

Unclassified

COM/ENV/EPOC/IEA/SLT(2006)11



Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

30-Oct-2006

English text only

**ENVIRONMENT DIRECTORATE
INTERNATIONAL ENERGY AGENCY**

**COM/ENV/EPOC/IEA/SLT(2006)11
Unclassified**

**DOMESTIC POLICY FRAMEWORKS FOR ADAPTATION TO CLIMATE CHANGE IN THE
WATER SECTOR**

PART II: NON-ANNEX I COUNTRIES

LESSONS LEARNED FROM MEXICO, INDIA, ARGENTINA AND ZIMBABWE

Ellina Levina, Organisation for Economic Co-operation and Development

The ideas expressed in this paper are those of the author and do not necessarily represent views of the OECD, the IEA, or their member countries, or the endorsement of any approach described herein.

JT03216818

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

English text only

Copyright OECD/IEA, 2006

Applications for permission to reproduce or translate all or part of this material should be addressed to:

Head of Publications Service, OECD/IEA

2 rue André Pascal, 75775 Paris Cedex 16, France

or

9 rue de la Fédération, 75739 Paris Cedex 15, France.

FOREWORD

This document was prepared by the OECD and IEA Secretariats in September-October 2006 in response to the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC). The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy-makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. However, the papers do not necessarily represent the views of the OECD or the IEA, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

The Annex I Parties or countries referred to in this document are those listed in Annex I of the UNFCCC (as amended at the 3rd Conference of the Parties in December 1997): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. Korea and Mexico, as OECD member countries, also participate in the Annex I Expert Group. Where this document refers to “countries” or “governments”, it is also intended to include “regional economic organisations”, if appropriate.

ACKNOWLEDGEMENTS

This paper was prepared by Ellina Levina of the Organisation for Economic Co-operation and Development. The author would like to thank Helen Adams for the research assistance and ideas she provided for the study, and colleagues Dennis Tirpak, Helen Mountford, Jane Ellis, Shardul Agrawala, and Katia Karousakis for their comments. The author is grateful to the Annex I Expert Group delegates for their comments, especially to Japan, the US and Austria for their written comments and suggestions on the earlier draft of the paper. The author would also like to thank Bharat Sharma, India; Victor Pochat, Claudia Natenzon, and Ana Maria Murgida, Argentina; Davison Gumbo, Sithabiso Gandure and Claudious Chichokozho, Zimbabwe, and Fernando González and Victor Magaña, Mexico for providing valuable information, ideas and insights into this study development.

Questions and comments should be sent to:

Ellina Levina
 OECD Environment Directorate
 2, rue André-Pascal
 75775 Paris cedex 16
 France
 Email: Ellina.Levina@oecd.org

All OECD and IEA information papers for the Annex I Expert Group on the UNFCCC can be downloaded from: www.oecd.org/env/cc/aixg

TABLE OF CONTENTS

EXECUTIVE SUMMARY	6
1. INTRODUCTION.....	8
1.1 Background	8
1.2 Water pollution.....	11
2. IMPACTS AND VULNERABILITY TO CLIMATE CHANGE.....	11
3. INTERNATIONAL AND DOMESTIC LEGAL FRAMEWORKS	16
3.1 Water rights	16
3.2 Domestic legislation	20
3.3 Transboundary water issues	23
4. INSTITUTIONAL LANDSCAPE	25
4.1 Governance.....	25
4.2 Key players.....	27
4.2.1 National institutions	28
4.2.2 Sub-national institutions	30
4.2.3 Water user associations.....	31
4.2.4 Community / traditional structures	32
4.2.5 Other stakeholders	33
4.3 Institutional capacity	34
5. WATER MANAGEMENT	35
5.1 Long term water management strategies.....	35
5.2 Flood management	37
5.3 Drought plans and water management plans.....	40
5.4 Water supply infrastructure	42
5.5 Water management policies	44
6. INFORMATION AVAILABILITY AND USE.....	46
7. CONCLUSIONS	49
REFERENCES.....	53
GLOSSARY	55
ACRONYMS.....	55
ANNEX A. CASE STUDY COUNTRY PROFILES	56
A1. Argentina	56
A2. India.....	58
A3. Mexico.....	62
A4. Zimbabwe.....	66

LIST OF TABLES

Table 1. Sample development indicators for six case study countries.....	10
Table 2. Expected climate change impacts on water resources in the countries of this analysis.....	12
Table 3. Summary of recent water development conflicts in India	18
Table 4. Selected governance indicators.....	27
Table 5. Access to drinking water and sanitation	42

LIST OF FIGURES

Figure 1. Correlation between rainfall and economic growth in Zimbabwe	9
Figure 2. Rule of Law	22

Executive Summary

Water is fundamental to human well-being, socio-economic development and the healthy evolution of ecosystems. In many countries, water access and management is a constant challenge. Climate change is likely to pose an additional burden on water resources and their management, especially in areas where water resources are already under stress due to meteorological conditions and demand pressures from society. To address these challenges and adapt water management to changing climatic conditions, it is necessary to ensure that the current meteorological trends and information on future water availability and demand (obtained from climate change scenarios and water demand projections) are taken into account in the processes of water resources management and policy development.

All countries have complex water policy frameworks that reflect historical precedents and their local circumstances. This paper examines domestic policy frameworks in the water sector in four developing countries (Argentina, India, Mexico, and Zimbabwe) and identifies how adaptation to climate change can be integrated into these frameworks. The paper draws lessons from these countries about the roles that national policy frameworks can play in adaptation to climate change in the water sector. These lessons may be applicable for a wider group of non-Annex I countries. Where possible, the study compares the findings of this paper with the conclusions of similar assessment of four Annex I countries as found in Levina and Adams, 2006. The key elements of the analysis in both cases were the same and included legislation, institutional structures, water management tools and policies, and information availability and use.

These four elements play very different roles in adaptation to climate change in Annex I and non-Annex I countries. Policy frameworks in Annex I countries (examined in the earlier study) are quite well developed. They are based on strong and enforceable legal provisions, sophisticated institutional structures, water management measures and policies that are constantly adjusting to changing climatic conditions. While not perfect, (most do not yet incorporate adaptation to climate change explicitly); they generally provide a good basis for adaptation in the water sector. The policy frameworks in the four developing countries include similar elements, but they are less mature, with weaker institutions, and less capable of providing for adaptation to climate change. This makes the water sector in these countries more vulnerable to future changes in climate.

The factors that contribute to ineffective governance also add to the vulnerability to existing extreme weather events and climate change. Therefore, an efficient way to start addressing adaptation in developing countries is through efforts that strengthen the fundamental building blocks of civil society. Transparent governance based on the rule of law, cooperation among government agencies, and involvement of stakeholders (including local communities) in the decision-making process are prerequisites for effective adaptation to climate change. Schooling, basic professional training and medical care accessible to all are essential elements of community-level capacity and are indispensable for adaptation to climate variability and change.

The countries examined in this paper need basic capacity to cope with existing meteorological challenges and extreme weather events. Efforts have been made by national governments to address the challenges of the water sector through policy instruments and water management strategies that promote accountability of water abstraction, water sharing, synergies with land-use planning, efficient use of water, and use of early warnings for floods and droughts. The international community offers assistance in these efforts through bilateral and multilateral projects. For example, on average, official development assistance (ODA) to water supply and sanitation in all recipient countries for 2000-2004 was around US\$ 2.4 billion per year (OECD, 2005). India has been one of the largest recipients of ODA in the water sector, receiving around US\$ 102 million annually. Multilateral donors' ODA commitments to the water sector in all recipient countries accounted for a further US\$ 1.8 billion in 2004.¹

¹ www.oecd.org/dac/stats/crs/water

In addition to basic capacity, supplementary measures will need to be implemented to address impacts of climate change on water resources. In some cases, additional precautions could be built into basic water management and infrastructure that is being developed now. Some other adaptation measures will have to be designed and implemented separately. The line between developing basic capacity in the water sector and additional capacity to handle greater challenges of climate change is difficult to define.

National policy frameworks that govern the water sector embody the basic capacity that is there to provide for water management. When properly designed, in view of future challenges, policy frameworks could also provide a basis for adaptation. Evaluating policy frameworks and their roles for adaptation should be conducted on a country by country basis. However, some general conclusions of this paper may be applicable to a wide variety of countries. These are outlined below.

A *fair and functioning system of water abstraction permits*, while not yet fully developed or implemented in the case-study countries, is an important tool that could help reduce water conflicts and encourage efficient use of water. Establishing and enforcing a system of water abstraction permits, with specific requirements/conditions related to the amount, timing, purposes and period of water abstraction would allow governments to have greater control over water resources and their management, and would provide flexibility in adjusting water abstraction depending on water availability. *Market mechanisms* for water sharing (e.g., trading of water abstraction rights, water contracts) provide flexibility and opportunity in water access and should be further developed and incorporated into legal frameworks.

Institutional capacity and co-operation are essential for effective implementation of water laws and policies, some of which could help adaptation to climate change if enforced. The *decentralised approach* to the water resources management promoted by the examined countries but not yet fully implemented down to the local level could be effective and facilitate adaptation when based on principles of cooperation and information sharing. *Stakeholder participation* should be an integral part of decision-making in developing countries. Poor communities in drought and flood-prone areas are most vulnerable to extreme weather events. They are currently too far removed from laws and institutions and need to be included in a process of water management, for example, through water user associations.

The *water infrastructure* of developing countries needs further development, since existing infrastructure often cannot provide water security during droughts and protect people during floods. In addition, substantial new infrastructure is needed to cover the 1.1 billion people currently without access to water and 2.6 billion without access to sanitation worldwide. Incorporating information on climate change, its risks and uncertainties and on other environmental concerns into decision-making on infrastructure projects is indispensable to economic growth. International assistance can play an important role in this respect, provided that national and local needs are fully taken into account. International development agencies would also require understanding of projected climate change impacts in the regions where they work to be effective and capable of facilitating and encouraging adaptation to climate change.

As for Annex I countries, improving the *use of available scientific information* and the exchange of information among stakeholders, particularly those dealing with weather/climate, water, energy, environment and agriculture at various levels can reap multiple benefits. Those include better decision making processes, improved water management and protection from extreme weather events for ordinary citizens.

1. Introduction

This paper represents Part II of the analysis of the roles that domestic policy frameworks can play in adaptation to climate change in the water sector, conducted under the auspices of the Annex I Expert Group. Part I focused on Annex I countries and synthesised experiences of four case study countries: Canada, Finland, UK and the US (Levina and Adams, 2006). This paper focuses on non-Annex I countries and is based on four case studies in non-Annex I countries: Argentina, India, Mexico, and Zimbabwe.

As in the previous paper, the water sector is defined as water resources (surface water and groundwater), their use (e.g. irrigation, public water supply, environmental needs) and their governance and management (legal and institutional issues, abstraction permitting, water infrastructure, water policies). Water quality issues are touched upon, as water quality and quantity issues cannot be looked at in isolation, but are not specifically analysed.

The paper is based on four developing country case studies developed by local consultants. It is structured around the selected four elements that construct policy frameworks: (1) legislation, (2) institutional arrangements, (3) water management and policies, and (4) information availability and use in decision-making. Section 2 briefly examines current and projected future climatic conditions that necessitate adaptation. Section 3 focuses on domestic and international legal issues and informal rules that govern the water sector while Section 4 identifies institutions and key players in the water sector who should also become the key actors in adaptation. Section 5 examines water management approaches and policies and analyses how adaptation could be incorporated into the everyday management of water. Section 6 evaluates information needs and existing mechanisms for information sharing and dissemination that would be instrumental for successful adaptation. The paper concludes with a summary of key findings. The comparison with Annex I countries is provided throughout the paper.

1.1 Background

The basic elements of policy frameworks in the water sector are the same in all countries, both developed and developing, and they are the following:

- International and domestic legal frameworks: transboundary water agreements, and national, sub-national and local legislation and regulations that govern water resources management;
- Institutional landscape: key players in the water sector and the government and private institutions within which they operate (governmental institutions at all levels; water providers, community groups and farmers);
- Water management policies and instruments: water resource management plans, flood and drought plans, pricing, metering, water-related strategies, public-private partnerships, infrastructure development, maintenance and renewal;
- Information: scientific capacity, monitoring systems, mechanisms and tools to translate available information for policy-makers, mechanisms for information dissemination.

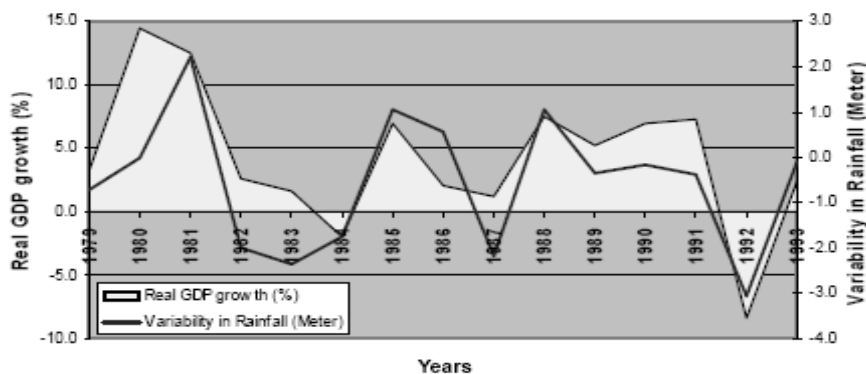
However, there are many other factors, specific to developing countries, which interact with the water sector frameworks and influence their performances and abilities to adjust to climate variability and change. These factors include poverty and disease (e.g., HIV/AIDS exposure), food security concerns, cultural, tribal and religious beliefs and rules that play an important role alongside civil governance, reliance on foreign development assistance, dominance of agriculture in terms of water consumption, and the large share of population that is involved in agriculture and depends on this sector for survival.

Each of the case study countries represents a unique situation regarding the status of water resources, climatic conditions, projected impacts from climate change, current policy setting, and other circumstances. However, each of them exposes one or more factors listed above that cannot be overlooked when domestic policy frameworks are examined and their roles in adaptation to climate change are analysed.

For example, in Zimbabwe one of every four adults is infected with HIV/AIDS virus. Since 1998, the life expectancy has dropped from 60 to 37 years, which has obvious and manifold implications not only for worker productivity but also for psychological wellbeing and stress in social relations (IDS Bulletin 36.4, 2005). Eighty-one percent (81%) of the Indian population lives on less than US\$ 2 per day, which also has implications for the choices of policies, e.g., water pricing. In Argentina, the majority of the rural population does not have access to either improved water sources² or sanitation. According to the World Bank, 29% of Argentinean population lives in poverty (EC, 2002). Mexico is the most developed of the four examined countries, nevertheless 26 million of its population lives on less than US\$ 2 per day, and only 39% of rural population has access to sanitation, and about 6 million people in rural areas do not have access to improved water sources.

Zimbabwe also illustrates a case of many African countries which mainly depend on rainfall for their water supply due to the lack of water infrastructure. Given the high percent of population involved in agriculture and the large share of agriculture in the national GDP, the correlation between rainfall variability and GDP growth is therefore strong (see Figure 1).

Figure 1. Correlation between rainfall and economic growth in Zimbabwe



Source: D.Grey and World Bank³

Table 1 compares some development indicators of the four non-Annex I countries of this study and the four Annex I countries of the Part I paper.

² Access to an improved water source refers to the share of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, or rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access to an adequate amount is defined as the availability of at least 20 liters a person a day from a source within one kilometre of the dwelling. (World Health Organization, 2002)

³ From the publication "Water and Climate Risks: A Plea for Climate Proofing of Water Development Strategies and Measures", 4th Water Forum, March 2006.

