed to augment irrigation water supply, although the latter carries considerable health risks unless stringent water-quality guidelines are in place and enforced. Given the leakiness of many irrigation canals, there are considerable opportunities to introduce deliberate managed conjunctive use in Pakistan, India and Bangladesh. Stephen Foster in Shah and Lele (2011) believes that conjunctive use of surface water and groundwater, especially by increasing groundwater use in upstream areas and improving surface water availability downstream is of central importance in the Indo-Gangetic Plain and in Pakistan's Punjab.

Pakistan and Sri Lanka have Drinking Water Policies that also propose technical measures to improve urban water use efficiency.

Groundwater levels and quality are already major issues in India and Pakistan. Both groundwater quantity and quality are likely to deteriorate further under climate change unless remedial actions are taken. Bangladesh, Bhutan, India, Pakistan, and Sri Lanka all have special provisions in their water policies to protect groundwater quality, while India has developed a draft model bill for groundwater. India has a clear strategy of rainwater harvesting and artificial recharge using treated wastewater to remediate overdrawn aquifers. However, Foster (in Shah and Lele 2011) warns against easy solutions, such as artificial recharge and technical irrigation improvements that avoid the basic issue of controlling over-abstraction. He believes that governments cannot avoid reducing over-abstraction of groundwater – extremely difficult as this is – but need to develop different solutions in different places that combine an understanding of the hydro-geological setting and the socio-economic situation.

5.1.5 Education, Participation and Communications

Ahmed and Suphachalasai (2014) say that a two-pronged approach is needed for adaptation – mainstreaming from top down policy and institutions, and awareness-raising and provisions for climate change at basin-level. This means that there needs to be institutional strengthening, genuine community participation, and development of national capacity and local and regional expertise. According to Gyawali (in Shah and Lele 2011) the household level is the key to climate change adaptation in South Asia. He says that, traditionally, South Asia muddles through from the bottom up rather than the policy level down.

All countries support community-level participation in adaptation activities in their climate instruments. The irrigation sector has the greatest experience with devolving responsibility to local water user associations, although there is little evidence that self-management of irrigation districts improves productivity. Mukherji et al (2009) found that there were no major differences between irrigation areas that had strong

participatory management and those that did not. Nevertheless, participatory management may help improve adaptive behaviors in the face of a changing climate.

Policies often include education and communications campaigns for local communities, participation of FOs and WUAs on committees. Sri Lanka has proposed a small grants program for local community-adaptation activities, while Nepal has now implemented 90 LAPAs that fit within a national framework.

There is widespread agreement about the importance of building an understanding of climate change and its implications for water resources amongst the general public as well as amongst sectoral groups and decision makers. Thus, the technical priority projects in the NAPAs typically include a community education and involvement component, while national climate change policies and strategies also include public educational and capacity-building components.

Of course, there are likely to be significant differences between the intentions of South Asian governments to improve water management and address the potential impacts of climate change and the reality of implementation. These intentions are not always translated into reality for a number of reasons including lack of funds, lack of political will, lack of skilled staff and opposition from vested interests. Paper 3 will examine the extent to which the financing and institutional aspects described in these water instruments have actually been realized.

5.2 Possible Topics for Phase II

A number of possible topics for further investigations are suggested by the above findings.

5.2.1 Water Resources Knowledge

1. A number of countries have proposed sharing water data across transboundary river basins and aquifers. This could include designing an online method for collating and reconciling data collected through different protocols across countries, examining administrative impediments to sharing surface water and groundwater data. This activity could be integrated with SAARC initiatives.
2. Community-level adaptation needs to be included as a significant part of the response to climate change. Methods need to be developed for community level monitoring and data sharing so that they can contribute to higher levels of management. This would include protocols for data collection, training and capacity development. Nepal may provide a useful case study.
3. To what extent is the growing understanding of scientific climate change impacts in the water sector being passed to, and understood by, decision makers? Is scientific information actually influencing the different adaptation responses needed in different South Asian countries? An analysis of potential bottlenecks in uptake of scientific information and actions to reduce any bottlenecks would be timely.

5.2.2 Water Resources Governance

1. What are successful models for effective coordination between highly water-dependent sectors and also between water agencies and institutions responsible for climate change in each country? Are water agencies or environmental agencies, or independent coordinating committees successful?
2. How well do water managers understand the impacts of climate change and how well do they understand that the IWRM model (even if difficult to implement) provides an adaptation response to climate change?
3. What is required to effectively mainstream climate change adaptation across water-dependent sectors? Education of officials in water related Ministries? Coordination with agencies responsible for climate change? How can adaptation activities be properly defined and tagged within Ministry budgets without incurring excessive overheads?
4. In federal systems (India and Pakistan) a significant proportion of the adaptation budget is directed through State/Provincial agencies. How well is this coordinated with the national effort and, also, with local adaptation activities?
5. The impacts of climate change on groundwater needs greater attention in both policy and practice. The best way to control groundwater use in different hydro-geological and socioeconomic settings need to be better understood (following concepts by Foster in Shah and Lele (2011)).

5.2.3 Water Resources Infrastructure

1. Most infrastructure plans focus on major structures for storage. But is it more effective to revive small, local structures, including traditional storage mechanisms or make more use of local groundwater storage (including sand dams)?
2. Major infrastructure will only provide adaptation to climate change if it is designed and operated taking account of climate change. How can design standards and operating rules be developed that take account of climate change. Bangladesh, in their 2nd Communication to UNFCCC, say that they will establish design standards for flood embankments that take account of climate change. Is this a useful case study?

5.2.4 Water Resources Planning and Management

1. Coordinating across national boundaries to develop water-sharing plans under the influence of climate change, is a major objective. Are there some preliminary studies that would build confidence and tackle some technical issues to help pave the way for transboundary water planning (see Report 3 on transboundary water recommendations)?
2. Introducing basin level planning and management is a major challenge. Are there lessons to be learnt from pilot studies in Nepal, Pakistan and elsewhere about how to do this?
3. How can water-related adaptation measure be designed to benefit the poor and disadvantaged? How can they be linked to PRSPs and other mechanisms for poverty alleviation?

4. Saltwater contamination of coastal aquifers will affect Bangladesh, India, Pakistan and Sri Lanka. However, it receives relatively little attention in climate changes strategies. Is it inevitable? Are there protective mechanisms that are cost effective?

5.2.5 Education, Participation and Communications

1. What are the identifiers of successful community engagement in adaptation actions? Case studies in Bangladesh or Nepal would be timely. Nepal now has 200 NAPAs in progress – how well do they work? What are the lessons? How should they be organized to provide nationally-coherent responses while still retaining local control? How should they be financed and provided with skills that may not be available locally? How can their lessons be disseminated?
2. What is the best way to raise general understanding of climate change impacts? Sri Lanka says that generic media campaigns are not effective and that targeted approaches through selected on-ground implementation agencies and small groups are more effective. Is this true more widely across South Asia?
3. Groundwater is likely to play an increasingly important role in climate change adaptation. How well do groundwater users understand the nature of a communal resource? Can the tragedy of the commons be avoided through education and technical knowledge about shared water resources? What can SAWI do to build this understanding in groundwater-dependent communities?
4. If community-level adaptation is to be a major component of adaptation activities, how can existing community and local institutions, including local government, be utilized? What guidelines, regulations, education, technical support are needed to help them become involved?

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Appendix. Water Instruments in South Asia

Afghanistan

Following the end of the Taliban regime in 2001, Afghanistan underwent a process of reconstruction and stabilization with assistance from the international community. This process was guided by the 2002 National Development Framework which identified water management as a priority area. The Framework foreshadowed an IWRM approach to water management, including the formation of river basin authorities. From this, a Strategy Policy Framework for the Water Sector was approved in 2005 and a Water Law was passed in 2009. A Water Sector Strategy and an Agriculture and Natural Resources Policy and Strategy were drafted in 2008 and 2005 respectively - the latter document includes sections on water used for irrigation[11]. An Environment Law was passed in 2007.

Afghanistan is mostly arid and semi-arid with an annual average rainfall of 240 mm. However, there is considerable variation across the country with the high areas in the northeast receiving about 1,200 mm while the southwest receives an annual average rainfall of only 110 mm (Ministry of Irrigation, Water Resources and Environment, 2004). Nevertheless, Afghanistan has adequate water resources because of snow and glacier melt from the Hindu Kush Mountains. The total annual discharge of the country's five river basins exceeds 75 billion cubic meters (Bm^3) (Mahmoodi 2008) and water availability is assessed at 2,775 m^3 per capita (Kakar 2011).

Afghanistan has experienced water shortages because of a series of droughts, poor water management and the effects of conflict. There has been a proliferation of deep wells and pumping from channels that have depleted water resources, irrigation infrastructure has fallen into disrepair, and irrigation water management has deteriorated. Irrigated area has fallen from 3.3 million hectares in 1980 to 1.8 million ha in 2008 (Mahmoodi 2008). Three quarters of Afghans lack access to protected drinking water (Kakar 2011). Development of the water sector is accepted as a national priority because over 80% of the population relies on agriculture (Ministry of Irrigation, Water Resources and Environment, 2004).

Water Resources Knowledge

The network of hydrological monitoring stations has been destroyed or degraded during years of conflict. The Water Sector Strategy says that rehabilitation of the network will be accompanied by data storage in a central database.

The Frameworks and the Water Law 2009 say little about monitoring water flows although the Water Law does require that all water extractions and discharges be monitored. However, Mahmoodi (2008) says that a special priority has been given to the rehabilitation of the hydrometric network. None of the instruments mentions education and promotion of an awareness of water resources amongst the general

[11] A Groundwater Development Policy is mentioned by Mahmoodi 2008 but this could not be located for review.

public or target groups such as decision makers. Nor do they mention research and knowledge acquisition.

Water Resources Governance

The Water Law 2009 regulates ownership, fees, rights, permits, and usage of water. Ownership of water is vested in the Afghan people and the government is responsible for its protection and management. All uses of water, except for basic human needs and navigation, require a permit. This includes new developments of surface water and groundwater, disposal of wastewater and drainage waters, sinking shallow and deep wells, and construction of dams and levees. The Law authorizes a water Policy and Strategy to guide development, storage, use, control and conservation of water resources.

The Law divides responsibility for water amongst a number of Ministries, with the Ministry of Energy and Water being responsible for the planning, management and development of water resources – defined as including both surface water and groundwater. However, groundwater investigations and monitoring is assigned to Ministry of Mines, while the Ministry of Agriculture, Irrigation and Livestock is responsible for irrigation infrastructure and operations. A Supreme Council of Water Affairs has been appointed to coordinate across these Ministries.

River Basin Agencies, overseen by River Basin Councils, are to be established for integrated water resources planning and management. The Councils determine water allocations, including issuing water permits, and monitor their use. Sub-Basin Councils are also to be formed with similar powers to the Basin Councils although they cannot issue water permits. The Agriculture and Natural Resources Policy and Strategy 2005 supports the need for an integrated approach to irrigation and natural resources management and also supports the devolution of responsibility to River Basin Authorities.

Afghanistan and Iran signed a treaty governing use of the waters of the Helmand River in 1973 (Ahmad 2013). Afghanistan shares the Kabul River with Pakistan but there is no water sharing treaty between the two countries. Disputes occur over dam developments between Afghanistan and both Pakistan and Iran – the latter in spite of the treaty.

