Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia

Background Paper 2

Review of Water and Climate Change Policies in South Asia

Richard Davis and Rafik Hirji

IWMI
International
Water Management
Institute

About this Report

This is one of three papers commissioned by the World Bank and jointly implemented with the International Water Management Institute (IWMI) as part of the first phase of a two-phase Technical Assistance (TA) project to assess the opportunities for adaptation to climate change in the water sector in seven countries in South Asia (Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka). The TA – Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia – is funded by the South Asia Water Initiative (SAWI), a partnership of the governments of Australia, Norway and the United Kingdom.

Background Paper 1 describes the scientific understanding of predicted impacts of climate change on water resources and associated risks.

Lacombe, G.; Chinnasamy, P.; Nicol, A. 2019. *Review of climate change science, knowledge and impacts on water resources in South Asia. Background Paper 1*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 73p. (Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia). doi: 10.5337/2019.202

http://www.iwmi.cgiar.org/Publications/Other/PDF/sawi-paper-1.pdf

Background Paper 2 (this paper) assesses the suitability of the enabling policy frameworks (existing policy, legislation, strategies and plans) for adapting to the impacts of climate change.

Davis, R.; Hirji, R. 2019. *Review of water and climate change policies in South Asia. Background Paper 2*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 120p. (Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia). doi: 10.5337/2019.203

http://www.iwmi.cgiar.org/Publications/Other/PDF/sawi-paper-2.pdf

Background Paper 3 assesses the financial, economic, and institutional landscape for adapting to climate change.

Suhardiman, D.; de Silva, S.; Arulingam, I.; Rodrigo, S.; Nicol, A. 2019. *Review of water and climate adaptation financing and institutional frameworks in South Asia. Background Paper 3.* Colombo, Sri Lanka: International Water Management Institute (IWMI). 110p. (Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia). doi: 10.5337/2019.204

http://www.iwmi.cgiar.org/Publications/Other/PDF/sawi-paper-3.pdf

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Background Paper 2

Review of Water and Climate Change Policies in South Asia

Richard Davis and Rafik Hirji

International Water Management Institute

The authors: Richard Davis is a consultant for the World Bank, Washington, DC, USA; and Rafik Hirji is Director for Water, Environment and Climate Solutions. He was Senior Water Resources Specialist, Task Team Leader at the World Bank, Washington, DC, USA, at the time this study was conducted.

Davis, R.; Hirji, R. 2019. *Review of water and climate change policies in South Asia. Background Paper 2*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 120p. (Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia). doi: 10.5337/2019.203

/ climate change adaptation / water resources development / water management / water policy / water governance / water users associations / water supply / river basin management / integrated management / knowledge / infrastructure / planning / communication / education / monitoring / surface water / groundwater management / groundwater recharge / water quality /water use efficiency / water storage / investment / flood control / drought / public administration / international waters / stream flow / aquifers / sea level / coastal waters / precipitation / dams / irrigation management / irrigation systems / legislation / meltwater / erosion / landslides / sedimentation / early warning systems / soil management / sanitation / conjunctive use / risk management / resource management / community involvement / South Asia / Afghanistan / Bangladesh / Bhutan / India / Nepal / Pakistan / Sri Lanka /

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Front cover photograph shows women working in a farm in India (*photo*: Richard Steckel/IWMI).

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This background paper is one of three papers commissioned by the World Bank and jointly implemented with the International Water Management Institute (IWMI) as part of the first phase of a two-phase Technical Assistance (TA) project to assess the opportunities for adaptation to climate change in the water sector in South Asia (including Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka). The TA – Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia – is funded by the South Asia Water Initiative (SAWI), a partnership of the governments of Australia, Norway and the United Kingdom. SAWI funds a multi-donor trust fund implemented by the World Bank that works to improve the management of the major Himalayan river systems of South Asia for sustainable, fair and inclusive development and climate resilience.

The first phase was implemented under the overall guidance of Dr. Rafik Hirji (formerly Senior Water Resources Specialist, Task Team Leader, World Bank, and currently, Director for Water, Environment and Climate Solutions) and Dr. Alan Nicol (Strategic Program Leader – Promoting Sustainable Growth, IWMI), who led the team from IWMI. The background papers were presented and reviewed at the Regional Conference on Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia, which was held in Colombo, Sri Lanka, on July 12-13, 2016. This regional conference was attended by 65 national, regional and international climate change and water resources experts, including over 20 representatives of governments in the region.

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
BCCTF	Bangladesh Climate Change Trust Fund
CAPA	Community Adaptation Plans of Action (Nepal)
CCSAP	Climate Change Strategy and Action Plan (Bangladesh)
COP	Conference of the Parties
CPCB	Central Pollution Control Board (India)
EIA	Environmental impact assessment
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FO	Farmer organization
GBM	Ganges-Brahmaputra-Meghna river system
GDP	Gross domestic product
GEF	Global Environment Facility
Gl	Giga-liter (10^9 cubic meters)
GLOF	Glacial lake outburst flood
GNI	Gross national income
GWP	Global Water Partnership
HKH	Hindu Kush Himalayan
ICIMOD	International Centre for Integrated Mountain Development
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated water resources management
IWRMP	Integrated Water Resources Management Plan (Bhutan)
IWMI	International Water Management Institute
KRA	Key results area (Bhutan)
LAPA	Local Adaptation Plan of Action (Nepal)
LDC	Least developed country
LKR	Sri Lankan Rupee
MAF	Mean annual flow
MAR	Managed aquifer recharge
MoU	Memorandum of understanding
MW	Megawatt
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)
NCCSAP	National Climate Change Strategy and Action Plan (Afghanistan)
NCCSP	Nepal Climate Change Support Program
NEAP	National Environmental Action Plan (Sri Lanka)
NEC	National Environment Commission (Bhutan)
NGO	Nongovernmental Organization
NIWRMP	National Integrated Water Resource Management Plan (Bhutan)
NPR	Nepalese Rupee
O&M	Operation and maintenance
PKR	Pakistani Rupee
PRSP	Poverty reduction strategy paper
R&D	Research and development
RNR	Renewable natural resources (Bhutan)

SAARC	South Asian Association for Regional Cooperation
SADC	Southern African Development Community
SAPA	Sectoral Adaptation Plan of Action (Bhutan)
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WARPO	Water Resources Planning Organization (Bangladesh)
WECS	Water and Energy Commission Secretariat (Nepal)
WAPDA	Water and Power Development Authority (Pakistan)
WSS	Water supply and sanitation
WUA	Water user association

Note: Names of government institutions were correct at the time of writing.

EXECUTIVE SUMMARY

This report assesses the suitability of the water and climate-related policy environment (existing policy, legislation, strategy and planning instruments) for adapting to the impacts of climate change in the water sector in South Asia. South Asia will be exposed to a variety of 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: for example, Bangladesh is particularly vulnerable to flooding and sea-level rise, while Nepal and Bhutan face the issue of glacial lake outburst floods (GLOFs). These impacts will have a major effect on the economies and social welfare of the countries in the region. The poor and disadvantaged are particularly vulnerable to climate shocks and are likely to be severely impacted by climate change.

This analysis was a desk study, confined to the content of the water and climate change instruments, and did not examine the extent to which these instruments were implemented in practice. Other analyses suggest that implementation of water instruments is weak across South Asia, and that the practice of water resources management lags behind the provisions in these instruments (see Paper 3 [Suhardiman et al. 2019]).

Climate change is likely to place additional pressure on groundwater because it is an attractive substitute for surface water, given that it is relatively isolated from the effects of increased climate variability and increased evaporation. Groundwater is already under severe pressure in parts of South Asia because of pollution and overuse fueled by the unreliability of surface water supplies—an issue that will be exacerbated by climate change. Consequently, it is essential that groundwater governance and management be improved as part of the measures to adapt to climate change.

Adapting to climate change, with a few exceptions, does not require a fundamentally new way of managing water resources—it largely requires better management of existing water resources. If water governance arrangements and water management practices are able to handle the existing variability in water availability and water demand, they will be well placed to cope with increased variability and changes in availability and demand as a result of climate change. There are two additional issues (the exceptions noted above) that climate change adds to conventional water management issues: (a) sea-level rise will lead to increased salinization of coastal surface water and groundwater resources, and (b) hydrological models, standards and procedures will need to take account of the effects of climate change on precipitation, snowmelt and ice melt, and temperature.

At the policy level, integrated water resources management (IWRM) is the accepted paradigm for water resources management. It is particularly suited for adapting to the impacts of climate change on the water sector, because it is designed to manage competition for increasingly scarce water resources. Moreover, it promotes joint surface water and groundwater management, emphasizes demand management as much as supply augmentation, is an adaptive and learning process, and it links management at the local, national and transboundary levels. The components of IWRM are grouped into five dimensions in this report: (a) water resources knowledge, (b) water resources governance, (c) water resources infrastructure, (d) water resources planning and management, and (e) water resources communications, education and participation. Twelve criteria that describe the desirable characteristics of water instruments for adapting to climate change were developed from these dimensions. The formally accepted 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. However, three of the seven South Asian countries— Nepal, Pakistan and Sri Lanka—do not have approved water policies, although they have subsectoral water policies. Four countries—Afghanistan, Bangladesh, Bhutan and India—clearly recognized the potential impacts of climate change in

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

their water instruments, while Pakistan and Sri Lanka acknowledge that climate change could impact water management. Nevertheless, the focus is on surface water impacts, and the links between climate change and groundwater have yet to be well defined and understood.

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; coordinating actions across water-dependent sectors; extending their water storage capacity (although these development plans do not usually incorporate the effects of climate change); undertaking basin-level planning, although (with the exception of India and Afghanistan) these plans do not have to include the effects of climate change; implementing demand management as well as technical measures for improving water-use efficiencies; protecting water quality; improving public understanding of water management; and 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 providing that intentions spelled out are actually implemented and reflected through actions on the ground.

The climate change instruments of South Asian countries, together with various reports to the United Nations Framework Convention on Climate Change (UNFCCC), were also examined against six criteria for their support to adaptation in the water sector. Overall, there is a widespread understanding of the importance of improving water resources monitoring for surface water and groundwater. Four countries—Afghanistan, Bangladesh, Bhutan and India—advocate that these data be held in a central repository and be made available when needed. Several countries recognize the importance of specific disaster monitoring systems, such as monitoring for 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 'Centers' 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 Nepal, Pakistan and Sri Lanka[2]. Consequently, these countries lack a coherent response to water problems and are reliant on subsector instruments or the policies of water-related sectors such as environment, energy and agriculture. All countries have a national climate change instrument, with India and Bhutan developing instruments for adaptation in the water and natural resources sectors, respectively.

All countries have established coordinating institutions, although the composition and authority of these bodies varies considerably from there being no inter-ministerial coordinating body in Sri Lanka to a National Water Resources Council in India chaired by the country's prime minister. However, the climate change documents, while detailing many aspects of water management, pay little attention to cross-sectoral coordination of water-dependent institutions despite 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 cognizant of climate change.

Most South Asian countries, with their many large and small transboundary rivers, recognize the need to take a regional approach to climate change adaptation. Some water resources issues, such as preparing for and managing large regional flood events, are best tackled cooperatively because they affect transboundary regions; others, which are essentially local or national in nature, such as arsenic contamination of groundwater and protecting against the effects of GLOFs, can still benefit from a cooperative approach through sharing

[2] Subsequent to the completion of this report, Pakistan has approved a new National Water Policy (MoWR, Pakistan 2018).

information and solutions. While Bangladesh, Bhutan, India, Nepal and Pakistan all advocate regional data sharing and cooperation in their water instruments, transboundary information sharing is focused on rivers and makes little mention of sharing information on transboundary aquifers.

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.

There is an emphasis on technical methods for improving water-use efficiencies, although nontechnical methods can be effective and are often cheaper. Conjunctive use and reuse of treated wastewater are also proposed to augment irrigation water supplies, although the latter carries considerable public health risks unless stringent water quality regulations and 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 also 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, it is, however, often seen as a top-down activity. Nevertheless, Nepal has now instituted about 90 Local Adaptation Plans of Action, while Bangladesh is recognized for its local responses to climate-induced disasters and Sri Lanka has proposed a small grants program for local community adaptation activities.

There is widespread agreement about the importance of building an understanding of climate change and its implications for water resources among the public, as well as among sectoral groups and decision makers. There is also a need to build a wider understanding among the public and decision makers that some climate change impacts are regional in scope and can best be tackled through regional cooperation.

This analysis also suggested several topics that could be developed under the second phase of this project to assist South Asian countries in climate change adaptations (Box ES.1).

Box ES.1. Potential topics for phase II.

Water resources knowledge

- Assistance with regional data sharing, especially for transboundary surface water and groundwater information
- Assistance with community-level monitoring and data sharing
- Building a greater understanding of scientific findings about climate change impacts among water managers

Water resources governance

- Identifying specific opportunities to support promising attempts to implement components of IWRM, particularly improving intersectoral coordination
- Building an understanding among water managers that implementing IWRM also helps adaptation to the impacts of climate change
- Helping mainstream adaptation activities
- Examining the contributions of state and provincial governments to adaptation in India and Pakistan
- Building a better understanding of groundwater management in the face of climate change

Water resources infrastructure

- Using local storage as an alternative to major infrastructure
- Developing design and operating rules to make infrastructure resilient to climate change

Water resources planning and management

- Trialing transboundary water planning studies
- Integrating adaptation measures with actions to assist poor and disadvantaged communities
- Investigating protection against saltwater intrusion into coastal aquifers

Water resources communications, education and participation

- Assessing the success factors in developing community-level adaptation
- Developing targeted campaigns to educate the general community about climate change impacts on water resources
- Improving groundwater users' understanding of the shared nature of the resource and the need for collaborative management

Chapter 1. Background

This is the second of three reports commissioned by the World Bank to assess opportunities for adaptation to climate change in the water sector[3] in South Asia. The first report (Lacombe et al. 2019) describes current scientific understanding of the predicted impacts of climate change on water resources and the associated risks in South Asia, while the third report (Suhardiman et al. 2019) assesses the governmental financial, economic and institutional landscape in South Asian countries for adapting to climate change. This report assesses the suitability of the enabling policy environment (existing policy, legislation, strategy and planning instruments) 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). However, it does not investigate the implementation of these instruments, although the third report does analyze the effectiveness of financing and institutional aspects of water and climate change instruments.

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 the first report (Lacombe et al. 2019) and from the Food and Agriculture Organization of the United Nations (FAO).[4]

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 Balochistan and coastal rivers of Bangladesh.

The Ganges-Brahmaputra-Meghna (GBM) River System

The GBM river system has an annual average flow of 1,310 cubic kilometers (km^3), which originates primarily from the 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[5] of 10.7 km^3. The groundwater resources of Bhutan, which lies within the Brahmaputra River Basin, are believed to be limited and have yet to be properly assessed or developed. Groundwater recharge in Bangladesh is estimated at 21 km^3 per year.

Irrigation represents 88% of water usage in the GBM. Other water uses, such as power generation (hydropower and cooling water for thermal power stations), recreation and navigation are rapidly increasing, largely owing to changing lifestyles associated with socioeconomic development. Current hydropower production in the Ganges Basin is about 12 terawatt-hours (World Bank 2014). Rapid urbanization is affecting water demands and water quality, especially in the Ganges River Basin. Water from the Ganges River is heavily used, compared with water from the Brahmaputra and Meghna rivers, with seven Ganges subbasins in India using more than 50% of their available water resources.

[3] The water sector encompasses both water resources (that is, water in nature) and the water-using sectors that rely on water resources (agriculture, hydropower, industry, etc.) (see Figure 2.1).

[4] Data from FAO's AQUASTAT database (http://www.fao.org/nr/water/aquastat/countries_regions/index.stm) may vary from data held by countries because of different definitions of key hydrological variables and the currency of the information.

[5] FAO defines the exploitable water resources or development potential as the component of natural freshwater (surface water or groundwater) that is practically available.

The Indus River Basin

About 35-40% of river flows in the Indus River Basin originate from glacier melt and snowmelt in the Hindu Kush Himalayan (HKH) mountains, providing perennial flows to the Indus River and some of its tributaries. If water from the Indus River was not used for irrigation, the river would discharge about 207 km^3 of water to the sea annually.[6]

The Indus River Basin contains an extensive aquifer. Prior to the development of the irrigation system, the water table was well below the surface (greater than 30 meters [m]). With the introduction of irrigation, increased percolation to the aquifer has resulted in a rise in groundwater levels, 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 for irrigation with dug wells and tube wells in the fresh groundwater zone. 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. According to FAO, annual diffuse recharge for all of Pakistan is estimated to be 55 km^3, while annual groundwater abstraction was estimated to be 62 km^3 in 2008. There is high connectivity between surface water and groundwater, such that surface water supplements diffuse aquifer recharge.

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 (at 63% of withdrawals), followed by India (36%), Afghanistan (1%) and China (less than 1%). Currently, there is an installed capacity of about 11,000 megawatts of hydropower generation from large dams in the basin, with another 19,000 megawatts of generating capacity under construction (SANDRP 2013).

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 HKH mountains and has a mean annual flow of about 15 km^3, although this is subject to extreme interannual 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 total surface water and groundwater withdrawals 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 supplies (Rout 2008).

Climate-related Risks in South Asia

South Asia is exposed to a variety of climate-related risks resulting from the geo-climatic characteristics of the region, many of which frequently transcend national boundaries.

Because of 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; and flooding in Pakistan in 2010 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. Extreme rainfall can also cause local flash flooding, mostly in mountainous areas. Glacial lake outburst floods (GLOFs) are a specific

[6] ACS, EGC and SMEC (2011) estimated that the mean total annual streamflow of the Indus River is 175 km^3, of which 130 km^3 are diverted for irrigation.

type of flash flood that occurs in the HKH mountains when unstable terminal lakes, formed by retreating glaciers, breach their walls.

Droughts cause the highest number of deaths and the greatest economic losses of all climate-related hazards in South Asia. Not only do droughts reduce surface water availability, but they also reduce groundwater recharge. In some cases, declining groundwater levels are accompanied by the intrusion of saltwater and other contaminants (for example, arsenic) 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 reservoirs, riverbeds and irrigation channels (Annandale et al. 2016; Palmieri et al. 2003). 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 (WARPO 2001).

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

Impacts of Climate Change on Water Resources in South Asia

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 results from the Intergovernmental Panel on Climate Change (IPCC) (CDKN and ODI 2014) showing increases in annual precipitation across the Himalayan region, Nepal and Sri Lanka with smaller increases in Bhutan. There is likely to be a reduction in annual precipitation in lower parts of Afghanistan and across India, Bangladesh and Pakistan. It is expected that there will be an increase in rainfall extremes (see Paper 1 [Lacombe et al. 2019] for details) and the assumption of climate stationarity will be breached (Box 1.1). However, CDKN and ODI (2014) warned about the high uncertainty of these rainfall projections for South Asia, exhibiting trends partly offset by the natural climate variability.

Box 1.1. Climate stationarity.

The conventional belief among hydrologists has been that, while climate varies between seasons within years and between years, the long-term mean and the variance of climate parameters remain constant, i.e., the average climate that we have experienced in the past and its variability around that average will continue into the future. This belief, called the stationarity assumption, allows engineers to plan for infrastructure by assuming that future hydrology repeats itself and will be the same as that experienced in the past. However, due to climate change, with its steady rise in temperatures and changes to other climatic parameters, this assumption will no longer hold. We cannot assume that the mean and variance of climate parameters will be the same in the future as it was in the past.

In their review, Nepal and Shrestha (2015) concluded 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 up to mid-century. Moreover, in the Brahmaputra Basin, there is likely to be a reduction in upstream water supply. There is likely to be a marked change in the seasonal distribution of flows in the Indus Basin, with a smoothed and earlier peak of the flood pulse because of its relatively high reliance on snowmelt and ice melt that will start earlier in the year. The changes in seasonality of flows in the Ganges and Brahmaputra rivers could lead to increased flooding.

Increasing temperature, more erratic rainfall patterns and altered flow seasonality will induce a rise in demand for irrigation water, leading to increasing pressure on water resources even in countries predicted to receive increases in precipitation unless there are significant improvements in water-use efficiencies and water storage capacities. The increased variability in precipitation is likely to cause increased frequency and intensity of droughts and floods. Importantly, climate change is expected to reduce food security across the region (Box 1.2).

Box 1.2. Food security under climate change.