Table 1. Sample development indicators for six case study countries

		Argentina	India	Mexico	Zimbabwe	Canada	Finland	UK	US
Population & Development	Population (millions)	36.8	1,064.40	102.3	13.1	31.6	5.2	59.3	290.8
	Urban population (% of total)	88.6	28.3	75	37.5	79.3	59	89.7	77.9
	GDP (USD billions)	129.6	600.6	626.1	17.8	857	162	1,795	10,949
	GNI (gross national income) per capita	3,810	540	6,230	500*	24,470	27,060	28,320	37,870
	Percent of GDP earned by Agriculture, 2000 ***	5%	25%	4%	18%	2%	4%	1%	1%
	UN Human Development Index ⁴ 2003****	0,863	0,602	0,814	0,505	0,949	0,941	0,939	0,944
	% of population living below USD 2 per day **	14	81	26	83	>>>	>>>	>>>	>>>
Agriculture	Land area (1,000 sq.km)	2,737	2,973	1,909	387	9,221	305	241	9,159
	Agriculture land (% of land area)	65	>>>	56	53	8	7	70	45
	Irrigated land (% of crop land)	4.5	33.6	23.2	3.5	1.7	2.9	3	13
	Fertilizer consumption (100 gram/ha arable land)	219	996	690	342	571	1,332	3,131	1,096
	Population density, rural (people/sq.km arable land)	12	466	102	255	14	97	107	37
Energy	Energy use per capita (kg oil equiv)	1,543	513	1,560	751	7,973	6,852	3,824	7,943
	Electric power consumption per capita (kWh)	2,024	380	1,660	831	15,613	15,326	5,618	12,183
Water resources	Internal freshwater resources per capita (m ³)	7,506	1,185	3,998	1,069	90,104	20,530	2,444	9,628
	Freshwater withdrawal								
	Total (% of internal resources)	10.4	39.7	19	8.6	1.6	2.1	8.1	16.7
	Agriculture (% of total freshwater withdrawal)	75	92	78	79	12	3	3	42
	Access to improved water sources (% of total population)		86	91	83	100	100		100
	Rural (% of rural population)	19 [^]	82	72	74	99	100		100
	Urban (% of urban population)	83.4 [^]	96	97	100	100	100	100	100
	Access to sanitation (% of total population)		30	77	57	100	100		100
	Rural (% of rural population)	0.6 [^]	18	39	51	99	100	>>>	100
Urban (% of urban population)	51 [^]	58	90	69	100	100	>>>	100	
Health & Education	Under-five mortality rate (per 1,000)	20	87	28	126	7	4	7	8
	% of population 15-49 with HIV/AIDS (2003-2004)**	0,7	0,9	0,3	24,6	0,3	0,1	0,2	0,6
	Combined gross enrolment rate for primary, secondary and tertiary schools (% 2002-03)****	95	60	75	55	94	108	123	93

Legend: * Sub-Saharan Africa, low income – 440. ** 2005 World Population Data Sheet. *** EarthTrends Country Profiles, WRI 2003

[^] (2001 data) Permanent Information System on Sanitation (Sistema Permanente de Información de Saneamiento- SPIDES) of the Argentinean National Entity of Water Works and Sanitation (Ente Nacional de Obras Hídricas de Saneamiento - ENOHSA)

**** UN Human Development Indicators 2003

Sources: The Little GREEN Data Book, 2005, the World Bank

⁴ The UN Human Development Index (HDI) is a comparative measure of poverty, literacy, education, life expectancy, childbirth, and other factors for countries worldwide. The index was developed in 1990.

When examining legal frameworks and institutional structures it is important to bear in mind the role that agriculture plays in the examined countries. In India and Zimbabwe the foremost purpose of agriculture is subsistence. Access to water directly translates into an ability to provide food for the family. For the majority of rural communities in these countries, which still represent a significant share of the population, (72% in India and 63% in Zimbabwe), access to water means almost the same thing as access to a bank account in developed countries. If there is enough water, enough crops can be generated, which means no hunger for the family, schooling for the children, and extra monetary revenues from selling excess crop, which can be spent on goods and medical care.

Developing countries with limited economic resources; poor infrastructure; insufficient levels of technology, information and skills; non-responsive bureaucratic institutions coupled with inequitable empowerment and access to resources among various social groups, have inadequate capacity to adapt and are highly vulnerable to climate change. Improvement of healthcare, schools, water supply, strengthening of national and local institutions, development of infrastructure, promotion of local level indigenous tools and measures that are used in water resources and agriculture will contribute to building the adaptive capacity.

1.2 Water pollution

Water pollution adds enormously to existing problems of water scarcity by contaminating large volumes of available water, thus making it unsuitable for use. This situation is especially notable in developing countries. Untreated sewage water, agricultural run-off and industrial effluent water enter surface water bodies and also contaminate ground water aquifers. Infiltration of sewage into drinking water supply systems due to leaks and poor maintenance makes drinking water dangerous for human consumption.

In Argentina, for example, the ground water contamination is now one of the most serious environmental problems in the country. One of the aquifers in Buenos Aires is polluted by leaks from household septic tanks and untreated industrial water, thus this source of groundwater can not be used for water supply. Another aquifer where the water quality is much better has been over-abstracted for many years leading to saltwater intrusion. As a result, both aquifers had to be replaced by surface water to supply drinking water for the population.

Stringent control of water quality should be one of the main aspects of water management. Water quality considerations should be incorporated into integrated water resource management plans and strategies. Analyses of sources of pollution of watersheds will help identify methods to protect water quality. The World Health Organization has developed plans, termed Water Safety Plans, which can help countries identify problems and create management solutions. Making available water clean and safe for drinking will contribute to addressing the issue of water scarcity.

2. Impacts and Vulnerability to Climate Change

All four case study countries are extremely vulnerable to climate change. Their geographic locations make these countries very sensitive to climate variability and projected climate change. The status of their development, infrastructure, institutional and legal frameworks contributes to these countries' vulnerability. Developing countries, such as Zimbabwe and India, also have an added vulnerability due to the greater reliance on climate-dependent industries such as agriculture and fisheries. Argentina is one of 18 countries with the highest probability of flood-related large economic losses worldwide (Freeman in Kreimer et al., 2001). At the same time, some parts of the country are vulnerable to droughts. India is extremely vulnerable to both floods and droughts. Mexico is vulnerable to droughts and flash floods. Zimbabwe is vulnerable to droughts. Table 2 illustrates water-related climate impacts that are likely to be of most importance to the countries examined in this study.

Table 2. Expected climate change impacts on water resources in the countries of this analysis

	Climate Impact						
	Snowmelt water supply	Drought/ desertification	Floods	Flash floods	Severe storms	Saltwater intrusion	Reduced snowpack
Argentina	X	X	X	X	X	X	X
India	X	X	X				X
Mexico		X		X	X		
Zimbabwe		X	X				

Source: author's summary.

Argentina

Argentina is characterised by a wide climatic variety due to a great north-south expanse of the country and the presence of the Andes, from subtropical climate in the north to the sub polar climate of the glacial regions of southern Patagonia. 76% of the territory is under arid and semi-arid conditions as it receives a mean annual precipitation of less than 800 millimetres. 85% of the country's water resources are located in the La Plata River Basin where the country's population and economic activity is concentrated (World Bank, 2000b). The main rivers in this basin are the Parana, Paraguay, Uruguay and Bermejo Rivers. The La Plata River Basin covers the northern part of Argentina and is shared by Argentina, Bolivia, Brazil, Paraguay and Uruguay. This basin accounts for only 30% of the country's surface area. In the southern part of Argentina, the Colorado and Negro Rivers rise in the Andes and flow to the Atlantic Ocean.

The Parana River is very important to the hydrology of Northern Argentina as it flows through a shallow aquifer covering impermeable basaltic bedrock. The annual flooding in the upper reaches of the river has a dramatic impact on the livelihood of the local residents and can often lead to devastating crop losses. The Basin has experienced notable positive trends in precipitation over the past century, and with increased precipitation due to climate change, this area will become increasingly inundated by floods (Pochat et al, 2006). There is some fear that the magnitude of these flood events may increase due to El Nino effects and they may also become more frequent.

On the other extreme, the arid and semi-arid regions in the centre, northwest, and south of the country (66% of total surface area) contain only 10% of total water resources. Some of these areas depend on snowmelt from the Andes for their water supply. Increasing temperatures will lead to a decrease in snowmelt and runoff. An accelerated retreat of the Andean glaciers is expected in a timeframe close to 40 years. Studies carried out by the Research Centre on Water and Atmosphere (CIMA) show significant reductions in runoff of the Colorado, Negro, Senguerr, and Patagonian Rivers (Pochat et al, 2006). Irrigation will become more difficult in these areas. According to the IPCC Third Assessment Report, summer temperatures in central Argentina are expected to rise by 1.57°C (+1.08-2.21°C) under the IS92a emissions scenario and winter temperatures are expected to rise by +1.33°C (+1.12-1.57°C) by 2050. Precipitation is expected to decrease by 12% in the summer and 5% in the winter.

Rosenzweig et al (2004) predict that major challenges for the water sector in Argentina will come from more extreme droughts and floods, and from the uneven distribution of water resources. Four climate scenarios examined as part of their study show increased runoff in the La Plata Basin by 2020. Flooding will be exacerbated by changes in storm intensity from the Atlantic Ocean and sea level rise.

Mexico

Climatic zones in Mexico vary greatly from tropical rainforests with over 3000 mm of annual rainfall in the south, to arid deserts with less than 100 mm in the north. Runoff variation is even more extreme, from over 2 million m³ per km² per year in the wettest areas to essentially zero in the driest. In the dryer parts of the country, precipitation and runoff are highly erratic with large variations from year to year and extreme seasonal differences. In these areas, rainfall occurs during a two- to four-month period and is related to thunderstorm and hurricane activity which can be very intense and cause flash flooding. Runoff is directly associated with precipitation and most streams, and even rivers, dry up during periods of no rainfall. In several places in the country, the intense rainfall events are the main source of water to fill the storage reservoirs.

Mexico has nearly 150 rivers; most are small, non-navigable, and 70% drain into the Pacific Ocean. Most of the largest river systems are found in central Mexico. Some of the large rivers include the Balsas, Conchos, Grijalva, Lerma, Panuco, Grande, Papaloapan, and Usumacinta. The Río Lerma has its headwaters in the Toluca Basin west of Mexico City and flows westward to form Lake Chapala, Mexico's largest natural lake. Water from the Lerma is tunnelled eastward through the mountains to help supply Mexico City's water needs. The Balsas is a major source of hydroelectric power. The Rio Grande, rising in the San Juan Mountains of the U.S. State of Colorado, flows generally south to the Gulf of Mexico and forms much of Mexico northern border with the United States. There have been severe water shortages on both sides of the border (and associated conflicts between Mexico and the US) due to frequent and prolonged droughts that affect Colorado River basin.

Less than a third of total runoff occurs within the 75% of the territory where most of the country's largest cities, industrial facilities and irrigated land are located (González and Magaña, 2006). Consequently, surface runoff and groundwater are increasingly insufficient to support the high growth rates and economic activity, resulting in disputes over surface water usage and the over pumping of aquifers. For example, a water conflict has already occurred in the Mexico basin, between Mexico City and the State of Mexico. Only 2% of water for Mexico City comes from local aquifers while the remaining 98% comes from various sources in the State of Mexico. The dispute for water resulted in a legal conflict for water rights and lasted for several years. Additionally, water pollution has reduced the potential beneficial use of certain rivers and water bodies.

According to the IPCC Third Assessment Report Mexico will become warmer and drier with climate change. Mexico is heavily affected by the El Niño Southern Oscillation (ENSO) phenomenon, which already creates disruptive climate extremes on an inter-annual timescale. For example, there are positive precipitation anomalies during winter over northwest Mexico and negative summer precipitation anomalies elsewhere in Mexico. A strengthening of the effects of El Niño (the warm phase of ENSO) with a rise in the surface ocean temperature could have severe consequences for Mexico.

India

The climate in India varies from temperate in the northern mountainous region to tropical in the south with large arid and semi-arid areas in the central and western regions. The regional climate is influenced predominantly by the monsoons. Approximately 70% of the total annual rainfall over the subcontinent is confined to the southwest monsoon season (June-September). There is more rainfall in the eastern Himalayas than the western Himalayas during the monsoon season (Sharma, 2006). Recent decades have exhibited an increase in extreme rainfall events over northwest India during the summer monsoon (Singh and Sontake, 2001). The number of rainy days during the monsoon along the east coast has declined in the past decade.

There is a considerable spatial variation in mean annual precipitation, which ranges from about 100 mm in western Rajasthan to more than 2500 mm in north-eastern areas with a world maximum of 11,000 mm near Cherrapunji. Coupled with a variety of geological and topographical conditions within a given basin it results in a large spatial variability of flow regimes ranging from regimes partially fed by snowmelt in the rivers

originating from Himalayan mountains, to regimes of alluvial plains rivers, which receive considerable base flow from groundwater in the autumn (Bandyopadhyaya, 1995).

India has a highly seasonal pattern of rainfall, with 50% of precipitation falling in just 15 days and over 90% of river flows occurring in just four months. The Indian mainland is drained by 15 major (drainage basin area >20,000 km²), 45 medium (2,000 to 20,000 km²) and over 120 minor (<2,000 km²) rivers, besides numerous ephemeral streams in the western arid region. For large-scale analysis of water resources, the country is often separated into some 19 major drainage regions (Sharma et al., 2006). The Indus, and Ganga-Brahmaputra-Meghna systems cover, respectively, some 10 and 35% of the entire country, and are characterized by extensive flood plains and deltas.

Irrigation constitutes the main use of water and presently accounts for 84% of the total water withdrawals. The share of per capita withdrawals by domestic and industrial sectors is some of the lowest in the developing world - 59 m³ per person in India compared to 132 m³ per person in China, (World Bank, 2005b). Environmental water needs for minimum flow in the rivers, water for wetlands/ mangroves and recreation are often not met. With increasing urbanization and per capita demand, the water demands of domestic, industrial and other sectors are expected to increase and become highly competitive with the irrigation sector. Presently, about 60-65% of the irrigation and about 90% of domestic and industrial water requirements is met through private groundwater resources (Sharma, Scott and Shah, 2004).

The spatial range of temperature is also significant, especially during winter. Extreme temperatures of over 45°C occur over the northwest part of the country during May-June. The warming trend over India has been reported to be 0.57°C per 100 years (Rupakumar et al., 1994). According to the WMO, the year 2005 was one of the two warmest years in the temperature record since 1850. In India extremely harsh heat waves in May and June 2005 brought maximum temperatures of between 45°C and 50°C. The maximum temperatures over the region were 5°C to 6°C above the long-term average. The delayed south-west monsoon rains allowed the heat wave to persist into June, claiming at least 400 lives.

Floods, droughts and cyclones are the main extreme climatic events in India. The total flood prone area in India is about 40 million ha or 12.16% of total land area (Sharma et al., 2006). 19% of India's area and 12% of the population (more than 100 million people) is affected by drought annually. Drought disasters are more frequent during years following ENSO events. Western parts of Rajasthan and the Kutchh region of Gujarat are chronically drought affected. Drought conditions have also been reported in Karnataka, Andhra Pradesh, Orissa and Bihar states (Sharma and Smakhtin, 2004). At least half of the severe failures of the Indian monsoon since 1871 have occurred during El Niño years (Webster et al., 1998).

With climate change, the intensity of the hydrological cycle will increase in India leading to stronger monsoons, and precipitation extremes. In 2005 the south-west monsoon during June-September brought unprecedented heavy rain and widespread massive flooding to parts of western and southern India, affecting more than 20 million people and resulting in more than 1800 deaths (WMO, 2005). Heavy rainfall continued unabated in south-eastern parts of India, during the north-east monsoon season of October-December. The associated devastating floods affected more than 2 million people with at least 300 fatalities and caused considerable adverse socio-economic impacts.

Extreme weather events associated with the ENSO are likely to become more intense with climate change (Sharma et al., 2006). During cold episodes the Indian monsoon rainfall tends to be greater than normal. During warm episodes, Indian monsoon rainfall tends to be less than normal, especially in northwest India where crops are adversely affected. With climate change, dry areas will receive less precipitation, wet areas will receive more, and the majority of the precipitation will fall over a shorter rainy season. According to the Regional Climate Model simulations (Lal et al.; 2002 cited in Sharma et al.; 2006) an increase in rainfall is simulated over the eastern region of India, while north-western deserts see a small decrease in the absolute amount of rainfall. Changes in soil moisture broadly follow those in precipitation except in eastern India, where they decrease as a result of enhanced drainage from soil. Global warming has the potential to increase frequency of tropical cyclones from the Indian Ocean. Studies have yet to agree on historical trends showing

an increase, but should tropical cyclones increase, the risk of flooding and infrastructure damage will also increase.

The retreat of Himalayan glaciers due to climate change will affect flows in several major rivers. Flows are likely to increase in the next 50 years as the glaciers melt giving rise to higher flood risk, then runoff will decrease leading to much reduced flows in the dry season, threatening the environmental use of the rivers. Estimates show that 95% of Himalayan glaciers are shrinking at the rate of 13 m to 30 m annually. The effects on river flows are likely to be substantially different in different areas. The Indus is likely to witness large increases in flows for the next half century, followed by up to 50% reductions from present levels of runoff. In the Ganges, there would be large impacts of deglaciations in the mountains but non-glacial forms of runoff in the plains may mitigate the impacts (Sharma et al., 2006).

India has 16% of the global population but only 4% of global water resources (Defra, 2005). Accompanying this is the inefficient use of water for irrigation and unsustainable groundwater abstraction. India currently relies heavily on groundwater for irrigation purposes and is extracting at a rate much higher than the natural system can replenish supplies. Groundwater recharge is expected to decrease with climate change. Catchment-based modelling studies carried out by the Tata Energy Research Institute (TERI) found that in the Lakhwar catchment in the Upper Yamuna basin in Himalayas annual groundwater recharge could decrease by 30-35% by 2060 (Sharma et al., 2006). Fall in groundwater tables is estimated at 6-8 m (by 2060) on account of climate change and cost of extraction of water would increase at least 3 to 4 fold over the same time period.

Zimbabwe

Zimbabwe is a sub-tropical country with one rainy season (November to March). The country's average rainfall is 657 mm/annum and varies spatially from the eastern highlands (1,000 mm) to low lying areas (400 mm) in the southern part of the country. Zimbabwe's rainfall pattern is erratic, unreliable, and insufficient.