Water Resources Infrastructure

The Water Sector Strategy 2008 identifies 31 infrastructure projects that need to be implemented for a water supply, irrigation, hydro power, flood control and groundwater recharge. Most are new or rehabilitated dams, but flood diversion and groundwater recharge projects are also included. It also advocates rehabilitating irrigation infrastructure that has been damaged or destroyed over the last 20 years. The Agriculture and Natural Resources Policy and Strategy 2005 notes the inadequacy of dams and canals. It calls for the rehabilitation of irrigation infrastructure, although it proposes that, in the long term, maintenance costs will be borne by users.

The 2002 National Development Framework identified the need to re-establish a working urban water supply and sewage system. It also gave urgency to the repair and

rehabilitation of irrigation infrastructure. The traditional karez systems could be revived and traditional law has successfully managed small scale irrigation in past.

Water Planning and Management

The Water Sector Strategy calls for Water Sector Master Plans for each river basin that includes, inter alia, climate change considerations with the purpose of placing demand side management on an equal footing with supply augmentation.

Under the Water Law 2009, water quality standards are to be established for drinking water supply, agricultural use and industrial wastewater discharge. The Law also prohibits pollution of water resources by wastewater, industry, chemicals beyond the established water quality limit. Water users cannot harm environmental systems, and are prohibited from actions that cause erosion and landslides.

Some of these provisions are backed up by the 2007 Environment Law. It also prohibits the discharge of pollutants to water[12] without a licence, requires protection of aquatic ecosystems and biological diversity, and the reduction and prevention of pollution of water resources. It is more explicit in some areas than the Water Law. For example, it says that Ministries must take watershed management, sustainability of groundwater abstractions, the regulation of water for industries and agriculture, and wetland protection into account when developing water management plans. The National Water Sector Strategy says that the riverbank protection program is providing emergency interventions in the short term and high priority river reaches are being identified for medium-term investment to control bank erosion.

The Agriculture and Natural Resources Policy and Strategy 2005 notes that tube wells being drilled illegally by wealthy farmers but does not advocate any particular action. However, the drilling of new deep wells is now covered by the 2009 Water Law. This policy also notes the damage to watersheds because of widespread deforestation. This is now subject to control under the Environment Law 2007.

The Agriculture and Natural Resources Policy and Strategy 2005 wants to improve irrigation methods and management by taking an IWRM approach. This would include improving water-use efficiency by reducing water losses, introducing drip irrigation and other technologies, and better sharing of water between upstream and downstream users. The Policy also advocates enhancing groundwater through reforestation, reducing the number of deep wells and storage ponds (the intention of this provision is not clear).

Education, Participation and Communications

There are a number of provisions in the various instruments for participation by water users. The Water Law 2009 says water users are to be engaged in river basin planning and management, and that River Basin Councils are to include water users, central government agencies and local departments. Water User Associations and irrigation associations are authorized under the Water Law (although their purpose is left undefined) with the Ministry of Agriculture, Irrigation and Livestock being authorized to delegate responsibility for water distribution to irrigation associations. The

[12] Water resources are not defined in this law and it is not clear if they include groundwater or not.

Agriculture and Natural Resources Policy and Strategy 2005 also encourages a participatory approach to management and requires WUAs to be strengthened for management of irrigation networks.

Summary
Although none of the instruments recognize the potential impacts of climate change, the basic structure of the water instruments is well grounded in IWRM principles, providing some basic mechanisms for climate change adaptation. A Supreme Council of Water Affairs, chaired by the First Vice-President, has been formed to coordinate across the various Ministries that have been assigned water-related responsibilities. River basin management has been initiated with the formation of River Basin Councils and participatory management has been approved under the Water Law. There are also complementary powers under the Water Law and the Environment Law to control water pollution and protect watersheds from degradation.

In spite of these potentially positive features, Thomas (2013) found that the new water management arrangements did not operate as envisaged in two sub-basins during the 2011 drought. He observed that participatory processes were bypassed by local governments and national water authorities. Conflicts between upstream and downstream water users were 'solved' by appeal to power brokers in Kabul rather than through local Councils, and ad-hoc water allocation commissions had to be formed to decide on irrigation allocations rather than the River Basin Councils. These ad-hoc Commissions operated on familiar provincial boundaries rather than on river basin boundaries. Thomas concludes that there are significant conflicts between traditional water management approaches and the new Water Law, and calls for a complete rethink of the IWRM approach in Afghanistan.

Bangladesh

The government of Bangladesh enacted a National Water Policy in 1999 that marked the first incorporation of IWRM principles in Bangladesh water management (Gupta et al 2005). The policy places emphasis on protection against natural disasters – principally floods, droughts and cyclones. It notes that floods are closely linked to erosion and sedimentation. The policy does not specifically refer to climate change as either a driver of water-related issues (such as accelerated erosion and sedimentation) or as a reason for adaptive action.

A National Water Management Plan was produced in 2001, two years after the Policy, because there was concern over the extent to which the actions required by different policies were to be coordinated among different Ministries (Gupta et al 2005). A strong institutional framework was needed and so WARPO, under the Ministry of Water Resources, was instituted as the apex planning and coordinating organization. The Plan discusses the likely impacts of climate change, such as the effects of climate change on sea-levels and cyclonic storm surges. Some of the elements of the Water Policy were formalized in the 2013 Water Act.

Water pollution is not dealt with under the Water Act but is to be controlled under the Environment Conservation Act 1995 and the 2010 Environment Conservation

Amendment Act, and the 2013 National River Protection Commission Act. Drinking water and sanitation are dealt with under the 1998 National Policy for Safe Water Supply and Sanitation. This policy is primarily concerned with extending the coverage of safe water supply and sanitation service although it does provide for protection of water source areas.

The government of Bangladesh approved a Coastal Zone Policy in 2005 (the Water Policy also recognizes the importance and vulnerability of the coastal areas to water-related issues). The Coastal Zone Policy fully recognizes that the country's vulnerability to natural disasters in coastal areas – cyclones, flooding, siltation – will be exacerbated by climate change. The policy accepts that the coastal zone is affected by the policies of a wide range of Ministries and requires all government agencies with water responsibilities to protect the environment.

A National River Protection Commission has been authorized under 2013 legislation to make recommendations to the government concerning encroachment on river banks, pollution and harmful use of waterbodies. However, the Commission will not have any executive powers and environmental groups doubt that it will be effective.

Water Resources Knowledge

According to the National Water Plan groundwater recharge, water use and changes in surface water and groundwater quality will be monitored and a central database of all water information will be established. Research should be expanded into practical issues such as flood control according to the National Water Plan. It also calls for more research into climate change implications and responses and the sustainability of groundwater resources. The Water Rules 2015 require local governments to keep an inventory of groundwater use so that safe yields can be established. Finally the Coastal Zone Policy advocates a coastal resources survey, a coastal resources database, information dissemination, and a capacity building program.

Water Resources Governance

Under the National Water Policy 1999, and the 2013 Water Act, ownership of water is vested in the State which will allocate water to beneficial uses. Under the Water Act water users (apart from domestic water users) are required to obtain a permit to extract water or to divert or impede water flows (unauthorized embankments have been a significant issue for flood management). The Act allows water stress areas to be declared and establishes a priority order for access to water in these areas, with domestic use and drinking water being given priority.

The National Water Resources Council is to be the apex water management institution with the tasks of overseeing coordination amongst water sector agencies and developing a National Water Management Plan. The Water Resources Planning Organization (WARPO) under the Ministry of Water Resources, was created in 1999. In the 2013 Water Act, WARPO is required to develop a National Water Resources Plan that promotes integration of surface water and groundwater, determines water quality standards and includes basin-wide development plans. This new Plan is still under development.

The National Water Policy recognized that water should be managed at the basin scale and looked to cooperate with other countries to manage transboundary waters. The Policy paid specific attention to groundwater. Irrigation with ground water was to be regulated. Surface water and groundwater quality would be protected.

WARPO has drafted Water Rules (2015) as required under the 2013 Water Act. The Rules appear to propose a new Water Policy to replace the 2003 Policy as authorized in the 2013 Water Act.

Given the importance of transboundary rivers to Bangladesh, it is not surprising that the Water Policy pays particular attention to management of this issue. It commits the government to exchange data with co-riparian countries and jointly understand the issues associated with these rivers, and to work collaboratively to share the development potential of the rivers.

Water Resources Infrastructure

The National Water Policy 1999 proposes that a Water Development Board be formed to institute large water resources infrastructure projects, such as dams and flood barriers for flood protection in sensitive areas. Rivers are to be desilted, and early flood warning systems are to be developed. The National Water Plan contains a number of infrastructure proposals including improved flood control, new irrigation schemes, and coastal protection works that take account of climate change. It also proposes more development of surface waters based on comprehensive plans because of the over-development of groundwater. The drafted Water Rules (2015) also specify the types of projects (flood management, irrigation, drainage, etc.,) that must be checked for consistency with the Water Resources Plan before being undertaken.

The Coastal Zone Policy 2005 promotes economic development and poverty alleviation, together with reduction in vulnerabilities to natural disasters including effects of climate change through infrastructure such as dykes and shelters.

Water Resources Planning and Management

According to the National Water Policy 1999, drought management plans would be introduced with consideration of technical measures such as conjunctive use during droughts. The Policy envisages that water planning will be based around the country's principal river systems together with the hilly areas to the east. The water needs of fisheries and wildlife will be included in water plans along with drainage schemes for wetlands with ecological values.

Many elements of IWRM are proposed under the National Water Plan - cost recovery, decentralized water management, community participation, clarity about rights and accountability, and conjunctive use because of the over-reliance on groundwater. Minimum steam flows will be maintained for navigation and to preserve coastal estuaries, although their role in maintaining environmental health is not mentioned. The Water Act 2013 legislates for environmental river flows; wetlands can be designated as flood passages; wetlands that support migratory birds cannot be drained for development; and potable water sources are protected. Flood embankments are to be protected from development.

Under the National Water Policy industrial and agricultural pollution will be regulated. The 1998 National Policy for Safe Water Supply and Sanitation also requires the prevention of pollution of surface water and groundwater sources. The 2013 Water Act does not deal with establishing ambient water quality levels or pollution discharge standards. Pollution control is left to the Environment Conservation Act 1995. However, this legislation does not provide the power to establish water quality standards or to regulate discharges of pollutants from industry or other sources to surface or groundwater (other than from accidental discharges). The 2010 Amendment Act does place some restrictions on misuse of water reservoirs but does not appear to strengthen powers to set water quality standards and control water pollution. The Coastal Zone Policy recognizes the seriousness of high groundwater arsenic concentrations while the 2003 Water Policy makes only one passing reference to this issue and does not propose remediation action.

Under the National Water Policy groundwater extraction would be controlled in recharge areas and conjunctive use will be encouraged, particularly in drought prone areas. The Water Act also recognizes that both surface water and groundwater have to be managed. It requires safe yields to be set for all aquifers in water stressed areas. Groundwater receives attention in the 2015 Water Rules. Aquifers that are under stress are to be identified and a safe yield established for each aquifer. All industrial and commercial abstractions of groundwater require permits.

Water pricing will be introduced so users recognize scarcity value, with funds to be retained locally according to the National Water Plan. Public water supply agencies can charge for services and financial incentives will be introduced for water reuse and conservation. The 1998 National Policy for Safe Water Supply and Sanitation also advocates pricing water at its economic value so as to cover the cost of supply. The Water Rules 2015 propose that water pricing be set based on volume of water abstracted (apart from subsistence and potable water uses).

Under the Water Rules, floodplains are to be delineated and no structures are permitted in the high flow portions of the floodplain without permission.

The Coastal Zone Policy also calls for sustainable natural resources management including environmental flows to prevent seawater intrusion and preserve coastal ecosystems, rainwater harvesting, water conservation and groundwater sustainability. Conservation of critical coastal ecosystems receives specific attention in the policy with the recognition that monitoring climate change effects and undertaking actions to adapt to climate change are required.