The impacts of climate change on crop production have been widely studied in South Asia, and it is commonly predicted that food shortages will occur because of reduced crop productivity (see, for example, CDKN and ODI 2014). A recent study has found that climate change could also kill more than 500,000 adults worldwide by 2050: not because of food shortages, but due to changes in diets and body weight. Most of these deaths are expected to occur in Southeast Asia and the Western Pacific Region, with 160,000 of the deaths occurring in India. The study considered both the quantity and quality of food consumption under a number of climate change scenarios. A decrease in global crop productivity is expected because of changes in temperature and precipitation as a result of climate change, leading to people consuming less red meat and fewer water-intensive fruits and vegetables. These dietary changes will lead to increases in diseases such as heart disease, stroke and cancer.

Source: Springmann et al. 2016.

Groundwater recharge will be affected by climate change, although it is difficult to predict the direction and magnitude of the change (Clifton et al. 2010). However, given that groundwater use is more compatible with a hotter and more variable climate than 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 an increased demand for groundwater.

The warming of the oceans and the melting of ice caps are 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, exposing coastal aquifers to risks of salinization. Bangladesh and Pakistan are highly vulnerable to rising sea levels, while coastal regions of India and Sri Lanka will also be affected.

Methodology

This report assesses the extent to which the policy instruments of South Asian countries are suited to adaptation for these likely effects of climate change in the water sector. 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 nongovernmental organizations (NGOs), together with analyses and critiques of policy environments published in the 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 conducted with government officials or other in-country sources. In particular, it does not examine the degree of success in the implementation of the various policy instruments. A draft version of this report was presented at a regional stakeholder conference held in Colombo, Sri Lanka, on July 12-13, 2016, and was circulated to experts in six of the seven countries (Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka) for feedback before being finalized.

Table 1.1 illustrates the range of adaptation options available 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 1.1. Climate-related risks to water resources and potential adaptation actions.

Climate risks	Knowledge	Governance	Infrastructure	Planning and management	Communications, education and participation
1. Primary risks					
Changes in precipitation (especially monsoon)	Research, weather monitoring	Coordination between meteorological, water and agriculture agencies	Dams, interbasin water transfers, groundwater recharge (including artificial options)	Flexible irrigation management systems, intersectoral responses to assist adaptation	Involvement of water user associations (WUAs) and farmer organizations (FOs), capacity development, communication to farmers and other stakeholders
Sea-level rise	Monitoring, research	Coordination between water agencies, agriculture and other water-using sectors, and coastal authorities	Embankments, subsurface groundwater barriers, maintaining and restoring natural shorelines	Groundwater use plans, controls over groundwater use	Involvement of coastal communities, capacity development
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 sharing
2. Secondary risks					
Floods	Monitoring and early warning systems	Coordination (interagency, 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

(Continued)

TABLE 1.1. Climate-related risks to water resources and potential adaptation actions. (Continued)

Climate risks	Knowledge	Governance	Infrastructure	Planning and management	Communications, education and participation
Droughts	Weather prediction and early warning communications, research, monitoring	Allocation priorities and planning mechanisms, coordination between agriculture, power, water resources and water supply, local institutional capacities to manage scarce water resources and improvise	Dams, interbasin water transfers, groundwater development	Water allocation plans, conjunctive use, demand management including pricing, water efficiency technologies, irrigation and urban water management, recycling and reuse	Involvement and sharing local solutions, capacity development
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 and 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
Increased erosion, landslides and sedimentation	Research into soil management and protection, monitoring and early warning systems	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

(Continued)

TABLE 1.1. Climate-related risks to water resources and potential adaptation actions. (Continued)

Climate risks	Knowledge	Governance	Infrastructure	Planning and management	Communications, education and participation
Reduced water quality (surface water and groundwater)	Monitoring, research into water quality treatment	Coordination between water resources 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
Glacial lake outburst floods (GLOFs)	Research, monitoring and early warning systems	Coordination between departments working on disaster management, geology, hydrometeorology	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 operation and maintenance (O&M), capacity strengthening

These options fall within the following five groups of integrated water resources management (IWRM) attributes: knowledge; governance structure; infrastructure; planning and management activities; and communications, education and participation. These groups were taken and extended from an earlier analysis of climate change adaptation for the Government of Zimbabwe that had been adapted from a report to the Southern African Development Community (SADC) on climate change adaptation in the water sector (SADC 2011).

Report Outline

The report consists of five chapters. Chapter 1 (this chapter) provides the background and context of the report. Chapter 2 introduces IWRM, the framework adopted in many policy instruments across South Asia, and explains why it provides many of the features needed for adapting to the impacts of climate change. Chapter 3 analyzes the water resources policy environment in each South Asian country (considered in this study) against 12 criteria (defined in the chapter) that describe the adequacy of these instruments for adapting to climate change. Chapter 4 analyzes 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 demand as a result of climate change. It also contains possible topics for phase II of this work. The Appendix contains a detailed description of the contents of both draft and approved water resources instruments.

Chapter 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. It also emphasizes the need to manage climate variability through data collection and management, infrastructure, planning and institutional coordination. 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.

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" (GWP 2000, 22). 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 a result, with benefits arising from the cycles of learning that emerge as water management practices are improved.

The term 'integrated' in IWRM carries several meanings. Most importantly, it refers to integration of water-dependent sectors (including irrigation, hydropower and domestic water supply) in making decisions about water use. However, it also includes integration of decisions made by those upstream 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 the 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 (GWP 2000):

- Taking an *intersectoral approach* to water resources development and management. 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 impenetrable barriers between them, and with technically competent staff that pursue narrow sectoral objectives (see Paper 3 [Suhardiman et al. 2019]). Establishing a genuinely intersectoral approach is probably the most contentious feature of IWRM, as 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 interdependent and need to be managed. Decentralization has proven to be 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 [Suhardiman et al. 2019]). 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 the environmental and social impacts of all distribution and water use decisions.
- Strengthening *demand management* by establishing prices for surface water and groundwater use that reflect its full value, introducing water-efficient technologies and a sense of responsibility among water user groups, and establishing decentralized water management authorities.

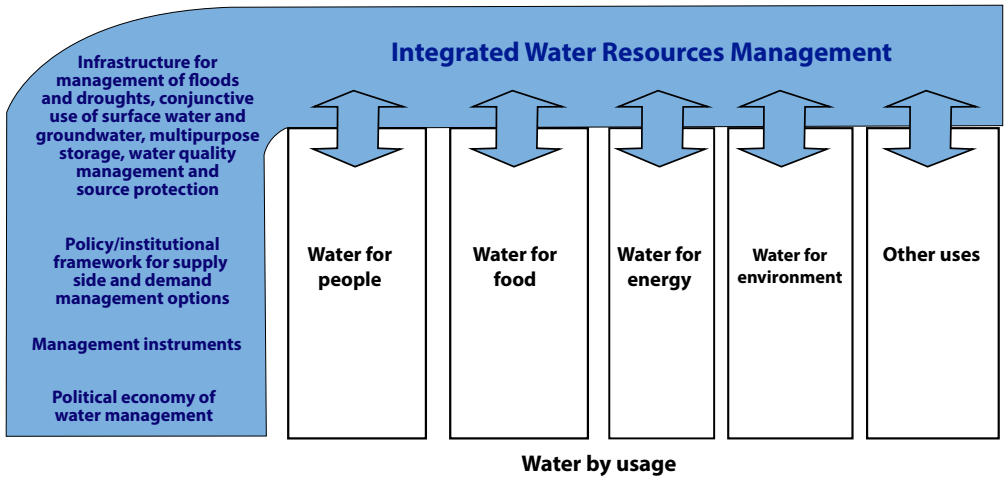
- Ensure *equitable access* to water by establishing water user associations (WUAs) that provide a voice for individual and community water users, including marginalized groups. It is also important to bear in mind equity considerations within policies, strategies and plans for infrastructure investments and management activities by, for example, extending the water supply to poor communities. Equity also implies that those groups that contribute to water resources issues should take responsibility for their impacts. This includes the corporate sector, which can seriously affect both the quantity and quality of surface water and groundwater.
- *Establishing policies* so that government intentions are clear regarding overarching 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 2.1), 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 as it (the environment) 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 water resources and the water-using sectors (i.e., the whole comb) is 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 2.1 shows that infrastructure provision is an essential element of IWRM, along with the policy and 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 2.1. Conceptual framework of integrated water resources management.



Source: Adapted from GWP 2000.

There is no universal model for implementing IWRM. Different features will be needed depending on the 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, this should be open for review and modification as experience is gained with what works and what does not work.

Limitations of IWRM

Various commentators have criticized IWRM on both conceptual and practical grounds (for example, 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 definition by the Global Water Partnership (GWP). 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 social and institutional relationships and assumptions. In their comprehensive review of IWRM, Snellen and Schrevel (2004, 14) concluded that, despite the difficulties of implementation, "It is generally accepted that to manage water resources there is no alternative to IWRM."

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

IWRM and Climate Change

Climate change affects many water-dependent sectors (irrigation, water supply and sanitation, hydropower generation, industry, environment and tourism) through changes in water availability and demand, and increases in the risk of extreme weather events. Consequently, several reports conclude that water is the medium through which most early climate change impacts will be felt (Alavian et al. 2009; GWP 2007; Sadoff and Muller 2009a; World Water Council 2009). 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 adapting to changes in water availability and demand, and water-related risk.

An important point is that adaptation to climate change is about improving existing water management rather than undertaking a fundamentally new approach. In their report from an International Water Management Institute (IWMI) and GWP workshop on adapting to climate change in the water sector in South Asia, Shah and Lele (2011, 14) 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." Having said this, there are two additional topics that need to be added to the suite of existing water management activities: the effects of nonstationarity of climate parameters (see Paper 1 [Lacombe et al. 2019]) now need to be accounted for (for example, in monitoring, modeling, and establishing infrastructure design standards and operating procedures); and the impacts of sea-level rise on coastal surface water and groundwater systems need to be added to existing coastal water quality concerns.

Adopting 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 several reasons:

- If countries follow a strictly sectoral approach to adaptation, 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, 2009b).
- The emphasis of IWRM 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 adaptation to increases in water variability from climate change (Cap-Net 2009). IWRM includes infrastructure and institutional responses, demand management and supply augmentation, as well as structural and non-structural approaches to efficiency (Box 2.1).
- IWRM is a reflexive learning process intended to allow for modifications as circumstances unfold. As Slootweg (2009) highlighted, 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.
- Adaptation will require better information and more responsive institutions alongside both infrastructure investments and structural and non-structural responses at all levels. IWRM offers a coherent way to implement these responses (GWP 2007).
- IWRM provides the tools to promote adaptation at all levels in a coherent way (Sadoff and Muller 2009a, 16). "The impacts of variability, aggravated by climate change, will have to be felt 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 2.1. Possible IWRM activities to respond to climate change.

In areas of water stress, adaptation interventions could consist of the following:

- Seasonal water rationing during times of shortage
- Adapting industrial and agricultural production to reduce water wastage
- Increasing capture and storage of surface runoff
- Reuse or recycle wastewater after treatment
- Desalination of saline or brackish water
- Better use of groundwater resources
- Rainwater harvesting

In areas where water quality is affected, possible measures include the following:

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

Source: Cap-Net 2009.

There are also shortcomings in using an IWRM approach to climate change adaptation. Slootweg (2009) cautioned that, even though IWRM advocates a multisectoral 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." Also, IWRM has been developed primarily for national water management, and there are few examples of the principles being successfully applied to transboundary water management: an important requirement in South Asia, with its major transboundary rivers. Gain et al. (2013) assessed six principles of IWRM against four desirable characteristics of adaptive approaches. While they concluded that, overall, IWRM does enhance adaptive responses to climate change, they see a need for IWRM to be more flexible if it is to be used to respond to the effects of climate change.

This report places emphasis on the management of groundwater because this is likely to become a more important source of water as climate change advances: 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 2.2).

Box 2.2. Regional groundwater vulnerability under climate change.

Clifton et al. (2010) constructed an index expressing the vulnerability of the World Bank's six regions to the likely effects of climate change (Table 2.1). The index incorporates the following 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 Döll and Flörke 2005)
- Exposure (sea-level rise): the exposure of regional water resources to sea-level rise and contamination due to storm surge
- Adaptive capacity: wealth, as measured by per capita gross national income (GNI), as a proxy for capacity to adapt

TABLE 2.1. Groundwater vulnerability to climate change (by region).

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

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

Source: Clifton et al. 2010.

Chapter 3. Water Instruments and Adaptive Capacity

The Five Dimensions of Integrated Water Resources Management

For convenience, integrated water resources management (IWRM) can be divided into five dimensions that are relevant to the discussion of climate change adaptation: (i) water resources knowledge; (ii) water resources governance; (iii) water resources infrastructure; (iv) water resources planning and management; and (v) water resources communications, education and participation. These dimensions are based on earlier studies of climate change adaptation in the water sector in Zimbabwe (Davis and Hirji 2014; SADC 2011). 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 communications, education 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, but are based on the authors' judgment of the most important 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 its preparedness to adapt to climate change in the water sector. Not all criteria are of equal importance in each country. For example, countries that are endowed with abundant water resources may not place as much emphasis on developing water storages as do countries that have scarce water resources.

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 centers of excellence in water resources and climate change, and establishing guidelines on how to effectively implement these provisions.

Staff need access to the best available information from meteorological and water monitoring networks, as well as from scientific models of quantity and quality of surface water and groundwater, and how these are affected by climate change. Water resources data should be held in databases that collate information from the various institutions that undertake monitoring. The data should be readily accessible at low or no cost. Where relevant, the data should be collated across national borders for transboundary river basins and transboundary aquifers. These monitoring and modeling requirements apply to meteorological data, 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 (for example, ministries of health or environment), the information needs to be freely shared so that it is available for decision making.

> *Criterion 1. Undertake climate monitoring, and monitoring of quantity and quality of surface water and groundwater, so that there is a factual basis on which to base strategies of adaptation to climate change.*

Water Resources Governance

Water needs to be treated as a common-pool resource, held in trust and managed by the state on behalf of the people, rather than as an individually owned resource (Schlüter 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 waste. Water use licenses should specify conditions of use such as limiting pollution of any water discharged.

State management helps institute equitable access to water, particularly when it is scarce; for example, to prevent upstream users from 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 defines institutional responsibilities and promotes 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 in all decisions that affect a number of sectors is probably the most important governance action to improve the allocative and technical efficiency with which water is used, and also to help prevent intersectoral 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, and 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-dependent sectors and a means for these sectors to work together effectively.

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 the responsibility for establishing and implementing water plans.[7] This includes transboundary river basins and aquifers where cooperation is key not only for tackling issues that are cross-border in nature, such as widespread flooding, but also for handling common issues such as arsenic and fluoride contamination of groundwater and saltwater intrusion in coastal aquifers. Regional activities could include data sharing, development of early warning systems, research and development, and capacity building across national institutions in a regionally coordinated way. Efforts to promote regional adaptation will have to account for the existing asymmetries in economic and political power, geography, resource endowments, skills, institutional capacities and country priorities.

Good governance also includes establishing means for community involvement in water management through water user associations (WUAs) or other such groups. Governance requires that cooperative mechanisms be implemented for managing transboundary surface water and groundwater.

Water governance involves 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.

[7] The management of floods and droughts also needs to be coordinated across relevant agencies, but the focus of this criterion will be on coordination of water allocation and management.

Water Resources Infrastructure

Dams help manage variability, and having sufficient water storage will become increasingly important as greater rainfall variability and reduction of ice melt and snowmelt (as a result of climate change) ensure an increase in streamflow variability (see Paper 1 [Lacombe et al. 2019] for details). Dams provide water for irrigation, hydropower, industry and domestic consumption, thereby contributing to both climate adaptation and mitigation efforts. Reducing sediment loads will prolong the life of existing storages (Annandale et al. 2016; Palmieri et al. 2003). However, even with improved water efficiencies and reduced sediment loads, increased storage (including natural storages such as aquifers and soil moisture) will eventually be needed to cope with increased variability in precipitation, as well as reduced precipitation and snowmelt and ice melt in some areas.

Interbasin water transfers have been proposed in South Asian countries (for example, the Sutlej-Yamuna link between the Indus and Ganges basins within India) to move water from regions of relative water abundance to those where water is scarce. However, they require detailed negotiations and benefit sharing before they can be implemented.

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 consider 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 the ability to cope with future extremes.

Infrastructure is not restricted to surface water development. Existing groundwater supply can be augmented through artificial recharge (managed aquifer recharge [MAR]). Small-scale infrastructure, such as household and community water tanks, and rainwater harvesting can also help to provide water during droughts.

However, 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 and 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 (high flows) and troughs (low flows) in water availability while aiming to preserve environmental flows*.

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), and canals and pipelines can move water from areas of abundance to those of shortage. These infrastructure investments could also be accompanied by non-structural flood and drought protection measures, such as flood mapping, land-use controls and preparation of emergency response plans.

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

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

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 among competing uses.

Criterion 7. Institute water allocation plans at the 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 wastage where there is increasing competition for the resource due to reduced water availability and increased evaporative losses as a result of climate change. Demand management includes establishing realistic prices for water, public education and participation, removal of perverse subsidies that encourage excessive agricultural water use, technical measures such as reducing leaks and illegal connections, and water-saving technologies in domestic water supply. Recycling and reusing water, in addition to the 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 the 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; industrial production procedures can be modified to reduce water use and contamination (and, therefore, minimize the need for expensive 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 uses downstream, including environmental flows. Markandya et al. (2017) undertook a preliminary assessment of the investments needed to achieve different levels of improvement in water-use efficiency in South Asian countries. Thus, a 10% improvement in efficiency in India requires an investment of USD 27 per hectare, while the same level of improvement in Sri Lanka requires an investment of USD 41 per hectare.

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

Climate change can potentially affect water quality in diverse ways. For example, increasing temperatures are likely to increase biological activity in rivers, lakes and other water bodies, exacerbating pollution problems; turbidity may increase as a result of more intense rainfall events; and coastal aquifers are likely to experience increased salinization from sea-level rise and more intense storms. Protecting water quality provides more usable water for irrigation and water supply in the face of increased evaporation and water demand, and, in some places, reduced water availability as a result of climate change. Water quality protection measures include protecting catchments or watersheds 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, land clearance and zoning schemes can be used to help protect watersheds. Additionally, having water quality discharge standards in place is important to control discharges to waterways and to protect 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 the available water more usable.

Water Resources Communications, Education and Participation

Many of the actions necessary to improve water management are not supported by sectoral interest groups as well as the general public. Vesting ownership of water in the state can challenge traditional beliefs among 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 to water reforms in Nepal, Pakistan and Sri Lanka can partly be traced to a lack of public and other stakeholder understanding about proposed changes. It is essential that the general public, as well as key water-dependent sectors (and key states or provinces in federal systems), 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 to ensure 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 to organize water user groups such as farmer organizations (FOs) and WUAs so that they can participate in the water management decision-making process. In many cases, governments have devolved responsibility to such groups for the management of irrigated areas.

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

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 and sanitation (WSS). There are also regional instruments such as international water agreements that are briefly described but not analyzed here (see Paper 3 [Suhardiman et al. 2019] for a fuller description of transboundary instruments). For example, the Indus Waters Treaty governs transboundary water management between India and Pakistan.

Policies are central to water resources management, because they describe the intentions of governments in relation to water management. In some cases, these policies are backed with legislation, strategies and plans that provide details of how policy provisions are to be implemented. The policies and other instruments of water-related sectors—WSS, industry, irrigation or agriculture, power and the 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 WUAs to manage their irrigation districts and thereby potentially enable greater flexibility in adapting to changing local conditions.

Table 3.1 provides the full list of water-related instruments, both drafted and approved, that were collated for this report. The Appendix describes the content of these instruments for each South Asian country, organized under the five dimensions of IWRM.

Analytical Framework

The water resources and water-related instruments of each South Asian country are analyzed in the following section against the 12 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 the Appendix. However, only those instruments that have been accepted by governments were included in the analysis in this chapter (shown in bold in Table 3.1).

This analysis was confined to water resources and water-related instruments. However, other government policies can have an indirect, but sometimes important, influence on water resources management. For example, a country's foreign policy establishes its relationships with riparian countries, and influences management of transboundary surface water and groundwater resources. These indirect influences, while undoubtedly influential, are too complex and diffuse to be included in this analysis.

TABLE 3.1. Water resources and water-related instruments in South Asia (by country).