Zimbabwe is a landlocked country; it lies between the Zambezi River in the North and the Limpopo River to the south. Major bodies of water include Lake Kariba on the western border with Zambia and Victoria Falls on the far western border with Zambia. Important river systems include the Zambezi, Limpopo, Runde and Save, and their numerous tributaries. There are seven internal river basins (Save, Runde, Mzingwane, Gwayi, Sanyati, Manyame, and Mazowe) whose watersheds yield 11.26 km³ of fresh water per year. In addition, the country also has 1 to 2 km³ of groundwater per year located in four aquifers: Lomagundi dolomite, Nyamandhlovu forest sandstone, Kalahari sands, and Save alluvial deposits. Thus, the country has 12.26 km³ of water available per year. Overall, groundwater presently contributes not more than 10% to the total water use in Zimbabwe.

Drought will be the biggest problem facing Zimbabwe with climate change. The IPCC suggests that the largest decreases in runoff by the year 2050 will be in the southern Africa region. Zimbabwe, among other countries, will shift into the high water-stress category as the water use to resource ratio changes with population growth and climate change.

Zimbabwe's economy is agro-based, and currently its economic development is tightly linked to a successful rainfall season. Only 37% of the country receives adequate rainfall for agriculture. Since some 80% of Zimbabwe's 13 million inhabitants are farmers, with 30% of them being city-dwellers but also engaged in agro-industry, the economic damage and human suffering associated with droughts are enormous. To date the 1991/2 drought stands as the worst. Linked to the El Nino event, Zimbabwe's temperatures reached record heights. Rainfall levels fell to just 40% of average, the water table dropped by 100-200 m, groundwater reserves (including traditional shallow wells and boreholes) dried up, and a number of rivers, reservoirs, and their related ecosystems disappeared. In this period, GDP declined by almost 8%. Also, 80% of Zimbabwe's electricity supply comes from the Lake Kariba dam, making not only agriculture but also electricity supply reliant on sufficient water.

Recent projections of precipitation and runoff in Africa suggest that up to 10% drop in precipitation is possible in most of southern Africa (including Zimbabwe) by 2050 (Wit and Stankiewicz, 2006). A 10% decrease in precipitation would reduce drainage by 17% in regions with 1000mm of rain per year, whereas in regions receiving 500-600 mm a year such a drop would cut 50% to 30% respectively of surface drainage. High and rising temperatures would also increase evaporation of water.

3. International and Domestic Legal Frameworks

The design and implementation of the water sector legal frameworks in examined non-Annex I countries is much weaker than in the Annex I countries studied in the Part I paper (Levina and Adams, 2006). The existing legal provisions that govern the water resources sector in the four developing countries are not clear and strong enough to address already existing challenges of the water sector and provide for an effective and efficient water management. The overall weakness of the legal foundation contributes to the unsatisfactory management of water resources and to the vulnerability of the water sector to climate variability and change.

A fundamental adaptation process (as opposed to fragmental adaptation actions) to climate change in these countries should start with resolving the key issues of legal water abstraction rights. A system that accounts for all water users and allocates water based on specific principles of water availability, beneficial use, environmental conditions of the water source and others is crucial for effective water management especially in the conditions of water scarcity. This is not easy given a huge emphasis on agriculture in these countries and numerous small water users and a history of not pricing water.

Integrated water resources management coupled with a well thought-through land use management approach is another key legal provision that is essential for adaptation. Some of the examined countries have these provisions on paper, however implementation of these rules is very weak, and there is almost no enforcement.

3.1 Water rights

A provision of water abstraction rights in one of the fundamental legal acts that govern management of water resources. First of all, it authorises the use of water which is a common good, and secondly, it sets principles (conditions and requirements) for water use. A system of water abstraction rights becomes especially important when water resources are scarce and have to be shared by multiple users.

A flexible system of water abstraction permits that accounts for all water users and provides mechanisms for water sharing (e.g., trading) is fundamental for adaptation in the water sector. None of the countries examined here has a comprehensive and well functioning system of water rights, although Mexico is making significant progress by implementing its 1992 legislation that introduced a comprehensive system of abstraction permits. Some Argentinean provinces have also made efforts to improve their systems of water abstraction concessions. All four countries used to have water allocations based on riparian water rights⁵ that were granted to land owners. Two countries, India and Zimbabwe, had riparian water rights systems with elements of prior appropriation doctrine⁶. Both systems were based on the principle of first in time first in right. For example, the Zimbabwe Water Act of 1976 allowed for water rights to be granted through the Priority Date system and in perpetuity, which meant that most rights were held by commercial farmers who had farmed the land since colonial times. Emergent commercial users and communal farmers had little chance of obtaining water rights (Sithole, 2001).

⁵ Riparian water right is the right to use water based on the ownership of the land adjacent to a natural watercourse.

⁶ Prior appropriation doctrine is the rule that grants senior water rights to the first user that claims it. It may or may not be associated with the ownership of the adjacent land.

Reforms in late 1990s of the water sector in Zimbabwe, India and Mexico brought many changes to the water management in these countries.

Zimbabwe

In Zimbabwe, the riparian rights have been replaced by statutory rights that eliminated ownership or possession of riparian land as a prerequisite to the claim and exercise of water abstraction rights (FAO, 2002). Water is no longer private and belongs to the State. Water abstraction permits give a person a legal right to use water and not to own it. Permits are time-limited. Time-limited licenses increase flexibility and allow abstraction to be stopped when water levels become too low. Removal of the private ownership of water and the preferential rights of water owners should allow more equal access to water, which will be important as precipitation patterns change.

The 1998 Water Act, the main water legislation in Zimbabwe, states that a water abstraction permit shall be valid for a period of twenty years or such shorter or longer period as a catchment council may decide. Currently, it has been suggested that permits be reviewed by catchment councils every five years. The Water Act also specifies conditions under which a permit may be amended or cancelled by the catchment council depending on how beneficial is the use to which the water is being put. This is a big step in the struggle for levelling the playing field for all water users. What it implies is that an opportunity has been created to review the allocations to different users and adjust them based on an assessment of the usefulness of the use of water. In some cases, this might free up a significant volume of water for other users to take up. However, real implementation of this new system of water permits is still very weak due to the lack of institutional and technical/monitoring capacity.

Mexico

In Mexico, a legal system of water rights was introduced in 1992-1994 to address the situation of water scarcity, pollution and conflicts among users. The overall goal of this system is a comprehensive accounting of all water uses. By December 2000, about 320,000 users had been granted abstraction permits in Mexico, which were recorded in the Water Rights Public Register (WRPR). In comparison, before 1992 only 2,000 users had a formal concession to use water (Bruns et al., 2005). However, the downside of this success story is that the total volume granted in many river basins and groundwater aquifers exceeds water availability. On the other hand, water abstraction and wastewater discharge levies that are incorporated into the system of water rights have contributed to increased water use efficiency. The tariffs for water abstraction depend on the specific use and the relative scarcity of the water source. They also contribute substantially to funding of water management. The levies represent - with the exception of 1998 - more than 50% of the National Water Commission's annual expenditures of around US\$1 billion (Bruns et al., 2005).

India

India does not have any explicit legal framework on water rights. Individual rights to both surface and ground water are recognized indirectly through land rights. Irrigation acts do not allow moving canal waters (surface water) to non-canal areas. So for groundwater a "water right" is similar to a property right, while for surface water it is more of a use right. Control over groundwater at the field level is governed by a system of rights as determined by farm size, the depth and number of wells, pumping capacity and economic power (Saleth, 2004). The lack of a clear system of water permits and legal provisions for water sharing creates frequent water conflict situations in India.

Table 3 gives a summary of recent conflicts over water in India.

Table 3. Summary of recent water development conflicts in India

Year	Location	Description	Information Source(s)
2000	Gujarat, India	Water riots reported in some areas of Gujarat to protest against the government's failure to arrange adequate supply of tanker water. Police are reported to have shot into a crowd at Falla village near Jamnagar, resulting in the death of three and injuries to 20 following protests against the diversion of water from the Kankavati dam to Jamnagar town.	FTGWR 2000
2002	Kashmir, India	Two people were killed and 25 others injured in Kashmir when police fired at a group of villagers clashing over water sharing. The incident took place in Garend village in a dispute over sharing water from an irrigation stream.	The Japan Times 2002
2002	Karnataka, Tamil Nadu, India	Continuing violence over the allocation of the Cauvery River between Karnataka and Tamil Nadu. Riots, property destruction, more than 30 injuries, arrests through September and October.	The Hindu 2002; The Times of India 2002.
2004	Sriganganagar, India	Four people were killed in October and more than 30 injured in November in ongoing protests by farmers over allocations of water from the Indira Gandhi Irrigation Canal in Sriganganagar district, which borders Pakistan. A curfew was imposed in the towns of Gharsana, Raola and Anoopgarh.	Indo-Asian News Service 2004

Source: Gleick, P., 2004

Argentina

Argentina has a riparian water rights system. There is no Water Code or Law of a national scope. The Republic's civil code, besides indicating various restrictions on the use of water, limits itself to indicating *concessions* as means of acquiring the right to use water. According to the Argentinean Constitution, provinces have authority over their water resources. With the exception of the province of San Luis, all other provinces adopt regulations that are based on a rather rigid framework sponsored by the Legal Principle of Inherent Rights. The Legal Principle states that water may only be used on the adjacent land and at the originally granted volume (World Bank, 2000a). Since non-transferable water rights are assigned to a piece of land in a specific amount whether used or not, this system does not encourage efficient water use and does not provide for water sharing among various users through transfer or purchase of rights.

Discussion: The examination of existing water right systems in the four case study countries demonstrates that these systems are not flexible (Argentina, India) or not sufficiently developed or implemented (Mexico, Zimbabwe) to be able to react to changing climatic conditions or even variations in weather. Riparian doctrines of Annex I countries that are not accompanied by abstraction permits and water trading provisions have similar shortfalls in regard to adaptation. Experiences of some of the Annex I countries which are trying to address this shortcoming may be very useful for developing countries. Examples of specific features built into existing systems of water abstraction rights that would facilitate adaptation to climate change in the water sector include: the UK provisions limiting water abstraction permits to 12 years and allowing watershed based trading; California's experience with water contracts; and an apportionment principle introduced in Canada to resolve inter-provincial and international disputes over water, (see details in Levina and Adams, 2006).

Conflicts over water are present in all the examined countries and strong legal provisions do not yet exist to handle these conflicts on a consistent basis. However, various arrangements are used for resolving conflicts at different levels. For example, *India* specifies water use prioritization that can provide a general framework

for resolving inter-sectoral water allocation conflicts. The order is as follows: drinking water, irrigation, hydropower, ecology, agro-industries and non-agricultural industries, navigation and other uses. In India the National Water Policy states that allocation systems should follow this prioritisation framework in a broad sense, but also allows for area/regional specific considerations that could require the priorities to be modified (Government of India, 2002). Inter-state conflict resolutions in India often rely on past negotiated agreements for developing/sharing water among concerned states/regions. When there is a difficulty in reaching the agreement, the concerned parties can rely on the tribunal established by the central government under the provisions of the Inter-state Water Disputes Act of 1956.

Argentina uses agreements for water abstraction. For example, there is the “Unique Programme for Enabling of Irrigation Areas and Distribution of the Colorado River Discharges”⁷ agreed by the five riparian provinces, on the basis of the results of specially developed optimisation and simulation models. In case of low flows, the Programme states that the structure of distribution of water among the provinces should be respected and, for extraordinary low-flow conditions declared as such by the law, priority will be given to those crops (among all the affected crops) that suffer the biggest damage.

Box 1. Water markets in Mexico and India

Mexico sets a very important example in allowing trading of water abstraction rights. Users are free to trade their rights within irrigation districts, with no intervention from the National Water Commission. Users are also free to transfer their rights when the user changes or within areas specially designated by the Director General of the Commission. All such transactions must be registered. All other transactions are subject to approval. Areas where water rights could be transferred separate from land property were prescribed through a presidential decree and a notice in the Gazette from the Commission Director General. This flexibility is very important in resolving situations of mismatch between water demand and supply and will play an increasingly important role in conflicts over water that are likely to increase with climate change.

So far, 510 trades have been registered in the Water Rights Public Registry for a total yearly volume of 143.27 million m³, mainly in dry regions or areas with tight water balances. The largest number (222 transfers, 47 million m³) has been within irrigation users and the largest volume (61 million m³, 40 transfers) has been from industry to industry. Water markets are considered to be a useful tool to allocate water more efficiently. However, presently in Mexico the water abstraction system is not entirely implemented yet for the water markets to be fully enforced. It is envisioned that the system would be based on computerised watershed and hydrological balances to provide certainty to the buyers that the water rights represent actual availability of water.

In **India**, *de facto* groundwater markets exist between agricultural landowners. The system is unbalanced because there are more buyers than sellers, and the buyers tend to be small farmers without a strong bargaining position. In some areas it is estimated that 80% of irrigated land is irrigated by water from groundwater markets, (Saleth, 2004). Since there is no system of water abstraction rights or permits, groundwater markets encourage over-abstraction from the aquifers. They also increase the inequity between large influential farmers and smaller, less resource-rich farmers (Saleth, 2004). There are also water-based tenancy contracts which are contracts between the water supplier and other farm inputs such as labour, land or capital. However, without a system of water abstraction rights, market-based mechanisms can further contribute to aquifer depletion. When there is no regulation on how much water can be abstracted, but water trading is possible, there is a tendency to over abstract so that more profit can be gained from water sales. All of these markets could be co-opted for water efficiency if they were incorporated into the right legal framework, with water use quotas assigned to each abstractor that could then be traded.

⁷Programa Único de Habilitación de Áreas de Riego y Distribución de Caudales del Río Colorado

Various forms of markets are used to facilitate access to water in Mexico and India. In Mexico, water markets are authorised by legal acts while in India they have an informal character and are not regulated.

In the absence of legal provisions for water sharing, traditional structures and approaches play an important role in resolving conflicts over water and facilitating access to water. There are several examples of the use of traditional tools in India and Zimbabwe.

Box 2. Traditional approaches in India and Zimbabwe

Micro-level water conflicts may be resolved through informal/traditional village level institutions, formal village councils and water user associations. Both India and Zimbabwe have traditional community-based rules and institutions that are used for resolving micro-level conflicts over water. In India, informal or traditional water rights for individuals and groups have existed since ancient times and continue (in a much weaker form) even today. For example, there is a water distribution roster which is practiced in western Maharashtra. Here the irrigation canal authorities issue time limited 'water passes' on first come-first served basis. Priority is based loosely on their duration, and they are non-transferable and contain quantitative specifications (Saleth, 2004). These community managed water distribution systems distribute the available water among all its members through well-accepted norms. These are generally good for adaptation purposes because they allocate water using councils and after taking into account current water levels.

In Zimbabwe rural communities also rely on their indigenous institutions and rules to share natural resources. During water shortages, not only water volumes but the type of water use is regulated. For privately owned wells, dug by the landowner or his predecessor, kinship ties (i.e. extended family) are used to access the water. An unwritten system whereby use of the water pump is paid back through other kind of labour is also important (Nemarundwe and Kozanayi, 2002). The value of these community-based mechanisms should not be underrated especially in areas where a reliable water supply is not available. (Sithole, 2001)

3.2 Domestic legislation

Domestic legislation addresses many aspects of water management and sets the rules for the sector that will also apply to adaptation efforts. The legal system of water resources management is not comprehensive and fully enforced in the examined countries. However, there are basic water laws that assign responsibilities for water management among various agencies, address water pollution issues and encourage integrated water resources management based on watershed.

Zimbabwe and Mexico have national level water laws, while Argentina assigns all responsibility for water resources management to provinces. India does not have any separate and exclusive water laws, but there are water-related legal provisions dispersed across various irrigation acts, central and state laws, provisions in the constitution, orders/decrees of courts, customary laws, and various penal and criminal procedure codes, (Sharma et al., 2006). As most of the water related legal provisions enacted in the past were characterized by water surplus conditions, they fail to reflect the current conditions of increasing water scarcity.

Argentina: In Argentina, where provinces have all the authority over water, provincial legislation is concerned with water use and registration, establishing water policies and principles for regulating water as a natural, environmental and economic resource. Most provinces have specific legal acts related to water resources. During the last third of the 20th century, laws were promulgated to regulate concepts such as water policy and planning, water emergencies, water risk areas, bioenvironmental impact, interprovincial waters, surface water sources and aquifer protection (Magnani, 2001). All provinces require water use concessions that are based on premises of beneficial and non-detrimental to other users use of water. It is common for provincial legislation to set priorities for water use, in accordance with the territory's economic use (World

Bank, 2000b). Various literature sources refer to inefficient and ineffective provincial legislations and inter-provincial agreements on water and call for a need of a national law in Argentina. On the other hand, a recent Law N° 25688 'Regime for Water Environmental Management', promulgated at the national level and pending regulation, also came against much criticism because it is deemed to be unconstitutional as it takes over provincial competences, i.e. water (Pochat, et al., 2006). To address the issue of inconsistent provincial regulations regarding water resources a project was launched in May 2005 that calls for "Adopting Argentina's Water Policy Leading Principles and other related matters as guidelines for the Nation's Policy". This project is an outcome of the *Federal Water Agreement*⁸ which was signed in September 2003 by most jurisdictions. Most provinces have also explicitly committed themselves to compatibilise and implement these principles in policies, legislations and management of water in their respective jurisdictions.