Education, Participation and Communications

The National Water Plan says that stakeholder participation will be encouraged in all project planning. The subsequent Water Rules 2015 propose the formation of Integrated Water Resources Committees at District, Upazila (sub-district), Pourashava (town) and Union levels, although these are largely comprised of government officials. The 1998 National Policy for Safe Water Supply and Sanitation encourages user participation in planning, development and operations. More generally, the National Water Plan says that there is a need to improve water knowledge, and raise public awareness of sustainability. Bangladesh published Rules for Participation in

2000 in order to help local people influence decisions that affected them, although the effectiveness of these attempts at inclusion have been questioned (Dewan et al 2014).

The National Water Plan calls for institutional capacity to be strengthened, while the 1998 National Policy for Safe Water Supply and Sanitation encourages building capacity specifically in water supply institutions as well as coordination with the National Water Policy and National Environment Policy.

Summary
Although there is no mention of climate change and the need to adapt to its impacts in the 1998 Water Policy, the 2013 Water Act or the Water Rules, its impacts are well recognized in the National Water Plan 2001 and the Coastal Zone Policy 2005.

There is a strong IWRM character throughout the water instruments. There is a water resources coordinating body - the National Water Resources Council chaired by the Prime Minister; a detailed Water Plan with costed programs; basin scale planning; and an intention to manage transboundary waters cooperatively. The instruments pay considerable attention to improving the management and monitoring of groundwater, including through conjunctive use with surface waters. Demand management is not explicitly proposed although water pricing to make consumers aware of the cost of the resource is proposed. Water quality management is advocated but there seem to be few mechanisms to control pollution from various sources. Devolution to water users is also proposed although the Committees to be formed under the Water Rules do not appear to have many individual water user representatives.

Many of the elements of IWRM that would assist adaptation to climate change are present in these instruments, although the big adaptation issues facing Bangladesh from sea-level rise, floods and drought, siltation of the delta areas, and changes to monsoon regimes will require full implementation of these and other (e.g. more reliance on local adaptation through more water user representation) measures.

Bhutan

Bhutan does not face pressing water problems at river basin scale yet, although there are local water shortages (Bhutan National Environment Commission, 2016). Other issues include flooding in specific locations and the threat of glacial lake outburst floods. Water shortages are expected to increase as irrigation water demand increases as a result of the Irrigation Master Plan and the extensive hydropower development plans. Climate change may result in more intense monsoonal rainfall with extreme river flows, while there will be lesser river flows in winter, although these possibilities are uncertain given the lack of data and modeling (Bhutan National Environment Commission 2016).

Bhutan has recognized the importance of an integrated approach to water resources management for a number of years, making it a cross-cutting objective of the environment sector in the Tenth Five-Year Plan, 2008–2013 and in the draft Eleventh Five-Year Plan, 2014–2019 (Asian Development Bank, 2014). The government of

Bhutan approved a Water Policy[13] in 2003 and a Water Act in 2011, both of which are based on the principles of IWRM. Climate change impacts were one of the drivers for the Water Act and the IWRM focus was specifically adopted to help respond to climate change impacts (Bhutan National Environment Commission, 2016). Water Regulations were promulgated in 2012.

Prior to the Water Policy, each water-using sector had been responsible for its own water use. While the Policy continued with this disaggregated approach, it envisaged a broad multi-sectoral framework within which each water-related sub-sector would contribute to the overall policy objectives. The Policy and Act assign responsibility for coordinating across sectors to the National Environment Commission (NEC) within the National Planning Commission. The NEC was also given responsibility for developing water legislation, establishing water quality standards and guidelines, research and development, undertaking capacity building, and managing water data. However, other functions remain with relevant departments. Thus, the Department of Power retained responsibility for hydrological and meteorological data collection, while the Ministry of Health manages rural WSS. The Water Act provides a table detailing these responsibilities.

The Water Regulations, approved in 2012, complement the Act. They require the NEC to establish a National Water Resources Board, comprising Directors from relevant Ministries, to act as a technical advisory committee to NEC.

These instruments are all aware of the potential impacts of climate change on Bhutan and are designed to provide greater resilience against current climate variability and the longer term impacts of climate change.

An Integrated Water Resources Management Plan (IWRMP) has recently been drafted but has yet to be approved by the government of Bhutan. It recognizes that, there are no pressing water problems yet at river basins scale. However, water-related problems are felt acutely at local level by dispersed communities who rely on water from small sources and rivulets. Their problems cannot be solved at central or even basin level, and should be addressed at the level of villages and Gewogs (Bhutan National Environment Commission 2016).

The IWRMP is a discussion document rather than a Plan. It explicitly recognizes that IWRM is an adaptation response to climate change. Its six components are: managing water at the basin level; optimizing water supply (i.e. conservation and evaluating environmental impacts); demand management (i.e. cost recovery, efficient technology, decentralized management); providing equitable access to water; establishing policy (e.g. polluter pays, water quality standards and market based regulation); and taking an inter-sectoral approach. The Plan recognizes the importance of mainstreaming IWRM. It states that IWRM will be integrated into Bhutan's next 5-Year plan (12th Plan 2018-2023) with possible key result areas (KRA) in water security for urban and rural water supply, economic water security for hydropower and irrigation, sustainable environmental flows, and climate change resilience. Climate change is one of the five key areas in the 12th 5-Year Plan. There is even a

[13] I have not located this Water policy and the following description comes from other commentators.

possibility that the water security KRA can be integrated into the current 11th 5-Year Plan.

The Bhutan government also adopted a new Irrigation Policy in 2010. The policy marks a shift away from development and towards improved irrigation management and sustainability, partly driven by changes in the water, land and environment sectors. The 2010 Irrigation Policy includes principles consistent with IWRM. The policy includes a coarse-scale analysis of climate change impacts that shows that growing irrigation water demand can still be met under the two climate change scenarios examined.

The National Environment Strategy 1998 – the Middle Path - is currently being revised. The National Environment Protection Act was passed in 2007. It has primacy over other Acts if there is a conflict. The Act requires water be provided for environmental flows, protection of watersheds, and the collection of water quality information.

Water Resources Knowledge

The Royal Government of Bhutan has identified addressing hydro-meteorological hazards and strengthening climate resilience as priority issues (World Bank 2015a). The World Bank (2015a), in their assessment for the Government, found that the information basis for assessing the risk of natural disasters is weak and needs to be strengthened. Hydrological and meteorological records are recorded manually; meteorological measurements are under-represented at the higher elevations; upper air observations need to be strengthened; and glacier and snow monitoring by public sector agencies is limited.

The 11th 5-Year Plan includes strengthening the hydro-meteorology data to facilitate reliable weather, GLOFs and water-related forecasting as an objective of the energy sector. The Plan anticipates an increase of hydro-meteorological stations from 94 to 166, an improvement in weather and river flow forecasts, and the introduction of three glacier mass balance monitoring stations.

The Water Policy identifies a number of research priorities including hydro-meteorology, assessment of water resources, watershed protection, groundwater hydrology and recharge, water-harvesting, water balance studies, crop–water requirements and cropping systems, soil erosion and bio-engineering, flood control and mitigation, erosion and sedimentation of reservoirs, safety of hydraulic structures, recycling and reuse of water, best practices, wastewater treatment, and water pollution and prevention. The Water Act reinforces this with requirements for research activities on water conservation, management and development, including methods to reduce water consumption and wastage and to promote sustainable water use. The National Water Resources Board is also to undertake research into climate change issues such as mitigation of the impacts of climate change.

The Water Act requires open access to water resources information, presumably because of the different Ministries tasked with collecting water information. World Bank (2015a) found that the hydro-meteorological network was weak with monitoring being recorded manually.

Water Resources Governance

The Water Policy and Water Act vests ownership of water (defined to include both surface water and groundwater) in the state. They also require river basin level management with River Basin Committees to be established to prepare River Basin Management Plans, promote community participation, monitor and collect data, and resolve water issues. The Water Policy establishes priorities for the major water uses.

The NEC is tasked with coordinating water management across Ministries. The IWRMP states that the Water Act and regulations need to be harmonized with other legislation

Water Resources Infrastructure

The 11th 5-Year Plan includes a target of 100% water supply coverage for all settlements (up from 81% coverage at commencement of the Plan). It also proposes the construction of 5 new water supply reservoirs and the construction of flood protection infrastructure. There are 3 new hydropower projects under construction and seven more to commence during the 5 Year Plan.

Water Resources Planning and Management

The NEC was required under the Water Act to develop an IWRM Plan (IWRMP) that will be mainstreamed into national policies, plans and programs. The IWRMP is a framework document - specific actions are to be contained in each river basin plan. While groundwater is included within all water resources, there are some specific requirements for groundwater management. Thus the Water Regulations 2012 require the IWRMP to analyze impacts on quality and quantity of groundwater, and the River Basin Management Plans to identify the location of groundwater, control pollution of groundwater, and monitor the quantity and quality of groundwater. The National Environment Strategy does not mention water allocation planning but does propose that land use planning occurs on water catchments.

The Water Act includes the principle of 'polluter pays', user pays for water use, and protection of water catchments to minimize the risk of erosion and landslides. The NEC can declare threatened water sources as Water Management Areas where special controls can be applied to water abstractions, discharges, vegetation loss and development of structures. The National Environment Strategy advocates maintenance of watersheds to reduce erosion and sediment loads, provide food and fodder and help maintain local climate. It also sees that controls over industrial pollutants and wastewater will protect rivers. The NEC is required by the Water Act to establish water quality standards and guidelines, set effluent discharge standards, and establish minimum environmental flows.

Both the Water Act and the National Environment Strategy recognize the need to maintain environmental flows in order to protect ecosystems downstream of dams.

The Water Policy establishes that sustainable water management should occur through use of water efficient technologies and good management practices. This is supported by the 2010 Irrigation Policy that requires environmental sustainable operations (including training of irrigation department staff in catchment protection,

payment for water use, and environmental mitigation), improved technical efficiency, and inter-sectoral planning.

The draft IWRMP recognises that there is a need to develop new infrastructure design standards, given the expected increase in high flow events under climate change.

Education, Participation and Communications
The Water Policy and Water Act require full participation of water users in water management decisions. Stakeholder participation in water management had been introduced earlier in the 1992 Irrigation Policy (and also included in the 2010 Irrigation Policy) which encouraged farmer participation, formation of Water User Associations for publicly owned irrigation schemes. Under the Water Act WUAs and traditional communities are to be on River Basin Committees.

India

Under the Indian constitution States have primary responsibility for water management, while the Union government has responsibility for navigation on national waterways and territorial waters, and to adjudicate on inter-State water disputes (Cullet and Gupta 2009). It also has responsibility for transboundary water matters with neighboring countries. We will examine only national water resources instruments in this assessment.

It was apparent by the 1980s that there needed to be a national approach to water, leading to the first National Water Policy in 1987, modified in 2002. The current Water Policy was approved in 2012, although with objections from a number of States. A draft Water Framework Bill was produced in 2013 to reflect this policy but has yet to be passed by Parliament and is now likely to be superseded by a new draft model bill. This most recent draft will focus on demand side measures, although it will also include measures to recharge groundwater. A Model Bill for the Conservation, Protection and Regulation of Groundwater had been drafted in 2011 to replace the outdated 2005 Model Groundwater Bill, although it has yet to be passed and, in the past, there has not been much uptake of these model bills by State governments. The new Bill has been carefully drafted to both reflect the current legal situation where groundwater is seen as a private property right (although the Supreme Court tends to view groundwater as a common pool resource) as well as to help control overuse and pollution of aquifers. It encourages the treatment of groundwater as a resource to be managed at the lowest possible level with technical support from State water agencies.