Country	Policy	Legislation	Strategy or plan	Other
Afghanistan	**Strategic Policy Framework for Water Sector 2005** **Agriculture and Natural Resources Policy and Strategy 2005** Groundwater Development Policy	**Water Law 2009** **Environment Law 2007**	**Water Sector Strategy 2008**	**National Development Framework 2002**
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** **Disaster Management Act 2012** National River Protection Commission Act 2013	**National Water Management Plan 2001** **National Plan for Disaster Management 2010-2015, 2010**	Guidelines for Participatory Water Management 2001 Water Rules (draft) 2015

(Continued)

TABLE 3.1. Water resources and water-related instruments in South Asia (by country). (Continued)

Country	Policy	Legislation	Strategy or plan	Other
Bhutan	**National Irrigation Policy 2010 (revised 2011)** **Bhutan Water Policy 2007**	**Water Act 2011** **National Environment Protection Act 2007** **Disaster Management Act 2013**	National Integrated Water Resources Management Plan (draft) 2016 **National Environment Strategy (The Middle Path) 1998** **National Disaster Risk Management Framework 2006** **Power System Master Plan 2003-2022 (2004)**	**Water Regulations of Bhutan 2012**
India	**National Water Policy 2012** **National Urban Sanitation Policy 2008** **National Agriculture Policy 2000**	Environment (Protection) Act 1986 **Water (Prevention and Control of Pollution) Cess Amendment Act 2003** **Water (Prevention and Control of Pollution) Act 1974** National Water Framework Bill (draft) 2013 Model Bill for the Conservation, Protection and Regulation of Groundwater (Draft) 2011 **Interstate Rivers Dispute Act 1956** **River Boards Act 1956**	**Ministry of Water Resources Strategic Plan 2011**	
Nepal	**Irrigation Policy 2003** National Water Supply and Sanitation Sector Policy 2014 (draft)	**Water Resources Act 1992** **Irrigation Act 2016 (in Parliament)**	**Water Resources Strategy 2002** **National Water Plan 2005**	

(Continued)

TABLE 3.1. Water resources and water-related instruments in South Asia (by country). (Continued)

Country	Policy	Legislation	Strategy or plan	Other
Nepal	**National Rural Water Supply and Sanitation Policy 2004** **National Rural Water Supply and Sanitation Sector Policy 2009** **National Urban Water Supply and Sanitation Sector Policy 2009** **Water Induced Disaster Management Policy 2006** **Water Induced Disaster Management Policy 2015** **Hydropower Development Policy 2001**	**Irrigation Rules 1999** **Electricity Act 1992** **Electricity Rules 1993** **Drinking Water Rules 1998** Environmental Protection Act 1996	**Scaling-up Renewable Energy Program Investment Plan for Nepal 2011** National Strategy for Disaster Risk Management 2009	
Pakistan	National Water Policy (draft) 2006 **National Sanitation Policy 2006** **National Drinking Water Policy 2009** **National Environmental Policy 2005** National Wetlands Policy 2009 (Draft) National Water Policy 2018	**Water and Power Development Authority Act 1958** **Environmental Protection Act 1997**	**Water Sector Strategy 2002**	**Pakistan 2025 One Nation-One Vision 2014**
Sri Lanka	**National Drinking Water Policy** **National Rural Water Supply and Sanitation Policy 2001**	**Water Resources Board Act 1999** **Irrigation Amendment Act 1994**	**National Water Use Master Plan 2013** **Comprehensive Program for Disaster Management 2014-2018, 2014**	

(Continued)

TABLE 3.1. Water resources and water-related instruments in South Asia (by country). (Continued)

Country	Policy	Legislation	Strategy or plan	Other
Sri Lanka	**National Policy on Disaster Management 2010** **National Environmental Policy and Strategies 2003** **National Wetland Policy and Strategy 2006** National Policy on Protection and Conservation of Water Sources, Catchments and Reservations in Sri Lanka 2014 (draft)	**Disaster Management Act 2005** **Agrarian Development Act 2000** **Mahaweli Authority Act 1979** **National Environmental Amendment Act 1988** **Irrigation Amendment Act 1994**		

Note: Instruments in **bold** were used for the analysis in this section.

Analysis of Water Resources Instruments

Criterion 1. Monitoring Surface Water and Groundwater

The need to monitor surface water and groundwater volumes and quality is widely recognized in water sector and subsector instruments, except for those in Sri Lanka, where monitoring is not included in the National Wetland Policy and Strategy 2006, National Rural Water Supply and Sanitation Policy 2001, or the National Drinking Water Policy. However, the Sri Lankan National Environmental Policy and Strategies 2003 advocate monitoring of industrial discharges, while the Comprehensive Program for Disaster Management 2014-2018 calls for an improved rainfall monitoring system. Nepal emphasizes, in particular, that groundwater monitoring needs to be expanded in order to obtain more comprehensive information on both water levels and quality in irrigation districts, while further exploration is needed to locate additional groundwater resources for development.

Several countries identify early warning systems for floods, droughts, landslides and glacial lake outburst floods (GLOFs) as priorities. In its National Disaster Risk Management Framework 2006, Bhutan wants to develop an early warning system for flash floods and GLOFs in vulnerable basins as part of its community approach to disaster management.

India establishes the link between climate change and monitoring in its National Water Policy 2012. The policy states 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 surface water and groundwater information, while India, through its National Water Policy 2012, proposes a national informatics center to hold data (Box 3.1). Bhutan specifies that there should be open access to its monitoring data, as do India and Pakistan.

Box 3.1. Collating water information in India.

The National Water Policy 2012 advocates improved information, including flood forecasting, flood mapping, community action plans and disaster preparedness. Climate and hydrological data, and use and quality of surface water and groundwater data should also be monitored in each river basin. A national water informatics center should be established and all possible data placed in the public domain. Because of climate change, more data are needed on snow and glacial dynamics, evaporation losses, tidal hydrology and hydraulics, river geometry, and erosion and sedimentation. Both the National Water Policy 2012 and the National Water Framework Bill (draft) 2013 propose that forecasting systems be developed.

Sources: MoWR, India 2012; Planning Commission, India 2011.

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 2013, for diverting or impeding flows, thus asserting government authority over embankments and other structures erected by landowners 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. In India, private ownership of water is incorporated in the constitution. 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. However, this assertion of public ownership clarifies the right of governments to implement actions to help adapt to climate change, such as controlling overabstraction and introducing artificial recharge and conjunctive use (Box 3.2).

Box 3.2. India's Model Bill for the Conservation, Protection and Regulation of Groundwater 2011.

The 2011 draft 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 landownership. It 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 allows state water authorities to control water extraction and overlying land uses, and to manage potential pollution of aquifers. The latter provides priorities for access to groundwater and encourages 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 Sector Strategy 2008 and Water Law 2009 around IWRM; Bangladesh incorporated IWRM principles into its National Water Policy 1999 (Gupta et al. 2005); India's National Water Policy 2012 requires IWRM to be the main principle for planning, development and management of water resources; and Pakistan's Water Sector Strategy 2002 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)" (MoWP 2002b, 25). Bhutan has institutionalized IWRM in the Water Act 2011, and has mandated the National Environment Commission to prepare a national integrated water resources management plan during the Eleventh Five Year Plan (2013-2018).

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 (Suhardiman et al. 2019). Approaches vary from Afghanistan's Supreme Council for Water Affairs Management, chaired by the First Vice President and containing all relevant ministers (now the Supreme Council on Land and Water chaired by the President), to India's long-established (since 1983) National Water Resources Council, chaired by the Prime Minister, and 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). India has had, for a long time, separate surface water and groundwater organizations (the Central Water Commission and the Central Ground Water Board), which has led to a lack of coordination and has hampered attempts to manage water resources as a whole. A recent review has recommended that the functions of these organizations be combined into a National Water Commission, which would also promote other IWRM principles such as participation by water users and river basin water allocation planning (Roche and Khanna 2016).[8]

Criterion 4. Recognition of Climate Change

Afghanistan, Bangladesh, Bhutan, India and, 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 Water Act 2011. In fact, an IWRM approach was adopted in the Water Act 2011 specifically to help respond to the threat of climate change (NEC 2016), while the National Disaster Risk Management Framework 2006 states that landslides, GLOFs, flash floods and forest fires will be exacerbated by climate change. The Indian National Water Policy 2012 clearly recognizes climate change as being one of three key pressures on water availability, along with population growth and increasing water demand. Climate change figures prominently throughout this policy, including a detailed section on adapting to climate change. The Bangladesh National Plan for Disaster Management 2010-2015 states that climate change could substantially increase the frequency and intensity of existing climatic events (floods, droughts and cyclones), and that floods and cyclones will start to occur outside their established seasons.

At the other extreme, Nepal does not mention climate change in its Water Resources Strategy 2002 or the National Water Plan 2005, apart from the need to study this issue by establishing a Himalayan Climate Change Study Center. Nepal's new Water Induced Disaster Management Policy 2015 clearly includes the potential effects of climate change, with the need to incorporate climate effects when estimating design floods. Because Pakistan and Sri Lanka do not have approved water policies, their recognition occurs through subsectoral policies. Pakistan's National Drinking Water Policy 2009 states that climate change will affect the planning and development of water supplies, but does not propose adaptive actions. On the other hand, Pakistan's 2025 One Nation - One Vision sees climate change as having a major influence on water availability and highlights that adaptive actions need to commence soon, including the construction of new storage facilities.

[8] Interview in The Hindu, August 19, 2016.

Sri Lanka's National Environmental Policy and Strategies 2003 states that management needs to be flexible to respond to changing circumstances such as the effects of climate change, while the National Policy on Disaster Management 2010 requires that the impact of climate change on the risk of disasters must be assessed. The Sri Lanka Comprehensive Program for Disaster Management 2014-2018 is quite explicit: "Climate Change impacts are likely to cause increased spatial and temporal variability in weather patterns, both temperature and rainfall leading to increased incidence of floods, droughts and epidemics in the country. 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, 15).

Criterion 5. Water Storage Investment

All South Asian countries, except Bangladesh, have plans for water storage expansion. Bangladesh, in its National Water Management Plan 2001, calls for a limited number of new irrigation schemes but does not specifically mention new storage facilities. However, the National Plan for Disaster Management 2010-2015 does recognize that increases in drought will mean that barrages will have to be installed across rivers to provide water, because groundwater resources are heavily used and, in some areas, contaminated with arsenic. As proposed in the national water policy, the Bangladesh Water Development Board is mandated to undertake large water-related infrastructure projects. The main water infrastructure issues in Bangladesh concern protection from floods, cyclones and storm surges, which are described in the next section.

The Afghanistan Water Sector Strategy 2008 proposes that a National Water Resource Development Plan be prepared to identify 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 2002 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 and Strategy 2005.

Pakistan, in its water sector strategy, makes 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 National Water Policy 2012 requires that all projects, including hydropower, should be planned as multipurpose 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 (Box 3.3). Nepal and Bhutan have ambitious plans to develop hydropower plants to generate export revenue by selling the electricity. The Scaling-up Renewable Energy Program Investment Plan for Nepal 2011 contains details of proposed mini hydropower schemes. Hydropower development has been included in both five- and three-year plans since the 1980s.

Box 3.3. Trends in variability of India's monsoons.

The standard projection from climate change research has been that extreme wet and dry events will become more frequent, and that drier regions are likely to become drier and wet regions will become wetter under climate change. However, a recent study from India has found that, while the intensity and frequency of extreme monsoonal rainfall events are increasing, the mean monsoonal rainfall is decreasing over the country's major water supply basins and increasing over drier areas. The water yield is decreasing in surplus river basins, while it is increasing in deficit river basins. These findings, contrary to standard beliefs, are important for reassessing the yield of existing river basins as well as for planning new infrastructure such as dams and interbasin water transfers.

Source: Gosh et al. 2016.

Finally, Sri Lanka has developed the National Water Use Master Plan 2013, which 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. Interbasin water transfers are a further option for the longer term, but there are likely to be resettlement issues. It is apparent that Sri Lanka has various surface water infrastructure options available for coping with increased variability in precipitation and changes in monsoonal rainfall, if funding is available. However, no groundwater development options were examined in the master plan.

Climate change is likely to affect these proposed storage developments, although the effects may not always be direct or immediate. For example, in countries with highly variable climates and where the financial conditions affect the economics of storages, the uncertainty introduced by climate change may be of secondary importance compared with other factors. Box 3.4 describes the decision tree approach that was developed to assess whether climate change is likely to be a major influence on infrastructure investments, compared with uncertainties arising from other sources. A recent World Bank report to the Nepal government found that smaller run-of-river hydropower projects will be most affected by climate change because they are the most susceptible to flow conditions; increases in climate risks (sediment transport, extreme floods, GLOFs) are the most important additional risk from climate change; and while climate change is potentially important, its impacts are outweighed by other issues and uncertainties such as pricing, regulatory conditions and institutional factors (World Bank 2017).

Expansion of groundwater use is proposed in some water instruments. Thus, the Afghanistan Water Sector Strategy 2008 argues for the installation of more wells, extraction equipment for both municipal and rural water supply, and the artificial recharge of depleted groundwater systems. In its National Water Policy 2012, 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*.[9] Pakistan recognizes that storing water in carryover 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.

Box 3.4. The decision tree approach to infrastructure investment decisions.

The decision tree approach has been developed to guide infrastructure investment decisions taking account of climate change. There are large uncertainties surrounding the effects of climate change on future hydrological resources because of the uncertainties in emission scenarios and the diverse results from different global circulation models and downscaling methods. Rather than attempting to incorporate the effects of climate change on local hydrological resources, the decision tree approach assesses the project performance objectives (safe yield, reliability of supply, etc.) which are likely to be affected by the range of possible climate change impacts. In many cases, the uncertainties arising from climate change are subsumed within uncertainties arising from other sources.

The decision tree approach has been applied to planning Nepal's Upper Arun Hydropower Plant and a closely related method (decision making under uncertainty) was applied to a portfolio of projects in the Koshi Basin. In the former trial, five possible hydropower designs were subjected to a "climate stress." All designs were robust to the range of possible climate change impacts. Among nonclimatic factors, the price of electricity and construction costs emerged as key risk factors. The latter trial identified various potential investment portfolios that could be implemented, depending on Nepal's preferences for water supply, irrigation, environmental flows and flood control.

Source: Karki et al 2015.

[9] The *terai* is a lowland region of southern Nepal.

Criterion 6. Flood Protection

Floods are one of the major climate-induced water risks in South Asia as described in Paper 1 (Lacombe et al. 2019). The source of the floodwaters varies from GLOFs in HKH countries to monsoonal rains in Bangladesh, India, Pakistan and Sri Lanka, and tidal surges and contamination of surface water and groundwater in low-lying and estuarine areas of 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.

Bhutan and Nepal have taken a risk reduction approach for flood protection, requiring flood zoning, hazard mapping and early warning systems for GLOFs. Bhutan instituted a National Disaster Risk Management Framework in 2006 and a Disaster Management Act in 2013. Under the Act, an Inter-Ministerial Taskforce is to be formed to oversee hazard zoning and risk reduction activities, among others.

On the other hand, Nepal has a specific Water Induced Disaster Management Policy 2015, 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), classifies flood-affected areas into different zones, and recommends different land uses for these zones. Bangladesh's Coastal Zone Policy 2005 specifically links the need for flood protection infrastructure to the expected impacts of climate change. India's National Water Policy 2012 and National Water Framework Bill (draft) 2013 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 nonstructural 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, and disaster recovery. Nonstructural measures include rehabilitation of natural drainage systems, changes in reservoir operating procedures and community flood planning. The Bangladesh Disaster Management Act 2012 makes it an offence to contribute to flood hazards and impede the flow of waters.

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 subbasin 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 National Water Policy 1999, opted to develop a National Water Management Plan in 2001, which recognizes different geographic areas of the country rather than basin-level plans. However, the National Water Policy 1999 makes it clear that Bangladesh is primarily interested in developing a basin plan for the entire Ganges Basin, and that would require greater levels of transboundary cooperation with India than what has been achieved to date. Although Pakistan has adopted most of the principles of IWRM, it has not included basin-level management in its Water Sector Strategy 2002. This may be because of the dominant position of the Indus Basin for water management in Pakistan—consequently, water management in the country is intrinsically basin-centered and heavily influenced by the Indus Waters Treaty and relations between provinces. Sri Lanka included basin-level water planning and management in its draft water policy of 2006, but it was not approved by the government. There are agencies (primarily the Department of Irrigation and the Mahaweli Authority of Sri Lanka) that are responsible for river basin management in the country, but these do not undertake the planning and management functions of river basin agencies envisaged in the IWRM model. Also, there are clear conflicts of interest, with the Ministry of Irrigation and Water Resources 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. While Afghanistan does not require that climate change be incorporated into basin plans, it does require that climate change be included in the national water resources development plan with which the basin plans must be consistent.

In its National Water Plan 2005, Nepal points out 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 (for example, the South African experience). The extent to which these institutions have been established in South Asia will be examined in Paper 3 (Suhardiman et al. 2019).

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 spelled out. This is the case in Afghanistan's Water Sector Strategy 2008, 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 2012, 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 toward cost recovery for operation and maintenance of surface water and groundwater irrigation, while Sri Lanka's National 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 National Water Management Plan 2005 of Nepal, as well as its Irrigation Policy 2003, while Bangladesh's National Water Policy 1999 and National Water Management Plan 2001 encourage conjunctive use generally. The former instrument makes special mention of its potential to help combat drought.

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, 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 for water sources but also to halt salinization and loss of usable groundwater. The Pakistan Water Sector Strategy 2002 estimates that there is the potential to save 5,800 giga-liters (Gl) annually by 2025 through increasing irrigation efficiency from the current efficiency of 40% to 45%.

There is also considerable scope for water-efficient technologies in urban water supply systems. Two countries, Pakistan through its National 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).

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. Thus, Bangladesh seeks to control pollution through three policies: the National Water Policy 1999, the National Policy for Safe Water Supply and Sanitation 1998, and the Environment Conservation Act 1995 and its 2010 Amendment.

Although country policies and legislation focus primarily on protecting surface water quality, there is also protection for groundwater quality in the instruments of Bangladesh, Bhutan, India, Pakistan and Sri Lanka. The Indian National Water Policy 2012 points out that groundwater quality requires special attention because of the difficulty of remediating groundwater once it is polluted. Unsurprisingly, one of the objectives of the Indian Model Bill for the Conservation, Protection and Regulation of Groundwater 2011 is the prevention of groundwater pollution and degradation.

There is also considerable concern about preventing contamination of surface water 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 Commission can declare threatened water sources to be water management areas where special controls can be applied, while the National Environment Strategy (The Middle Path) 1998 advocates maintenance of watersheds to reduce erosion and sediment loads. In Nepal, the Water Induced Disaster Management Policy 2006 calls for catchment conservation work to prevent landslides, and river corridor tree plantings and inclusion of environmental conservation as part of watershed conservation. The National Water Plan 2005 proposes an environmental action plan to rehabilitate degraded watersheds to reduce erosion and the danger of landslides.

The Indian National Water Policy 2012 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 National Agriculture Policy 2000 also advocates watershed development programs to protect water quality.

Criterion 11. Education of the Public and Government Officials

Despite the importance of building public support for water reforms, it is uncommon to find much attention paid to this criterion in the instruments analyzed. However, in its National Water Management Plan 2001, Bangladesh recognizes that there is a need to improve water knowledge and raise public awareness of sustainability, while Nepal's National Water Plan 2005 recognizes the need to raise awareness of the advantages of IWRM among all stakeholders, the 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 subsectoral policies on wetlands and drinking water propose awareness campaigns on the importance of wetland conservation and watershed protection, respectively.

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

Criterion 12. Participation by Water Users

Participation by water users is widely advocated in water instruments. Irrigation and agricultural policies have, for some decades, pursued the establishment of WUAs and 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 proved difficult to fully develop them, largely because they lack a formal institutional status (CPHD 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 also endorsed in agricultural or irrigation policies. 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 National Agricultural Extension Policy 2012 and the Indian National Water Policy 2012 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 states, "Climate change adaptation in agricultural extension may include . . . documenting and promoting indigenous farmer practices against disasters and vulnerabilities" (MoA 2012, 10). The Sri Lankan National Policy on Disaster Management 2010 also proposes that indigenous knowledge should be drawn on when responding to disasters, including those arising from climate change.

Summary

The water instruments generally contain most of the features needed for adapting to climate change. 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 the following:

- Monitoring surface water flows and groundwater levels
- Coordinating actions across water-dependent sectors
- Extending their water storage capacity (although these development plans do not usually incorporate the effects of climate change)
- Undertaking basin-level planning, although (with the exception of India and Afghanistan) these plans do not have to include the effects of climate change
- Implementing demand management as well as technical measures for improving water-use efficiencies
- Protecting water quality
- Improving public understanding of water management
- 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 spelled out are actually implemented and reflected in actions on the ground.