Zimbabwe: In Zimbabwe the devastating effects of the 1991/92 drought gave impetus for the reform of the water sector. The reforms culminated in 1998 with the passage of the National Water and National Water Authority Acts. The National Water Authority Act sets an administrative structure of water management and sets up the Zimbabwe National Water Authority. The National Water Act provides the legal bedrock for this sector and incorporates such provisions as time bound water permits, their administration by catchments councils, polluter pay principle, allocation of water for environmental purposes, drought preparedness, and others.

Mexico: Mexico has a Law for National Waters (LAN⁹) that establishes the legal and regulatory framework needed to manage scarce water resources (González et al., 2006). At present the LAN does not include clear statements regarding climate change, but its existence means that there is a framework into which adaptation can be easily incorporated. Through the LAN, special administrative and reserve zones can be established by decree where over-use, water quality or drought necessitates special action to be taken to preserve the environment or water supplies. The LAN also established the new water rights administration system discussed above in Section 3.1. The stated objective of the law is "to regulate the extraction, use, distribution and control of the nation's waters as well as preserve their quantity and quality in order to achieve sustainable integral development".

India: In the absence of a special national legislation on water resources, the Union Ministry of Water Resources (MOWR) formulated India's first National Water Policy (NWP) following the unprecedented drought of 1987. The NWP laid out the approaches of the Central and State Governments on water resources planning, development, allocation and management. The NWP did not suggest any major economic and institutional changes for better management of the resources and soon became redundant. A new NWP was agreed in 2002, which in addition to the earlier provisions recognized the role of private sector participation and the need for a paradigm shift from resource development to efficient utilization of the developed resources. However, it did not fully incorporate the current level of thinking with regards to effective basin management. This policy also failed to address the economic and institutional issues that are constraining the water sector in India such as acute scarcity of funds for renovation/ repairs of a deteriorating irrigation infrastructure and funds for completion of a large number of on-going irrigation projects. (Sharma et al., 2006) To resolve inter-state water disputes, the Water Disputes Act of 1956 was established that gave an important role to the central government in resolving water disputes. The analysis indicates that existing legislation is not sufficient to resolve water quantity and quality issues between states in India, (Sharma et al., 2006).

The examined countries have other national and sub-national laws relating to water management. All of these countries have regulations regarding water quality. For example, the Environment Management Act (2002) in Zimbabwe provides a legal foundation for sustainable management of natural resources, prevention of pollution and environment degradation, and for preparation of national and other environmental management plans. The act also gives the Environmental Management Agency the authority to set and enforce effluent water standards. Mexico has state laws that regulate potable water and sewage. It also has national standards

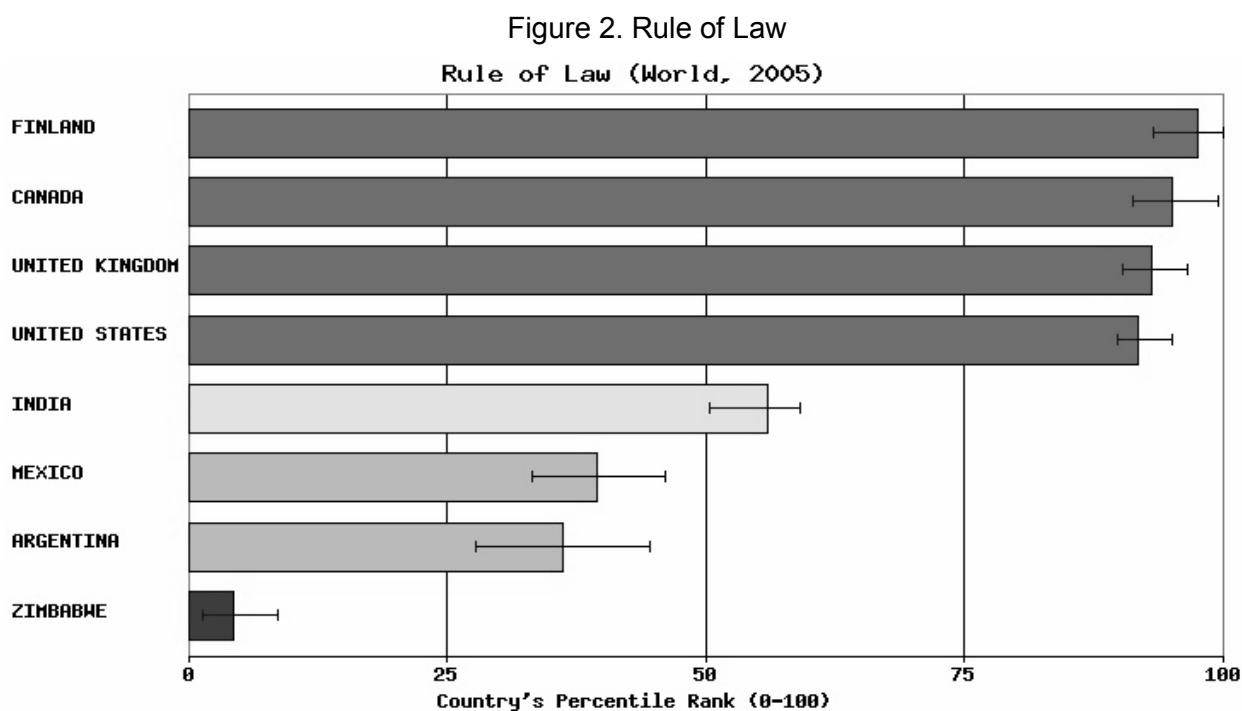
⁸ Acuerdo Federal del Agua

⁹ Ley de Aguas Nacionales

for allowable levels of various pollutants in potable water. There are also secondary pieces of legislation that encourage water conservation.

Legislation regarding specific provisions on wetland management is very important for countries vulnerable to floods. Argentina, India and Zimbabwe already experience significant damages from floods and are projected to be even more susceptible to floods due to climate change. However, none of these countries have strong and enforceable legal provisions regarding floodplains. In Zimbabwe legislation both under the Water Act (1998) and the Environment Management Act (2000) forbids the cultivation of wetlands (dambos) and stream banks, but due to the variability in rainfall and the presence of fertile soils in these zones subsistence farmers have continued to work in these restricted areas. The extent of enforcement is limited since there are conflicting provisions authorising these areas as food producing zones in cases of droughts. There has been a move to ensure that wetlands are sustainably managed, which would require a localised management of each particular wetland.

Real implementation and enforcement of many of the existing laws and regulations is weak. Figure 2 below provides the World Bank's ranking of countries on their performances on the rule of law. Percentile rank indicates the percentage of countries worldwide that rate below the selected country (subject to margin of error). The figure includes four Annex I countries from the previous study for comparison. The figure gives some indication of how laws are respected and implemented in general.



Source: World Bank, 2006. Kaufmann D., A. Kraay, and M. Mastruzzi 2006: Governance Matters V: Governance Indicators for 1996-2005¹⁰

Laws that encourage integrated water resources management, water quality and water savings will facilitate adaptation to climate change when they become truly operational and enforceable. It is clear that many issues

¹⁰ The governance indicators presented here reflect the statistical aggregation of responses on the quality of governance given by a large number of enterprise, citizen and expert survey respondents in industrial and developing countries, as reported by a number of survey institutes, think tanks, non-governmental organizations, and international organizations. The aggregate indicators in no way reflect the official position of the World Bank, its Executive Directors, or the countries they represent. Countries' relative positions on these indicators are subject to margins of error and should be taken into consideration when making comparisons across countries.

surrounding water - its availability, uses, rights distribution, etc. - still need to be resolved by the examined countries.

3.3 Transboundary water issues

Argentina, Mexico, India and Zimbabwe share waters with other nations and participate in international agreements relating to these shared bodies of water. International treaties on water bodies are important tools that allow all countries to resolve disputes over water in a constructive way. Treaties are also important adaptation tools since they provide frameworks for accountable and sustainable water use and sharing. With projected impacts from climate change such as increased incidents of low runoffs, droughts and floods in the examined non-Annex I countries, international treaties and their specific provisions will become even more important.

Since 1814 about 300 international treaties have been negotiated worldwide to deal with non-navigational issues of water management: flood control, hydropower projects, and allocations for consumptive or non consumptive uses in international basins (Hamner et al., 1998). There are around 145 treaties dating from 1870 and later which deal with water per se, excluding those which deal only with boundaries, navigation, or fishing rights. One hundred twenty-four of these treaties (86%) are bilateral, twenty-one (14%) are multilateral (Hamner et al., 1998).

Most treaties focus on hydropower and water supplies, thirteen focus on flood control. More than half of all the treaties have provisions for monitoring. Just over one third of the treaties clearly defined allocation agreements. Of that number, fifteen treaties specify equal portions, and thirty-nine provide a specific means of allocations. It has been observed that the treaties which specify allocations often favour "needs based" allocation (based on irrigable land or population, for example) rather than "rights-based" ones. They do not explicitly use economic benefits in deciding on allocations, although economic principles have helped guide definitions of "beneficial" uses. Only three agreements deal with groundwater supply. Treaties that focus on pollution usually mention groundwater, but do not quantitatively address the issue. Treaties which allocate water also include payments for water; forty-four treaties include monetary transfers or future payments. Treaties also recognize the need to compensate for hydropower losses and irrigation losses due to reservoir storage.

Argentina is a signatory to the Treaty of the La Plata Basin together with Bolivia, Brazil, Paraguay and Uruguay. The Treaty is a general framework that can be supplemented with specific bilateral and multilateral agreements. The Treaty promotes reasonable utilisation of water resources, especially by means of the regulation of watercourses and their multiple and equitable development. Argentina and Chile created the *Argentinean-Chilean Working Group on Shared Water Resources*¹¹ to perform inventory and management planning activities in the numerous basins with shared water resources by both countries. Argentina and Paraguay have agreed on an equitable distribution of the Lower Pilcomayo River Basin discharges towards their respective territories, equivalent to about 50% for each one of the countries. Droughts are frequent in the Lower Pilcomayo River Basin due to low flows in winter months. This river is characterised by a very irregular annual regime and, at the same time, the transport of a very large amount of sediments, which causes the interruption of its bed and a very variable distribution of water over the Argentinean and Paraguayan banks.

India is a signatory to nineteen Treaties that deal with transboundary water issues, thirteen of them deal directly with water quantity¹². For example, India has signed four agreements with Nepal regarding the Kosi River. It also has agreements with Pakistan. In 1960, India signed the Indus Waters Treaty with Pakistan which restored an equitable distribution of water between India and Pakistan. The Indus System of Rivers

¹¹Grupo de Trabajo Argentino-Chileno sobre Recursos Hídricos Compartidos

¹² www.transboundarywaters.orst.edu/publications/.

comprises three Eastern Rivers - the Sutlej, the Beas and the Ravi; and three Western Rivers - the Indus, the Jhelum and Chenab. With minor exceptions, the treaty gives India exclusive use of all of the waters of the Eastern Rivers and their tributaries before the point where the rivers enter Pakistan. Similarly, Pakistan has exclusive use of the Western Rivers. Pakistan also received one-time financial compensation for the loss of water from the Eastern Rivers. The countries agree to exchange data and co-operate in matters related to the treaty. For this purpose, the treaty created the Permanent Indus Commission, with a commissioner appointed by each country.

Zimbabwe has signed four agreements with Zambezi regarding the Zambezi River, one of them deals with water quantity.

Mexico has a long history of water agreements with the US. Back in 1889 a special International Boundary and Water Commission (IBWC) was established to manage the boundary and water treaties between the United States and Mexico and settle differences that may arise out of these treaties. The IBWC is an international body composed of the United States Section and the Mexican Section, each headed by an Engineer-Commissioner appointed by his/her respective president.

The two Governments through the IBWC jointly administer the terms of the 1944 Water Treaty relating to the Colorado River, which provides that (a) a guaranteed annual quantity of 1,850,234,000 cubic meters is allocated to Mexico, and (b) any other quantities arriving at the Mexican points of diversion with certain conditions stipulated in the 1944 Treaty.

The application of these terms began in 1950. The procedure is as follows: Mexico, before the first of each calendar year, presents through the IBWC an annual schedule of requested deliveries by months, within the Treaty annual allotment and specified rates. Mexico also submits a weekly schedule of deliveries by day, within the monthly amounts scheduled. Mexico's requests are transmitted by the United States Section to the Bureau of Reclamation, which makes the releases as necessary from the United States storage works on the Colorado River to fulfil the delivery schedule. The deliveries to Mexico are jointly monitored by the IBWC to ensure compliance with the Treaty allotment and schedules.

The 1944 Water Treaty between Mexico and the US gives an example of how international water treaties might evolve with time depending on climate conditions. New strategies and programs of the IBWC have been developed in response to the emerging circumstances and necessities. For example, additional provisions for protection from floods were added to the original agreement later and proved to be necessary. A possible reform of the treaty of 1944, is now being discussed by the governments of Mexico and the United States in order to deal with issues that did not exist (e.g., drought) in 1944 (Alamo, U., et al., 2005). In 2002 both governments signed the agreement regarding water conservation to address water scarcity resulting from population growth and frequent droughts. The textbox below provides a fragment of this agreement.¹³

¹³ Source: www.nadb.org

Box 3. The US-Mexico water agreement

BOARD DOCUMENT BD 2002-3
STATEMENT OF PRINCIPLES
NADB WATER CONSERVATION INVESTMENT FUND

The U.S.-Mexico border region is characterized by a predominantly arid climate, and this, together with increasing economic and population growth, have progressively strained existing water supplies in the U.S.-Mexico border region. In recent years, drought has afflicted important parts of this region and caused economic hardship. Increased water consumption due to economic and population growth has caused increased ecological strain on important binational rivers, such as the Rio Grande and Colorado River, which generally run dry before they reach, respectively, the Gulf of Mexico and the Sea of Cortez. Finally, in parts of the border region, aquifers are being exploited at unsustainable rates.

In both the U.S. and Mexico, agricultural producers are generally the largest consumers of water, using approximately 80% of the water in the region. These producers generally do not pay a market cost for the water they use, and water use in the agricultural sector has a tendency towards inefficiency. Many experts agree that application of improved technology and changes in practices, particularly in the agricultural sector, could save significant amounts of water in both countries. Such salvaged water could be put to a range of uses, such as to comply with obligations under the 1944 Treaty Relating to the Utilization of the Waters of the Colorado and the Tijuana Rivers and the Rio Grande between Mexico and the United States (the "1944 Treaty"), to supply water to growing urban areas and industries, and to ensure sufficient river flows to maintain water-dependent ecosystems.

In June, 2002, the Governments of Mexico and the United States reached an agreement under IBWC Minute 308 with respect to Mexico's obligations under the 1944 Treaty to deliver certain quantities of water into the main channel of the Rio Grande from six treaty tributaries, one-third of which is allocated to the United States. Related to this agreement, Mexico intends to carry out a water conservation program to modernize and upgrade irrigation districts and units in the Rio Grande basin, as well as promote water conservation in its border communities.

To help finance this program in Mexico, as well as water conservation projects on the U.S. side of the border, the two governments agreed to support use of North America Development Bank resources to finance infrastructure investments and technical assistance to conserve water and increase water use efficiency.

4. Institutional Landscape

4.1 Governance

Three of the four examined countries have federal governance structure. Argentina, Mexico and India are governed by a federal government and numerous regional (state and provincial) governments with independent institutional and legal systems. In Zimbabwe central government forms policies and delegates their implementation to regional offices. While federal governance structure provides flexibility in the way water is managed in various regions and allows for local conditions to be considered, a top-down way of policy development still prevails in all the examined countries. There are many factors related to the institutional framework that contribute to the inefficiencies of water management in the case study countries, including lack of clarity in division of responsibilities, lack of communication and co-ordination among agencies, a very limited involvement of local stakeholders, and deficiency of financial resources. These same drawbacks will impede adaptation to climate change.

Both Mexico and Zimbabwe are making efforts of transforming from centralised top-down system towards a much more decentralised one where sub-national structures have greater roles. In *Mexico* the National Water

Commission (CAN) has been set up to modernise and decentralise the management of the nation's water resources (OECD 2003). The main principals have been the inclusion of all uses and preservation of the environment. One of the Mexican States, Guanajuato took the lead in terms of requesting autonomous responsibility for water. This state has very low water availability per capita, as annual cubic meters per person have fallen from 1,500 m³ in 1970 to 750 m³ in 2000. The State established a State Water Commission in 1991 as a decentralised public entity for the provision of drinking water, sewage removal and sanitation. The state was the first to pass a law on water in 2000. Following this pioneering example, 27 States have passed their water laws, and 13 have set up water commissions.

Decentralisation in *Zimbabwe* in the water sector is implemented through the creation of the National Water Authority, Catchment Councils, and through establishing their linkages with the Rural District Councils (RDC). Decentralisation has become a reality in terms of structure but what is unclear is the extent to which the central government has accepted to “let go” (Gumbo, 2006). This is largely due to the limited capacity to generate revenues both at Catchment and Rural Council levels. The lack of capital as well as capacity has meant that decentralisation has occurred on paper only as in reality these structures rely on handouts from central government for survival.