Water pollution is regulated under provisions of the Environment (Protection) Act 1986 and Water (Control and Prevention of Pollution) Act 1974. The 1974 legislation established the Central Pollution Control Board (CPCB) and encourages State governments to establish State Pollution Control Boards. The CPCB role is to promote cleanliness of streams[14] and wells through technical assistance to State

[14] Streams are defined to include groundwater in the Act.

Boards, training, analysis of pollution data, establishing water quality standards in consultation with State Boards, and undertaking a national pollution control program. The 1997 Water (Prevention and Control of Pollution) Cess Act (updated 2003) provides government with the power to apply volumetric pollution discharge levies to polluting industries.

Other relevant national instruments include the National Agriculture Policy 2000, and the National Urban Sanitation Policy 2008. Drinking water is included in the National Water Policy 2012. In the absence of water resources legislation, water is primarily managed through the 1974 Water (Control and Prevention of Pollution) Act and the 1986 Environment Protection Act which are concerned with water quality and do not deal with the surface water and groundwater availability and sharing issues facing India today.

In addition, each State has its own instruments and institutions dealing with water resources. The plethora of institutions and legislation governing water at central, State and local levels together with the existence of traditional rules for water access have led to diffused accountability and inaction on important water issues, such as overdraft of groundwater. The Supreme Court has stepped into the breach a number of times. For example, it ruled that under Article 21 of the Constitution the right to life includes a right to access to basic water requirements and that this should be the highest priority for water sharing, and has been asked to rule on a water sharing dispute between Karnataka and Tamil Nadu over the waters of the Kaveri River.

India has a number of transboundary treaties in place with neighboring countries. The 1960 Indus Treaty with Pakistan has allowed the Indus waters to be shared peacefully for 50 years. However, the Kosi River Treaty with Nepal has been a matter of concern for Nepal. The 1996 Mahakali Agreement is less contentious and there is technical cooperation between the two countries. Although the 1972 Agreement with Bangladesh on sharing transboundary waters led to the institution of the Joint Rivers Commission, there is continuing tension between the two countries, particularly over the Farakka Barrage on the Ganges River. There are no water sharing treaties with China although there is a MoU covering data sharing signed between the countries.

Water Resources Knowledge

The Water Policy advocates improved information, including flood forecasting, flood mapping, community action plans and disaster preparedness. Also climate and hydrological data should be collected for each river basin as well as water use data for surface water and groundwater. Surface water and groundwater quality should also be monitored in each river basin. A national water informatics center should be established and all possible data put into public domain. Because of climate change, more data is needed on snow and glacial dynamics, evaporation losses, tidal hydrology and hydraulics, river geometry, and erosion and sedimentation. Both the National Water Policy and the Framework Bill propose that flood forecasting systems be developed. More R&D and training are needed and a water policy research center should be established.

The National Hydrology Project, Phases I and II, have assisted the central government and several State governments in southern India expand their institutional and

technical capacities including flow, water quality and meteorological monitoring. Under Phase III of this project, currently being prepared, this assistance will be extended across all India and will support a river basin approach for integrated water resources management. The interstate dimensions of the major river basins and aquifers will be handled by participating central agencies.

Water Resources Governance

The National Water Resources Council, established in 1983 and chaired by the Prime Minister with State Chief Ministers as members, is the apex body for water management in India. It is supported by the National Water Board at Secretariat level.

India's National Water Policy 2012 marks a change in direction for water management in India (Singh et al undated). It proposes: a rational approach to water sharing based on water budgeting and auditing; that State governments appoint water regulators, introduce systems for water tariff and establish criteria for water charges; subsidies for rural electricity for groundwater be removed; government water service providers shift to regulatory and facilitator roles; a national legal framework be introduced to guide State water legislation; and that all forms of subsidies to be abolished in agriculture and domestic water although subsidies would be available to industry for recycling and reuse. The National Water Framework Act 2013 repeats many of the principles of the Policy, including State ownership of water, river basin management, water resources should be planned and managed in a coordinated way across national, state and local levels, participation and transparency, and provision of environmental flows to protect ecosystems.

The Policy clearly identifies climate change as one of the three key drivers of water management along with population growth and increasing demand, and contains a section on adapting to climate change. The Policy contains a number of IWRM elements. It states that water is a common pool resource held under trust by the state (both surface water and groundwater, the latter of which is seen by many citizens to be associated with land ownership). The Model Groundwater Bill 2011 breaks with tradition by emphasizing State custodianship of groundwater. This assertion opens up the possibility of management based on aquifers as opposed to land titles, as well as having major equity implications. The Bill proposes that permits are required for medium-major irrigation and industrial uses that draw on groundwater (Cullet 2012).

The National Water Policy also requires a national perspective on water planning, managing and development; equity over water allocation; water as an economic good; ecosystems have a right to water (the Model Groundwater Bill extends this to include groundwater); integrated management of water quantity and quality; planning and management at river basin level; increased emphasis on demand management including water use efficiency; integrated water quality and quantity management and use of economic instruments for pollution control; and public participation and accountability. IWRM should be the principle for river basin planning and institutions should be restructured to promote a multi-disciplinary approach to water management. The National Agriculture Policy 2000 also states for an integrated plan of augmentation and management of national water resources needs to receive special attention.

Water Resources Infrastructure

The Water Policy recognizes that water storage will need to be increased, from small to large storage structures, because of increased variability from climate change. Other approaches to water supply augmentation should also be explored to cope with rising demand including desalination, direct rainfall use, and ET control. All infrastructure planning should include the effects of climate change.

Planning and Management

The Water Policy supports water planning on a basin and sub-basin scale including surface water and groundwater. Basin authorities will need to be established for this purpose. Water resources planning should include environmental water needs and account for trends resulting from climate change. The Water Framework Bill 2013 also proposes basin committees should be established at central and State levels to prepare water resources plans out to 2050, support basin management, and undertake investigations into issues such as pricing and climate change. In particular the Policy says that the environmental needs of the Himalayan regions, aquatic ecosystems and wetlands and floodplains should be included in water planning. Both the National water Policy and the Water Framework Bill require planning for infrastructure such as dams, embankments, etc., should incorporate strategies to cope with the effects of climate change, presumably by ensuring that design standards take account of changes in critical hydrological parameters.

The National Water Policy places strong emphasis on demand management in irrigation areas, along with water recycling and reuse, technical improvements, and conjunctive use of canal seepage. Demand management can help combat the impacts of climate change through improved water application methods and alignment with compatible agricultural strategies. The National Agriculture Policy 2000 also promotes optimal water use through water conservation, conjunctive use, and control over receding groundwater levels. However, it is silent on water pricing and does not consider the effects of climate change on water availability or crop growth.

Water and land conservation should be practiced according to the National Water policy to protect river corridor, wetlands and floodplains. Encroachments into waterbodies and drainage channels should be prevented and developments upstream of key sensitive areas, including groundwater recharge zones, should be strictly regulated. The Agriculture Policy 2000 also advocates watershed development programs to protect water quality. The Model Groundwater Bill requires a groundwater security plan for all declared protection zones and other aquifers selected by government. The plan should allow for ASR, conjunctive use, social equity, efficient water use and incentives for conservation.

Small scale water harvesting should be encouraged according to the National Water Policy although developers need to be aware of possible downstream effects.

The water policy says that pollution should be prevented and punitive action taken against polluters. This is especially true for groundwater because of the difficulty of remediating polluted groundwater. The policy states that erosion is likely to be worse because of increased rainfall intensity from climate change. The National Water

Framework Act 2013 states that pollution should be managed through provisions of the Environment (Protection) Act 1986 and Water (Control and Prevention of Pollution) Act 1974 including waste reduction and setting water quality standards. However, the Model groundwater Bill includes provisions for protection of groundwater from pollution and depletion.

The Framework Bill enshrines many of the operational features of the National Water Policy such as priority for demand management, use of water harvesting and micro-watershed management, water pricing based on economic principles (with prices set after wide consultations and through an independent State level water regulatory authority), and encouragement of reuse and recycling. Floods and droughts are to be managed through both structural and non-structural measures.

For groundwater, the Policy proposes that overuse needs to be controlled, aquifers should be mapped, and artificial recharge should be used where possible. The Water Framework Bill has a special section on groundwater which calls for conjunctive management, local management of groundwater extraction, reduction of electricity subsidies, protection of recharge areas, protection of groundwater quality, and public provision of groundwater information.

The National Water Policy says that urban water supply should be from surface water, using conjunctive sources including water harvesting. Leakages and theft should be reduced, pricing should include sewage costs, industry in water short areas should consider water reuse, overuse and contamination from industry should be prevented, and there should be subsidies and incentives for industrial water recycling.

Education, Participation and Communications

The Water Policy strongly supports community involvement in water management for a number of reasons. First it sees that climate change adaptation can be carried out at community level although communities will need capacity building. Also irrigation WUAs should be given statutory powers to manage and allocate water within their areas and be allowed to establish water rates, and collect and retain a portion of water charges. It also encourages water users to be involved in water quality monitoring of issues such as salinization as part of prevention and remediation. Local organizations, (WUAs, local government, etc.,) should be included in project planning and there should be community involvement in all projects. The Model Groundwater Bill also advocates user representation on water decisions with a hierarchical structure of representative committees from Gram Panchayat level to the State Groundwater Advisory Council to devolve management to a local level wherever possible.

Training will be needed by State government personnel in design practices, planning and management techniques and modern field practices. Regular training courses should be held in water management along with a national campaign to improve water literacy.

Nepal

Background

The 1992 Water Resources Act remains the primary water legislation in Nepal. A Water Resources Strategy was adopted in 2002, followed by a National Water Plan to implement the Strategy in 2005. The Strategy and Plan are both based on IWRM concepts with the intention of moving away from a sector-by-sector approach to a coordinated, integrated approach to water management. The Strategy provides the framework for water resources development, recognizing that previous development efforts have not been effective. It proposed that a National Water Policy be developed to unify the fragmented approach to water development and management in Nepal, along with a more comprehensive and modern Water Act. The 2005 Water Plan provides details of specific projects and investments for implementing the Strategy. The Water Plan recognized that existing institutions needed to be reorganized and new institutions created at river basin level if the Strategy was to be successfully implemented as well as respond to broader societal changes, such as wider community participation and greater private sector involvement. Importantly, the Water and Energy Commission Secretariat (WECS) would be strengthened and restructured so that it had the capacity to effectively coordinate water-dependent sub-sectors.

Although an Integrated Water Resources Policy and an Integrated Water Resources Act were subsequently drafted, they were not approved by Parliament, largely because of concerns from the Ministry of Energy about loss of autonomy if WECS became an independent coordinating institution with authority over sectoral development plans (Suhardiman et al 2015). Consequently, WECS remains a weak coordinating institution and the other provisions of the Strategy and the Plan remain without legislative backing.

Consequently, water policy is based on the policies for the three major water-related subsectors – Irrigation (2003), Hydropower (2001), and Water Supply and Sanitation (2014 draft) which was drafted in 2014 to replace separate rural and urban water supply and sanitation policies approved in 2004 and 2009 respectively. Only the latter policy recognizes the impact of climate change – in particular on water availability, especially for small water supply schemes dependent on sources with variable and limited flows. The Water Induced Disaster Management Policy 2006 does not mention the effects of climate change on disasters.