Table 3.2 provides a summary of the extent to which each country meets the 12 criteria for adaptive management of water resources. These scores and the above analysis are based on the approved government instruments alone. They do not represent the full range of government, traditional or informal procedures or practices. Thus, in Sri Lanka, there are several initiatives under way to improve water management, even though the country does not have a water policy. Not every criterion is of the same importance in each country; as explained in chapter 2, IWRM can be implemented with different emphases in different circumstances. With these qualifications, Table 3.2 provides a snapshot of the extent to which each country's water instruments are well suited to promoting adaptation to climate change.

TABLE 3.2. Assessment of the preparedness for climate change adaptation in water sector instruments (by country).

Instrument type	Afghanistan	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
Water resources knowledge							
Monitoring	1	2	2	2	2	1	0
Water resources governance							
State custodianship of water	2	2	2	2	2	0	0
Integrative policy framework	2	2	2	2	2	1	1
Climate change recognition	2	2	2	2	2	1	1
Water resources infrastructure							
Storage investment program	2	1	1	2	2	1	2
Flood protection	2	2	1	3	2	2	0
Water resources planning and management							
Basin water management	2	1	2	2	2	0	0
Demand management, reuse and conjunctive use	1	2	0	2	1	1	1
Technical efficiency measures	1	1	1	2	1	2	1
Protecting water quality	2	1	2	2	2	2	2
Water resources communications, education and participation							
Education	0	1	1	0	1	1	1
Participation	2	2	2	2	2	2	1

Notes: 0 = not present in main water instruments; 1 = mentioned or small description, but not major inclusion in main water instruments; 2 = significant feature in main water instruments. Draft instruments are not included in the assessment, and more recent instruments have been given more weight.

Chapter 4. Climate Change Instruments and the Water Sector

Climate Change Documents

All South Asian governments are signatories to the United Nations Framework Convention on Climate Change (UNFCCC), 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 communication reports to the UNFCCC on progress with both mitigation and adaptation actions every 4 years. They are also required to submit biennial update reports every 2 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 Conference of the Parties (COP 21) in Paris in December 2015. This report focused on mitigation activities, but countries were invited to also include adaptation activities.

The UNFCCC provides funding to help least developed countries (LDCs) develop National Adaptation Programs 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 Global Environment Facility (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 bring climate adaptation into national and subnational development, and sectoral planning into the mainstream. No South Asian country has yet submitted a NAP to the UNFCCC, although Afghanistan and Nepal have stated they intend to develop NAPs, Bhutan has developed sectoral 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 the government, and consequently describe the agreed position of the government in dealing with climate change. Some states in India and provinces in Pakistan have also developed climate change instruments, but these will not be analyzed here. Table 4.1 summarizes the various reports and instruments analyzed in this chapter.

TABLE 4.1. Climate change instruments in South Asian countries.

Country	Policy	Legislation	Strategy or plan	Other
Afghanistan			National Adaptation Program of Action 2009 National Climate Change Strategy and Action Plan 2015 National Adaptation Plan 2015	Intended Nationally Determined Contributions (INDC) 2015 First National Communication to UNFCCC 2013
Bangladesh		Climate Change Trust Fund Act 2010	National Adaptation Program of Action 2009 Climate Change Strategy and Action Plan 2009	Second National Communication to UNFCCC 2012 INDC 2015
Bhutan			National Adaptation Program of Action 2006 Renewable Natural Resources Sector Adaptation Plan of Action 2016	Second National Communication to 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 to UNFCCC 2012 INDC 2015 First Biennial Update Report 2016
Nepal	Climate Change Policy 2011		National Adaptation Program of Action 2010	Second National Communication to UNFCCC 2014 INDC 2016
Pakistan	National Climate Change Policy 2012		Framework for Implementation of Climate Change Policy (2014-2030) 2013	First National Communication to UNFCCC 2003 INDC 2015
Sri Lanka	National Climate Change Policy 2012		National Climate Change Adaptation Strategy 2011-2016 (2010)	Second National Communication to UNFCCC 2011

(Continued)

TABLE 4.1. Climate change instruments in South Asian countries. (Continued)

Country	Policy	Legislation	Strategy or plan	Other
			Information, Education and Communication Strategy for Climate Change Adaptation 2010 National Adaptation Plan for Climate Change Impacts 2015	Water Sector Vulnerability Profile 2010 Technology Needs Assessment and Action Plans 2011 INDC 2015

Analytical Structure

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

Do the climate change documents recognize adaptation opportunities in the water sector?
The Intergovernmental Panel on Climate Change (IPCC) recognizes that many climate change impacts will be mitigated directly and indirectly through changes in water availability and demand. Each country's climate change documents should recognize this and explain clearly how changes in water availability 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 and estuarine waters to the extent relevant in each country.

Do the documents propose strengthening the elements of integrated water resources management as an adaptation response?
Chapter 3 analyzes the extent to which the various documents incorporate good water management practices as advocated through integrated water resources management (IWRM), and which documents would strengthen a country's ability to adapt to climate change. The major adaptation opportunities—coordination across water-dependent sectors, improving water-use efficiency, developing water allocation plans at basin level (Box 4.1), controlling demand, etc.—should be reflected in the adaptation sections of the climate change documents. The water resources instruments would provide the details of management practices, but the climate change documents should be consistent with the broad outlines of the former.

Box 4.1. The Rufiji Basin Plan, Tanzania.

The Rufiji River Basin, covering 20% of Tanzania, is vital to the country's economic development. It provides over 80% of the country's hydropower capacity, contributes 15-18% of gross domestic product (GDP) through agriculture, and contains the country's largest national park—a major tourist attraction. The catchment's water is already heavily committed, with water use permits representing 61% of annual average water supplies in 2015. Moreover, water use is projected to reach 82% of water availability in 2035. The catchment's wetlands, including the Great Ruaha National Park, have experienced severe water shortages because of the upstream irrigated areas, with wetland areas decreasing from 180 km^2 in 1990 to 120 km^2 at present. Power generation has also been affected by upstream abstractions for irrigation, with frequent load shedding during the dry season. The sectoral plans for expansion of the irrigated areas and development of further hydropower stations are unsustainable at present rates of water use.

Climate change will exacerbate the situation, with temperatures predicted to rise by 1.5-3.9 °C by 2097; potential evapotranspiration will increase by 7-11%, while annual precipitation will increase by 3-5% in the wet season and decrease by 11-21% in the dry season. Proposed increases in water use combined with the effects of climate change could see annual runoff decrease by about 60%.

The Rufiji Integrated Water Resource Management and Development Plan is based on a detailed hydrological and climatological study that incorporates the potential effects of climate change on water availability and irrigation water demand. The plan proposes a wide variety of actions across five key areas: social development, environment, economic development, disaster management and water governance. The key to meeting development plans is to make irrigation water use more efficient through technical improvements together with stricter regulation. With these improvements, a new hydropower dam can be developed and some wetlands can be restored, while providing minimum environmental flows to the National Park.

Source: Georgakakos 2016.

Do the documents address the major water-related risks from climate change?
Each country identifies the major risks it faces 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?
Adaptation needs to be undertaken at all levels, from that of the individual to national governments and transboundary actions (Box 4.2). Community-level adaptation is important, because local impacts vary and it is necessary to take advantage of different local experiences of dealing with variability in water availability, and to build ownership among water users (see Paper 3 [Suhardiman et al. 2019] for a more detailed discussion). However, some adaptation activities are best undertaken at a river basin or aquifer level, because they affect users of a whole water resource, while other activities need to be conducted nationally or even across borders. A comprehensive climate change adaptation document should incorporate all such scales of activity.

Box 4.2. Adaptation across scales.

Adaptation requires actions across the continuum from individuals to groups (including the private sector) to governments, and to transboundary and international actions. These actions can be motivated by private benefits (in the case of individuals, companies and self-organized groups) as well as by societal protection. However, adaptation is most effective when it occurs within a common framework, because individual actions can generate both benefits and costs when wider scales or time frames are considered. For example, flood control embankments may help one community avoid the impacts of increased flooding, but can also shift the flooding problem downstream or upstream unless embankments are part of a wider basin-scale adaptation plan.

Burton et al. (1993) classified adaptation actions as falling into three broad categories: reduce sensitivity to climate change; reduce exposure to climate change; and increase resilience to cope with climate change. All three categories can occur at any scale. Thus, expansion of reservoir storage and planting climate-resilient crops are both actions that reduce sensitivity to climate change, although the former would operate at basin scale while the latter would occur at individual or community scale.

In some cases, reducing exposure to impacts may only generate individual benefits if others collectively invest in these adaptations, e.g., by developing defenses against sea-level rise in coastal communities. Even when an individual action can generate the adaptation benefit, it will often require a permissive regulatory framework.

Source: Adger et al. 2005; Burton et al. 1993.

Do the documents include regional opportunities for responding to climate change?
Water resource risks are usually best managed across an entire connected water body, including transboundary river basins and aquifers. Thus, large regional floods and 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 [Suhardiman et al. 2019] for a more detailed discussion). Information and data sharing, research and development (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, and separate sources of funding and management structures, usually centered on 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, including from a financing perspective (see Paper 3 [Suhardiman et al. 2019]).

Water Resources Adaptation in Climate Change Documents

Afghanistan

Afghanistan has three UNFCCC documents describing its climate change adaptation actions: the National Adaptation Program of Action (NAPA) 2009, the First National Communication to UNFCCC 2013, and the Intended Nationally Determined Contributions (INDC) 2015. The government has also recently approved two climate change instruments—a National Climate Change Strategy and Action Plan (NCCSAP) and a National Adaptation Plan (NAP) in 2015. While short-term priorities were reflected in the NAPA, the NAP includes both short- and long-term strategies and actions.

According to the NCCSAP and the NAP, floods and landslides, drought and associated desertification are the major water-related and climate-related threats facing Afghanistan.

Recognition of adaptation opportunities in the 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 water-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 First National Communication to UNFCCC 2013 explicitly recognizes that strengthening water resources management contributes directly to adapting to the impacts of climate change. Thus, externally funded projects, such as the Asian Development Bank (ADB) USD 300 million Water Resources Development Program and the European Union (EU)-funded Multi-annual Program, which 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 Water Law 2009, which authorizes IWRM and river basin management with multi-stakeholder participation, and the water sector policy, which endorses a river basin and subbasin approach to management, are contributing to adaptation in the face of changes brought on by global warming.

The NCCSAP and the NAP include water resources and irrigation as an immediate adaptation priority, because declining or uncertain water availability is a direct threat to the majority of Afghanistan's population, who rely on agriculture and livestock for their livelihoods. The increasingly erratic and unpredictable patterns of precipitation also increase the frequency of flooding and erosion of topsoil. Water resources adaptation activities include (a) watershed management; (b) increased use of traditional irrigation systems; (c) introduction of global best practices; (d) canal and river networks; and (e) water resources management in drylands.

Strengthening IWRM elements

All climate documents call for improvements in climate and water resources monitoring and knowledge. The First National Communication to the UNFCCC 2013 calls for predicting climate-induced disasters, including the ability to communicate information to people in advance. It also states that the government will attempt to rehabilitate damaged weather and meteorological stations, and add a few new facilities, including at high altitudes to monitor glacier lakes. Moreover, the INDC Report states that the draft NAP includes a proposal to strengthen and expand hydrometeorological monitoring networks, and develop a national database at a cost of USD 100 million.

Governance structures also need to be improved. 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, 55). The draft NAP also recognizes that there are significant barriers to coherent policy formulation and implementation when responsibilities are divided between the Ministry of Mines and Petroleum (groundwater management), the Ministry of

Energy and Water (surface water), and the Ministry of Agriculture, Irrigation and Livestock (irrigation systems). It states that the responsibility for water resources should be centralized under a single body.

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 Report 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
- Increase irrigation to 3.14 million hectares (Mha) through restoration of irrigation systems: USD 4.5 billion

The First National Communication Report recognizes the importance of IWRM to adaptation in the water sector. The Water Law 2009, in particular, required the establishment of river basin organizations. The NCCSAP also states that it is important to promote basin-level, integrated water resources management.

The NCCSAP and the NAP propose strengthening traditional irrigation infrastructure, such as the *karez*,[10] to improve water availability to the community in the dry months from April to October. They also propose developing a canal network to facilitate irrigation and help build community-level resilience to climate change impacts.

The 11 priority projects in the NAPA contain components aimed at improving the 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. The NAP advocates improving irrigation water-use efficiency by drawing on international experience, especially on micro and drip irrigation techniques and sprinklers, particularly for dryland areas where effective use of limited water resources is crucial to sustaining the local economy.

The First National Communication Report concludes that more attention is needed to educate the public about climate change and its potential impacts.

Addressing water risks

The NCCSAP and NAP include adaptation responses to the main water-related climate issues of drought, floods and landslides. A combination of strengthening traditional irrigation systems, new water storage and distribution networks, and a strong afforestation initiative will provide adaptation against drought and desertification. Adaptation to floods includes short-term measures such as flood preparedness, early warning systems and structural measures to reduce the impact of flash floods, as well as longer-term measures such as improvements to community-level resilience and avoiding settlements in flood-prone areas. Controlling overgrazing and deforestation, and replanting vegetation provide adaptive responses to landslides.

The First National Communication Report reinforces this focus on the major water-related risks when it states 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.

[10] Ancient groundwater supply systems.

Enhancing local community capacity for adaptation

The NCCSAP states that in the next 10-15 years, community-level action will remain central to any effective strategy to enhance resilience to climate change impacts; hence, it seeks to promote climate change adaptation at the subnational and local levels in addition to the national level. It also points out that, while the Disaster Risk Reduction Plan does not explicitly identify the linkages between climate change and disaster risks, it includes actions by various line ministries that would improve community-level resilience to climate change impacts, such as flood forecasting and strengthening irrigation projects against disasters.

This is consistent with the NAPA, where the first project sought to reduce the vulnerability of livelihoods in drought-affected communities through improved water distribution and utilization at the community level, while the second project dealt with watershed management issues at the community level.

Regional approach

The First National Communication Report states that Afghanistan proposes to engage in the South Asian Association for Regional Cooperation (SAARC) Thimpu Declaration program for regional education and awareness. This involves developing regional educational material on climate change for use in schools, and establishing information sharing and capacity building among national institutions.

While the NCCSAP recognizes that up to two-thirds of the water received is lost to neighboring countries, it does not incorporate any proposal to engage with neighboring 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 (CPHD 2011) points out that most of Afghanistan's neighbors depend on surface water resources originating from within the country. Therefore, Afghanistan must address these transboundary water management issues in its plans for infrastructure development.

Mainstreaming adaptation in the water sector

All 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" (Government of Afghanistan 2015, 4). The First National Communication Report states that the government is committed to mainstreaming climate adaptation into national and sectoral development strategies, and to performing climate risk screening to make adaptation programs and projects produce beneficial outcomes: "Climate mainstreaming and developing national and sectoral policies is vital" (Government of Afghanistan 2015, xii). Both the NCCSAP and the NAP are designed to be mainstreamed into national policies and sectoral strategies.

The INDC states that some policies and plans already include climate change, such as the National Water and Natural Resources Management Priority Program. It states that other policies, such as the Strategic Policy Framework for Water Sector, do not currently include climate change but have entry points that 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 the national level.

Discussion

Afghanistan has recently approved two climate change instruments that provide a coherent all-government response to climate change mitigation and adaptation, with good recognition of the opportunities to undertake adaptive actions in the water sector. 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 main climate risks are all water-related and these documents contain methods for strengthening adaptive responses to these risks, including strengthening local-level resilience.

Bangladesh

As well as the three UNFCCC reports—the National Adaptation Program of Action (NAPA) 2009, the 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 Bangladesh Climate Change Trust Fund (BCCTF) 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 following threats to Bangladesh from climate change:

- Greater monsoonal rains leading to flooding
- Sea-level rise causing coastal flooding and aquifer contamination
- Increased droughts
- Erosion of stream banks
- Increased sedimentation

Bangladesh's NAPA points out that the country has a 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; second, adaptation activities are not integrated into ongoing programs and policies in key sectors such as water (although the CCSAP is a step toward such integration); and third, Bangladesh still lacks the tools and knowledge at both an institutional as well as an individual level. Consequently, knowledge generation and dissemination are vital for effective adaptation.

Recognition of adaptation opportunities in the water sector

Bangladesh sees climate change through the lens of water resources. There is a very high recognition of the potential impacts on the country and, not surprisingly, its climate change (and other) 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 in the riverbed level due to sedimentation and changes in morphological processes due to seasonal variation of water level and flow are also critical for the country. The National Plan for Disaster Management 2010-2015, 2010, has a section on the likely impacts of climate change on the country's water resources.

The PRSP identifies climate change as a major threat to Bangladesh along with various water-related threats such as flooding, droughts and cyclones. The NAPA points out that climate change is likely to exacerbate these existing threats and, as such, the NAPA complements the activities in the PRSP.

The discussion of adaptation in the INDC is almost entirely focused on water-related hazards. However, the adaptation activities described largely revolve around infrastructure such as embankments, polders and cyclone shelters, while nonstructural responses receive little attention.

Strengthening IWRM elements

The various documents recommend a number of activities and programs that are included in the IWRM approach to water management. The CCSAP includes the following:

- 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, storm and flood warning systems, modeling hydrological impacts of climate change, and establishing a new Center for Research and Knowledge)
- Building capacity
- 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. It includes research and improved knowledge, such as hydrological modeling and the formation of a new Center 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 NCCSAP call for maintenance of this infrastructure and the construction of new protective measures. 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 training. Drinking water and sanitation projects should be implemented in areas at risk from both floods and droughts. Importantly, the Second Communication Report to the UNFCCC and the NAPA state that the design standards for flood protection embankments should be modified to take climate change effects into account. While the Second National Communication Report calls for community-based flood management, the adaptive responses are biased toward infrastructure.

There are limited options for preventing seawater contamination of coastal aquifers resulting from sea-level rise. However, the Second National Communication Report suggests that improvements in the Ganges River flow regime and a barrage across the river 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 usable.

The CCSAP does not propose many drought adaptation options, apart from changing cropping strategies, and implementing drinking water and sanitation programs in drought-prone areas. However, the NAPA and the Second National Communication Report 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 limit erosion of stream banks to meet the altered conditions expected with climate change.

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

Enhancing local community capacity for adaptation

Bangladesh is renowned for its community response program for floods and cyclonic storms. Communities have learned to adapt to floods and cyclones, often using local solutions such as

planting short-duration crops and artificial temperature controls in poultry sheds (MoEF 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 adaptations, the CCSAP is focused on top-down approaches.

The Bangladesh National Agricultural Extension Policy 2012 makes it clear that one of the reasons for advocating stakeholder participation is to advance adaptation to climate change at the local level (Box 4.3): "Climate change adaptation may include ... documenting and promoting indigenous farmer practices against disasters and vulnerabilities" (MoA 2012, 10).

Box 4.3. 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, followed by devastating floods in 2004 and again in 2007. With the assistance of a nongovernmental organization (NGO), the villagers decided to lift all houses and farm buildings above the 1998 flood level. They intend to also lift all tube wells above this flood level.

Source: MoEF 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 Second National Communication Report states, "85-86% of the river surface water flow originates outside the international border in the neighboring 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" (MoEF 2012, 133). The CCSAP states that the government is trying to work with neighboring countries to manage climate change impacts through regional action plans. The government also wants to enhance cooperation with neighbors on key issues, including water security.

There are also various regional organizations that Bangladesh has joined for exchanging environmental information and helping to develop scientific expertise.

Mainstreaming adaptation in the water sector

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

The CCSAP, NAPA and the INDC propose that all sectoral policies be reviewed for the 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 for climate change impacts to be included in all sectoral planning. The NAPA states, "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 stand-alone activities at higher cost" (MoEF 2009, 36).

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 the Bangladesh 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 [Suhardiman et al. 2019]).

Discussion

Bangladesh has put adaptation in the water sector at the center of its adaptation activities, with a strong emphasis on infrastructure and knowledge development in the 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 is that the CCSAP does not raise them as being important to improved water resources management. 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.

Transboundary activities, within the continuum of scale for adaptation actions, are recognized as essential for adapting to climate change. The CCSAP states that the government will work with neighboring countries to manage the impacts of climate change and to improve water security. The CCSAP also clearly recognizes that adaptation must involve civil society and the business community, and proposes to work with civil society organizations to develop innovative approaches to climate change adaptation.