While decentralisation has its positive aspects, the way it is implemented may have adverse implications. In Zimbabwe, the danger that arises is that of having new institutions operating independently from existing local governments and traditional authorities creating even greater complexity and ambiguity. In some cases the decentralised institutions are there but the central government is unwilling to delegate responsibilities (Sithole, 2001). The decentralisation promoted by the CAN in Mexico follows the geographical distribution of water resources, with basins that cover several states. While river basin management approach is an effective and progressive policy tool, it introduces discrepancy and conflicts between states in the absence of formal mechanisms for co-ordination and resolution of disputes.

The decentralised structure of *Argentina* brings other challenges. The lack of inter-institutional co-ordination and the deficiency of communication and information exchange between different agencies results in institutional gaps and overlaps, favouring the development of inter-jurisdictional and inter-sectoral conflicts (especially between competitive uses such as irrigation and hydroelectric energy generation). These conflicts have been initiated over flow quotas, management of flood water exceeding volumes and the contamination of interprovincial water courses.

In India, Argentina and Mexico, where states with some degree of autonomy exist, the problem is how to ensure that individual states or provinces work together on shared river basins and large-scale water projects.

In *Argentina*, ten River Basin Committees were set up to help co-ordinate inter-provincial activities. For example, one of these Committees supervises the “Unique Programme for Enabling Irrigation Areas and Distribution of the Colorado River Discharges”¹⁴ which provides a framework for cooperation for the five participating riparian provinces. The Committee was initially successful but its effectiveness has diminished due to the lack of funding. In addition, the federal Water Council was created in 2003 to facilitate co-ordination of water management among provinces and the federal government.

Similarly, in *India* the National Water Resources Council and the National Water Board containing high level ministers from each of the states are used to try and ease conflicts between the states. In order to achieve a consistent level of adaptation across the country in a decentralised system, and in order for large scale water projects (e.g. inter-basin transfers) to take place, states/provinces must work together and some central oversight/co-ordination may be required for this to occur.

Decentralisation can lead to inconsistency among states and provinces in managing water resources. For example, the model Bill to regulate and control development of ground water was developed by *Indian* central government and was circulated by the Indian Central Ground Water Board to state governments for

¹⁴Programa Único de Habilitación de Áreas de Riego y Distribución de Caudales del Río Colorado

enactment; first in 1970 and then again in 1992. It was also circulated in 1996 by the Ministry of Water Resources (GOI, 2002a). Each state has passed groundwater regulations to different degrees and only covering certain aspects of water resources, e.g. drinking water. Only one state has enacted the entire legislation.

Developing countries exhibit the weaknesses of both centralised and decentralised systems that were identified in the Annex I countries in terms of these systems' ability to address adaptation to climate change. Limited inclusion of local interests and various stakeholders in the decision-making that may be attributed to a centralised system of governance is clearly detected in the examined developing countries. Lack of co-ordination among various sub-national governments which may be attributed to a decentralised system is also prominent in these countries. The level of information sharing and especially passing it on to subordinate governments and structures is very low in the four developing countries.

While in general decentralised structures allow for more flexibility in incorporating various local interests into policy development, it is not the case in the examined countries where local communities have very little say in the decision-making processes.

General governance and its particularity in the water sector - including cooperation among governmental agencies, effectiveness of laws and regulations, transparency, sustainable financing, etc. - create either favourable or negative conditions for water management.

Table 4 below provides the World Bank's ranking of examined countries (including four Annex I countries from the previous study) on their performances on such three components of governance as: government effectiveness; rule of law; and control of corruption. Percentile rank indicates the percentage of countries worldwide (213 countries were examined in the World Bank' study) that rate below the selected country (subject to margin of error). Higher values indicate better governance ratings.

Table 4. Selected governance indicators

	Argentina	India	Mexico	Zimbabwe	Canada	Finland	UK	US
Governance, 2005 (percentile rank)								
Rule of law	36.2%	56.0%	39.6%	4.3%	95.2%	97.6%	93.2%	91.8%
Control of corruption	41.9%	46.8%	43.8%	5.4%	94.1%	99.5%	94.6%	91.6%
Government effectiveness	46.9%	56.9%	59.3%	10.5%	95.7%	96.2%	94.3%	93.8%

Source: World Bank Governance Indicators 2006

The World Bank's ranking relates to governance in general, and not particularly to the water sector, but it gives an indication of the governance cultures in the examined countries. According to the World Bank's ranking, four non-Annex I case study countries are placed much lower than four Annex I countries of the previous study on the scale of the quality of governance. While all four Annex I countries rank in the top 90% in their government effectiveness, rule of law and control of corruption, four non-Annex I countries are situated below 50% mark (for the most part). There is also a significant difference among the non-Annex I countries. India ranks at 56% in two indicators: rule of law and government effectiveness. Mexico ranks at almost 60% in government effectiveness. While Zimbabwe is placed almost at the bottom of the list regarding the rule of law and control of corruption, reaching only 4.3% and 5.4% respectively for the two mentioned indicators.

4.2 Key players

The water sector in developing countries is as complex as it is in the Annex I countries in terms of the number and diversity of different players that are involved in water resources management at different levels.

Potentially all of these players need to be exposed to the concepts of climate change and adaptation. The weaknesses that are identified in institutional structures of the four developing countries contribute to these countries' vulnerability to climate change and will impede adaptation.

4.2.1 National institutions

The administrative structure at the national level is quite diverse and comprehensive in the examined non-Annex I countries. All of them have national level institutions that are responsible for various aspects of water management from general planning to regulation of irrigation, environmental, and other issues. Given the leading and coordinating role that these organisations play in water resources management, they are well positioned to provide leadership in adaptation of water resources to climate change. Unclear institutional responsibilities, lack of co-ordination and cooperation among national level institutions and between national level and sub-national level institutions create unfavourable conditions for adaptation. Competing immediate priorities and lack of funding also push adaptation to long-term climate changes to the bottom of priority lists. Integration of adaptation into decision-making in developing countries will be a difficult process given all the barriers mentioned above. On the other hand, however, developing economies might offer more opportunities for integration of adaptation measures into new infrastructure and water policies since the development decisions that are being made now can be informed by the latest findings on changing climate.

In **India** the following organisations are responsible for water resources management at the national level: Union Ministry of Water Resources (MOWR) - the national organisation that is responsible for overall planning and management of the water resources in the country; Central Water Commission (CWC), the Central Ground Water Board (CGWB) and the National Water Development Agency (NWDA) – all under the MOWR – provide the overall monitoring and technical support; Indian Council of Agricultural Research (ICAR); and the Planning Commission, which provides project clearance and approves financial allocation to various water (irrigation/ hydropower/ multipurpose) projects in different states.

There are also important organisational arrangements to achieve inter-state and centre-state co-ordination. These include various river boards created under the River Boards Act of 1956 and the National Water Resources Council (NWRC) set up in 1983, and the National Water Board (NWB) set up in 1990. The NWRC is an important policy organ in the Indian water sector as it is the apex body chaired by the Prime Minister and includes the Union Minister of Water Resources and the Chief Ministers of each state. The NWB – considered as executive arm of NWRC and is chaired by the Secretary of MOWR and includes the Chief Secretaries of all the states, secretaries of the concerned Union ministries as well as the Chairman of CWC.

In **Argentina** the main national organisation for water resource management is the Undersecretariat of Water Resources (SSRH)¹⁵, in the Secretariat of Public Works (SOP) in the Ministry of Federal Planning, Public Investment and Services (MPFIPyS)¹⁶. Its objectives, among others, are: elaboration and execution of the national water policy and the proposal of the regulatory framework regarding water resources, relating and coordinating the actions of the other jurisdictions and organisations involved in water policy; the elaboration and execution of programmes and actions related to the management of shared international water resources and interprovincial water regions; the formulation and execution of infrastructure, and development of water programmes and actions.

Many other national organisations are involved in water resource management, including Ministry of Internal Affairs (MI)¹⁷, Ministry of Foreign Affairs, International Commerce and Cults (MRECLyC)¹⁸, Secretariat of

¹⁵ Subsecretaría de Recursos Hídricos.

¹⁶ Secretaría de Obras Públicas, in the Ministerio de Planificación Federal, Inversión Pública y Servicios

¹⁷ Ministerio del Interior

¹⁸ Ministerio de Relaciones Exteriores, Comercio Internacional y Culto

Agriculture, Livestock, Fisheries and Food¹⁹ in the Ministry of Economy and Production (MEP)²⁰, Secretariat of Energy²¹, Dam Safety Regulator (ORSEP)²², Secretariat of Environment and Sustainable Development (SAyDS)²³ in the Ministry of Health and Environment (MSyA)²⁴, and others.

In *Mexico*, in accordance with the National Water Plan and the Law for National Waters, the National Water Commission (CNA) was established to modernise and decentralise the management of the nation's water resources considering all uses and the preservation of the environment. The CNA was created to unite all aspects of water management. CNA has a central office located in Mexico City and has recently decided to reorganise CNA's regional dependencies into 13 regional offices with their boundaries being located along river basin boundaries. CNA had functioned in a centralised way, but has recently adopted and is currently implementing a policy whereby the Central Office functions will include oversight of water management activities and establishment of overall policy, criteria and uniform guidelines and procedures; and the Regional Offices will have principle responsibility for water management, including: development of hydrographic regional plans; promotion and strengthening of basin councils; co-ordination of water resources planning and management activities both by public and private sector participants; water quantity and quality monitoring activities; reservoir operation; the registry of water users into the National Public Water Rights Register; and dam safety.

Other public and private entities, including the Federal Electricity Commission (CFE²⁵), which operates reservoirs, must do so with CNA authorisation and oversight. CFE operates 64 dams with hydroelectric plants. The Director General of CNA presides over a Technical Committee for the Operation of Hydraulic Works. The committee makes overall decisions relative to the operation of the nation's reservoirs including considerations related to floods, droughts, multiple uses (irrigation, municipal and industrial, hydropower, navigation, recreation, etc.) and environmental protection. At the national level, a federation of water user associations (WUAs) called the National Association of Water Users (ANUR²⁶) has been established and represents WUAs in negotiations with CNA, and Secretariat of Agriculture, Livestock, and Rural Development (SAGAR²⁷). CNA is the supervising organisation for the operation, maintenance, and management of the transferred infrastructure and equipment. CNA also provides WUAs with technical assistance in carrying out operational activities.

In *Zimbabwe* the Department of Water Development, under the Ministry of Water Development, is responsible for policy formulation and standards for planning, water pricing, management and development. The Ministry of Water Development is custodian of water rights (Gumbo, 2006). The Zimbabwe National Water Authority (ZINWA), also under the Ministry of Water Development, is involved in the practical application of water pricing systems and the management of water resources. It also provides technical assistance to the Catchment Councils (Mtisi and Nicol, 2003). There are many other institutions at the national level that are involved in water management, however, their various roles are not necessarily complementary (Gumbo, 2006) These institutions include Ministry of Agriculture and Rural Development, Agriculture and Rural Development Authority, the Ministry of Water Development, Ministry of Local Government, Public Works and National Housing, Ministry of Environment and Tourism, and others.

¹⁹ Secretaría de Agricultura, Ganadería, Pesca y Alimentos

²⁰ Ministerio de Economía y Producción

²¹ Secretaría de Energía

²² Organismo Regulador de Seguridad de Presas Dam Safety Regulating Organism

²³ Secretaría de Ambiente y Desarrollo Sustentable

²⁴ Ministerio de Salud y Ambiente

²⁵ Comisión Federal de Electricidad

²⁶ Asociación Nacional de Usuarios de Riego

²⁷ Secretaría de Agricultura, Ganadería y Desarrollo Rural

4.2.2 Sub-national institutions

Sub-national institutions provide an important link between national governments and local communities. Unfortunately, in many cases, sub-national institutions are very weak and due to the lack of funding and capacity cannot fulfil their roles. In adaptation to climate change, sub-national institutions can on the one hand provide an important input for policy formulation that would incorporate local concerns and conditions, and on the other hand, facilitate implementation of national policies and strategies on the ground. Strengthening of sub-national institutions, clarifying their roles and responsibilities, and empowering them with scientific information on climate change impacts will facilitate adaptation to climate change. In addition, the concept of watershed based administration should be encouraged to facilitate integrated water resources management.

As water is a state subject in *India*, it is the states that are responsible for financing, cost recovery and management of surface irrigation and water supply related activities within their territory. Even though the states have the major responsibility for water sector financing, the central government also plays a significant role by providing finances to states through central assistance, undertaking the construction of irrigation projects of national importance and implementing schemes such as the 'Command Area Development' (developed mainly for improving productivity in canal command areas through various on-farm development activities).

In many states the administration and functional responsibilities for managing water resources are unclear and spread over a number of different government institutions (irrigation/ water resources departments, public works department, revenue departments, groundwater boards, minor irrigation corporations, pollution control boards, municipal corporations etc.), making it particularly difficult to develop an integrated approach to water management. As with many countries, water administration is based on administrative boundaries and projects rather than on hydro-geological/water basin boundaries. This gives rise to several water sharing disputes among the states sharing a common river or other water resource.

At the provincial level in *Argentina*, the institutional situation is characterised by a great diversity. Nonetheless, there are some common features. The submission of water abstraction licenses; the overseeing of reliable supply of safe drinking water; flood and drought predictions, plans, management and recovery actions; and the ownership of dams and reservoirs, among other issues, are in principle under the responsibility of the provinces. Nevertheless, given the fact that water resources are generally shared by two or more provinces and taking into account the magnitude of investments required to deal with the frequently complex water problems and the necessity of keeping an equitable distribution of available resources, the federal government has also generally played a very important role, having even had, until the beginning of the 1990s, the ownership of national companies devoted to the construction and operation of large works, such as dams.

Most of provincial water resources administrations are generally branches of different ministries: including irrigation administration, authorities or departments of water, irrigation, drinking water and sanitation. Several models have been adopted by the provinces for management of their water resources. For example, in Mendoza, the General Department of Irrigation (DGI)²⁸ is a designated water administration, appointed by the Provincial Constitution. The Province delegates water resources management to the DGI, which does the same with users' organisations for water management in their respective irrigation areas. The funds coming from tariffs charged for the concession of water abstraction rights, allow to perform an effective management of the water resources, monitor their availability and uses and deal with conflicts with low costs. In the case of the Province of Buenos Aires, a recently approved Water Code establishes an autonomous entity, the Water Authority²⁹, in charge of planning, recording concession and protecting water use rights as well as police power, among other functions. The diversity of institutions with direct involvement in water resources has generally been accompanied by a shortage of inter-institutional communication and co-ordination.

²⁸Departamento General de Irrigación.

²⁹Autoridad del Agua

The new institutional framework for *Zimbabwe's* water sector is dominated by the Zimbabwe National Water Authority, Catchments and sub-Catchment Councils. While these have compelling positions with respect to water management, there are several government institutions, quasigovernmental agencies, and non-governmental organizations that are involved in water management in general and irrigation in particular. Therefore the water system is very hierarchical in Zimbabwe with successively lower and more local levels having more 'hands-on' responsibilities in the management and allocation of water, but less or no (in the case of local water point committees) legal standing (Gumbo,2006).

Catchment Councils are based on the seven major watersheds in Zimbabwe. Since they cover very large areas, Sub-Catchment Councils were formed as a smaller management unit. At an even lower level there are water user boards and local water point committees. Catchment and sub-catchment councils are responsible for preparation of plans for the optimum development and utilization of the water resources in their areas, development of an inventory of water resources of their catchments, and major water uses within the river system, development of recommendations for water allocation, and other. These functions are fundamental to the success of the management framework of water in Zimbabwe; however, technical capacity of the employees is not sufficient to perform these functions. Furthermore, the boundaries of sub-catchment areas (ecological river catchment boundaries) and even the main catchments themselves do not coincide with district and provincial boundaries making coordinated planning a difficult task. Largely, this has set the scene for paralyses decision making and bickering leaving the ZINWA to make the major decisions (Gumbo, 2006).

All examined countries recognise the importance of an integrated river basin management approach for efficient management of water resources. Integrated river basin approach encourages strategic planning and water resources management that incorporates sustainable supply-side and demand-side management, drought measures, flood protection, water quality issues and environmental health of the basin. The approach itself is a measure of adaptation to growing challenges of water resources management associated with more frequent and/or severe floods and droughts, environmental concerns and problems with water quality. However, institutional arrangements in these four countries that are not accompanied by provisions for coordination and cooperation impede the implementation of this concept.

4.2.3 Water user associations

Water User Associations are self-governing bodies that make decisions regarding water distribution among users and also concerning maintenance of water infrastructure. Between countries the priorities of water user associations differ. In Mexico they are primarily concerned with the operation and maintenance of the irrigation infrastructure. In India, they work more like councils deciding how much access to water each farmer gets although they are also involved in collecting money and looking after the infrastructure. Water user associations can be important players in adaptation to climate change in the four developing countries.