Nepal's current hydropower policy, which dates from 2001, is primarily focused on development of the hydropower resource. It does not discuss the potential effects of climate change on hydropower generation. However, a recent report (Sangroula 2015) makes it clear that hydropower production is exposed to a range of natural hazards, including floods, landslides and debris flows, extreme weather events, glacier lake outburst floods and landslide dam outburst floods that will be exacerbated by climate change. It is also vulnerable to changes in runoff patterns and river hydrology that will make it more difficult to maintain electricity generation throughout the year. Sediment-induced wear on hydraulic machinery is currently one of the major issues in hydropower operations and this is likely to increase with increased rainfall intensities and erosion under climate change (Aryal and Rajkarnikar 2011). A World Bank

funded project has recently commenced to improve the readiness of the power sector agencies for regulatory and institutional reforms by, inter alia, developing recommendations for updating the Water Resources Act and to support IWRM based river basin planning in selected river basins (World Bank 2015b).

In 2011, WECS published a report on the effects of climate change on the country's water resources (Aryal and Rajkarnikar 2011). This emphasized that the country is vulnerable to floods through a variety of mechanisms including cloud bursts, glacial lake outbursts, landslides, infrastructure failure, and sheet inundation, all of which will be exacerbated by climate change. The report proposes that the best responses are to invest in research including on Himalayan snow and glacial melt, strengthen the water resources observation network, undertake programs into integrated river basin management, develop suitable climate models, redefine water structure design criteria, identify vulnerable areas, conserve water resources through reduction, reuse and recycling, and address impacts on landslides, debris flows, floods and droughts. Also programs need to be developed to build mass awareness of climate change, and to build expertise in climate responses. Relevant sectoral policies also need to include awareness of climate change on water resources.

The 2006 Water-Induced Disasters Management Policy considers actions to mitigate and respond to landslides, GLOFs, erosion, sediment deposition, and flooding. Although it does not consider the potential for climate change to exacerbate these disasters, it does advocate IWRM approaches to watershed management including watershed protection, protection of riparian areas, conservation of wetlands, and involvement of local user groups.

Water Resources Knowledge

One of the Water Resources Strategy and Plan's 10 outputs is to strengthen water information systems. This includes environmental databases, mapping important watersheds and ecosystems, rehabilitation of existing flow monitoring stations, and extensions to the monitoring network. The Plan includes monitoring stations at strategic points to detect GLOFs and other catastrophic events. The 2002 Water Resources Strategy envisages a Groundwater Regulation Authority that would undertake investigations to assess the potential for development of groundwater.

At present, water modeling is embryonic in Nepal and developing river basin flow models will require training and investment in software and hardware as well as helping managers understand how to use models in decision making. Disaster management will also require capacity for flood forecasting.

Water Resources Governance

Under the 1992 Water Resources Act and its associated regulations (1993) ownership of water is vested in the state and all users, apart from specific exemptions for individual users, must obtain a license to use water. The Act gives priority to water for drinking purposes, followed by irrigation and agriculture, hydropower, and other smaller uses. Environmental water is not recognized as a legitimate use in the Act, although water uses should not affect the environment through floods, erosion, etc. Water for hydro-electric generation must be developed and managed in accordance with this Act. The Act authorizes the government to formulate regulations governing

water quality standards and pollution discharge standards. The Act makes no specific mention of climate change and, while usefully clarifying that water is owned by the State and not by land owners or water users, it provides few tools for adapting to climate change.

The Water Resources Strategy recognized that Nepal needed a comprehensive Water Resources Policy if it was to overcome the fragmented and antiquated policy and legal framework. Apart from the proposal for a Himalayan Climate Change Study Centre, the Strategy does not explicitly mention the need for water resources management to adapt to the effects of climate change although it recognizes that global warming will increase the incidence of natural disasters. Nevertheless, eight of the Strategy's 10 outputs are relevant to building climate change adaptation. The governance outputs include sustainable management of watersheds and ecosystems; building regional cooperation for transboundary waters; developing an IWR Policy and an amended Water Resources Act; and improve institutional mechanisms such as enhanced planning and implementation capacities and improved WECS coordination.

The Strategy looks forward 25 years and suggests that NPR 1,000 billion will be needed (excluding hydropower development) for implementation, with 75% of these funds coming from the government and donor budgets – i.e. NPR 30 billion a year on average.
The 2005 Water Plan says they need a lead institution responsible for the management of aquatic ecosystems and pollution control, need to strengthen the capacity of government institutions, and establish a coordination body. Also the Plan says that groundwater not is properly conserved and lacks legal protection. These will be included in a new Water Resources Act that will resolve contradictions between other Acts.

The Plan says that new basin level institutions need to be established and that regulatory and operational entities need to be separated. The Irrigation Policy, dating from the same time as the Strategy, supports the need for the institutional reforms set out in the Strategy, primarily because it recognizes groundwater needs better protection from pollution and over-exploitation. This policy also advocates that irrigation fees be introduced.

In the absence of a Water Policy the Irrigation Policy 2003 says that water taken for irrigation should leave enough water in rivers for environmental flows and that development activities should coordinate with the Department of Irrigation at local and central levels.

The 2001 Hydropower Development Policy proposes that hydropower needs to be developed "in broader context of the macro-economy in developing and managing hydropower in line with the concept of developing water resources in an integrated manner" (Ministry of Water Resources 2011, p5). The recently drafted Water Supply and Sanitation Policy also notes that it is difficult to protect water supply sources from degradation because of legislative weaknesses.

Water Resources Infrastructure

The Water Resources Plan includes irrigation expansion as a major priority. Where feasible, irrigation development will be integrated with multipurpose water storage projects and inter-basin transfers. The storage projects are recognized as being important to reduce the potential impacts of climate change. The Water Resources Plan also includes a feasibility study for a dedicated navigational canal from Chatara to Kursela on the Ganges River as part of the proposed Kosi High Dam. The Water Resources Plan calls for water induced disaster flood structural measures dikes, check dams, and embankments. There are also major infrastructure investments planned for WSS, amounting to 18% of total water sector investment in the 14th 3-Year Plan. Hydropower represents the largest infrastructure investment in the Water Plan, accounting for 46% of the total water sector investment portfolio.

Nepal also has plans to invest in mini- and micro-hydropower systems according to the Renewable Energy Investment Program Plan 2011. The Water Plan has a detailed section on economic costing of infrastructure for irrigation, WSS, and hydropower for a total cost of NPR 950 billion.

Water Resources Planning and Management

The National Water Plan has a section on river basin management. Says that the correct enabling environment needs to be in place – policies and legislation; institutions; management instruments.

The Water Resources Strategy and National Water Plan describe a number of activities that would help adapt to climate change including managing the effects of water-induced disasters, many of which are exacerbated by climate change, improving irrigation management and moving towards more sustainable hydropower development. Some of the changes proposed in the Strategy are already underway; for example the government is moving towards full cost recovery for groundwater irrigation, and shifting responsibility for de-sedimentation of surface water irrigation channels to WUAs. The draft Water Supply and Sanitation Policy (2014) (as well as the earlier WSS policies) advocate the protection of groundwater from pollution from human wastes.

The National Water Plan proposes an environmental action plan to protect watersheds and aquatic ecosystems from flash floods, pollution and the effects of deforestation. Degraded watersheds need to be rehabilitated to reduce erosion and the danger of landslides. Water quality (including instream flow requirements) and wastewater standards need to be developed and enforced. Standards also need to be established for agricultural water use. EIA rules and regulations need to be reassessed and guidelines need to be introduced for conservation and protection in water supply catchments.

The Water Induced Disaster Mitigation Policy 2006 also focusses on landslips and erosion causing loss of life and economic damage. It also deals with floods including GLOFs. It requires landslide and flood risk areas to be mapped, and watershed conservation to be implemented in these risk areas. It supports the involvement of local user groups in watershed conservation activities.

The Plan also advocates a number of ways in which irrigation water use efficiency could be improved including conjunctive use in existing irrigation areas, rehabilitation of existing schemes, improving on-farm water management and participation, and introducing efficient technologies (e.g. drip and sprinkler systems) in new irrigation areas. It also proposes a program for groundwater recharge.

The Water Induced Disaster Management Policy and the NWP both call for disaster hazard mapping and zoning to restrict development in hazardous areas.

Irrigation policy also advocates that irrigation fees be introduced. Some of the changes proposed in the Strategy are already underway; for example the government is moving towards full cost recovery for groundwater irrigation. The Water Plan does not mention demand management or recycling or reuse. The Plan also advocates a number of ways in which irrigation water use efficiency could be improved including conjunctive use in existing irrigation areas, rehabilitation of existing schemes. The Irrigation Policy says "This demands promoting the conjunctive use of groundwater and surface water irrigation systems technical efficiency measures" (p1). The Plan also advocates a number of ways in which irrigation water use efficiency could be improved including, improving on-farm water management and participation, and introducing efficient technologies (e.g. drip and sprinkler systems) in new irrigation areas. It also proposes a program for groundwater recharge. Not a lot of detail and technical efficiency hardly mentioned in Irrigation Policy 2003.

Education, Participation and Communications

River basin management is central to IWRM and this will require an education program to raise awareness with legislators, the public, and management groups. It will also require data to be collected on river basin basis. Groundwater monitoring needs to be expanded to provide information on both water levels and water quality in irrigation districts, while exploration is needed to locate further groundwater resources for development.

The National Water Plan advocates education in water conservation through soil conservation training, academic training courses on water and the environment. There is a need to strengthen water management capacity in local irrigation institutions and to train farmers in water management. Research is needed into ecological water requirements, glacial lakes, dam structures and climate change.

Community engagement is already included in existing sub-sector policies. The Irrigation Policy 2003 places considerable emphasis on participatory management of irrigation systems and the formation of Water User Groups. Urban and Rural Water Supply and Sanitation policies have been successful in improving water supply and sanitation coverage while increasing community participation and ownership of water supply schemes. The draft 2014 policy is designed to further improve consumer involvement as well as tackle a range of new issues facing the sub-sector, primarily to do with service levels, coverage for poor and marginalized groups, and sustainability. The National Water Plan says that community participation is also needed in watershed management but that this will require legislative changes if it is to be effective.

Summary
Without an agreed national water resources policy, water management in Nepal remains fragmented, with the policies followed by water-dependent sectors not always being consistent. Water resources legislation is outdated and not designed to implement the changes envisaged in the 2002 Strategy and 2005 Plan. Overall, Nepal remains committed to an IWRM approach to water resources management although at watershed rather than national level.

The National Water Plan says that there are few formal instruments for implementing policy. Guidelines exist for project planning and environmental assessment and project evaluation but these are dated and not fully comprehensive. WUAs set up during project development are not always sustainable in the long term. Hydro-meteorological monitoring is not comprehensive and is reliant on manual recording methods. There is no open access policy for monitoring data.

Pakistan

Background
Under the Pakistani constitution, water management is the responsibility of Provincial governments with the federal government taking responsibility for coordination and policy formulation at the national level. Since 2001, district governments have been responsible for water supply and sanitation while irrigation remains a provincial responsibility (Abro 2009). However, provincial governments have shown little enthusiasm for development of new irrigation areas and the federal WAPDA has gradually taken responsibility for irrigation development, although provincial Irrigation and Drainage Authorities continue to manage irrigation districts.

Pakistan's severe water problems have been documented in a number of reports (Briscoe et al 2005; Ministry of Water and Power 2002a, 2002b, 2002c; Associated Consulting Engineers 2011, FODP 2012). Average water availability is low at about 1,000 m^3 per capita (2010), putting Pakistan into the UNs water stressed category. Per capita availability is predicted to drop to 800 m^3 per capita by 2025 (Planning Commission, 2005). The current water shortage will intensify because of growing industry and domestic demands together with increasing pollution of surface water and groundwater.