Bhutan

Bhutan has not developed a climate change policy or strategy, although it clearly acknowledges the potential impact of climate change on the water, land and energy sectors in its water instruments. Bhutan completed a National Adaptation Program of Action (NAPA) in 2006. It submitted its Second National Communication to UNFCCC in 2011 and its INDC Report in 2015. The Ministry of Agriculture and Forest has developed the Renewable Natural Resources (RNR) Sectoral Adaptation Plan of Action (SAPA) 2016, in which water resources are included as part of the RNR sector. At a sectoral level, this is the most detailed document on Bhutan's adaptation plans, while the INDC Report confirms that the Second National Communication Report still provides the best overall summary of the country's adaptation plans. The NAPA I project has been completed successfully and the NAPA II is under implementation.

The SAPA reports the NAPA taskforce findings that the current water sector vulnerabilities are as follows:

- Temporal and spatial variability in flow affecting electricity production
- Increased sedimentation of rivers, reservoirs and distribution networks
- Reduced ability of catchments to retain water and runoff with extra soil erosion
- Deterioration of drinking water quality

The NAPA lists the country's major vulnerabilities as a result of climate change as follows:

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

All the vulnerabilities mentioned above 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, poor scientific knowledge and information, lack of technical capacity and, according to the SAPA, limited understanding of the impacts of climate change, as well as divergences between Bhutan's water, forestry, biodiversity and agricultural policies.

Recognition of adaptation opportunities in the 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 the Thorthormi Lake, GLOF hazard zoning in Chamkhar Chu Basin, and flood protection of industrial and agricultural areas in the Taklai River Basin. Five of the eight activities under the NAPA II projects are related to water, namely landslide management and flood prevention, enhancing national capacity for weather stations and seasonal forecasting in Bhutan, community-based food security and climate resilience, flood protection for downstream industrial areas, and rainwater harvesting and drought adaptation.

The Second Communication Report and the INDC Report also recognize the importance of water resources to climate change adaptation. The SAPA devotes considerable attention to adaptation opportunities in water resources, with the identified actions being watershed management planning, a comprehensive water resources inventory and assessment, promotion of rainwater harvesting to assist during water shortages, and the use of traditional knowledge and local perspectives in adapting to climate change.

Strengthening IWRM elements

The Second 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, local government and WUAs. It also calls for an 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 to provide decision makers with better technical information on climate change.

The need to take an integrated approach was further confirmed in the Water Act 2011. The Water Act requires the river basin to be used as a unit for the management of water resources in an integrated manner. In line with the Water Act, the National Environment Commission was mandated to prepare a National Integrated Water Resource Management Plan (NIWRMP) in the Eleventh Five Year Plan (2013-2018). The NIWRMP was prepared and published in 2016.

The INDC Report confirms the Second National Communication 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 for GLOFs and climate extremes. Mounting a public awareness and education campaign is important, and capacity building and institutional strengthening will be essential.

The NIWRMP provides a framework for coordination and management of water resources in achieving water security in the country. The framework is built on the Asian Water Development Outlook, and consists of five key dimensions: rural drinking water supply and sanitation; economic water security; urban water security; environmental water security; and disaster and climate change resilience.

The SAPA argues that improved irrigation efficiency will be needed to help adapt to climate change, along with improved water supply infrastructure, better community awareness about climate change impacts, rainwater harvesting to build adaptive capacity against droughts, and an expansion of hydrometeorological stations to build a better understanding of changes in water resources.

The NAPA 2006 Report proposes six priority projects to address immediate hazards. These are not intended to be considered as 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. However, they do not include any of the institutional and governance activities described in the Second Communication Report.

The Second National Communication Report and the SAPA both identify a baseline water resources assessment as a high priority, since one has never been undertaken in Bhutan. This would provide 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 development of a GLOF early warning system and strengthening of the climate observation network.

The latter recommendation is reinforced in the INDC Report. Strengthening the hydrometeorological network, and introducing flood and weather forecasting is a priority for adapting to climate change.

Addressing water risks

GLOFs from moraine-dammed 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 caused by high levels of rainfall intensity, the second risk from climate change, the NAPA proposes a number of remedial measures such as soil conservation activities, riverbank protection, 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 preventive measures and early warning systems. The NAPA proposes that watershed catchment management, integrated with land management, 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 system for flash floods.

Bhutan proposes adapting 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 proposes building impoundments to store water for use during lean seasons. Bhutan also needs to undertake a study into the reasons why springs and small streams are drying up. These are important sources of water for drinking and irrigation across the country and their decline is of serious concern.

Enhancing local community capacity for adaptation

The Bhutan Second National Communication Report to the UNFCCC, along with the SAPA, describe the importance of education and awareness of climate change among decision makers as well as the

public. While several community-level programs are proposed, none of the documents highlight the importance of empowering communities to respond to climate change impacts at a local level and providing support to these activities.

Regional approach

None of the reports refer to Bhutan undertaking regional consultations with its neighbors on adapting to climate change. All the actions described in the NAPA, Second Communication Report, and the INDC Report are internally focused, except for reference to the use of the regional climate model and the use of a regional flood warning system of the International Centre for Integrated Mountain Development (ICIMOD).

Mainstreaming adaptation in the water sector

The NAPA 2006 was developed to be consistent with Bhutan's development goals, including the PRSP, which has several crosscutting issues that are supported by projects in the NAPA.

The Second Communication 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 SAPA was developed to help mainstream adaptation actions into the water resources (and other renewable resources) activities.

The water security index, developed as a framework for a coordinated approach for management of water resources, focused on mainstreaming water management in the five-year development planning cycle, starting with the 12th Five Year Plan (2018-2023). The work on enhancing the indicators of the water security index is in progress.

Discussion

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 the management of groundwater, but this is not a major source of water in Bhutan. However, The Water Regulations of Bhutan 2012 highlights the importance and need for the study of groundwater as an alternate source of water. Public education, capacity building, resource assessment and hydrometeorological monitoring are all recognized as important activities to improve Bhutan's adaptive capacity.

Along the continuum of scale at which adaptation actions can be taken, Bhutan has focused much of its attention at the national scale. The climate change adaptation reports do not mention regional activities in the water sector, while basin-level activities are confined to GLOF hazard zoning and early warning systems in the Chamkar Chu and Pho Chu basins, respectively. While community-level activities are proposed, there is no mention of empowering communities to undertake adaptation actions themselves.

India

India's National Action Plan on Climate Change (NAPCC) 2008 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 2015 Report. The National Mission on Strategic Knowledge for Climate Change is also relevant to adaptation in the water sector.

India also submitted a Second National Communication to UNFCCC in 2012, followed by a Biennial Update Report 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 four goals:

- Development of a water database in the public domain, particularly in relation to assessment of the impact of climate change on water resources
- Promoting water conservation, augmentation and preservation, focusing attention on overexploited areas from a water use perspective
- Increasing water-use efficiency by 20% through regulatory mechanisms
- Promoting basin-level IWRM

India's adaptation actions are to be carried out at both national and state levels. Each state has put in place a State Action Plan on Climate Change. These subnational climate plans focus on adaptation (Box 4.4).

Box 4.4. State Action Plan on Climate Change for Andhra Pradesh 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 is not identified as a key sector, although water-related concerns arise in several water-dependent sectors such as irrigation and water supply, and manufacturing.

Adaptation actions in agriculture include improving water-use efficiency, 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 and alternative water sources) to protect industrial production from disasters, while existing urban and rural water supply and sanitation (WSS) facilities will be remodeled to reduce vulnerability to climate change. Watershed degradation will be reversed. The state also proposes to undertake agroclimatic vulnerability studies in major river basins. There is little attention to support household and community adaptation actions.

Source: EPTRI 2012.

According to Shah and Lele (2011), climate change will result in the following:

- *Kharif* (monsoon) season crops will be subject to heightened risk of floods and droughts.
- *Rabi* (winter) season and, in particular, summer crops will experience increased evapotranspiration and thus will need greater, more frequent irrigation.
- Surface water storage—large and small—will benefit from increased runoff, but will also suffer increased evaporation from the large open surfaces of reservoirs and open canal networks, as a result of a higher mean temperature.

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

1. Increased droughts
2. Increased floods
3. Groundwater quality decline

4. Changes in recharge
5. 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 NAPCC 2008 are intended to build the capacity for adaptation[11]—water is one of these four missions. While the Water Mission is currently being revised, recent reports, such as the INDC Report and Biennial Update Report, make it clear that the Water Mission remains central to India's adaptation response. The NAPCC points out that the national water policy stresses nonconventional methods for utilizing water such as interbasin 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 its five goals. The mission identifies intersectoral 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 multipurpose hydropower dams.

The mission identifies various 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. It also calls for the water policy to be revised and for climate change considerations to be incorporated when new projects are being considered. Improving regulatory and institutional measures for groundwater is seen as one of the most important measures. Some of these proposals, including a new water policy, have now been implemented.

The document calls for basin- and subbasin-level authorities to be established with stakeholder representation, so that river basin management can be introduced. It also calls for technical improvements to help meet the water-use efficiency targets, including evaporation management and wastewater reuse. Other actions include better flood management, greater emphasis on estuarine management, and better data collection.

To improve groundwater overexploitation, 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 states that the Indian Network on Climate Change Assessment, called for in the Water Mission, has now been established.

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

Addressing water risks

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

1. Responses to increased risk of drought include economic studies into the effects of drought, production of drought management plans (unspecified), and several technical improvements including groundwater recharge, pollution abatement, reuse of effluent on crops, improving irrigation efficiency, reducing evaporation, and modeling the effectiveness of conjunctive use.
2. Adaptive actions for increased flood risk include constructing embankments for flood protection and developing multipurpose dams, modeling flood risk areas, using floodwater for productive uses, conjunctive use of groundwater and floodwater, and preventing reservoir siltation. The INDC Report points out that there are also various state and national flood management programs.
3. The Water Mission has little to say on protecting groundwater quality, except for the need to model the effects of sea-level rise on salinity of coastal aquifers.
4. The Water Mission specifically recognizes 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 Second National Communication Report to the UNFCCC confirms that water from rainwater harvesting and recycled water are to be used for groundwater recharge.
5. Responses to increased seawater intrusion into coastal aquifers include models of saline intrusion, better monitoring of coastal aquifers, and modeling the implementation of seawater intrusion barriers.

Enhancing local community capacity for adaptation

While the National Water Policy 2012 states that local adaptation is needed to combat climate change, there is little detail evident in the reports examined. There are details 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 Second National 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 proposes engaging in cooperative regional flood forecasting and modeling—possibly under the auspices of the 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 effects of climate change need to be documented in the Ganges Basin, since they have not been foreseen, while it welcomes improved cooperation in the Indus Basin, taking account of increased water demand, reducing resources and ecological water needs.

India also recognizes the need for a regional approach to climate modeling, particularly for the Himalayan region where snowmelt 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, stating 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 adaptive capacity and adaptation was around USD 91.8 billion in 2013-2014. 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.[12]

Discussion

India's NAPCC 2008 is very closely aligned with its water resources instruments. In fact, the National Water Policy 2012 and the new Model Bill for the Conservation, Protection and Regulation of Groundwater 2011 were both called for in the NAPCC. 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.

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 goals of the Water Mission.

The climate change documents incorporate some actions along the continuum of scale.

1. They deal, in a limited way, with the increased pressure on transboundary water, both upstream and downstream of India, because of climate change. Thus, they propose transboundary flood management, but stop short of wider transboundary water sharing and management. Increased pressure on transboundary aquifers (because of climate change) is likely to require modification to existing treaties. The INDC Report states that transboundary and regional issues need to be factored in, but does not elaborate.
2. The documents contain considerable detail on actions that the national government will implement, including strengthening data collection and analysis, expanding infrastructure for flood management, better management of groundwater, and improved legislation.
3. The National Water Mission calls for legally empowered basin authorities to be established, in line with the National Water Policy.
4. States have established State Action Plans on Climate Change that are consistent with the National Plan and that focus on adaptation.
5. While the National Water Mission has community and state action as one of its five goals, it is relatively silent on how communities can be empowered to take action at the local level to build adaptive responses.

Nepal

Nepal approved a Climate Change Policy in 2011 and had completed its National Adaptation Program of Action (NAPA) the previous year. Nepal's Second National Communication Report was submitted to the UNFCCC in 2014, and the INDC Report was completed in 2016.

According to the vulnerability mapping (MoE 2010) carried out for the NAPA, the water-related climate change risks facing Nepal are as follows:

- Temperature and rainfall trends
- Landslides and floods in mountain and hill ecological zones

[12] Oxfam challenges the accuracy of this claim.

- Floods in the *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 combined effort by UNFCCC and NAP or a separate national effort.

Recognition of adaptation opportunities in the water sector

The Climate Change Policy 2011 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. The NAPA puts this succinctly, noting "Water and the hydrological cycle are both the root cause of climate change related problems as well as the mainspring of solutions" (MoE 2010, 25). 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 hydropower, solar power, prevalence of forest fires, siltation and landslips. The Second Communication Report to the UNFCCC contains many details of the modeled impacts on river flows, glaciers and GLOFs, and suggests several 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. The NAPA states that the National Water Plan 2005 remains the basis for adaptation action. However, the Water Resources Strategy 2002 and the National Water Plan 2005 are based on IWRM.

Strengthening IWRM elements

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

The Climate Change Policy 2011 proposes that the network of climate observation centers should be expanded and a real-time data acquisition system developed. A Climate Change Center will be established to formulate climate change-related programs and research. Village-level early warning systems will be developed for floods and landslides according to the Second National Communication Report to the UNFCCC, together with an early warning system for GLOFs. One of the more important research initiatives is the Optimum Sediment Exclusion project, which will facilitate developing 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, rainwater 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 Report and in the Second National Communication to UNFCCC.

The Second National Communication Report also describes sprinkler and drip irrigation, and rainwater harvesting as water-saving measures and a "reorientation of supply-driven approaches" (MoSTE 2014, 109), implying a shift toward demand management. The GLOF threat from Tsho Rolpa Glacial Lake has been reduced by lowering the lake's water level.

The Climate Change Policy emphasizes the participation of NGOs and user groups in the formulation and implementation of programs related to climate adaptation, as well as the need for public awareness and capacity building programs. 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 Second National Communication Report explains that various structural and nonstructural 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, 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 resulting from climate change.

Apart from various cropping and agronomic practices that are being introduced to help combat increased incidence of drought, the Second National Communication 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, and to educate and engage local people in adaptation activities and in 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 seven municipalities, and there are about 375 local adaptation plans and nearly 2,200 community adaptation plans of action (CAPAs) for community forests.

Localizing 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 local and national planning processes. This includes mainstreaming disaster prevention and mitigation efforts for floods, landslides and GLOFs. The Environment-friendly Local Governance Framework 2013 (Ministry of Federal Affairs and Local Development 2013) is specifically designed to help incorporate climate change adaptation and environmental activities into local planning processes.

Discussion

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. However, Nepal is drafting an integrated water resources policy and Water Resources Act that will embrace the IWRM and climate change adaptation

strategy. There are a large number of less urgent adaptation actions it intends to take into account in the water sector.

The NAPA and Climate Change Policy emphasize actions at some points along the continuum of scales at which adaptation should ideally occur. While the climate change documents make little mention of engaging in regional water management initiatives as part of water resources adaptation, they do provide a strong basis for national adaptation actions in the water sector, including adoption of a basin approach to water management, consistent with its National Water Plan 2005. 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.

Pakistan

Pakistan approved a National Climate Change Policy in 2012, followed by a Framework for Implementation of Climate Change Policy in 2013. It had submitted its First National Communication to UNFCCC in 2003, but has not provided further communications or updates. Although it provided an INDC Report 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 snowmelt and glacier melt as well as from rainfall. According to Ghazanfar Ali, "Once the glaciers are 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" (Shah and Lele 2011).

According to the Framework for Implementation of Climate Change Policy (2014-2030), 2013, the important water-related climate change threats to Pakistan are as follows:

- 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 (according to Nasir Gilani, the increasing intensity of flood events is Pakistan's major threat [Shah and Lele 2011]).
- Greater demand for water due to increased evapotranspiration rates at elevated temperatures.

Recognition of adaptation opportunities in the 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 mainly based on snow and glacier melt and monsoon rains, both being highly sensitive to climate change" (Government of Pakistan 2013, 10).

Strengthening IWRM elements

The Climate Change 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 at 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 2013, 11). The framework briefly comments that the draft national water policy needs to be approved and implemented (this policy has subsequently been approved by the Government of Pakistan).

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, mostly 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 water for irrigation and domestic use. Farmers should participate in making decisions about their irrigated areas. Groundwater needs protection through regulatory frameworks, licensing 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. Furthermore, 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 climate change 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 emphasis of the climate change policy 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 droughts.

Apart from a proposal to use floodwaters for irrigation in Balochistan, the policy has little to propose on flood responses other than studies to identify flood-prone areas, developing floodplain regulations and laws, and mapping flooded areas.

There is little mention of responding to GLOFs in the policy or the implementation framework, apart from establishing an early warning system and conducting research.

Although the policy makes no mention of adaptation responses to higher temperatures and increased evapotranspiration, many of the water efficiency measures together with some of the agricultural responses (for example, 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. However, there is a brief mention of this impact later in the policy.

Enhancing local community capacity for adaptation

Although Pakistan recognizes, in its First National Communication to UNFCCC, 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 various 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 neighboring countries (presumably referring to the Indus catchment), although it will also safeguard the country's rights on transboundary water inflows. It will also look at developing a water treaty with Afghanistan and entering into an agreement with neighboring 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 neighboring 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 states that it has been developed as a catalyst for mainstreaming climate change concerns into decision making and national planning.

Discussion

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 the 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 nontechnical 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 (the national water policy was approved in April 2018). The policy also recognizes the need for raising public awareness and improving hydrological monitoring. There is little evidence that the government recognizes the need to mainstream climate change into its regular water management activities.

The policy is strongly focused on adaptation activities that are led from the national level. However, 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 only. The implementation framework envisages that provincial governments will also be engaged in adaptation actions along with the private sector and civil society. At this stage, community actions are seen as being directed from the national level.

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 National Adaptation Plan (NAP) reports. These two documents constitute the definitive instruments for climate change adaptation in Sri Lanka. The National Climate Change Policy 2012 includes adaptation, but is also concerned with mitigation and other issues. An Information, Education and Communication 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 communication reports to the UNFCCC (2000 and 2011) and submitted its INDC Report in 2015. The Second National Communication to UNFCCC 2011 identifies the risks to water resources as follows:

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

Recognition of adaptation opportunities in the 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, 6). The policy and the NCCAS both recognize the potential impacts and needs for adaptation across the sectors dependent on water. The strategy recognizes that climate change will affect not only water availability and the risk of disasters but also the demand for water as a result of errant precipitation patterns and increased temperatures.

The NAPCCI provides an additional reason for focusing on water sector adaptation to climate change. It quotes the National Water Development Report (Imbulana et al. 2006) as noting that there is no policy, plan or program in the water sector, and consequently the NAPCCI provides an opportunity to state the adaptation needs in the 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 mention 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.

According to the NCCAS, more water storage is needed along with interbasin transfers. However, the National Water Use Master Plan has concluded that interbasin 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 rainwater harvesting systems (for example, ferro-cement tanks and rooftop 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 program 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 to strengthen early warning systems. Although the instruments advocate monitoring sea levels, there is no proposal to check the intrusion of saltwater into coastal aquifers resulting from sea-level rise.

The Information, Education and Communication Strategy recommends working through small groups and selected on-the-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 detailed 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 rainfall. 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 the flood-prone areas.

Increases in salinity resulting from 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 or 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 Program 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 Center.

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, local government and the extensive grassroots networks of the NGO sector, could be mobilized toward climate change adaptation. However, regulations and incentives are lacking. The NAP has a section on building the adaptive capacities of local communities through the 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

As 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 NAP states that sectoral and macro policies and other instruments will be assessed to identify options for mainstreaming adaptation. No other details are provided as to how the mainstreaming will be implemented.

Discussion

Sri Lanka has developed a specific adaptation strategy and, separately, an adaptation plan. It fully recognizes the centrality of water resources to adaptation activities and particularly recognizes 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 to improving water-use efficiencies in irrigation and urban areas, watershed management and promoting IWRM. Sri Lanka has developed a specific information, education and communication 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 spelled out, although details on how it is to occur are not provided.

Summary

Table 4.2 summarizes the assessment of preparedness of South Asian countries for water sector adaptation to climate change.

TABLE 4.2. Assessment of preparedness of South Asian countries for water sector adaptation in climate change reports (by country).