India: Several forms of cooperatively operated and community-managed irrigation activities exist for lift irrigation schemes and small water-harvesting structures in mountainous and water deficit areas. Creation of Watershed Association is an important trend under the centre, - state, - and NGOs sponsored watershed management programs currently under implementation in India. Watershed associations along with the watershed professionals develop the watershed development plans, implement the community-agreed plans and have the responsibility for operation and maintenance of the infrastructure. From the perspective of institutional performance, the existing local institutions and large public institutions, particularly those related to inter-basin transfers, inter-sectoral allocations, and conflict resolution, are too weak to address the problems like water distribution and allocation, charging and collecting water and energy fees, operation and maintenance of irrigation infrastructure, regulation of water abstraction and ensuring water quality standards. The institutions also need to be made more effective for resolution of conflicts at various levels and for regulation and enforcement of the adopted policies.

Mexico: Irrigation sector reform in Mexico took the form of massive transfer of public irrigation systems to user groups. The transfer program began in 1988 following a set of sweeping economic reforms which were introduced beginning in 1986. By the end of 1996, 87 % of the area under medium and large scale irrigation districts in the country had been transferred to 386 Water User Associations (WUA) to manage about 2.9 million hectares and 46% of the total area under all irrigation. In Mexico the Water Users Associations' main function is the operation, maintenance, and management of the irrigation infrastructure. They can be established as civil associations and granted certain fiscal privileges. The boards of directors of these associations are selected by the assembly comprised of water users of the irrigation modules in the irrigation districts or units. In several irrigation districts that have been transferred, federations of WUA's are being established as societies of limited responsibility (SRL) which are given charge of the operation and maintenance of the major canal, drain, and road networks and serve all WUAs within their jurisdiction. In some relatively large districts, more than one SRL has been formed.

Argentina: The transfer of management and infrastructure to users has not been achieved in most provinces with full administrative and financial autonomy. There is a somewhat undefined position regarding the powers transferred to them. This situation is caused in some cases by the lack of political willingness to carry out the actual transfer and, in others, by resistance from users who associate decentralisation with the loss of subsidies. However, there are several relatively successful cases of decentralisation and transferring powers to user association. For example, Mendoza River watershed Committee is comprised of 76 users' agencies that administer the irrigation network of the Mendoza River "oasis".

Zimbabwe: There are various types of water user groups in Zimbabwe. Some of them are formed by communal farmers, others by commercial farmers; there are also several small-scale farmers groups. Representatives of water user groups participate in the rural councils. The prime concern of water user groups and sub-catchment councils in Zimbabwe is regulation of access to water.

4.2.4 Community / traditional structures

Local level institutions and communities can play a significant role in the water resources management in developing countries. Historically, these stakeholders have not always been recognised as valuable partners by national authorities. This issue is especially critical in India and Zimbabwe where around 70% of the population lives in rural areas and is involved with agriculture production. These communities depend on water resources for their daily survival and should be directly involved in the official process of water management. There is generally a growing recognition that local communities and organisations should have a greater say in water resources management. Some measures to address this issue have been introduced.

The inherent ability of local and user-based institutions to adapt to and cope with climate change is high. This is because even though a set amount of water is usually received from the government, the way in which it is shared between the users is decided by a council or committee and is re-evaluated on a seasonal timescale.

India has more than 25 indigenous water management, irrigation and drinking water systems which have developed through out its many diverse communities. For example, the *Phad* system in India is a traditional communal irrigation system where a council meets to decide on which crops will be grown that year and on water allocation. Crops are rotated, with each farmer able to grow cash crops approximately every three years. The key to this system is that rationing and allocation is decided on the water level in the river at that time. There is no predetermined quantity that each farmer is entitled to. Water user associations are a more formal way of empowering farmers to maintain and operate their own irrigation system and allocate their own water. Combining these indigenous water techniques with decentralized water decision making will provide India with flexibility, creativity and adaptability to incorporate sustainable water solutions for the future. However, indigenous water management approaches are not sufficiently being incorporated into water policy.

Involving the farmers in the irrigation system is one obvious remedy to address the problem of adequate water management. By entrusting responsibility for irrigation to a village or a group of villages, efficient use of available water can be promoted. There is an example of Orissa State in India where parts of the irrigation system were transferred to farmers for maintenance and management. The farmers formed water user associations (Pani Panchayats) and they were registered as legal entities. The maintenance improved and agricultural productivity also improved. The Orissa Government has later transferred all irrigation networks to Pani Panchayats.

Several case studies have been conducted in *Zimbabwe* and they came up to similar conclusions that communities are capable of deploying sophisticated livelihood diversification strategies that can help them adapt to climate variability and change. Local communities in Zimbabwe are not connected to the whole system of water management: legal provisions have almost no relevance to them; they are too poor and far away to have an access to relevant institutions, even Catchment Councils. On the other hand, their local concerns and tools that they use to cope with water stresses (from unwritten ancient rules for conflicts resolution and water sharing to methods to use water efficiently and adjust crops) are not taken into account by government agencies. Decentralising authority to the local-traditional leaders can help protect natural resources and improve livelihoods of people. Legal basis should be available for communities to form their own legal entities and directly participate in market activities.

The *Mexican* government's policy since 1980 has also been to promote farmer-managed irrigation schemes where possible. At the level of farmers in smallholder irrigation schemes, Irrigation Management Committees (IMCs) have been established to help encourage farmer management. However, the IMCs have no legal standing and their effectiveness varies from scheme to scheme.

In developing countries where the majority of the population is involved with agriculture and directly depends on water resources, participation of all the stakeholders in water management is especially important. Poor communities in drought and flood prone areas should be directly involved with water management and decision-making. They are the ones who need a wide choice of adaptation measures to be available to them from crop selection to water harvesting to moving away from agriculture (temporarily or permanently). If they lose their crop, they need to know where they can find help. Higher level government agencies also need to be in direct contact with these communities to be able to incorporate important community-level information into water and agriculture planning and management.

4.2.5 Other stakeholders

There are many other stakeholders who are involved in water resources management in the four examined countries. They include local governments such as municipalities and village councils, NGOs that assist communities in developing water sources by building dams, installing boreholes, teaching them methods of rain water harvesting. NGOs also play an important role in promoting community level adaptation measures by for example, educating communities on agriculture methods (selection of type of crop and time of planting) that take climate variability into account. **Local governments** such as municipalities and village councils also play an important role in drinking water supply and water pollution control.

Multilateral institutions are also an essential stakeholder who provides technical assistance with capacity building, scientific knowledge development and dissemination, education, policy formulation, etc. Multilateral institutions also provide funding and loans for infrastructure update and development. For example, The World Bank lending for water sector in India represents US\$ 900 million a year. The World Bank funds projects that develop information systems, modernise infrastructure, address issues of water rights, watershed management, capacity building, urban and rural water and sanitation projects, and others. Additional role of multilateral and bilateral institutions that provide development assistance to developing countries should be in disseminating information on climate risks that might influence development projects and to incorporate climate change concerns into the assistance projects design. The study that the OECD conducted on the opportunities and trade-offs faced in "mainstreaming" responses to climate change in

development planning and assistance concludes that not all climate risks are being incorporated in decision making, even with regard to natural weather extremes, (Agrawala (ed.), OECD, 2005).

Private water suppliers can also influence the way how water resources are managed. The analysis of the four Annex I countries provides examples of how private water suppliers in the UK develop their own water management plans and sometimes initiate measures, like for example, water metering, that facilitate water savings, accountability and adaptation to climate change. Private water suppliers are present in Argentina, Mexico and India, however, their status and share of the services provided vary significantly from country to country. In *Argentina* water supply and sanitation services are operated by a total of 1,548 companies or organisations, with 70% private entities. The private concessionary companies serve about 61% of the urban population (Pochat, 2006). In *Mexico* during the 1980's many local water utility companies³⁰ were formed as part of the decentralisation of the public water system. However, as in the irrigation sector, decentralisation is incomplete as these companies are still operating as municipal or state entities (OECD, 2004). In larger cities and towns in *India*, water for drinking and some other pressing needs is sometimes supplied by small private contractors (though at exorbitant costs) especially during summer months when municipal supplies fall well short of the soaring demands (Sharma, 2006). Some studies indicate that although private sector investments in water supply and sanitation improve the efficiency and quality of services, the regulatory framework in which they function is still weak.

4.3 Institutional capacity

One of the single most important drawbacks to adaptation is the lack of institutional capacity. Many government agencies at all levels in the examined countries lack some form of capacity to manage the water resources effectively. It ranges from inadequate staffing and insufficient training of personnel to limited technical capabilities and weak institutional linkages among institutions and organizations that operate in the water sector. The wide involvement of stakeholders is critical in the water sector as the risks and uncertainties induced by climate change should be addressed at all levels of water resources use and management.

All four case studies mentioned capacity building as one of the first steps in developing adaptation to climate change. The needs for capacity building and training have been expressed by many developing countries in their national communications to the UNFCCC. The sixth UNFCCC compilation and synthesis report (FCCC/SBI/2005/18Add.5) highlighted the critical gaps in institutional and human capacity building needs.

The Zimbabwe case study reiterates the main conclusions of the UNFCCC synthesis. It states that institutions lack necessary capacity and it is not likely that their capacity will be strengthened in the near future due to reduced flows of money from the central government. Village level institutions are not strong enough to address issues of disaster management and cannot even organize and take the lead in the construction of flood protection measures. As a result, the institutional arrangements for disaster management in Zimbabwe may be in place but the extent to which they can deal with the unfolding disasters is limited. The Catchment Councils are not adequately capacitated either to meet the demands of their own mandates. The elected officials have little or no knowledge of water management related issues. Critical entities such as the local water point committees have a say in how water is shared and management and yet they are left out of the main training. (Gumbo, 2006).

It is important to recognise that some aspects of institutional capacity, (for example, clear division of responsibilities, formal links and co-ordination among various governmental agencies and at all levels, certain training courses, amongst others), should be addressed by the governments themselves. Other aspects might need to be supported by capacity building actions of the international community, for example, various forms of scientific and risk management training, sharing methods of efficient governance, sharing knowledge and experiences with effective policies and water management approaches.

³⁰ Organismos Operadores, (OOs)

5. Water Management

As stated in Levina and Adams, 2006, water management can be distilled down to three key tasks: development of long term water resources management strategies; regulation of water abstraction, supply and demand; minimising the risk from floods and droughts.

5.1 Long term water management strategies

Long term water management strategies are present in all examined countries. Most exist as formal strategies; others exist as long term goals. Although none of the examined countries included climate change concerns into these strategies, emphasis on efficient water use, infrastructure development, prevention and planning for floods and droughts directly facilitates adaptation to climate change. The main problem with long-term plans and strategies in these countries is very weak provisions for actual implementation. Lack of financial resources, legal gaps and insufficient institutional capacity indicate that there is a slim chance that these strategies can be implemented under current policy frameworks.

However, the fact that governments find it necessary to develop comprehensive strategic plans and dedicate resources for this is very important. The process of preparation of long-term plans and strategic thinking that accompanies it is the first step in effective water resources management.

For example, *Zimbabwe* has moved towards more integrated water resources management through the Water Resources Strategy which led to the promulgation of the Water Act of 1998 and the National Water Authorities Act of 2002. The Strategy reflects the user-pay principle and suggests measures such as fair water sharing and full pricing of water. These measures if implemented in practice will increase the resilience of the water and agricultural sectors to climate change. However, in reality these measures can not be implemented due to the lack of capacity, funds and water users who are able to pay the full cost of water.

Mexico also has a National Water Plan which is based on six major objectives:

- Encourage the efficient use of water in agricultural production.
- Encourage expansion of coverage and quality of drinking water, sewer and sanitation services.
- Achieve integrated and sustainable management in watersheds and aquifers.
- Promote technical, administrative and financial development of the water sector.
- Consolidate water user participation as well as the involvement of organized society in water management. Promote a new culture on good use of water.
- Prevent risks of floods and droughts and provide assistance after and during these episodes³¹

The final stage of the National Water Plan involves the creation of Regional Long Range Vision Water Plans for 2001-2025.

Planning for *India's* water resources is part of the Planning Commission's Five Year Plans. The current Five Year Plan runs from 2002 to 2007. Its priorities include ensuring that all of the rural population receives a sustainable and set supply of water, increased decentralisation of water supply management, mandatory water audits in order to monitor water demand, efficient water use, increased storage of monsoon rains as 'groundwater sanctuaries' and maintaining historic minimum flows in rivers to help dilute surface water pollution. An increase in water user associations to manage irrigation infrastructure and the charging of water at its true rate is encouraged. In regard to flood control the Five Year Plan suggests the formation of a new integrated Flood Management Commission. All of these measures will help adaptation in various practical

³¹ Taken from *Mexican Portfolio of Water Actions*, document from the 3rd World Water Forum <http://www.worldwaterforum4.org.mx/uploads/documents/mexpowa.html>

and policy-based ways. The abatement of water pollution is also essential because a reduction in water quality leads to a reduction in water quantity.

Although, *Argentina* does not have a national plan for water resources management, it is moving towards a Water Resource Management Master Plan based on a set of principles for the management of the whole country's water resources³². Actions have been carried out in this respect. Among them, the project for the Argentina's Water Resource Management Master Plan, the elaboration of which started in 1994 as an instrument of programming, budget assignment and management control. The first step, between 1994 and 1996, was to carry out a Preliminary Diagnosis of Water Resource Management.

The document on Water Policy Leading Principles agreed in 2003 by all the political jurisdictions sets out the courses of action for integrating the technical, social, economic, legal, institutional and water-environmental aspects of water resource management in pursuit of a sustainable development. The statement of these political courses of action or guidelines of the integrated water resources management is meant to guide legislators and orient the public administrators. The government has also initiated the development of the Integrated Water Resources Management Plan for La Plata basin, the plan will include adaptation to climate change.

Other sectors' long term strategies will also play a role in the adaptation of water sector to climate change. For example, sustainable land use planning, including protection of wetland can have a significant effect on flood prevention and management. Sustainable agriculture strategies can adopt practices that better retain soil moisture and reduce water demand during dry periods. Projections on increased runoff might be incorporated into strategies for hydro power development (Levina and Adams, 2006). Due to a high reliance of societies in many developing countries on **agriculture**, water management plans and strategies should be directly linked to agriculture strategies. The agriculture sector will need to adjust to changing patterns of temperature and precipitation by making the right decisions regarding types of crops and timing of seedings. In addition, agriculture sector can offer numerous opportunities to use available water more efficiently either through rain water harvesting, or special technics that allow to keep water on fields, etc.

In countries with a big **hydropower** potential, energy sector strategies should be linked with water management strategies. For example, in Argentina, the share of electricity produced by hydro power plants can vary from 50% to 30% depending on water flow. The annual electric energy generation reached 92,974 GWh in 2003, out of which the hydroelectric generation was 31,821 GWh, representing 36% of the total, percentage that has been maintained to date³³. It is very important to study in depth the effects of climate change on hydroelectricity, with a focus in the basins of the Paraná and Uruguay rivers (Litoral region) - with a rainfall regime - and of the Limay and Neuquén rivers (Comahue region) - with a mixed rain-snow precipitation regime. These two regions provide 85% of Argentina's annual hydroelectric supply.

There is no indication yet that sectoral plans and policies of the studies developing countries incorporate climate information into long-term planning. Adaptation to climate change of the water sector and related sectors such as agriculture and hydroenergy must begin with inclusion of climate projections into long-term planning. The developed countries examined in Part I of the study have also not yet incorporated climate change information into development plans. The Annex I countries have only recently started evaluating impacts of climate change on various sectors and regions. National Strategies for Adaptation represent a useful tool that can facilitate institutional dialogue on expected impacts from climate change and formulate principles for future development that takes climate change risks into account. These strategies are not common yet in either Annex I countries or in developing countries. In the Annex I group, only Finland has developed a National Strategy on Adaptation. The UK is in the process of developing a comprehensive Adaptation Policy Framework. France and Denmark are also working on national adaptation strategies. Among non-Annex I countries, Mexico is in the lead by developing a Draft National Program on Adaptation

³² Principios Rectores de Política Hídrica

³³ Secretaría de Energía de la Nación and Comisión Nacional de Energía Atómica (CNEA)

to Climate Change. Some other non-Annex I countries (e.g., South Korea) are initiating processes for the development of national adaptation plans.

Disaster preparedness and mitigation are integral components of adaptation. The four case-study countries are prone to such natural disasters as floods and droughts. Some of them also experience flash floods and storms. Floods cause the biggest economic damage among all the disasters in Argentina and India. Zimbabwe, India, and Mexico bare significant economic losses from droughts. Large shares of population are affected by droughts in Zimbabwe and India. The four examined countries have National Disaster Management Plans or Strategies. These plans are important tools for preparing for and managing natural disasters. Given that the climate change forecasts project more severe and/or frequent natural disaster events (e.g., droughts and floods), there is a need for systematic approach to these hazards with regular revisions and incorporation of up to date information on existing trends and projections.