The Indus Basin Irrigation System is the world's largest contiguous irrigation system covering 17 million ha (Mukherji et al 2009). However, water use efficiencies in the Indus Valley are very low. For example, only 0.13 kg/m^3 of cereals are produced in the Indus Valley compared to 0.39 kg/m^3 water in India. Water losses are very high at about 40%, with about half being unrecoverable because it is lost to saline aquifers. These high water losses coupled with inefficient irrigation practices that cause widespread water logging and salinity problems further adding to low crop yields. In addition, the diversion of Indus River flows to irrigation and upstream water use in India have led to significant declines in flows to the delta, causing environmental problems in estuarine ecosystems and the intrusion of salt water into the lower Indus (Iftikhar, 2002).

Apart from the Indus Basin, Pakistan has two smaller river basins. The Makran Basin in Baluchistan discharges into the Arabian Sea, while the Kharan Basin is a closed basin with flows from the Pishin, Mashkhel and Baddo rivers discharging into shallow lakes and ponds that dry out completely in the hot season (Ministry of Water and Power 2002b). The total inflow of the two basins is less than 4 MAF annually. About 25% of the inflow of these rivers is used for flood irrigation.

The waters of the Indus River are shared between Pakistan and India according to the provisions of the Indus Waters Treaty signed in 1960. Water sharing between Pakistan's four provinces in the Indus Valley is governed by the 1991 Water Apportionment Accord which is implemented by the Indus River System Authority.

Water storage capacity is low by world standards at only 9% of average annual flows (Planning Commission 2005). Because of its limited surface storage capacity and its inefficient irrigation system, there has been a massive expansion in groundwater irrigation to the point where groundwater now accounts for 80% of rural domestic water supply and 50% of irrigation water use. Groundwater use is unregulated and uncontrolled leading to over-abstraction, secondary salinization, and chemical pollution of aquifers (Associated Consulting Engineers et al 2011). Over-abstraction is occurring in both the shallow aquifers of the Indus Valley and the deeper hard rock aquifers such as the barani areas of Baluchistan. Groundwater abstraction was about 70 Bm^3 in 2011 from 1 million tube wells (Associated Consulting Engineers et al 2011).

Pakistan also experiences floods and droughts as a result of variability in monsoonal precipitation. There are also high sediment loads in river flows because of the high erosion rates in rivers rising in the HKH, causing siltation of dams and barrages. In some areas, farmers have erected river bank flood levees, causing further problems as sediment is deposited onto the river bed, raising the levels of river beds and further increasing flood risk (Associated Consulting Engineers 2011).

Water Resources Knowledge

Pakistan's 2002 Water Strategy recognizes that monitoring and evaluation are important if management is to be effective but delegates this aspect of IWRM to sub-sectoral strategies yet to be developed. The draft 2006 Water Policy takes a broader view. It proposes that a national planning database will be established to consolidate water information from diverse agencies and to make it easily available to the public. The ability of water agencies to collect data will be strengthened and data sharing will be encouraged. The Policy also requires that industrial wastewater be treated and that the effluent discharge be monitored to meet "international standards", and that a national water quality monitoring program be established to set water quality standards and to develop a monitoring program. The Policy also proposes that groundwater be monitored to determine potential and to prepare groundwater budgets for sustainable development. The 2006 Water Policy acknowledges that flood forecasting has been strengthened through additional weather radar and telemetric system, but that there needs to be greater emphasis on accurately forecasting precipitation in catchment areas, and on the development of a flood early warning system.

The current draft Water Policy (2016) requires monitoring of drinking water quality and the prohibition of it dropping below specified standards. Each water delivery agency has to develop a Water Quality Monitoring Plan. Similarly industrial discharges will be monitored and water quality standards will be enforced. The Drinking Water Policy (2009) also proposes that a water quality monitoring program be established to protect water users. Under the 2016 draft Water Policy, groundwater monitoring will be enhanced to help assess sustainable yields while early warning flood systems will be introduced. The proposed National Water Quality Monitoring Program would include an information system for storing and disseminating water quality data.

The 2006 National Water Policy says that national water research agenda will be encouraged and given high priority. The research includes water conservation in irrigation districts, drought prediction, drought tolerant crops, technologies to reuse agricultural drainage for beneficial uses, sediment control in watersheds, and artificial recharge from rainwater harvesting. The Wetlands Policy also proposes research into wetlands processes and establishing the values provided by wetlands in Pakistan. The 2006 Water Policy advocates that more work be done on flood forecasting and warning systems and flood plain mapping of some major river reaches. The current draft Water Policy (2016) does not nominate specific research topics but proposes that a national water research agenda be developed with 1% of projects costs being allocated for this research.

Water Resources Governance

Pakistan does not have a national water policy[15] or Water Act. The Pakistan Vision 2025 (Planning Commission 2014 p62) puts this bluntly "Institutional structure for water management in Pakistan is fragmented and there is no holistic national water management policy". Provincial water legislation is either old or passed for specific aspects of water management (Associated Consulting Engineers et al 2011). The main national water-related Acts are the Pakistan Water and Power Development Authority Act (1958), the Environmental Protection Act (1997). A Strategy was developed in 2002 to modernize Pakistan's water management, including production of a new Water Policy. The Policy was drafted in 2006 but was not adopted. A new National Water Policy has recently been drafted by WAPDA (Bagel 2016).

Pakistan has sub-sectoral water policy, including a National Sanitation Policy (2006) and a National Drinking Water Policy (2009) and a National Wetlands Policy (2009), but no Irrigation or Agriculture Policy.

Both the 2006 and the current (2016) draft Water Policies are aware of the likely impacts of climate change on Pakistan's water resources and the need for adaptation. The 2006 Policy advocated that climate change impacts should be incorporated into strategies for planning, development and management. The current draft Policy proposes adaptive anticipates the effects of temperature rises on agriculture, changes in precipitation patterns and the consequent effects on glacier melt and increased

[15] Baluchistan has an Integrated Water Resources Management Policy (Associated Consulting Engineers 2011) while a new national Water Policy is currently being drafted.

siltation of reservoirs. The 2009 Wetlands Policy is also fully aware of the possible impact of climate change on wetlands because of changes in river flows (with a focus just on changed glacial melt as the cause) and the need for adaptive action. It also understands that wetlands, if they can be protected, act as buffers against natural disasters. The 2006 National Sanitation Policy does not mention climate change while the 2009 Drinking Water Policy sees climate change as impacting planning and development of drinking water supplies but provides no details.

The 2002 Water Sector Strategy as well as both drafts of the National Water Policy (2006 and the current draft policy) follow the principles of IWRM and proposed that water management be undertaken in a coordinated framework. The earlier Policy proposed a single apex water institution, the Pakistan Water Council comprising senior national and provincial politicians and other leaders that would direct the water reform process, with a Pakistan Water Commission to carry out the reform effort. However, provincial Irrigation and Drainage Authorities would need to take back their construction responsibilities from WAPA. It also proposed that the numerous legislations dealing with water be consolidated into a small number of comprehensive Acts, and that this revised legislation empower institutions to carry out their mandates effectively. The current draft Policy spells out the establishment of a new National Water Commission.

The 2006 Water Policy recognized the environment as a legitimate water sector although it had a low priority in water allocation decisions. The current draft Water Policy (2016) requires that river flows be maintained to preserve the ecology and morphology of rivers, deltas and coastal ecosystems.

Although the 2002 Strategy and both Water Policies recognize the serious overdraft of groundwater in many aquifers, there are few legal tools available for controlling overuse. The National Study of Groundwater Availability and Conjunctive Management reviewed water legislation and concluded that there is no primary legislation in place that allows control of groundwater levels (Associated Consulting Engineers et al 2011). The Punjab Soil Reclamation Act 1952 (amended 1964) has been promulgated to all provinces and acts as the legislative basis for groundwater management. But this Act only authorizes controls where salinization is a declared problem and doesn't apply for overdraft or other issues. It concluded that groundwater abstraction was mostly unregulated and uncontrolled and proposed a groundwater management strategy. The National Drinking Water Policy also recognizes that groundwater is largely unregulated and proposes that legislation be introduced to regulate groundwater use and quality.

The draft 2006 Water Policy states that Pakistan will work with national administrations and neighboring countries to understand river basin potentials and develop strategies for optimal use particularly during flood and drought conditions, as well as working with through international agencies to prevent chemical and biological pollution of shared waters. The new Water Policy currently being drafted proposes mechanisms for improving management of transboundary aquifers and watersheds including sharing real-time water information and a study to assess the impact of developments in the upper catchments of western rivers.

A recent document (Planning Commission 2014) says that the goal is to establish a National Water Commission with power to manage all water subsectors (surface, groundwater, rainfall) and their sectoral and regional allocations. The Commission intends to formulate an Integrated Water Resources Management Strategy and recommends that a comprehensive National Water Policy should be adopted soon. Amongst other things, the policy should give due consideration to climate change. The current draft Water Policy echoes these intentions by calling for the National Water Commission to be established and for it to oversee water resources development and management activities across all relevant sectors at national and provincial levels.

Water Resources Infrastructure

Irrigation, flood control, hydropower and WSS sub-sectors have plans to develop water resources infrastructure. While addition storage and flood protection development is an integral part of adapting to the effects of climate change, none of the relevant policies mentions this as a rationale for the development. Vision 2025 (Planning Commission 2014) says that the goal is to build new storages for irrigation, industry and domestic use so that retention times increase from 30 days to 45 days by 2018 and to 90 days by 2025. Vision 2025 proposed that an Integrated Water Resources Master plan be developed to determine needs and potential for a water storage development program. However, no infrastructure Master Plan has been developed at this stage. The Medium Term Development Framework (Planning Commission, 2005) also recognizes that structural as well as non-structural measures are needed for flood control.

Earlier, the Water Sector Strategy (Ministry of Water and Power, 2002b) also saw the need for rehabilitation and development of existing infrastructure across the main water-using sub-sectors. It called for an urban water supply strategy including infrastructure improvement and expansion; the modernization of old barrages, and rehabilitation of irrigation infrastructure and the safe conveyance of saline water to the sea in the irrigation sub-sector; new infrastructure to harness hill torrents and floodwaters in Baluchistan; and new large hydropower storages at Kalabagh and Basha and raising Mangla dam, along with new run of river schemes.

The 2002 Water Sector Strategy also contains a Medium Term Investment Plan for consideration by World Bank, ADB and others. There is a total of USD 12 billion in infrastructure, excluding hydropower projects. Projects include multi-purpose storages, drainage projects, WSS, and flood protection.

The 2006 draft Water Policy says that expansion of irrigation will come partly from improved irrigation efficiencies and partly from additional irrigation areas serviced by new infrastructure. It also encourages harnessing hill torrents and the development of additional storages and run-of-river schemes for hydropower. It estimates that, despite a massive investment in flood protection embankments (over 5,800kms) breaches are common causing heavy loss of life and property. Further flood protection will be needed but design standards will needed to be reviewed and further development should follow an integrated approach for the entire reach. It also recognized that additional carryover storages would be needed to combat drought years, although

none of these additional storage options are linked to the expected effects of climate change.

The 2016 draft Water Policy recognizes that existing water storages were reaching the end of their design lives and require replacement. It does not mention additional new storages. However, it says that new water projects should take effects of climate change into account.

The 2009 Drinking Water Policy envisages significant expansion of water supply coverage. It does not explicitly require new water storages although it does propose that existing infrastructure be rehabilitated. It also requires that the effect of climate change be included in any planning and development.