	Afghanistan	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
Policy or strategy	2	2	2	2	2	2	2
Recognition of adaptation opportunities in the water sector	2	2	2	2	2	2	2
Strengthening IWRM elements	2	2	2	2	2	2	1
Addressing water risks	2	2	2	2	2	1	2
Enhancing local community capacity for adaptation	1	2	1	1	2	1	1
Regional approach	0	2	0	2	1	1	-
Mainstreaming adaptation in the water sector	1	2	2	2	2	0	1

Note: 0 = not present in main climate change documents; 1 = mentioned or minor description, but not major inclusion in main documents; and 2 = significant feature in main documents. Draft documents are not included in the assessment, and more recent documents have been given more weight.

Chapter 5. Findings and Possible Topics for Phase II

Findings

There is generally 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 the 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, including for transboundary basins where there is little experience of successful applications. 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 the basin level, if it meets the economic, social and environmental aspirations of stakeholders.

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. Four countries—Afghanistan, 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 glacial lake outburst floods (GLOFs) in Bhutan and Nepal. Nepal specifically recognizes the importance of village-level early warning systems for floods (including GLOFs) and landslides.

Transboundary actions are largely restricted to technical cooperation. Bangladesh, Bhutan, India, Nepal and Pakistan all advocate regional data sharing and cooperation in their water instruments. Some countries, such as Bangladesh and Pakistan, also advocate assessing the development potential of transboundary rivers, while others propose cooperation in managing transboundary river basins. However, most of these transboundary information-sharing proposals are focused on rivers and do not include sharing information on transboundary aquifers.

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

Water Resources Governance

Probably the biggest gap in water instruments is the absence of agreed water policies and legislation in two countries: Nepal and Sri Lanka, with the recent approval of the national water policy in Pakistan. Consequently, these countries lack a coherent response to water problems, and are reliant on subsector instruments or the policies of water-related sectors such as environment, energy and agriculture. While Ahmed and Suphachalasai (2014) found that there was a shortage of climate change instruments in South Asia, this review has found that all countries have now developed strategies or policies for

responding to climate change. In fact, two countries—Afghanistan and Sri Lanka—have developed instruments to guide their adaptation activities generally. Two others—India and Bhutan—have even produced instruments specifically on adaptation in the water sector.

Four of the seven South Asian countries considered in this study—India, Nepal, Pakistan and Sri Lanka—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. Pakistan and Sri Lanka acknowledge climate change. On the other hand, Nepal, which is likely to be heavily impacted, does not address climate change in its Water Strategy 2002 or Water Plan 2005, beyond a commitment to study the phenomenon. However, the Integrated Water Resources Policy, currently being prepared, will incorporate climate change adaptation.

The four least developed countries (LDCs) in South Asia—Afghanistan, Bangladesh, Bhutan and Nepal—have produced national adaptation programs of action (NAPAs), and all except for Bhutan[13] 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 has been recognized by the United Nations Framework Convention on Climate Change (UNFCCC), and it has proposed that national adaptation plans (NAPs) be developed to help countries mainstream medium- and long-term adaptation actions into their regular management activities.

The Intergovernmental Panel on Climate Change (IPCC) also emphasizes 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 (CDKN and ODI 2014). Afghanistan, Sri Lanka and Bhutan have developed NAPs, while Nepal has indicated that it is developing these instruments. In the meantime, most countries recognize the importance of mainstreaming adaptation. India already includes mainstreamed activities in its accounting for adaptation (Ganguly and Panda 2010).

The key institutional feature of IWRM, coordination across water-dependent sectors, is recognized as being 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 weak intersectoral coordination in Sri Lanka to a National Water Resources Council in India, which is chaired by the country's prime minister. 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. Afghanistan is an exception: its National Climate Change Strategy and Action Plan (NCCSAP) and NAP call for the formation of a single water resources management institution.

Climate change policies also need to be coordinated across central and sectoral ministries (including finance, economics, environment, energy, transport, water and health) (ADB 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 (Suhardiman et al. 2019).

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

[13] On the other hand, Bhutan has a strategy for incorporating climate change adaptation into some of the sectors, including water, which is likely to be heavily affected by climate change.

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 (for example, hydropower plants 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 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 the demand for groundwater, climate change is expected to have an impact on supply of the resource 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 with surface water, and attempts to raise the profile of groundwater management (for example, India's Model Bill for the Conservation, Protection and Regulation of Groundwater 2011) have had little impact in practice. Given that the region has come to depend heavily on using groundwater for irrigation, greater analysis and sound policy on the resource are critical for South Asia's agricultural future.

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 Basin 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 among national institutions. Many countries recognize this in their climate change documents. For example, in its climate change policy, the Pakistan government offers to explore joint watershed management of transboundary basins with neighboring 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 caused by climate change. Some technical solutions such as lining canals are popular, but they often do not achieve any real water savings (Facon and Mukherji in Shah and Lele [2011]). Nontechnical 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 the irrigation service to farmers.

Conjunctive use and reuse of treated wastewater are also proposed to augment the supply of water for irrigation, 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. 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 Plains 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, which are already major issues in India and Pakistan, 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 for rainwater harvesting and artificial recharge using treated wastewater to remediate overdrawn aquifers. However, Foster (in Shah and Lele [2011]) warned against easy solutions such as artificial recharge and technical irrigation improvements that avoid the basic issue of controlling overabstraction. He believes that governments cannot avoid reducing overabstraction of groundwater, extremely difficult as this is, but need to develop different solutions in different places that combine an understanding of the hydrogeological setting and the socioeconomic situation.

Water Resources Communications, Education and Participation

Ahmed and Suphachalasai (2014) stated that a two-pronged approach is needed for adaptation: (a) mainstreaming from top-down policy and institutions, and (b) awareness raising and provisions for climate change at the basin level. This means that there needs to be institutional strengthening, genuine community participation, the 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 stated 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 change instruments. The irrigation sector has the greatest experience with devolving responsibility to local water user associations (WUAs), 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 irrigated 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 communication campaigns for local communities, and the participation of farmer organizations (FOs) and WUAs in committees. Sri Lanka has proposed a small grants program for local community adaptation activities, while Nepal has now implemented 90 Local Adaptation Plans of Action (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 among the general public as well as among 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. There is also a need to build a wider understanding among the public, as well as decision makers, that some climate change impacts are regional in scope and can best be tackled through regional cooperation.

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 (Suhardiman et al. 2019).

Possible Topics for Phase II

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

Water Resources Knowledge

1. A number of countries have proposed sharing water data across transboundary river basins and aquifers. A project could be developed to provide regional data collection guidelines and support information. These regional data collections should be publicly accessible, and this may need legislative and administrative agreement from participating countries. The project 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 South Asian Association for Regional Cooperation (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. It would be useful to explore methods for passing on the growing understanding of scientific climate change impacts in the water sector to decision makers. An analysis of potential bottlenecks in the uptake of scientific information and actions to reduce these bottlenecks would be timely.

Water Resources Governance

1. IWRM is widely adopted within water resources instruments across South Asia, but its implementation is lacking. Existing studies into the reasons for this lack of implementation could be reviewed, and experts could be interviewed to identify some specific entry points—water management topics, countries or catchments, institutions—where there is a likelihood that components of IWRM may be adopted. A project could be initiated to support these opportunities.
2. The characteristics of successful institutional coordinating mechanisms could be investigated so that models can be developed of effective coordination between agencies and institutions responsible for water management and climate change, both within each country and with neighboring countries.
3. While most water instruments examined here recognize the potential impacts of climate change, many water managers do not still understand these impacts. A project could be developed to improve their understanding and to reinforce the importance of IWRM (even if components of this approach are difficult to implement) as an adaptation response to climate change.
4. It is important to mainstream climate change adaptation across water-dependent sectors, so that adaptation becomes the normal business of each ministry. A project could be developed to educate officials in water-related ministries, coordinate agencies responsible for climate change, and design ways that adaptation activities could be properly defined and tagged within ministry budgets.
5. In federal systems (India and Pakistan), a significant proportion of the adaptation budget occurs through state or provincial agencies. These contributions could be examined to assess how well they are coordinated with both the national effort and local adaptation activities.

6. The impacts of climate change on groundwater need greater attention in both policy and practice. The best ways to control groundwater use in different hydrogeological and socioeconomic settings need to be better understood (following concepts by Foster in Shah and Lele [2011]).

Water Resources Infrastructure

1. Most infrastructure plans focus on major structures for storage. However, it may be more effective to revive small, local structures, including traditional storage mechanisms, or make more use of local groundwater storage (including sand dams). A pilot project to help restore these local storages could be undertaken to build understanding of alternatives to major storage infrastructure, taking account of the circumstances under which smaller structures are more vulnerable to climate change (World Bank 2014).
2. Major infrastructure will only provide adaptation to climate change if design standards and operating rules are developed to take account of climate change. Bangladesh, in its Second National Communication Report to the UNFCCC, states that it will establish design standards for flood embankments that take account of climate change. This could be used as a case study.

Water Resources Planning and Management

1. Some preliminary confidence building studies could be undertaken to pave the way for transboundary water planning (see Paper 3 [Suhardiman et al. 2019] on transboundary water recommendations).
2. Introducing basin-level planning and management is a major challenge. There may be lessons to be learned from examining pilot studies in Nepal and Pakistan, as well as international efforts to introduce climate change considerations into basin planning (for example, the Rufiji Basin, Tanzania), and drawing on the experience of the ADB about how to do this.
3. Water-related adaptation measures need to be designed to benefit the poor and the disadvantaged. It would be valuable to examine how they can be linked to poverty reduction strategy papers (PRSPs) and other mechanisms for poverty alleviation.
4. Saltwater contamination of coastal aquifers will affect Bangladesh, India, Pakistan and Sri Lanka. However, this impact receives relatively little attention in climate change strategies. Protective mechanisms need to be examined and understood for different geophysical circumstances.
5. While the development and sharing of transboundary river information receives attention in some water instruments, transboundary aquifer management is almost absent. It would be useful to undertake projects to develop information sharing for transboundary aquifers as an initial step in managing these resources, in the face of increased drought risk from climate change.

Water Resources Communications, Education and Participation

1. Building community-level action is essential to adaptation in the water sector. Bangladesh has considerable experience of community adaptation to climate extremes, while Nepal now has 200 NAPAs in progress. It would be timely to undertake an examination of the success of these community action initiatives. Such an examination would assess how they can be organized to provide nationally coherent responses while still retaining local control, how they should be financed and provided with skills that

may not be available locally, what guidelines are needed, and how they can be scaled up across a country.

2. Often, the general public has little appreciation of the potential impacts of climate change. Sri Lanka says that generic media campaigns are not effective, based on the deep public mistrust of donor-driven processes. Can a targeted approach be devised through selected on-the-ground implementation agencies and small groups to improve understanding in a pilot ecological zone?
3. Groundwater is likely to play an increasingly important role in climate change adaptation. However, there is often little understanding among groundwater users about the common-pool nature of the resource and its implications. A project to help educate groundwater users about working collaboratively to manage the resource would be very valuable.

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Appendix. Water Instruments in South Asia.

Afghanistan

TABLE A.1. Water instruments in Afghanistan.

Policy	Legislation	Strategy/plan	Other
A Strategic Policy Framework for the Water Sector 2005 Agriculture and Natural Resources Policy and Strategy 2005 Groundwater Development Policy	Water Law 2009 Environment Law 2007	Water Sector Strategy 2008	National Development Framework 2002

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 National Development Framework 2002, which identified water management as a priority area. The framework foreshadowed an integrated water resources management (IWRM) approach to water management, including the formation of river basin authorities. From this, A Strategic 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.[14] An Environment Law was passed in 2007.

The climate of Afghanistan ranges from arid and semi-arid, with an annual average rainfall of 240 millimeters (mm). However, there is considerable variation across the country; the high areas in the northeast receive about 1,200 mm, while the southwest receives an annual average rainfall of only 110 mm (MIWRE 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 Gl (Mahmoodi 2008) and water availability is assessed at 2,775 cubic meters (m^3) per capita (CPHD 2011). However, the country is projected to become drier under most climate change scenarios.

Afghanistan has experienced water shortages because of a series of droughts, poor water management and the negative effects created by years 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. The irrigated area has fallen from 3.3 Mha in 1980 to 1.8 Mha in 2008 (Mahmoodi 2008). Three-quarters of Afghans lack access to protected drinking water (CPHD 2011). Development of the water sector is accepted as a national priority, because over 80% of the population relies on agriculture (MIWRE 2004).

[14] A Groundwater Development Policy is mentioned by Mahmoodi (2008).

Water Resources Knowledge

The network of hydrological monitoring stations has been destroyed or degraded during years of conflict, although the system is now being rebuilt and the number of installed and rehabilitated monitoring stations has increased. The Water Sector Strategy 2008 states 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 all water extractions and discharges to be monitored. However, Mahmoodi (2008) states that special priority has been given to the rehabilitation of the hydrometric network. None of the instruments mention education and promotion of awareness of water resources among the general public, or target groups such as decision makers. They also do not 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 water, 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 among a number of ministries, with the Ministry of Energy and Water being responsible for the planning, development and management of water resources—defined as including both surface water and groundwater. However, groundwater investigations and monitoring are assigned to the 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 activities 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 monitoring their use. Subbasin councils are also to be formed with similar powers to the river basin councils, although they will not be authorized to 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. Moreover, it also supports the devolution of responsibility to river basin authorities.

Afghanistan and Iran signed a treaty governing the use of 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 water supply, irrigation, hydropower, flood control and groundwater recharge. Most are new or rehabilitated dams, but there are also flood diversion and groundwater recharge projects included in the strategy. 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 National Development Framework 2002 identified the need to reestablish a working urban water supply and sewage system. It also gave urgency to the repair and rehabilitation of the irrigation infrastructure and revival of the traditional *karez* systems, as traditional law has been used successfully to manage small-scale irrigation in the past.

Water Resources Planning and Management

The Water Sector Strategy 2008 calls for Water Sector Master Plans for each river basin that include, among others, 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 and 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 Environment Law 2007. This also prohibits the discharge of pollutants to water[15] without a license, 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 2009. For example, it states 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 Water Sector Strategy 2008 states that the riverbank protection program is providing emergency interventions in the short term. It also identifies high priority river reaches for medium-term investment to control riverbank erosion.

The Agriculture and Natural Resources Policy and Strategy 2005 notes 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 Water Law 2009. This policy also notes the damage caused to watersheds from 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 water sharing between upstream and downstream users. The policy also advocates enhancing groundwater through reforestation, and reducing the number of deep wells and storage ponds.

Water Resources Communications, Education and Participation

There are several provisions in the various instruments for participation by water users. The Water Law 2009 states that 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 (WUAs) and irrigation associations are authorized under the Water Law (although their purpose is left undefined), and the Ministry of Agriculture, Irrigation and Livestock is authorized to delegate responsibility for water distribution to irrigation associations. The 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. WUAs will be based on traditional *mirabs*,[16] but will be reorganized with agreed powers and expanded roles (DAI 2006; Thomas and Ahmad 2009).

[15] Water resources are not defined in this law and it is not clear whether they include groundwater.

[16] Traditional water management system using water masters with the power to determine water allocation.

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 (now the Supreme Council of Land and Water chaired by the president), has been formed to coordinate across the various ministries that have been assigned water-related responsibilities, given that many have unclear mandates and overlap in terms of ministerial responsibility. 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.

Despite these potentially positive features, Thomas (2013) found that the new water management arrangements did not operate as envisaged in two subbasins 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 referring to the river basin councils. These ad hoc commissions operated on familiar provincial boundaries rather than on river basin boundaries. Thomas (2013) concluded 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

TABLE A.2. Water instruments in Bangladesh.

Policy	Legislation	Strategy/plan	Other
National Water Policy 1999	Water Act 2013	National Water Management Plan 2001	Guidelines for Participatory Water Management 2001
National Agriculture Policy 1999	Environment Conservation Act 995	National Plan for Disaster Management 2010-2015, 2010	Water Rules (draft) 2015
National Agriculture Policy 2010 (draft)	Environment Conservation Amendment Act 2010		
Coastal Zone Policy 2005	Water Development Board Act 2000		
National Policy for Safe Water Supply and Sanitation 1998	Disaster Management Act 2012		
National Agricultural Extension Policy (draft) 2012	National River Protection Commission Act 2013		

The Government of Bangladesh enacted a National Water Policy in 1999 that marked the first incorporation of IWRM principles in water management in the country (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. This policy was supported by a National Plan for Disaster Management 2010-2015 in 2010 and a subsequent Disaster Management Act in 2012. This Plan and Act clearly recognize that water-related disasters in Bangladesh will be exacerbated by climate change.

A National Water Management Plan was produced in 2001, two years after the national water policy was enacted, 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. Therefore, the Water Resources Planning Organization (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-level rise and cyclonic storm surges. Some of the elements of the water policy were formalized in the Water Act 2013.

Water pollution is not dealt with under the Water Act 2013. However, it is envisaged that it will be controlled under the Environment Conservation Act 1995 and the Environment Conservation Amendment Act 2010, and also by the National River Protection Commission Act 2013. Drinking water and sanitation are dealt with under the National Policy for Safe Water Supply and Sanitation 1998. This policy is primarily concerned with extending the coverage of safe water supply and sanitation services, 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 and 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 riverbanks, pollution and harmful use of water bodies. 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 Management Plan 2001, 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. According to this Plan, research should be expanded into practical issues such as flood control. 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 to ensure that safe yields are established. The National Plan for Disaster Management requires a flood monitoring and floodplain mapping program, together with erosion prediction and monitoring activities. 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 of 1999 and the Water Act 2013, 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-stressed areas to be declared and to establish a priority order for access to water in such areas, with domestic use and drinking water given priority.

The National Water Resources Council is to be the apex water management institution, with the tasks of overseeing coordination among water sector agencies and developing a national water management plan. WARPO, under the Ministry of Water Resources, was created in 1999. In the Water Act 2013, 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 encouraged cooperation with other countries to manage transboundary waters. The policy paid specific attention to groundwater. Irrigation with groundwater was to be regulated. Surface water and groundwater quality would be protected.

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

Given the importance of transboundary rivers to Bangladesh, it is not surprising that the water policy pays particular attention to the 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.

Although the 1972 agreement with Bangladesh on sharing transboundary waters led to the institution of the Joint Rivers Commission, there is continuing tension between India and Bangladesh, particularly over the Farakka Barrage on the Ganges River. There are no water sharing treaties with China, although there is a memorandum of understanding (MoU) covering data sharing signed between China and Bangladesh.

Water Resources Infrastructure

The National Water Policy 1999 proposes that a Water Development Board be established 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 Management Plan contains a number of infrastructure proposals, including improved flood control, new irrigation schemes and coastal protection work that take account of climate change. It also proposes more development of surface waters based on comprehensive plans because of the overdevelopment of groundwater. The National Plan for Disaster Management recognizes that barrages will have to be built across rivers to provide additional water for drought periods, because groundwater resources are heavily used and are unsafe because of arsenic contamination. 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 a reduction in vulnerabilities to natural disasters, including the 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 taking into consideration 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 Management Plan: cost recovery, decentralized water management, community participation, clarity about rights and accountability and conjunctive use because of the overreliance on groundwater. Minimum streamflows 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 National Policy for Safe Water Supply and Sanitation 1998 also requires the prevention of pollution of surface water and groundwater sources. The Water Act 2013 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 water or groundwater (other than from accidental discharges). The Environment Conservation Amendment Act 2010 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 National Water Policy 1999 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 must be managed. It requires safe yields to be set for all aquifers in water-stressed areas. Groundwater receives attention in the draft Water Rules 2015. 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 that users recognize scarcity value, with funds to be retained locally according to the National Water Management Plan. Public water supply agencies can charge for services, and financial incentives will be introduced for water reuse and conservation. The National Policy for Safe Water Supply and Sanitation 1998 also advocates pricing water at its economic value to cover the cost of supply. The draft Water Rules 2015 propose that water pricing be set based on the 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 resource 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.

Water Resources Communications, Education and Participation

The National Water Management Plan 2001 states 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* (subdistrict), *pourashava* (town) and union levels, although these are largely composed of government officials. The National Policy for Safe Water Supply and Sanitation 1998 encourages user participation in planning, development and operations. More generally, the National Water Management Plan 2001 states that there is a need to improve water knowledge, and raise public awareness of sustainability. Bangladesh published Rules for Participation in 2000 to help local people influence decisions that affected them, although the effectiveness of these attempts at inclusion has been questioned (Dewan et al. 2014).

The National Water Management Plan 2001 calls for institutional capacity to be strengthened, while the National Policy for Safe Water Supply and Sanitation 1998 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 National Water Policy 1999, the Water Act 2013 or the draft Water Rules 2015, its impacts are well recognized in the National Water Management Plan 2001, the Coastal Zone Policy 2005, and the National Plan for Disaster Management 2010-2015, 2010, and its associated Disaster Management Act 2012.