The Hyogo Framework for Action 2005-2015 adopted in January 2005 by the World Conference on Disaster Reduction under the International Strategy for Disaster Reduction (ISDR) provides an international framework for strategic and systematic actions for reducing vulnerabilities and risks to hazards. The priority actions include governance (ensure that disaster risk reduction is a national and local priority with strong institutional basis for implementation); risk identification (identify, assess and monitor disaster risks and enhance early warning); knowledge (use knowledge, innovation and education to build a culture of safety and resilience at all levels); reduce the underlying risk factors; and strengthen disaster preparedness for effective response. The adoption of the Hyogo Framework has triggered a myriad of disaster risk reduction activities worldwide. The signatory governments, UN agencies and regional organizations have embarked on redefining national plans and strategies and setting up national platforms as well as promotional campaigns to facilitate implementation of the Hyogo Framework.

5.2 Flood management

Flood management is composed of two different activities: long-term flood mitigation and flood response. While the study of several Annex I countries showed that both types of activities are given considerable attention and funding support, the analysis of developing countries reveals a bigger emphasis on response and recovery measures.

However, the importance of **planning for floods** has been recognised by examined non-Annex I countries in the last several years, and national and local flood management plans have been developed. For example, *Argentina* has the Federal Plan for Flood Control³⁴, which consists of structural and non-structural measures. The structural measures include works for the protection of urban areas, productive lands and infrastructure. The non-structural ones comprise activities such as, among others: a) technical assistance for establishing or strengthening capacity of each province to face flood problems, b) preparation of plans and regulations for land use in flood-prone zones; c) installation of an early warning system; d) co-ordination of activities of the warning system and the civil defence; e) preparation of shelters for the affected population; f) organisation of education and public awareness campaigns³⁵. The autonomous city of Buenos Aires has its own Master Plan for Hydraulic Management and Floods Control³⁶.

The most recent flood in the Salado River in 2003 was unusually dramatic due to its intensity as well as the lack of integrated policies of disaster monitoring and prevention. As a result of the disaster, around 140 thousand people were displaced and the damage and losses were estimated at about US\$ 1 billion (Pochat et al., 2006).

³⁴ Plan Federal de Control de Inundaciones

³⁵ http://www.corrientes.gov.ar/hacienda/entes-ministro/supce/web/supce_archivos/frame.htm#slide0074.htm

³⁶ Plan Maestro de Ordenamiento Hidráulico y Control de Inundaciones

Recently, the **Mexican Government** decided to create a new fund to move from response to the emergency to preparedness to major threats. The so called National Fund for Preparedness to Natural Disasters (FOPREDEN) is intended to move from a culture of reaction to a disaster to a “culture of reduction of vulnerability” to extreme events. FOPREDEN is at its early stages and there are no projects in the areas of major hydrometeorological disasters.

India started planning for flood management after the devastating floods in 1954 with the establishment of the National Flood Commission (Rashtriya Barh Ayog)³⁷. The major emphasis has been on structural measures and an estimated area of 16.45 million ha has benefited through construction of 34,398 km of embankments; enlargement of capacity and straightening of 51,318 km of drainage channels; 2400 town protection works; and the relocation of 4721 villages onto raised lands (CWC, 2004). The major non-structural measures have included (a) flood forecasting and warning (b) flood plain zoning (c) flood proofing (d) disaster preparedness and response planning and (e) flood relief. However, there is still an urgent need to develop an integrated planning for extreme climatic events/ disasters at all levels from district to state and central government. This also needs to include the relevant communities and civil society organizations. Another drawback in existing structures is lack of funding. The high powered National Planning Commission has advised that 10% of the plan funds at the national, state and district levels be used for schemes which specifically address prevention, reduction, preparedness and mitigation of extreme events (no regret measures). This provision is still advisory in nature.

In **Zimbabwe** some plans have been created to address floods. They highlight among other things the alert mechanisms / procedures, evacuation procedures, stock of resources available both material and human, contact details of focal human resources. These plans are required to be reviewed regularly at least once a year. Central to the plans are information dissemination and education about the dangers of floods. The current approach has been to limit these plans to flood prone areas such as the Limpopo, Save and Zambezi.

Institutional arrangements in the four developing countries are still evolving and seem to be incomplete, although efforts have been made to create special flood-related structures. For example, in **Argentina** several governmental institutions are directly involved in flood management³⁸. They are: Undersecretariat for Water Resources; specially created Central and Provincial Sub-Units of Co-ordination for Emergency³⁹; Emergency Federal System (SIFEM)⁴⁰; the Warning Systems of the La Plata Basin and of other provincial basins. The Federal Emergency System was specially created in 1999 to coordinate disaster management. However, this System’s current location within the sectoral structure is not very efficient due to this agency’s limited capacity and insufficient political power.

In **Zimbabwe**, the government set up a disaster management framework under the Civil Protection Organization to address an increasing threat of floods and storms. The framework is comprised of the following government departments: health, foreign affairs, water, mining, state security, and information. Other organizations related to floods may be co-opted as and when required. Zimbabwe National Water Authority (ZINWA) and the Meteorological Department form the early warning unit and are responsible for the weather and flood forecasts. Zimbabwe Defence Force and Republic Police, Civil Aviation and Ambulance services are there to provide rescue operations and relocate victims of floods as well as provide security during flood crisis. Other agencies are involved in medical and social care of the victims. Local government will coordinate the activities by these different actors in their areas. There is an important role that Catchment Councils can play in disaster preparedness. These entities should be directly involved in the

³⁷ <http://planningcommission.nic.in/reports>

³⁸ Natenzon, C. and Viand, 2005. Gestión de los desastres en Argentina. Instituciones nacionales involucradas en la problemática de las inundaciones. Mesa Redonda “Manejo integrado, riesgo y vulnerabilidad social”. 6º Encuentro de Geógrafos de América Latina – EGAL

³⁹ Subunidad Central de Coordinación para la Emergencia

⁴⁰ Sistema Federal de Emergencias

development of catchment level flood mitigation plans by involving communities and households. However, Catchment Councils lack capacity to implement these tasks.

The response measures that are the centre of risk management need to be strengthened. For example, in *India* there is a pressing need for improvement and strengthening of existing institutional arrangements and systems to make the initial response to a disaster more effective and professional. While there is a National Disaster Management Authority (NDMA), there is still a need for establishing a national standby, quick reaction team, which can provide an experienced response at the affected location in the country. Modern unified legislation for disaster management with clear definitions of what constitutes a disaster/extreme event at national/ state/ local level is also necessary. Providing adequate financial support to both on-going and new centrally-sponsored development schemes, which enhance adaptation and reduce disaster vulnerability of communities, is also very important.

In the Annex I countries there are more or less clear institutional arrangement for preventing and dealing with floods. Central and sub-national government create policies, strategies and provisions to prevent and prepare for floods. Usually local agencies have primary responsibility for the management of response measures. Higher level government agencies get involved only when local authorities have difficulties in handling flood situations. These institutional schemes proved to be efficient. The examined developing countries report insufficient involvement of local authorities and communities which contributes to inefficiencies and also in some cases makes rescue measures impossible.

Local level stakeholders can play an important role in flood management. The authorities in the four case study countries still need to ensure an institutionalized mechanism for dialogue with an emphasis on integrated and comprehensive strategy for risk reduction, including the whole cycle of disaster management (prevention, preparedness, mitigation, response, recovery and rehabilitation). This can more appropriately be provided for by taking into consideration socioeconomic and cultural factors and actively involving the civil society, from the international to the local level.

Flood forecasting and early warning systems play an important role in timely response measures. All examined countries have developed extensive monitoring systems and special institutions with the capacity to compile all available information and come up with forecasts and warnings. Some details of information systems in place in the four non-Annex I countries examined here are presented in Section 6.

There is an urgent need to place more efforts into non-structural measures of flood management. Farmers have to live with floods and learn better techniques to minimize losses with more reliance on integrated farming systems that blend of aquaculture and agriculture. Integrated farming systems can provide better livelihood means for the vulnerable communities, and if appropriately designed, can be more resilient to extreme events. This can be achieved through demonstrations of successful models, capacity building of staff and communities and allocation of adequate funds.

Updating and digitisation of flood plain zoning maps and better enforcement of flood plain zoning regulations will considerably mitigate the flood impacts. Community participation in flood management is crucial, as communities will have better knowledge of local needs and potential and can assist in building quick resilience. This will require setting up of a community oriented and powerful institutional framework backed by strong capacity building measures.

Availability of comprehensive, robust and accessible databases of the land use, demography and infrastructure along with current information on climate, weather, and water resource will improve planning, warning and assessment of impacts. Much of the necessary data already exists, but either because of security concerns or institutional constraints is not readily available.

International agencies can assist the governments of developing countries in putting more emphasis on disaster prevention. So far, international agencies have been more interested in rescue and reconstruction efforts. For example, six months before the Mozambique flood disaster of 2000, its government appealed to

the international community for US\$ 2.7 million dollar to prepare for the floods. It received less than half of this amount. After the floods came, Mozambique received US\$ 100 million on emergency assistance and a pledge of US\$ 450 million for recovery (Simms and Reid, 2005 cited in Water and Climate Risks, 2006).

In Argentina the Inter-American Development Bank, through a Loan Contract, partially subsidises the Emergency Programme for the Recovery of the Zones affected by Floods in Argentina, carrying out activities of mitigation, reconstruction and rehabilitation of the socioeconomic infrastructure, and the design of prevention activities to reduce the damage of similar phenomena in the future. Out of the US\$ 300 million of the Loan, 265.4 million were assigned to the Reconstruction Component and 25 million to the Prevention Component. Recent studies indicate that for every US\$ 1 spent on preparing for disasters, a further US\$ 7 is saved in the cost of recovering from it.

5.3 Drought plans and water management plans

Droughts are much more common and have more profound impacts on the examined developing countries than on the Annex I countries analysed in the previous study. Yet, non-Annex I countries are much less prepared to handle droughts and mitigate their effects. The Annex I countries examined in the Part I paper have long and short term drought plans that prescribe specific measures to be taken when drought conditions are detected. Annex I countries are cautious in making long-term expensive decisions that would allow them to adapt to long-term projected climate change, they constantly monitor their situations with regards to droughts and adjust their drought plans regularly (e.g., annually in the UK). This incremental adaptation (while perhaps not ideal in terms of cost-effectiveness) still allows many developed countries to be prepared for climate trends. Analysis of four developing countries demonstrates that these countries are not even ready to handle current onsets of droughts. Climate models project increase of droughts for all four countries, so addressing this issue is even more urgent.

The level of preparedness and measures taken by governments to prepare for and mitigate droughts differ from country to country. The government of *Zimbabwe* has developed the National Policy and Programme for Drought Mitigation. International organisations provide financial assistance to regional programs that aim at mitigating droughts. For example, the regional Early Warning System and the Drought Monitoring Centres have been established with the assistance from international organisations. Drought Monitoring Centres issue bulletins that provide pre-seasonal forecast in September. However, once the forecast is made, the government does not have a good system in place to use these predictions.

Action by government actors is not necessarily oriented toward cautious planning in advance of an event, but rather toward swift, heroic action once a catastrophic situation arises. Risks are high when acting in anticipation of an uncertain future. Budgetary resources are often not available for preventive measures, only for disaster response. (Orlov et al., 1999) However, in late 90s the government of Zimbabwe adopted proactive measures to mitigate the effects of the anticipated drought rather than merely seeking disaster relief. Backing from global and regional organisations, along with greater use of forecast and greater media involvement encouraged the government to issue drought warning. A number of specific recommendations were made: plant early, chose drought-tolerant and early-maturing varieties, adopt water conservation measures, and prepare to sell animals.

The major concern with declaring a drought early has been the fear of a wrong forecast. Some studies document that the tolerance of end-users for incorrect forecast may be quite variable. If the behavioural response to an incorrect forecast is not costly to the end user, users are more likely to tolerate incorrect forecasts (Orlov et al., 1999).

In *Argentina*, the civil protection sector prepared projects responding to the lack of long term drought plans. However there were no financial resources to implement them. Response plans to drought do exist, mostly involving the Civil Protection Agency and the agriculture industry giving money to those affected.

In **India** based on the rainfall deficiency, on average 19% of the area and 12% of the population is annually affected by droughts in the north-western and southern states of the country. The primary impacts are reduced water availability for domestic, agriculture and livestock; low to failed agriculture production and reduced hydropower generation. This leads to reduced incomes for the people dependent on farming and livestock, dwindling fodder stocks, decline in nutrition and health status. It also has impacts on the wider economy with the reduced availability of agricultural produce and constraints on power production.

Government schemes to combat droughts include the Desert Development Program (DDP), the Drought Prone Areas Program (DPAP), the Integrated Watershed Development Program (IWDP) and the National Watershed Development Program for Rain fed Areas (NWDPR). These are area-based development programs where certain structural measures like stabilisation of sand dunes, regeneration of pasture lands, maintenance of traditional water resources and afforestation with region specific species is undertaken. Specific research institutes have been devoted to the development of technologies, practices and policies for better adaptation to droughts.

Traditional coping strategies in response to drought include migration of human and livestock population to safer areas, sale of assets, dependence on government relief works, and water and food aid, sharing and cooperation, diversification in sources of income and borrowing from banks and money lenders. State government also makes arrangements for supply of drinking water to the affected populations through water tankers and special water trains. NGOs play an important role through supplies and management for alleviating the drought impacts in remote and inaccessible habitats. Water harvesting at individual, community and state level has emerged as a strategic tool for effectively mitigating the droughts and improving productivity and livelihoods (Sharma, 2004). Even in drought affected areas some storms generate considerable runoffs which when harvested in underground cisterns (drinking water for human/ cattle population); village ponds (cattle and domestic needs) and runoff-based farming systems can help the communities to be well prepared to face droughts of different intensities. However, such interventions are not universally applicable, especially where prolonged droughts are expected.

The past efforts in drought management at the central and state government level have ensured that droughts do not trigger wide spread food famines and epidemics. Medium and long range weather forecasts, creation of food and fodder depots, providing employment and relief to the affected families, building resilience into traditional agricultural systems appear to be good steps in combating low /medium intensity droughts. But most of the responses and institutional mechanism are at best 'ad-hoc drought/ famine relief works for managing an event when it strikes rather than measures for drought preparedness, drought management and drought proofing of the vast areas which might be impacted as a result of climate change.

In **Mexico**, so far, only response plans for drought exist in the Civil Protection Agency and in the Agriculture Ministry. In both cases, a monetary compensation is given to those affected by drought. The use of seasonal climate predictions is limited, and no plans to prepare for drought exist. Recently, the Secretary of Environment requested the academics in the field of climate to develop a National Project to produce climate information, including drought predictions. The Plan was produced but so far, there are no funds to finance this initiative. (Gonzalez, et al. 2006)

To address a present and future major threat of limited water availability and drought, a number of state level adaptation initiatives were defined through close interaction with stakeholders. The State of Sonora that has been experiencing shortages in water in recent years due to population growth and prolonged periods of droughts, considered a number of solutions like trading of rights of water, desalinisation plants and a large number of treatment plants. Through a close interaction with stakeholders two adaptation measures were proposed: 1) a culture of water program to reduce water consumption and demands, and 2) an enhanced infiltration of water after extreme precipitation events. The "culture of water" program would include a home water saving kit (for the shower, toilet, sink, etc) which could be distributed among the homeowners and the costs distributed in a number of water bills. This program was partially implemented in a few homes, but due to the lack of resources it has been difficult to estimate the impact of this program in terms of water savings. A culture of water program, to reduce water consumption from 330 lt/person/day to 180 lt/person/day,

through the use of new technologies for the bath and kitchen. This program considers technologies already available in the Mexican market.

Detailed vulnerability maps of droughts based on long-term trends and real time data are essential for developing strategic management plans. Decision support systems for estimating losses of crops, orchards, trees, grasslands, and livestock; and surface and groundwater resources may be calibrated for different vulnerable regions and livelihood opportunities. Crop- centered management policy should shift in favour of robust and integrated livestock, trees, agro-forestry and grassland based livelihood opportunities along with promotion of off-farm income generation skills. Water harvesting at local, community and regional level should be considered as a long-term strategic intervention for mediating the drought impacts.

5.4 Water supply infrastructure

One issue surrounding infrastructure in the examined non-Annex I countries is that it is not reaching all those who require it. Argentina is trying to bring its water supply infrastructure up to date with the rest of its public works by expanding the water and sanitation supply networks. India is struggling to keep up with rapid population growth in its cities and rural areas. In Zimbabwe many irrigation dams have been constructed without the corresponding irrigation infrastructure. It has been noted that those not connected to the water supply infrastructure with the buffering effects of multiple sources of water, are most affected during droughts and floods. Therefore, connecting the population to a functioning water supply network will also increase its resilience to the impacts of climate change.

Table 5. Access to drinking water and sanitation

	Argentina	India	Mexico	Zimbabwe
<i>Access to improved water sources (% of total population)</i>		86	91	83
rural (% of rural population)	19*	82	72	74
urban (% of urban population)	83.4*	96	97	100
<i>Access to sanitation (% of total population)</i>		30	77	57
rural (% of rural population)	0.6*	18	39	51
urban (% of urban population)	51*	58	90	69

* Argentinean Permanent Information System on Sanitation, National Census, 2001. Source: World Bank, 2005 from the World development Indicators, the World Bank

It has been estimated that annual spending on water and sanitation (including new infrastructure investments and operational expenditures on water resource development, transmission, treatment, distribution, wastewater collection, wastewater treatment and disposal) should be between 0.35% and 1.2% of GDP for high-income countries, from 0.54% to 2.6% for middle-income countries, and from 0.7% to 6.3% for low-income countries⁴¹ (OECD, 2006).