Water Resources Planning and Management

The 2006 National Water Policy proposes that planning, development and management should be devolved to an appropriate level corresponding to river basin boundaries, insofar as it is feasible. These plans should be integrated with sectoral development plans and include water conservation measures. A number of issue-based national plans are also proposed in the 2006 draft National Water Policy and the 2005 Medium Term Development Framework (Planning Commission 2005) including separate drought management plans for the Indus Valley and for the Hill Torrent Basins, a water conservation plan, and a national plan for irrigation efficiency. The drought management plans should take account of the effects of climate change because climate change may lead to an increasing prevalence of droughts.

The major water management issue in Pakistan revolves around sustainable use of the irrigation system and its surface water and groundwater sources. The 2002 Water Sector Strategy proposed that irrigation water use efficiency be improved from 40% to 45% through modern irrigation technology, lining canals, laser leveling, and other technologies. This alone would save to conserve 5.8 Bm^3 per annum. Non-structural measures are important too in water conservation. The 2016 draft Water Policy advocates adequate water pricing for proper operation and maintenance of the irrigation system and to improve its long term sustainability. The Water Vision 2025 endorses this, saying that proper water pricing and crop-based price variations should be used as tools for promoting water conservation. Programs are underway to improve irrigation efficiency (Associated Consulting Engineers et al, 2011). The National Project on the Improvement of Watercourses will improve 88,000 watercourses at a cost of PKR 66 billion (about USD 0.8 billion in 2009) and the National Program for Water Conservation for Productivity Enhancement using High Efficiency Irrigation System provides a subsidy of PKR 90,000/ha (USD 1,070/ha in 2009) for installation of water conservation technologies such as sprinkler and drip irrigation.

The draft Water Policy currently being developed advocates an integrated water resources management regime including water conservation, improved water reliability and water quality, controlling groundwater overdraft, introducing realistic water pricing for long term irrigation sustainability and maintenance, managing for floods and drought, catchment protection. It includes aquifer recharge in areas prone to drought. The 2006 draft Water Policy also proposed that groundwater use should

be controlled in both the Indus Valley and in hardrock aquifers to avoid overdraft and that groundwater tables under irrigation districts should be lowered to prevent salinity and water-logging. Lateral movement of saline water needs to be controlled and groundwater recharge should be promoted. This Policy also endorses the concept of realistic water pricing (taking account of user's ability to pay) in all sub sectors, not just irrigation, in order provide realistic information to users on the cost of water provision. The current draft Policy also wants water prices to be increased for irrigation to meet the O&M costs of water supply.

As part of its strategy for regulating groundwater use, the government commissioned a national study of groundwater availability and conjunctive management in 2011 (Associated Consulting Engineers et al 2011). It identified areas where artificial recharge, including floodwaters, could be employed to augment natural recharge of overdrawn aquifers. Conjunctive management of surface water and groundwater in irrigation areas could be employed by regularizing and controlling the current excessive leakage of surface water into groundwater systems while maintaining water quality. The various Provincial Irrigation and Drainage Authorities already have responsibility for both surface water and groundwater use and so are institutionally best placed to employ this management technique.

There are also improvements needed in water management outside the irrigation sector. For urban water supply, the 2006 draft Water Policy proposed full financial sustainability through reduction of non-revenue water and the introduction of comprehensive water metering while rural water supply should be at affordable rates. Drinking water sources – surface water and groundwater – should be protected from contamination and groundwater abstraction should be regulated. The Drinking Water Policy 2009 specifically states that the impacts of climate change should be considered in planning and development. The Policy also wants ambient water quality standards for drinking water to be introduced, rainwater harvesting to be expanded for household use and to recharge groundwater, recycling and reuse, water metering encouraged, and use of water efficient technology. The Policy does not mention pricing to control demand and provide operating funds.

The Water Policy currently under development advocates watershed management such as soil conservation, and provision of environmental flows to maintain the ecology of rivers and the Indus delta. The Medium Term Development Framework (2005-2010) also proposed soil conservation and watershed improvement activities.

The 2006 draft National Water Policy advocates the policy of polluter pays, treatment of wastewater prior to discharge, enforcement of EPA water quality standards for surface water and groundwater coupled with measures to reduce pollution from industry, agricultural drainage, and municipal wastewater, and a study into a National Water Quality Monitoring Program. The National Sanitation Policy 2006 requires liquid and solid effluent and industrial wastes to be treated before discharge to waterways and, where possible, for wastes to be reused and recycled through, for example, land disposal schemes. Pollution charges for industrial wastes can be imposed rules introduced under the Environment Protection Act (1997).

Floods control will require review of the design and maintenance standards for flood protection structure (draft Water Policy 2006), flood zoning to control development in flood-prone areas and the development of flood management plans and flood manuals to help introduce a systematic response (Medium Term Development Framework 2005). Reservoir operating rules need to be reviewed and flood forecasting and early warning systems should be introduced. Drought management also needs good predictive modeling. Because droughts are likely to place more pressure on groundwater resources, it is sensible to promote artificial recharge of aquifers in drought prone areas.

Education, Participation and Communications

The 2006 Water Policy called for stakeholder participation at all levels of water planning and management and in all aspects of irrigation, drainage, domestic, flood protection, drought, wastewater discharge and pollution control. It also sees that improved awareness of farmers and government delivery service personnel and the participation of communities and farmers in irrigation management decisions will improve the sustainability of irrigation infrastructure. However, no details were provided about how this ambitious proposal would be organized or funded. The recent 2016 draft Water Policy also calls for active stakeholder involvement in all aspects of water management. The 2009 National Drinking Water Policy also advocated community participation for planning, managing and monitoring local drinking water schemes as part of the expansion of water supply. However, Associated Consulting Engineers et al (2011) warns that participation, by itself, is not enough. Because farmer organizations have no control over the water actually being delivered to them, participative management can be illusory unless there are concomitant reforms to irrigation agencies.

The 2002 Water Sector Strategy called for enhanced public awareness of water quality issues and, more generally, states that public awareness is lacking on water management issues in Pakistan. It will be necessary to improve awareness to build public support for the changes that will be necessary in water management in the short- to medium-term. The 2006 Water Policy recognizes that an education program will be needed to build public awareness of water management issues, including an awareness of the importance of environmental needs and conservation. There is specifically a need to build awareness amongst farmers of the advantages of reforming irrigation water management. The 2009 Wetlands Policy argues for a broad communications strategy to develop a public awareness of wetlands and to sensitize environmental magistrates towards wetland issues and regulations, as well as designing an education campaign targeted at wetland stakeholders and users. The 2009 Drinking Water Strategy also wants to build public awareness about water conservation to help maintain domestic water supplies. The Vision 2025 document (Planning Commission 2014) says that there is need for a comprehensive awareness drive to educate people about the benefits of judicious consumption of water and shared consequences of wastage.

The Drinking Water Policy advocates for capacity development for all agencies involved in water supply, with training on planning, implementing and monitoring the provision of safe water supply. The Wetlands Policy recognizes that the sustainable use of wetlands is impeded by a lack of capacity amongst the agencies charged with

managing wetlands. It proposes that human capacity be developed amongst local communities and users of wetlands built as well as provision of training for staff of those agencies with a mandate for wetland management.

Summary

The most notable shortcoming in Pakistan's water governance is the absence of an accepted coherent water policy and legislation, despite a number of attempts to develop such a policy. Provincial water legislation is old. Earlier water sector strategy and policy, not endorsed by government, were comprehensive in calling for significant improvements in water management through both structural and non-structural means, consistent with IWRM approaches. Without an over-arching national policy and accompanying legislation, Pakistan will find it difficult to respond coherently to the impacts of climate change on irrigation, hydropower, environment and water supply and sanitation. It remains to be seen whether the water policy currently under development will be accepted and implemented.

Sub-sectoral policies for drinking water, sanitation and wetlands include many sensible proposals for improving water use efficiencies within their realms that would contribute to climate change adaptation. However, there is no agreed policy for the all-important irrigation sub-sector. It is not possible to tell, from assessing these policies, whether their components have been implemented in practice or not.

The impacts of climate change are recognized in policies and reports since about 2006.

Sri Lanka

Background

Although Sri Lanka has adequate water availability on average (2,450 m^3 per capita) (SMEC, 2013), there is considerable variation in its temporal and spatial distribution. The south-western corner receives an annual average rainfall of 2,500 mm falling principally during two monsoonal periods, late-May to late-September and late-November to February. The dry zone, covering about 60% of the country, receives an annual average rainfall of 1,750 mm. The dry zone can be affected by failure of NE monsoons. Surplus water in wet zone with 2 monsoon seasons; deficit in dry and intermediate zone.

Groundwater potential is estimated at 7,800 million cubic meters (Mm^3) per annum (UNEP 2005). Most groundwater use is for domestic use and for irrigation in the sand aquifers of the north-west and for industry in the wet zone. Access to groundwater is limited in the dry zone (Imbulana et al 2006). UNEP (2005) reports that, where it occurs, abstraction of shallow ground water is largely uncontrolled and causes the intrusion of brackish water into shallow aquifers.

Irrigation is the major consumptive water user, accounting for about 8,740 Mm^3 or 94% of water use (SMEC, 2013). Paddy production has increased to 3.9 million tons in 2011, about 75% of which is irrigated. Hydropower is the other major water user with a through-put of 9,800 Mm^3. Water storage is 2,282 Mm^3 of which 80% in

Mahaweli River Basin. There are 1,382 MW of hydropower generation (49% of total energy capacity). There is continuing competition between irrigation and hydropower for access to water during times of shortage. Because most large hydropower sites are now either developed or in the pipeline, hydropower will be proportionately less important in future as new thermal generation comes on stream.

For some decades Sri Lanka has had multiple institutions, operating under different Acts, responsible for various aspects of water management. The various Acts were not fully consistent and there was no overall coordination of water development and management. By the early 1990s a consensus had developed within the Sri Lankan government that a consistent water policy was needed in order to meet future water demands and improve water quality. An IWRM-focused project, supported by the ADB, commenced in 1992 to draft a national water resources policy and supporting legislation. The draft policy was passed by cabinet in 2000 and supporting legislation was drafted. However, the draft policy and legislation were never adopted because the process became highly politicized. The major points of dispute revolved around issuing entitlements to water users and introducing a tariff for water use; introducing water conservation and efficiencies that were seen as undermining small farmers; the marginalization of the Irrigation Department and the Mahaweli Authority in the policy development; and the introduction of an apex water resources institution that would threaten the expertise and independence of existing institutions such as the Irrigation Department (Ariyabandu 2008).

Water relevant policies include the National Drinking Water Policy National Environment Policy (2003), successive National Environmental Action Plans (NEAP), the National Watershed Management Policy (2004), National Policy on Wetlands (2005), the National Disaster Management Policy (2010) and the draft National Policy on Protection and Conservation of Water Sources (2014). Water sector legislation is generally old and concerned with development rather than management and conservation[16]. Sri Lanka produced a Water Sector Vulnerability Profile in 2010 as part of its Climate Change Strategy.

Water Resources Knowledge

The National Policy on Protection and Conservation of Water Sources includes sections on monitoring for unauthorized activities in water catchments and monitoring the condition of water reservoirs. The 2003 Environment Policy advocates a mechanism to monitor all industrial discharges. The 2013 Disaster Management Policy includes a disaster early warning system, although the types of disasters are unspecified. However, there is little in the government instruments about monitoring flows, groundwater levels or ambient water quality presumably because there is no National Water Policy where monitoring would be dealt with comprehensively.