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 budgeted 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 water. 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 measures (for example, more reliance on local adaptation through more water user representation).

Bhutan

TABLE A.3. Water instruments in Bhutan.

Policy	Legislation	Strategy/plan	Other
National Irrigation Policy 2010 (revised 2011) Bhutan Water Policy 2007	Water Act 2011 National Environment Protection Act 2007 Disaster Management Act 2013	National Integrated Water Resources Management Plan (draft) 2016| National Environment Strategy (The Middle Path) 1998 National Disaster Risk Management Framework 2006 Power System Master Plan 2003-2022 (2004)	Water Regulations of Bhutan 2012

Bhutan does not face pressing water problems at river basin scale yet, although there are local water shortages (NEC 2016). Other issues include flooding in specific locations and the threat of glacial lake outburst floods (GLOFs). 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 reduced river flows in winter, although these possibilities are uncertain given the lack of data and modeling (NEC 2016). The National Disaster Risk Management Framework 2006 states that landslides, GLOFs, flash floods and forest fires will all be exacerbated as a result of climate change.

Bhutan has recognized the importance of an integrated approach to water resources management for a number of years, making it a crosscutting objective of the environment sector in the Tenth Five Year Plan 2008-2013, and in the draft Eleventh Five Year Plan 2013-2018 (ADB 2014). The Government of Bhutan approved a Water Policy in 2007 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 focus on IWRM was specifically adopted to help respond to climate change impacts (NEC 2016). Water Regulations of Bhutan 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 multisectoral framework within which each water-related subsector 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 the 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 the responsibility for hydrological and meteorological data collection, while the Ministry of Health manages rural water supply and sanitation (WSS). The Water Act provides a table detailing these responsibilities.

The Water Regulations of Bhutan, 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 the NEC.

These instruments are all aware of the potential impacts of climate change on Bhutan. Hence, they are all designed to provide greater resilience against current climate variability and the long-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 at river basin scale at present. However, water-related problems are felt acutely at the 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* (group of villages) (NEC 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 intersectoral approach. The plan recognizes the importance of mainstreaming IWRM. It states that IWRM will be integrated into Bhutan's next Five Year Plan (Twelfth Plan 2018-2023) with possible key result areas (KRAs) in water security for urban and rural water supplies, 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 Twelfth Five Year Plan. There is even a possibility that the water security KRA can be integrated into the current Eleventh Five Year Plan.

The National Disaster Risk Management Framework 2006 describes eight types of disasters that Bhutan is prone to, including landslides from heavy rain, GLOFs (arising from climate change), flash floods and artificial dam bursts. It states that droughts have not been a major issue in Bhutan. The framework argues for an integrated water resources approach and the installation of early warning

systems, especially for GLOFs. The framework was backed by the Disaster Management Act 2013, which established the institutional framework at all levels of administration for anticipating, preventing and responding to disasters.

The Government of Bhutan also adopted a new National Irrigation Policy in 2010 (revised 2011). The policy marks a shift away from development toward improved irrigation management and sustainability, partly driven by changes in the water, land and environment sectors. The National Irrigation Policy 2010 includes principles consistent with IWRM. The policy includes a coarse-scale analysis of climate change impacts that shows that increasing 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, and this has primacy over other Acts if there is a conflict. The Act requires that water be provided for environmental flows, watersheds be protected and that water quality information be collected.

Water Resources Knowledge

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

The Eleventh Five Year Plan includes strengthening the hydrometeorological data to facilitate reliable weather, GLOFs and water-related forecasting as an objective of the energy sector. The plan anticipates an increase in the number of hydrometeorological stations from 94 to 166, an improvement in weather and river flow forecasts, and the introduction of three glacier mass balance monitoring stations.

The National Disaster Risk Management Framework 2006 argues for an early warning system, based on a community approach, for flash floods and GLOFs in the most vulnerable basins. It also promotes an improved hydrometeorological network.

The water policy identifies a number of research priorities: for example, hydrometeorology, assessment of water resources, watershed protection, groundwater hydrology and recharge, water harvesting, water balance studies, crop-water requirements and cropping systems, soil erosion and bioengineering, flood control and mitigation, erosion and sedimentation of reservoirs, safety of hydraulic structures, recycling and reuse of water, best practices, wastewater treatment and prevention of water pollution. The Water Act 2011 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 hydrometeorological network was weak, with monitoring recorded manually.

Water Resources Governance

The Water Policy and Water Act vest 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 Eleventh Five Year Plan includes a target of 100% water supply coverage for all settlements (up from 81% coverage when the plan commenced). It also proposes the construction of five new water supply reservoirs and the construction of flood protection infrastructure. There are three new hydropower projects under construction, and seven more will commence during the Eleventh Five Year Plan. The 2004 revision of the power sector master plan ranks 11 candidate hydropower projects against a number of criteria, including danger from GLOFs and sedimentation of reservoirs. As these will be run-of-river projects, the Master Plan accepts that their power production will be seasonal and does not regard water availability as a factor influencing the selection of preferred projects.

Water Resources Planning and Management

The NEC was required, under the Water Act, to develop an 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 groundwater quantity and quality. 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 principles 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 to be water management areas, where special controls can be applied to water abstractions, discharges, vegetation loss and development of structures. The water policy and the national environment strategy advocate maintenance of watersheds to reduce erosion and sediment loads, provide food and fodder, and help maintain local climate. They also see 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 to protect ecosystems downstream of dams.

The Water Policy establishes that sustainable water management should occur through the use of water-efficient technologies and good management practices. This is supported by the National Irrigation Policy 2010, which requires environmentally sustainable operations (including training of irrigation department staff in catchment protection, payment for water use, and environmental mitigation), improved technical efficiency and intersectoral planning.

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

Water Resources Communications, Education and Participation

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 Irrigation Policy 1992 (and also included in the National Irrigation Policy 2010), which encouraged farmer participation, and the formation of WUAs for publicly-owned irrigation schemes. Under the Water Act, WUAs and traditional communities are to be on river basin committees.

Summary

The potential impacts of climate change are well recognized across a number of Bhutan's water-related instruments. The National Disaster Risk Management Framework 2006 describes potentially catastrophic impacts of extreme events, such as increased risk of GLOFs and landslides, although the risks from more gradual shifts in climate parameters are less well recognized. However, the extent and timing of changes brought about by climate change are uncertain because of a lack of data and modelling across Bhutan.

Bhutan's Water Policy 2007 and Water Act 2011 include many elements of IWRM such as state custodianship of water, community participation, planning and management at the river basin level, and coordination across ministries through the NEC. IWRM concepts are also incorporated in other water-related instruments such as the National Irrigation Policy 2010. The National Integrated Water Resources Management Plan 2016, required under the Water Act 2011, has been drafted. While it incorporates IWRM concepts, it is intended as a framework document and the implementation of these concepts is reliant on the individual basin plans being developed and the basin authorities being instituted and funded.

Climate change is to be incorporated as a key area in Bhutan's next Five Year Plan and the intention to also include IWRM in the plan will strengthen the country's ability to respond to climate change impacts in the water sector. However, there remain significant implementation issues including provision of data and knowledge, institutional coordination, devolution to basin level and empowerment of local communities.

India

TABLE A.4. Water instruments in India.

Policy	Legislation	Strategy/plan	Other
National Water Policy 2012	Water (Prevention and Control of Pollution) Cess Amendment Act 2003	Ministry of Water Resources Strategic Plan 2011	
National Urban Sanitation Policy 2008	Water (Prevention and Control of Pollution) Act 1974		
National Agriculture Policy 2000	Environment (Protection) Act 1986		
	National Water Framework Bill (draft) 2013		
	Model Bill for the Conservation, Protection and Regulation of Groundwater (draft) 2011		
	Interstate Rivers Dispute Act 1956		
	River Boards Act 1956		

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 the responsibility for transboundary water matters with neighboring countries. We will examine only national water resources instruments in this assessment.

It was apparent that, by the 1980s, there needed to be a national approach to water, leading to the first National Water Policy in 1987, which was modified in 2002. The current water policy was approved in 2012, although with objections from a number of states. A draft National 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 Model Groundwater Bill 2005. However, this bill has yet to be passed and, in the past, there has not been much uptake of these model bills by state governments. Groundwater is still governed by colonial-era legislation, in which the resource is seen as a private property right. The new bill has been carefully drafted to both reflect the current legal situation (the Supreme Court tends to view groundwater as a common-pool resource) and 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 (Prevention and Control 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 role of the CPCB is to promote cleanliness of streams[17] and wells through technical assistance to state boards, training, analysis of pollution data, establishing water quality standards in consultation with state boards, and undertaking a national pollution control program. The Water (Prevention and Control of Pollution) Cess Amendment Act 1997 (updated in 2003) provides the 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 Water (Prevention and Control of Pollution) Act 1974 and the Environment (Protection) Act 1986, 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. The court has been asked to rule on a water sharing dispute between Karnataka and Tamil Nadu over the water of the Kaveri River.

India has a number of transboundary treaties in place with neighboring countries. These include the 1960 Indus Treaty with Pakistan, which has allowed the Indus waters to be shared peacefully for 50 years, along with a number of other agreements. 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. The 1972 agreement with Bangladesh on sharing transboundary waters led to the institution of the Joint Rivers Commission on the Ganges River. However, both countries remain dissatisfied with the limitations of the 1996 Ganges River Treaty and 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 an MoU covering data sharing signed between the countries.

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

Water Resources Knowledge

The water policy advocates improved information, including flood forecasting, flood mapping, community action plans and disaster preparedness. Climate and hydrological data should also 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 placed in the public domain. Because of climate change, more data are needed on snow and glacial dynamics, evaporation losses, tidal hydrology and hydraulics, river geometry, and also on erosion and sedimentation. Both the national water policy and the National Water Framework Bill (draft) 2013 propose that flood forecasting systems be developed. More research and development (R&D) and training are needed, and a water policy research center should be established.

The National Hydrology Project, phases I and II, have helped the central government and several state governments in southern India to 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 of India and will support a river basin approach for IWRM. 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. 2013). It proposes a rational approach to water sharing based on water budgeting and auditing; state governments appoint water regulators, introduce systems for water tariff and establish criteria for water charges; subsidies on rural electricity for groundwater abstraction 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 be abolished for agricultural and domestic water use. However, subsidies would be available to industry for recycling and reuse. The draft National Water Framework Bill 2013 repeats many of the principles of the policy, including state ownership of water, river basin management, and that water resources should be planned and managed in a coordinated way across national, state and local levels. It also calls for 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 landownership). The Model Bill for the Conservation, Protection and Regulation of Groundwater 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, and has major equity implications. The bill proposes that permits be required for medium to major irrigation and industrial uses that draw on groundwater (Cullet 2012).

The national water policy also requires a national perspective on water planning, management and development, and equity over water allocation. Water is seen as an economic good, and ecosystems have a right to water (the Model Bill for the Conservation, Protection and Regulation of Groundwater 2011 extends this to include groundwater). The policy requires 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, 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 multidisciplinary approach to water management. The National Agriculture Policy 2000 also states that 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 evapotranspiration control. All infrastructure planning should include the effects of climate change.

Water Resources Planning and Management

The water policy supports water planning on a basin and subbasin 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 draft National Water Framework Bill 2013 also proposes that basin committees should be established at central and state levels to prepare water resources plans up to 2050, support basin management, and undertake investigations into issues such as pricing and climate change. In particular, the policy states 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 draft National Water Framework Bill require planning for infrastructure such as dams and embankments, and 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 irrigated 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.

According to the national water policy, water and land conservation should be practiced to protect river corridors, wetlands and floodplains. Encroachments into water bodies and drainage channels should be prevented, and developments upstream of key sensitive areas, including groundwater recharge zones, should be strictly regulated. The National Agriculture Policy 2000 also advocates watershed development programs to protect water quality. The Model Bill for the Conservation, Protection and Regulation of Groundwater 2011 requires a groundwater security plan for all declared protection zones and other aquifers selected by the government. The plan should allow for managed aquifer recharge (MAR), conjunctive use, social equity, efficient water use and incentives for conservation.

According to the national water policy, small-scale water harvesting should be encouraged, although developers need to be aware of possible downstream effects.

The water policy states that pollution should be prevented, and punitive action should be 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 Bill 2013 states that pollution should be managed through provisions of the Environment (Protection) Act 1986 and the Water (Prevention and Control of Pollution) Act 1974, including waste reduction and setting water quality standards. However, the Model Bill for the Conservation, Protection and Regulation of Groundwater 2011 includes provisions for protection of groundwater from pollution and depletion.

The National Water Framework Bill (draft) 2013 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 nonstructural 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 National Water Framework Bill (draft) 2013 has a special section on groundwater that 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 states 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, industries in water-short areas should consider water reuse, overuse and contamination from industries should be prevented, and there should be subsidies and incentives for industrial water recycling.

Water Resources, Communications, Education and Participation

The water policy strongly supports community involvement in water management for several reasons. First, it sees that climate change adaptation can be carried out at the community level, although communities will need capacity building. Irrigation WUAs should be given statutory powers to manage and allocate water within their areas, allowed to establish water rates, and collect and retain a portion of water charges. The policy also encourages water users to be involved in water quality monitoring of issues such as salinization as part of prevention and remediation. Second, local organizations (WUAs, local government and others) should be included in project planning and there should be community involvement in all projects. The Model Bill for the Conservation, Protection and Regulation of Groundwater 2011 also advocates user representation in 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.

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

Summary

Adaptation to climate change is clearly embedded in many of India's water instruments. Notable, the National Water Policy 2012 identifies climate change as one of the three main drivers of change in the country's water sector. The policy marks a major change from the past. It embraces the principles of IWRM which, if put into practice, would strengthen India's ability to respond to the impacts of climate change. However, there are structural impediments to implementing the policy. The policy is reliant on provisions of the National Water Framework Bill (draft) 2013 being adopted and implemented by states, and this has proven to be difficult in the past.

Nepal

TABLE A.5. Water instruments in Nepal.

Policy	Legislation	Strategy/plan	Other
Irrigation Policy 2003	Water Resources Act 1992	Water Resources Strategy 2002	
National Water Supply and Sanitation Sector Policy 2014 (draft)	Irrigation Act 2016 (in parliament)	National Water Plan 2005	
National Rural Water Supply and Sanitation Policy 2004	Irrigation Rules 1999	Scaling-Up Renewable Energy Program Investment Plan for Nepal 2011	
National Urban Water Supply and Sanitation Sector Policy 2009	Electricity Act 1992	National Strategy for Disaster Risk Management 2009	
Water Induced Disaster Management Policy 2006	Electricity Rules 1993		
Water Induced Disaster Management Policy 2015	Drinking Water Rules 1998		
Hydropower Development Policy 2001	Environmental Protection Act 1996		

The Water Resources Act 1992 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 National Water Plan 2005 provides details of specific projects and investments for implementing the strategy. The water plan recognized that existing institutions need to be reorganized and new institutions created at the river basin level if the strategy was to be successfully implemented, as well as to respond to broader societal changes such as wider community participation and greater private sector involvement. Importantly, the Water and Energy Commission Secretariat (WECS) will be strengthened and restructured so that it will have the capacity to effectively coordinate water-dependent subsectors.

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 WSS (2014 draft); the latter was drafted in 2014 to replace separate rural and urban WSS policies approved in 2004 and 2009, respectively. Only the latter policy recognizes the impact of climate change, particularly on water availability, especially for small water

supply schemes dependent on sources with variable and limited flows. The recent Water Induced Disaster Management Policy 2015 mentions 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) highlighted that hydropower production is exposed to a range of natural hazards, including floods, landslides and debris flows, extreme weather events, GLOFs 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, among others, 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 cloudbursts, GLOFs, 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 Himalayan snow and glacial melt, to strengthen the water resources observation network, to undertake programs into integrated river basin management, and to develop suitable climate models. It also proposes redefining design criteria for water structures, identifying vulnerable areas, conserving water resources through reduction, reuse and recycling, and addressing impacts on landslides, debris flows, floods and droughts. Programs also 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 impacts on water resources.

The Water Induced Disaster Management Policy 2006 considers actions to mitigate and respond to landslides, GLOFs, erosion, sediment deposition and flooding. It advocates IWRM approaches to watershed management, including watershed protection, protection of riparian areas, conservation of wetlands and involvement of local user groups.

Nepal has signed the Kosi River Treaty as well as the Mahakali Agreement with India. The latter has led to technical cooperation between the two countries.

Water Resources Knowledge

One of the ten outputs of the water resources strategy and plan 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 Water Resources Strategy 2002 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, as such, developing river basin flow models will require training and investment in software and hardware, as well as helping managers to understand how to use models in decision making. Disaster management will also require capacity for flood forecasting.

Water Resources Governance

Under the Water Resources Act 1992 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 hydroelectric generation must be developed and managed in accordance with this Act. The Act authorizes the government to formulate regulations governing water quality and pollution discharge standards. It makes no specific mention of climate change and, while usefully clarifying that water is owned by the state and not by landowners or water users, provides few tools for adaptation.

The water resources strategy recognized that Nepal needed a comprehensive water resources policy if it were to overcome the fragmented and antiquated policy and legal framework. Apart from the proposal for a Himalayan Climate Change Study Center, 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 integrated water resources policy, an amended Water Resources Act, and a requirement to 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 National Water Plan 2005 states that the lead organization for aquatic ecosystems and pollution control, as well as government institutions, need training in the relevant areas. Moreover, it mentions the need for a coordinating body. The plan also states that groundwater is not properly conserved and lacks legal protection, and that it will be included in a new Water Resources Act that will resolve contradictions between other Acts.

The plan states 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 that groundwater needs better protection from pollution and overexploitation. This policy also advocates that irrigation fees be introduced.

In the absence of a water policy, the Irrigation Policy 2003 states 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 Hydropower Development Policy 2001 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" (MoWR, Nepal 2001, 5). The recently drafted National Water Supply and Sanitation Sector Policy 2014 also notes that it is difficult to protect water supply sources from degradation because of legislative weaknesses.

Water Resources Infrastructure

The National Water Plan 2005 includes irrigation expansion as a major priority. Where feasible, irrigation development will be integrated with multipurpose water storage projects and interbasin transfers. The storage projects are recognized as being important to reducing 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: for example, 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 Three 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 Scaling-up Renewable Energy Program Investment Plan for Nepal 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. This states that the correct enabling environment needs to be in place: policies and legislation, institutions and management instruments.

The Water Resources Strategy 2002 and National Water Plan 2005 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 toward more sustainable hydropower development. Some of the changes proposed in the strategy are already under way; for example, the government is moving toward 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 Sector Policy (2014) (as well as the earlier WSS policies) advocate the protection of groundwater from pollution by 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. Environmental impact assessment (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 Management Policy 2006 also focuses 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 National Water Plan also advocates various 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 (for example, drip and sprinkler systems) in new irrigated areas. It also proposes a program for groundwater recharge.

The Water Induced Disaster Management Policy 2006 and the National Water Plan 2005 both call for disaster hazard mapping and zoning to restrict development in hazardous areas.

The Irrigation policy also advocates that irrigation fees be introduced. Some of the changes proposed in the strategy are already under way; for example, the government is moving toward full cost recovery for groundwater irrigation. The irrigation policy states, “This demands promoting the conjunctive use of groundwater and surface water irrigation systems” (DoI 2003, 1). The Irrigation Policy 2003 does not include a lot of detail and hardly mentions technical efficiency.

Water Resources Communications, Education and Participation

River basin management is central to IWRM, and this will require an education program to raise awareness with legislators, the public and the management groups. It will also require data to be collected on a 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, as well as conducting 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 into ecological water requirements, glacial lakes, dam structures and climate change is needed.

Community engagement is already included in existing subsector 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 WSS coverage, while increasing community participation and ownership of water supply schemes. The draft National Water Supply and Sanitation Sector Policy 2014 is designed to further improve consumer involvement and tackle a range of new issues facing the subsector, primarily to do with service levels, coverage for poor and marginalized groups, and sustainability. The national water plan states that community participation is also needed in watershed management, but 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 Water Resources Strategy 2002 and the National Water Plan 2005. Overall, Nepal remains committed to an IWRM approach to water resources management, although at the watershed level rather than at the national level.

The national water plan states that there are few formal instruments for implementing policy. Guidelines exist for project planning and environmental assessment, as well as for project evaluation, but these are dated and not fully comprehensive. WUAs set up during project development are not always sustainable in the long term. Hydrometeorological monitoring is not comprehensive and is reliant on manual recording methods. There is no open access policy for monitoring data.

Pakistan

TABLE A.6. Water instruments in Pakistan.

Policy	Legislation	Strategy/plan	Other
National Water Policy (draft) 2006 National Sanitation Policy 2006 National Drinking Water Policy 2009 National Environmental Policy 2005 National Wetlands Policy 2009 (draft) National Water Policy 2009 National Water Policy 2018	Water and Power Development Authority Act 1958 Environmental Protection Act 1997	Water Sector Strategy 2002	Pakistan 2025 One Nation-One Vision 2014

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. The Water and Power Development Authority (WAPDA) was formed under the Water and Power Development Authority Act 1958 to develop irrigation, water supply, drainage and flood control schemes. It was also given powers to manage this infrastructure, including power to control erosion, train rivers and streams, and manage watersheds. Since 2001, district governments have been responsible for WSS, while irrigation remains a provincial responsibility (Abro 2009). However, provincial governments have shown little enthusiasm for the development of new irrigated 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 (ACS, EGC and SMEC 2011; Briscoe and Qamar 2005; FODP 2012; MoWP 2002a, 2002b, 2002c). Average water availability is low, at about 1,000 m^3 per capita (2010), putting Pakistan into the United Nations (UN) water-stressed category. Per capita availability is predicted to drop to 800 m^3 by 2025 (Planning Commission, Pakistan 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 Mha (Mukherji et al. 2009). However, water-use efficiencies in the Indus Valley are very low. For example, only 0.13 kilograms (kg) of cereals are produced per cubic meter of water in the Indus Valley compared with 0.39 kg per cubic meter of 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 waterlogging and salinity problems, further add 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 saltwater into the lower Indus (Iftikhar 2002).

Apart from the Indus Basin, Pakistan has two smaller river basins as well as several smaller rivers that arise in Afghanistan. The Makran Basin in Balochistan 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 (MoWP 2002b). The total inflow of the two basins is less than four mean annual flows (MAFs). 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, Pakistan 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 overabstraction, secondary salinization and chemical pollution of aquifers (ACS, EGC and SMEC 2011). Overabstraction is occurring in both the shallow aquifers of the Indus Valley and the deeper hard rock aquifers, such as the barani areas of Balochistan. Groundwater abstraction was about 70 billion cubic meters (Bm^3) in 2011 from 1 million tube wells (ACS, EGC and SMEC 2011).

Pakistan 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 Region, causing siltation of dams and barrages. In some areas, farmers have erected riverbank flood levees, causing further problems as sediment is deposited onto the riverbed, raising the levels of riverbeds and further increasing flood risk (ACS, EGC and SMEC 2011).

Water Resources Knowledge

Pakistan's Water Sector Strategy 2002 recognizes that monitoring and evaluation are important if management is to be effective, but delegates this aspect of IWRM to subsectoral strategies, which are yet to be developed. The draft National Water Policy 2006 takes a broader view. It proposes that a national planning database will be established to consolidate water information from diverse agencies and 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 is treated, effluent discharge is monitored to meet "international standards", and that a national water quality monitoring program is established to set water quality standards and to develop a monitoring program. The policy also proposes that groundwater is monitored to determine its potential and to prepare groundwater budgets for sustainable development. The draft National Water Policy 2006 acknowledges that flood forecasting has been strengthened through additional weather radar and telemetric systems, but 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 National Water Policy (2016) requires monitoring of drinking water quality and prohibits it from dropping below specified standards. Each water delivery agency must develop a water quality monitoring plan. Similarly, industrial discharges will be monitored and water quality standards will be enforced. The National Drinking Water Policy (2009) also proposes that a water quality monitoring program be established to protect water users. Under the current draft National Water Policy 2016, 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 draft National Water Policy 2006 states that a 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 wetland processes and establishing the values provided by wetlands in Pakistan. The draft National Water Policy 2006 advocates that more work needs to be done on flood forecasting and early warning systems as well as floodplain mapping of some major river reaches. The current draft National Water Policy (2016) does not nominate specific research topics but proposes that a national water research agenda be developed, with 1% of project costs being allocated for this research.

Water Resources Governance

Pakistan does not have a national water policy[18] or Water Act. The Pakistan Vision 2025 (Planning Commission, Pakistan 2014, 62) 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 was passed for specific aspects of water management (ACS, EGC and SMEC 2011). The main national water-related Acts are the Water and Power Development Authority Act (1958) and 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 a subsectoral water policy; it also has a National Sanitation Policy (2006), a National Drinking Water Policy (2009) and a draft National Wetlands Policy (2009), but no irrigation or agriculture policy.

Both the 2006 and the current (2016) draft water policies recognize 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 that adaptive measures are put in place in anticipation of the following: the effects of temperature rises on agriculture, changes in precipitation patterns and the consequent effects on glacier melt, and increased siltation of reservoirs. The National Wetlands Policy 2009 also recognizes the possible impact of climate change on wetlands because of changes in river flows (with a focus only on changes in glacial melt as the cause) and the need for adaptive action. It also acknowledges that wetlands, if they can be protected, act as buffers against natural disasters. The National Sanitation Policy 2006 does not mention climate change, while the National Drinking Water Policy 2009 sees climate change as affecting planning and development of drinking water supplies, but provides no details.

The Water Sector Strategy 2002 and both drafts of the national water policy (2006 and the current draft policy 2016), while following the principles of IWRM, 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 who 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 retrieve their construction responsibilities from WAPDA. The earlier policy also proposed that the numerous legislations dealing with water be consolidated into a small number of comprehensive Acts, and that this revised legislation empowers institutions to carry out their mandates effectively. The current draft policy spells out the establishment of a new National Water Commission.

The National Water Policy 2006 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.

[18] Balochistan has an IWRM policy (ACS, EGC and SMEC 2011), while a new national water policy is currently being drafted.

Although the Water Sector Strategy 2002 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 (ACS, EGC and SMEC 2011). The Punjab Soil Reclamation Act 1952 (amended in 1964) has been promulgated to all provinces and acts as the legislative basis for groundwater management. However, 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 2009 also recognizes that groundwater is largely unregulated, and proposes that legislation be introduced to regulate groundwater use and quality.

The draft Water Policy 2006 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. Moreover, it states that Pakistan will be working with and through international agencies to prevent chemical and biological pollution of shared waters. The new water policy that is currently being drafted proposes mechanisms for improving management of transboundary aquifers and watersheds, including sharing real-time water information and undertaking a study to assess the impact of developments in the upper catchments of western rivers.

A recent document (Planning Commission, Pakistan 2014) states that the goal is to establish a National Water Commission with powers to manage all water subsectors (surface water, groundwater and rainfall), and their sectoral and regional allocations. The Commission intends to formulate an IWRM strategy and recommends that a comprehensive national water policy be adopted soon. Among 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 as well as management activities across all relevant sectors at national and provincial levels.

Water Resources Infrastructure

Irrigation, flood control, hydropower and WSS subsectors have plans to develop water resources infrastructure. While additional storage and flood protection development is an integral part of adapting to the effects of climate change, none of the relevant policies mention this as a rationale for the development. Vision 2025 (Planning Commission, Pakistan 2014) states that the goal is to build new water storages for irrigation, industry and domestic use so that retention times will increase from 30 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, Pakistan 2005) also recognizes that structural as well as nonstructural measures are needed for flood control.

Earlier, the water sector strategy (MoWP 2002b) also highlighted the need for rehabilitation and development of existing infrastructure across the main water-using subsectors. It called for an urban water supply strategy, including infrastructure improvement and expansion, and the modernization of old barrages, rehabilitation of irrigation infrastructure and the safe conveyance of saline water to the sea in the irrigation subsector. It also called for new infrastructure to harness hill torrents and floodwaters in Balochistan, new large hydropower storages at Kalabagh and Basha, and raising the Mangla Dam, along with new run-of-river schemes.

The Water Sector Strategy 2002 also contains a medium-term investment plan for consideration by the World Bank, the Asian Development Bank (ADB) and others. There is a total amount of USD 12 billion in infrastructure, excluding hydropower projects. Projects include multipurpose storages, drainage projects, WSS and flood protection.

The draft Water Policy 2006 states that expansion of irrigation will come partly from improved irrigation efficiencies and partly from additional irrigated 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 5,800 km), breaches are common and cause heavy loss of life and property. Further flood protection will be needed, but design standards will have to be reviewed. Any further development should follow an integrated approach for the entire reach. It also recognized that additional carry-over 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 draft Water Policy 2016 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 states that new water projects should take the effects of climate change into account.

The National Drinking Water Policy 2009 envisages significant expansion of water supply coverage. It does not explicitly mention requirements for new water storages; however, it does propose that existing infrastructure be rehabilitated. It also requires that the effects of climate change are included in any planning and development.

Water Resources Planning and Management

The draft National Water Policy 2006 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. Various issue-based national plans are also proposed in the draft National Water Policy 2006 and the Medium-Term Development Framework 2005-2010 (Planning Commission, Pakistan 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, as this may lead to an increasing prevalence of droughts.

The major water management issue in Pakistan revolves around the sustainable use of the irrigation system and its surface water and groundwater sources. The Water Sector Strategy 2002 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 facilitate conservation of 5.8 Gl per year. Nonstructural measures are also important in water conservation. The draft Water Policy 2016 advocates adequate water pricing for proper operation and maintenance of the irrigation system, and for improving its long-term sustainability. The Water Vision 2025 endorses this, stating that proper water pricing and crop-based price variations should be used as tools for promoting water conservation. Programs are under way to improve irrigation efficiency (ACS, EGC and SMEC 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 will provide a subsidy of PKR 90,000 per hectare (USD 1,070 per hectare) 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, and catchment protection. It includes aquifer recharge in areas prone to drought. The draft Water Policy 2006 also proposed that groundwater use should be controlled in both the Indus Valley and in hard rock aquifers to avoid overdraft, and that groundwater tables under irrigation districts should be lowered to prevent salinity and waterlogging. 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 users' ability to pay)

in all subsectors, not just irrigation, in order to provide realistic information to users on the cost of water provision. The current draft water policy also advocates an increase in water prices for irrigation to meet the operating and maintenance 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 (ACS, EGC and SMEC 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 irrigated 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 are therefore 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 draft Water Policy 2006 proposed full financial sustainability through reduction of nonrevenue 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 National Drinking Water Policy 2009 specifically states that the impacts of climate change should be considered in planning and development. The policy also calls for the introduction of ambient water quality standards for drinking water, rainwater harvesting to be expanded for household use, and groundwater to be recharged. It also calls for recycling and reuse, encouragement of water metering, and the use of water-efficient technology. The policy does not mention water 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 (Planning Commission, Pakistan 2005).

The draft National Water Policy 2006 advocates the policy of polluter pays, treatment of wastewater prior to discharge, and enforcement of water quality standards for surface water and groundwater. These would be 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 discharging them 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 by rules introduced under the Environmental Protection Act (1997).

Flood control will require a review of the design and maintenance standards for flood protection structures (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 (Planning Commission, Pakistan 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.

Water Resources Communications, Education and Participation

The draft Water Policy 2006 called for stakeholder participation at all levels of water planning and management, and in all aspects of irrigation, drainage, domestic water supply, flood protection, drought, wastewater discharge and pollution control. It also recognizes 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 implemented or funded. The recent draft Water Policy 2016 calls for active stakeholder involvement in all aspects of water management. The

National Drinking Water Policy 2009 also advocated community participation for planning, managing and monitoring local drinking water schemes as part of the expansion of water supply. However, ACS, EGC and SMEC (2011) warned that participation, by itself, is not enough. Because farmer organizations (FOs) 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 Water Sector Strategy 2002 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 draft Water Policy 2006 recognizes that an education program will be needed to build public awareness of water management issues, including awareness of the importance of environmental needs and conservation. There is, specifically, a need to build awareness among farmers about the advantages of reforming irrigation water management. The National Wetlands Policy 2009 argues for a broad communications strategy to develop public awareness of wetlands, and to sensitize environmental magistrates toward wetland issues and regulations, as well as designing an education campaign targeted at wetland stakeholders and users. The National Drinking Water Policy 2009 also wants to build public awareness about water conservation to help maintain domestic water supplies. The Vision 2025 document (Planning Commission, Pakistan 2014) states that there is a 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 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 among the agencies charged with managing wetlands. It proposes that human capacity be developed among local communities and users of wetlands, and calls for training to be provided 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 various attempts to develop such a policy. Provincial water legislation is old. Earlier water sector strategies and policies, although not endorsed by the government, were comprehensive in calling for significant improvements in water management through both structural and nonstructural means, consistent with IWRM approaches. Without an overarching 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 by the government.

Subsectoral 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 subsector. 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 have been recognized in policies and reports since around 2006.

Sri Lanka

TABLE A.7. Water instruments in Sri Lanka.

Policy	Legislation	Strategy/plan	Other
National Drinking Water Policy	Water Resources Board Act 1999	National Water Use Master Plan 2013	
National Rural Water Supply and Sanitation Policy 2001	Irrigation Amendment Act 1994		
National Policy on Disaster Management 2010	Disaster Management Act 2005		
National Environmental Policy and Strategies 2003	Agrarian Development Act 2000		
National Wetland Policy and Strategy 2006	Mahaweli Authority Act 1979		
National Policy on Protection and Conservation of Water Sources, Catchments and Reservations in Sri Lanka 2014 (draft)	National Environmental Amendment Act 1988		
	Irrigation Amendment Act 1994		

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 southwestern corner receives an annual average rainfall of 2,500 mm, falling principally during two monsoonal periods, i.e., 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 the failure of northeast monsoons. There is a surplus of water in the wet zone, with two monsoon seasons, and a deficit of water in the dry and intermediate zones.

Groundwater potential is estimated at 7,800 million cubic meters (Mm^3) per year (Imbulana et al. 2006). Most groundwater use is for domestic purposes, for irrigation in the sand aquifers of the northwest, and for industry in the wet zone. Access to groundwater is limited in the dry zone and, where it occurs, abstraction of shallow groundwater is largely uncontrolled and, as such, 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 increased to 3.9 million tons in 2011, about 75% of which is irrigated. Hydropower is the other major water user, with a throughput of 9,800 Mm^3. Water storage is 2,282 Mm^3, of which 80% is in the Mahaweli River Basin. Hydropower generation amounts to 1,382 megawatts (MW) (49% of the total energy capacity) with 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 the future as new thermal generation is scheduled to come 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 ADB, commenced in 1992 to draft a national water resources policy and supporting legislation. The draft policy was passed by the 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 of Sri Lanka in the development of policy, 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 and Strategies (2003), successive National Environmental Action Plans (NEAPs), the National Watershed Management Policy (2004), the National Wetland Policy and Strategy (2006), the National Policy on Disaster Management (2010), and the draft National Policy on Protection and Conservation of Water Sources (2014). In general, the water sector legislation is old, and is concerned with development rather than management and conservation.[19] A Water Sector Vulnerability Profile was produced in 2010 as part of the National Climate Change Adaptation Strategy for Sri Lanka 2011 to 2016.

Water Resources Knowledge

The National Policy on Protection and Conservation of Water Sources, Catchments and Reservations in Sri Lanka 2014 includes sections on monitoring of unauthorized activities in water catchments and monitoring the condition of water reservoirs. The National Environmental Policy and Strategies 2003 advocates a mechanism to monitor all industrial discharges. The National Policy on Disaster Management 2010 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 National Rural Water Supply and Sanitation Policy 2001 identified one of the government's roles as the conducting of research for development of the subsector. The National Wetland Policy and Strategy 2006 also advocates research into wetland ecosystems to assist with their conservation, sustainable use, restoration and adaptive management. The strategy accompanying this policy proposes multidisciplinary 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 risk of disasters. The draft National Policy on Protection and Conservation of Water Sources, Catchments and Reservations in Sri Lanka (2014) does not see climate change as a potential accelerator of water source degradation (although the National Climate Change Policy 2012 does recognize the need to

[19] The Sri Lankan government website has been checked for all legislation passed since 1991.

conserve water resources and biodiversity), while the Water Sector Vulnerability Profile 2010 contains considerable detail on the threat posed by climate change as well as adaptation actions.

The absence of an overarching 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 subsectoral policies, laws and regulations. The water sector vulnerability profile states, "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" (Ministry of Environment 2010, 23). 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 National Rural Water Supply and Sanitation Policy (2001) contains high-level IWRM principles,[20] which could lay the foundation for an adaptive approach in this subsector, but most of the policy is concerned about the provision of WSS services. However, the policy does state that the role of the government is to decentralize decision making, introduce a legal framework for regulating water extraction from natural sources, set water quality standards, and conserve watersheds. This policy has now been replaced by the National Drinking Water Policy (undated), developed to accommodate community WSS schemes. This also states that the government will ensure coordination among 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 for the WSS subsector in the face of climate change.

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

The draft National Policy on Protection and Conservation of Water Sources, 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 being 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 water service reform bill in 2003 sought to introduce regulation into the subsector, but the bill did not proceed because of legal challenges (Fan 2015). The 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.

[20] Policy principles include the following:

- Freshwater 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 a participatory approach involving users, planners and policy makers at all levels.
- All sector activities should be in harmony with the environment.

Water Resources Infrastructure

The National Water Use Master Plan (2013) reports that the paddy cultivation area is projected to increase by 1.5% per year up 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 increase at 9.7% per year up to 2020; and total hydropower capacity will increase from 1,778 MW in 2015 to 2,021 MW in 2025.[21] 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 term (5 years), medium term (6-10 years) and long term (over 10 years) for the three main water-using sectors, i.e., irrigation, domestic water supply and hydropower. These include 10 dams in the short term at a total investment of LKR 94,000 million and 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 interbasin water transfers, all with a considerable history. The authors of this report are cautious about these major investments because of their high cost and the large number of people likely to be affected. It is apparent that Sri Lanka has various 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 under way to improve urban water supply operational efficiencies, primarily through reductions in nonrevenue water by replacing aged pipes, detecting illegal connections and replacing common outlets with individual connections (Fan 2015). Water metering and charging are also being expanded to improve revenue and help control demand. While these activities contribute toward climate change adaptation, Fan (2015) made it clear that there remain many other opportunities through catchment protection, water quality management, rainwater harvesting, demand management and nonpotable 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 National Rural Water Supply and Sanitation Policy 2001 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 Environmental Policy and Strategies 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 that recognizes the need for watershed management to reduce erosion and sedimentation of downstream storages, groundwater regulation to reduce overexploitation, and prevention of pollution from irrigation, industry and human settlements. The policy proposes a range of

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

actions that would improve water quality including soil conservation and erosion control, mobilization of farmer 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 contributing to climate change adaptation.

The Irrigation Amendment Act 1994 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 to adapt to changing climate; for example, 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 2000 encourages the formation of FOs that promote soil conservation, water-use efficiency and control the discharge of waste into watercourses. The Act pays little attention to groundwater, although it does mention the requirement for approval to drill wells in paddy areas.

The National Water Use Master Plan 2013, as well as assessing infrastructure development options, also examined several measures to improve water-use efficiency in irrigated areas, largely through nonstructural 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.

Water Resources Communications, Education and Participation

There has been a long history of farmer participation in irrigation management in Sri Lanka, stemming from the Agrarian Services Act 1991. FOs are able to formulate rules for maintenance, conservation and management, control the distribution of water, and levy charges for operation and maintenance. The Irrigation Amendment Act 1994 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 irrigated areas. The National Rural Water Supply and Sanitation 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 National Policy on Protection and Conservation of Water Sources, Catchments and Reservations in Sri Lanka (2014) also advocates stakeholder participation as an essential ingredient in the protection of water sources.

Several water-related policies have 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 water service providers to 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 on the importance of conserving wetlands. The national drinking water policy wants to build public awareness among stakeholders about the importance of watershed and catchment protection, and promote awareness of demand management and water conservation. Furthermore, the draft policy on protection and conservation of water sources also encourages public education on the importance of watershed and catchment protection to maintain clean water supplies.

Summary

The absence of an overarching water resources policy and legislation is the biggest obstacle to effective adaptation to climate change in the water sector in Sri Lanka. Each water subsector operates without coordination under its own legislation and regulations. There is no effective mechanism for coordinating their plans, investments or management activities. Nevertheless, the subsectoral 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 irrigated areas, implementing water-use efficiency in urban water supply and irrigated 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, which could help respond to a more variable precipitation pattern. The master plan provides an implementation schedule for these projects, although prioritization among these possibilities has yet to occur with a commitment to funding infrastructure.

The long-standing policy of transferring responsibility for managing irrigated 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 subsector 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.

Postal Address
P O Box 2075
Colombo
Sri Lanka

Location
127 Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Telephone
+94-11-2880000

Fax
+94-11-2786854

E-mail
iwmi@cgiar.org

Website
www.iwmi.org

IWMI is a CGIAR Research Center and leads the: CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

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