The National Drinking Water Policy encourages research into water saving technologies, improved system designs and services, while the 2001 Rural Water Supply and Sanitation Policy identified one of the government's roles as being the conduct of research for the development of the sub-sector. The National Wetlands Policy 2006 also advocates research into wetland ecosystems to assist with their

[16] Checked Sri Lankan government website for all legislation passed since 1991.

conservation, sustainable use, restoration and adaptive management. The Strategy accompanying this Policy proposes a multi-disciplinary research into wetland conservation and sustainable use while seeking external funding support.

Water Resources Governance

Some of the policies are concerned with the effects of climate change. The Environment Policy recognizes that management needs to be flexible to respond to changing circumstances such as the effects of climate change. The National Policy on Disaster Management mentions climate change in passing as an issue needing coordination. It is not recognized as a cause of increased disaster risk. The draft National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka (2014) does not see climate change as a potential accelerator of water source degradation (although the 2012 National Climate Change Policy does recognize the need to conserve water resources and biodiversity) and the 2010 Water Sector Vulnerability Profile contains considerable detail on the threat posed by climate change as well as adaptation actions.

The absence of an over-arching water policy means that Sri Lanka's water resources management continues to be fragmented and uncoordinated (Ratnayake 2014), with multiple institutions governing water management based on sub-sectoral policies, laws and regulations. The Water Sector Vulnerability Profile says "the absence of a governing policy with regard to the institutions involved with water resource management is a major factor that impedes water resource management in the country" (p23). There are over 50 Acts dealing with water management leading to confusion, duplication, and inaction. However, according to the Profile, there are no laws governing excessive extraction by civil society or the private sector.

The Rural Water Supply and Sanitation Sector Policy (2001) contains high level IWRM principles[17] which could lay the foundation for an adaptive approach in this sub-sector but most of the policy is concerned about provision of WSS services. However, the policy does state that the role of government is to decentralize decision making, introduce a legal framework for regulating water extraction from natural sources, set water quality standards, and conserving of watersheds. This policy has now been replaced with the National Drinking Water Policy (undated), developed to accommodate community WSS schemes, which also states that the government will ensure coordination amongst stakeholders, establish guidelines for efficient use of water resources, promote decentralization to provincial, regional and local levels, and promote social and environmental sustainability. All these actions would provide better water governance of the WSS sub-sector in the face of climate change.

[17] Policy principles include:

- Fresh water is a finite and vulnerable resource essential to sustain life and ecosystems
- Water is a basic human need which warrants equitable allocation.
- Water has an economic value and should be recognized as an economic good
- Sector activities should be based on participatory approach involving users, planners and policy makers at all levels
- All sector activities should be in harmony with the environment

The Environment Policy (2003) recognizes the need for institutional coordination to tackle environmental issues. It also states that the Ministry of Irrigation and Water Management develop water management policies and supporting legislation and regulatory bodies.

The draft National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka (2014) incorporates both surface water and groundwater sources. It sees the impediments to better water source protection as: boundaries of catchments not identified, shortcomings in legislation and regulations, institutional problems, misuse of land, encroachments on water source catchments, lack of public participation, and limited resources and information. The draft Policy proposes that existing watershed legislation needs to be amended and institutions need to be strengthened for better water source protection. The regulations to implement the Soil Conservation Act (2000), administered by the Agriculture Department, have yet to be gazetted.

The Irrigation Amendment Act, passed in 1994, is largely concerned with development rather than conservation, while the Agrarian Development Act (2000) is primarily concerned with the rights and responsibilities of owners and tenants of paddy lands.

Water supply and sanitation is regulated under the Water Supply and Drainage Board Act of 1975 (amended in 1992). A 2003 water service reform bill sought to introduce regulation into the sub-sector but the bill did not proceed because of legal challenges (Fan 2015). WSS regulation is now the responsibility of the Public Utilities Board under the Public Utilities Act. Presently, water service providers are responsible for overseeing their own performance, which may affect the efficiency of operational and investment decisions. The Drinking Water Policy encourages private sector involvement in water supply. Without independent regulation there is a danger that the private sector will seek to maximize its profits at a higher than necessary level of risk to the consumer.

Water Resources Infrastructure

The Water Use Master Plan (2013) reports that paddy cultivation area is projected to increase by 1.5% p.a. to 2020; total drinking water requirements will increase from 514 Mm^3 in 2010 to 1,191 Mm^3 in 2030; industrial water requirements will grow at 9.7% p.a. to 2020; while total hydropower capacity will increase from 1,778 MW in 2015 to 2,021 MW[18] in 2025. The Master Plan is based on the understanding that competition between irrigation and hydropower for water may be exacerbated by climate change. The Plan considers a number of development options in the short (5-year), medium- (6-10 years) and long-term (>10 years) for the three main water using sectors – irrigation domestic water supply, and hydropower. These include 10 dams in the short term for a total investment of LKR 94,000 million providing additional water for all three sectors. A further 16 infrastructure projects are proposed for the medium-term, including the Kelani Ganga and Munderi Aru schemes, at a total cost of LKR 264,000 million. Possible long-term investments included four inter-basin

[18] Major hydropower opportunities are almost exhausted and this increase will come largely from mini-hydropower schemes.

water transfers, all with considerable history. The report is cautious about these major investments because of their high cost and the large numbers of people likely to be affected. It is apparent that Sri Lanka has a number of infrastructure options available for coping with increased precipitation variability and changes in monsoonal rainfall, if funding is available.

The Water Use Master Plan does not consider other storage options such as expansion of small tank storages (which are ideal for adapting to climate change) or making greater use of groundwater storages. However, the Vulnerability Profile recognizes that maintenance of traditional tanks and hydraulic infrastructure in the Dry Zone is a contribution to adaptation to reduced rainfall.

Water Resources Planning and Management

There are a number of activities underway to improve urban water supply operational efficiencies primarily through reductions in non-revenue water by replacing aged pipes, detecting illegal connections, and replacing common outlets with individual connections (Fan 2015). Water metering and charging is also being expanded to improve revenue and help control demand. While these activities contribute towards climate change adaptation, Fan (2015) makes it clear that there remain many other opportunities through catchment protection, water quality management, rainwater harvesting, and demand management and non-potable wastewater reuse.

Under the National Drinking Water Policy the National Water Supply and Drainage Board will promote water source protection programs. The policy also advocates water demand management, water conservation (including rainwater tanks and wastewater reuse), pollution prevention and the use of incentives for water conservation and efficiency. This includes establishing a water use tariff that covers costs. It also proposes that district level coordination would help improve disaster preparedness for floods, droughts, and landslides. The 2001 Rural Water Supply and Sanitation Policy did promote protection of both surface water and groundwater source areas from pollution. The Water Sector Vulnerability Profile describes programs to trial rainwater harvesting and artificial groundwater recharge to augment drinking water supplies.

The National Environment Policy 2003 contains a number of clauses of relevance to water management including the polluter pays principle, advocacy of recycling and reuse, and charging for environmental services such as provision of clean water. The policy contains a section on water management where the need for watershed management to reduce erosion and sedimentation of downstream storages, groundwater regulation to reduce over-exploitation, prevention of pollution from irrigation, industry and human settlements are all recognized. The policy proposes a range of actions that would improve water quality including soil conservation and erosion control, mobilization of farmers groups, restrictions on sand mining, safe sewage disposal, conservation and reuse of water, and rainwater harvesting. The Vulnerability Profile lists a number of projects that have been carried out to reduce siltation of reservoirs by protecting catchments and thereby contribute to climate change adaptation.

The Irrigation Amendment Act is primarily concerned with development and management issues rather than with water conservation and efficiency. However, it does contain some powers that would assist irrigation groups adapt to changing climate - it authorizes charging for water use thereby potentially promoting water conservation and encourages local advisory groups, although these mainly comprise government officials. The Agrarian Development Act encourages the formation of farmer organizations that promote with soil conservation, water use efficiency and control the discharge of wastes into watercourses. The Act pays little attention to groundwater although it does require approval for wells to be drilled in paddy areas.

The Water Use Master Plan, as well as assessing infrastructure development options, also examined a number of measures to improve water use efficiency in irrigation areas, largely through non-structural means such as farmer education, demand management, and institutional strengthening. It found that structural water use efficiency measures (such as lining channels) were not usually cost effective.

Education, Participation and Communications

There has been a long history of farmer participation in irrigation management in Sri Lanka, stemming from the 1991 Agrarian Services Act. Farmer organizations are able to formulate rules for maintenance, conservation and management, control the distribution of water and to levy charges for operations and maintenance. The Irrigation Amendment Act also authorizes irrigator associations to be established for participatory management. Samad and Vermillion (1999) found that this transfer of responsibility was only partially implemented with continuing strong government intervention, and that participatory management only resulted in improved agricultural productivity when it was accompanied by rehabilitation of infrastructure. While they did not investigate whether the transfer of management resulted in increased responsiveness to changing environmental conditions, local management does open up the possibility of applying local solutions to changing climate conditions in irrigation areas. The National Rural Water Supply and Sanitation Sector Policy 2001 and the National Drinking Water Policy also encourage user participation in the development and management of rural water supply and sanitation facilities. The draft Policy on Protection and Conservation of Water Sources also advocates stakeholder participation as an essential ingredient in the protection of water sources.

A number of the water-related policies advocated capacity building in the water sector. For example, the draft Water Source Protection Policy identifies a need for improved capacity within institutions that manage water catchments, while the National Drinking Water Policy requires that water service providers have the capacity to match best industry practice. The National Wetland Policy and Strategy advocates training for managers and other staff.

The National Wetland Policy also proposes awareness programs for the general public, policy makers and politicians along with school based education programs into the importance of conserving wetlands. The National Drinking Water Policy wants to build public awareness amongst stakeholders about the importance of watershed and catchment protection as well as promoting awareness of demand management and water conservation, while the draft Policy on Protection and

Conservation of Water Sources also encourages public education on the importance of protection to maintain clean water supplies.

Summary

The absence of an over-arching water resources policy and legislation is the biggest obstacle to effective adaptation to climate change in the water sector. Each water sub-sector operates without coordination under its own legislation and regulations. There is no effective mechanism for coordinating their plans, investments or management activities. Nevertheless, the sub-sectoral policies and legislations do contain elements that provide some of the flexibility and efficiency needed for climate change adaptation in the water sector. These include protection of water source areas, charging for water use in irrigation, promoting local management of irrigation areas, implementing water use efficiency in urban water supply and irrigation areas, and controlling water pollution from irrigation, industry and domestic sources. The Water Use Master Plan provides a road map of possible water resources infrastructure, almost exclusively dams, that could help respond to a more variable precipitation pattern. The Master Plan provides an implementation schedule for these projects although prioritization amongst these possibilities has yet to occur with a commitment to funding infrastructure.

The long-standing policy of transferring responsibility for managing irrigation areas to farmer organizations has not been notably successful in raising productivity but it may assist adaptability in the face of climate change. While the sub-sector policies – Rural Water Supply and Sanitation, Drinking Water, Wetlands, Source Protection – advocate education, public awareness and research, it is not clear whether these intentions have been turned into practical programs.

Climate change is the responsibility of the Ministry of Environment which has failed to engage the attention of other relevant Ministries, including the Ministry of Irrigation and Water Resources Management. Consequently, the above water resources instruments have (mostly) not been developed with climate change impacts in mind. Nevertheless, the inclusion of many elements of IWRM for dealing with climate variability and changes in water availability, and increases in climate-related risks means that the water sector is well placed to adapt to the impacts of climate change. The task will be to implement these instruments within the water sector with an increased awareness of climate change.

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