For example, the annual requirement for rehabilitating existing infrastructure in India is estimated to be US\$ 4.6 billion, while the India Water Vision expects new investments to cost about US\$ 4.14 billion per year. Annual allocations in the past have been between US\$ 0.2 billion and US\$ 3.9 billion a year. Based on preliminary estimates, meeting the Millennium Development Goals targets in urban areas in India would require an investment of US\$ 21.8 billion up to 2017 and recurrent expenditures of about US \$ 21.1 billion over the same period. In the rural areas the figures would be US\$ 16.5 billion and US\$ 15.6 billion respectively. This totals to 0.71% of India's GDP (OECD, 2006).

⁴¹ The water supply costs do not include large dams or similar infrastructure as this is locally specific.

Low or non-existent payments for water services prevent governments for collecting necessary funds for infrastructure development, maintenance and improvements. In Mexico, for example, the infrastructure has suffered dilapidation through the lack of maintenance, as much as 40% of the water is lost through leaks, (OECD, 2004). Sometimes international organisations offer assistance. For example, Inter-American Development Bank and the World Bank fund the National Entity of Water Works for Sanitation in Argentina to extend water services to the population that does not have access to drinking water. Some loans are also available for private providers (Pochat et al., 2006). In India, the World Bank recently provided US\$ 100 million for improvements in urban water and sanitation services.

The largest proportion of water supply infrastructure in developing countries relates to irrigation, and involves dams, canals, tanks, underground canals. Building large dams and canals has been a popular water management measure in the past. For example, in the last 50 years 4291 large dams have been built by the Indian government⁴² and 8000 dams have been built in Zimbabwe. There are over 100 major storage dams in Argentina; most of them are for multiple uses (electrical generation, municipal and industrial water supply, irrigation, flood mitigation, navigation and recreation). Thirty-one of them are mainly for hydroelectric use. Most of dams (for multiple uses) still lack “dam safety” provisions.

Large dams do not always provide sustainable solutions to water challenges. Access to water for the population in disperse rural areas can be achieved through low-cost, off-grid options such as small-scale drip systems, rainwater harvesting, groundwater recharging, check dams and embankments. The discussions on dams and development held under the Fourth World Water Forum (16-22 March, 2006, Mexico) highlighted that both approaches (large dams and small-scale infrastructure) are essential. The planning and development of the infrastructure should be based on comprehensive assessment of specific needs and conditions and the full range of options. In both cases careful planning and participatory decision-making processes are crucial for addressing environmental and social impacts (UNEP, 2006). Climate change forecast should be carefully evaluated (together with the associated uncertainties) when decisions on infrastructure development are made.

India has conducted three Minor Irrigation Censuses, the last with a reference year of 2000-2001. These are particularly useful for adaptation purposes because they look at those schemes that are underutilised and not fulfilling their irrigation potential. They also examine the water distribution devices – this will become even more useful as water resources become scarce and irrigation methods need to be streamlined. For example, most minor irrigation systems at the moment use sprinkler or open channel irrigation over drip irrigation or underground channels⁴³. The most inefficient irrigation areas can then be targeted with more efficient technology. The permanent melting of the Himalayan icecaps will mean that precipitation that falls on the Himalayas during winter will not be stored there as ice and released during the dry season. Presently there is no infrastructure to adapt to these changes, as much more storage will be required to adapt to increased winter precipitation and snow melt. The Government of India has also been looking into inter-basin water transfers as a possible measure to address water shortages. It has already developed a National Integrated Water Development Plan and National River Linking Project that call for the transfer of water from relatively water-rich eastern (and possibly northern) Himalayan rivers to the deficit southern basins. These infrastructure development plans should be carefully evaluated. There is a need for a comprehensive strategic analysis of the available options and environmental, climate, economic and social concerns.

Urban water infrastructure needs are different from the rural ones outlined above. Given India’s pace of urbanisation, its demand for water in the domestic sector is expected to double by 2030 with a similar scale increase in industrial demand (OECD, 2006). To meet the increases there will have to be transfers of the current allocation from agriculture to the domestic and industrial sectors. The problems this will cause will be exacerbated as most of the domestic growth will be located in the water-scarce areas of the country. In the

⁴² Government of India, Ministry of Water Resources website: <http://wrmin.nic.in/projects/postind.htm>

⁴³ Government of India, Ministry of Water Resources, 3rd Census of Minor Irrigation Schemes 2000-2001 website, Results and Findings: <http://wrmin.nic.in/mi3census/chapter5.pdf>

urban conglomerate of Buenos Aires over the past 30 years more than 500 water supply wells had to be taken out of service due to quality problems caused by over exploitation and nitrates content. Groundwater contamination is one of the most serious pollution problems in Argentina.

It is now recognised that the large-scale centralised systems may no longer be viable in all cases, due to high maintenance costs and resource needs. This is true for both water supply and wastewater infrastructure. In general, water services require rates of capital and maintenance investment with a low return on assets (typically 5%), (OECD, 2006). Small-scale infrastructure near the use point is likely to be more appropriate, particularly in the less dense settlements. The low cost “ecosanitation” system uses local water supplies stored and treated with basic but adequate standards. It also joins the supply side to the waste side with reuse and recovery that makes nutrient and energy management more efficient. This approach avoids the use of precious water to transport the wastes, making it unsuitable in the long term for regions with water scarcity. For example, in the United States, on-site sanitation systems now comprise some 40% of all new developments (OECD, 2006). Decentralised systems are also better at coping with the need to expand services. In the area of storm water drainage, there is also a growing use of “source control” technologies that handle storm water near the point of generation, also providing opportunities for direct use, for example, toilet flushing. In developing countries, decentralised systems are seen by many as the only affordable option (OECD, 2006).

In addition to specific water infrastructure, general infrastructure for basic needs is necessary: roads, access to markets. Development of this infrastructure will make water more accessible. New infrastructure should incorporate climate change forecasts into development; new building standards for dams, bridges, and roads need to be introduced.

5.5 Water management policies

Water pricing: It is generally recognised by the developing countries that water should be treated as economic good and the real price for water should be paid. Full cost recovery water pricing can help to provide economic incentives for efficient water use, thus reducing water wastage in areas of low water availability – an important measure to support adaptation. However, the real world of poverty, inefficient and un-enforced laws, and cultural beliefs that water is a free good makes it very difficult for these countries to translate this concept into practice.

For example, the prevailing cost recovery and water-pricing policies in *India* fail to capture and convey the scarcity value of the resources and induce discipline and efficiency in its use. The Committee on Pricing Irrigation Water recommended the recovery of not only full operation and maintenance costs and one percent capital cost, but also a percentage of the depreciation cost. Unfortunately, the recovery policy, despite its widespread approval was never implemented, (mainly due to political considerations) as it recommended an upward revision in water rates and a radical change in the method of its determination. Water charges for irrigation services are fixed by irrigation/ revenue departments of the state and depend upon the crop and area to be irrigated. These charges are very low and vary from US\$ 2 to US\$ 10 (sugarcane, paddy) per hectare per season for different crops and among different states. Several states have even abolished these charges and in others the collection rates are very low. In *Mexico*, water pricing is differentiated and only in a few states are the actual costs of water covered. This is apparently the case in Mexico City. Most regions in the country seldom pay the actual cost of water. Only 2/3 of the water used by customers is actually billed and only 4/5 of that is paid for. The water actually paid for represents 32% of water supplied (OECD, 2004).

To secure funds for water infrastructure development *Argentina* came up with an interesting solution. It established a so-called “Water Infrastructure Tax” by the Decree N° 1381 of 2001. This tax is a percentage of the price of gasoline that is applied in the whole National Territory, in order to promote the development of water work infrastructure projects. The purpose of these projects is the recovery of the productive lands, flood mitigation in rural zones, and drainage and protection of the road and railway infrastructure in rural and

peri-urban zones, starting with the regions under water emergency at that time. The application of this Decree allowed the establishment of the *Federal Plan for Flood Control* (PFCI).

Public-private partnerships: In addition to pricing policies, the developing countries' governments are trying to address the issue of insufficient funds for developing and maintaining infrastructure and improving water services by involving more private entities in water management. Compared to the analysed Annex I countries, where the governments provide major funding for infrastructure and water supply; developing countries are more likely to engage into public-private partnerships. For example, in India a special Committee on Private Sector Participation in Major and Medium Irrigation Projects was established in 1995 to develop the rationale for involving the private corporate sector, especially in the constriction and modernisation of irrigation schemes (Saleth,2004). In addition, many governments are handing the operation and maintenance, along with pricing and collecting charges for water, over to water user associations.

Insurance: Insurance can be a powerful tool for reducing vulnerability to climate change by transferring or sharing risk. Weather-indexed insurance can help farmers protect their overall income and reduce vulnerability to climate variability and change.

Governments, households, and businesses in poor countries cannot easily afford commercial insurance to cover their disaster risks. Whereas low-cost microinsurance for independent risks is now widely available in developing countries, this is not the case for dependent risks that affect many communities at the same time. The cost of catastrophe insurance is usually substantially higher than the pure risk premium, mainly because of the insurer's cost of backup capital to cover dependent claims. Consequently, people can pay more for disaster insurance than their anticipated losses over the long term. For example, in the Caribbean region, catastrophe insurance premiums were estimated to represent about 1.5% of GDP during the period 1970 to 1999, whereas average losses per annum (insured and uninsured) amounted to only about 0.5% of GDP. This helps explain why only 1% of households and businesses in low-income countries and only 3% in middle-income countries have catastrophe insurance coverage, compared with 30% in high-income countries. Without support from insurance, family, or the government, disasters exacerbate poverty as victims take out high-interest loans (or default on existing loans), sell assets and livestock, or engage in low-risk, low-yield farming to lessen exposure to extreme events. (Linnerooth-Bayer et al., 2005)

Mexican authorities are planning to reinsure their national catastrophe relief and reconstruction fund (FONDEN) with a catastrophe bond. This is an instrument whereby the investor receives an above-market return when a specific catastrophe does not occur within a specified time (e.g., an earthquake of magnitude 7.0 or greater on the Richter scale in the vicinity of Mexico City over a 1-year period) but sacrifices interest or part of the principal after the event. The government's disaster risk is thus transferred to international financial markets that have many times the capacity of the reinsurance market. Although Mexico, a middle-income developing country, will finance the bond out of its own means, a similar, but donor-assisted, bond is an option for poorer countries. Risk-transfer instruments are also emerging to address higher frequency, slower onset disasters such as droughts.

Demand side management: For demand side management to occur in these countries, radical changes will be needed in the way irrigation and agricultural water is managed. In these countries irrigation uses over 70% of all water abstracted (71% in Argentina, 84% in India, 80% in Mexico). Encouraging drip irrigation over spray irrigation, and the uptake of practices to reduce evaporation from canals and reservoirs, charging the true price for electricity to slow the rate of groundwater abstraction and ensuring that irrigation systems work at the highest efficiency possible are the tools that can reduce the demand for water.

In urban settings water is wasted through illegal connections, faulty metres, high water losses and due to insufficient institutional and monitoring capacity (Pangare et al, 2004). For example, the city of Nagpur in the Indian state of Maharashtra dealt with the problem of illegal connections by giving plumbers financial incentives to find unauthorized connections. They regularized 71% of connections within four months.

Water demand might also be reduced if the unofficial water trading schemes that have become established are fitted into a regulatory framework. For example, in *India* there is no legal limit to what each farmer can abstract from the aquifer, and they can sell as much as they want. Farmers are abstracting much more water than they need so that it can be sold at a profit, and draining groundwater reserves in the process.

Mexico is considering new regulations in housing projects that consider more carefully the characteristics of climate in a semiarid region in order to reduce energy and water consumption in cooling systems. Until recently, there have not been any clear regulations on how to better use energy and water in semiarid regions. Mexico is also implementing several projects on water conservation in the agriculture sector. In Guanajuato State, Mexico, 17,000 wells are abstracting (mainly for grain production) twice as much as it is possible to naturally recharge in a year, causing a yearly drawdown of two meters, severe land subsidence, and water quality deterioration. The government of that state established 17 aquifer management organisations. However, when water-saving techniques are introduced, the tendency is to expand the irrigated land. The government does not have the capacity to monitor 17,000 wells. State of Sonora with its programme “culture of water” (discussed in section 5.3) provides another example of demand side policy approaches.

In countries where water resources are scarce, the greater emphasis needs to be placed on improving water use efficiency. The initiatives of the examined developing countries to address the issue of water conservation, especially in the agriculture sector, have to be supported by bilateral and multilateral assistance agencies so that they can be widely spread and achieve greater results.

6. Information Availability and Use

To manage water resources effectively and incorporate climate risks into management decisions, the policy makers and other stakeholders at all levels need various types of information (see discussion in Levina and Adams, 2006) including:

- patterns of precipitation and temperature
- groundwater levels, river flows, river levels and reservoir levels
- types of soil, soil moisture retention
- climate change forecasts on precipitations and temperature
- social forecasts on population growth, and many others.

The analysis presented in the four case studies indicates that Argentina, India, Mexico and Zimbabwe have sufficient scientific and monitoring capacity and generate necessary data on a regular basis. They also take part in various international scientific and monitoring networks and receive additional information through partnerships with other countries and institutions. It is recognised that information availability may not be as good in many other developing countries where basic monitoring and scientific capacity is still very low. For example, deficiency of data on Africa has been stressed in the G8 Gleneagles Plan of Action, 2005. The lack of observational climate data, particularly in Africa, is recognised as a constraint to understanding current and future climate variability (UNFCCC, 2006).

Zimbabwe has a fairly comprehensive data gathering and monitoring network which brings together government, universities, and research institutions. Meteorological information has been collected on a regular basis since the 1950s and daily rainfall data are collected from 120 stations, and reported by telephone to either the Harare or Bulawayo offices of Meteorological Services. Close to 1,200 rainfall records are submitted monthly but there is close to a two-week delay in the compilation and capture of the data. Data are captured in the WMO CLIMCOM database and data are available at a fee. The meteorological service has a web page with current forecasts. In terms of water, information for Zimbabwe is available in the form of the SADC (the South-African Development Community) Water Resource Database on CD-ROM. Quantities of surface flows are monitored through a network of gauging stations that record dam

levels and the amount of flow in rivers. Dam levels are recorded twice a week, and telephoned through to the central Hydrology Office in Harare where the amount of water in each dam is calculated and summed for each province. The change in water volume is monitored weekly for each of the important national dams. River water quality is monitored routinely by provincial pollution control officers. A network of sampling sites is visited at least every three months. Chemical analyses of water are performed by the Water Quality Analysis Laboratory in Harare. In addition, information is also captured by the Department of Water Development on groundwater which includes water levels and quality, the nature of the geological formation and the results of pumping tests. Water levels are monitored on a monthly basis in order to optimise rates of abstraction by users.

A Hydrological Warning Operative Centre in *Argentina*, which was established in 1983 after extraordinary floods of 1982 and 1983, collects and disseminates information on water flows in main rivers. The National Meteorological Service is in charge of observation and evaluation of the meteorological situation, with its own operative network of 114 weather stations, getting also 12 geo-stationary meteorological satellite images. Hydroelectric power stations jointly operated by Argentina and Uruguay and Paraguay, have hydro-meteorological networks of numerous stations that produce hydrometric and rainfall data. The inter-jurisdictional organisation of six Argentinean provinces and the Nation has a Hydrological Information System with 12 hydrometric stations installed on the Bermejo, Iruya, Pescado and San Francisco rivers. The information is updated daily on the internet (www.corebe.org.ar). The Research Centre on Water and Atmosphere analyses hydrological and meteorological data and develops forecasts of climatic conditions. Responsibility of the National Warning System is to warn, as early as possible, the national and provincial organisations in charge of water emergency control, of navigation, and of the population and environment protection, about the occurrence of situations of strong floods or low flows in La Plata Basin. The Warning System collects information from various organisations from bilateral commissions of hydropower (including their numerous hydrometric stations) between Argentina and neighbouring countries Uruguay and Paraguay, the National Meteorological Service, the National Commission for Space Activities to agro-meteorological stations, and regional and provincial river basin stations.

There are several governmental and scientific institutions in *Mexico* that participate in monitoring and generate forecasts and other information. The Civil Protection Agency interacts with scientific experts who work at the National Center of Disaster Prevention (CENAPRED⁴⁴). There, a number of actions have been taken in order to diminish vulnerability to hurricanes and severe storms. An example is the establishment of a severe weather Early Warning System that alerts the authorities and the population of when to expect severe weather, particularly intense precipitation associated with hurricanes. The Early Warning System for Hurricanes has proven to be an efficient method to reduce the number of lives lost due to the effects of tropical cyclones. Since 2000, the number of deaths during the hurricane season has diminished from hundreds to only a few.

India's observational and research capabilities have been developed to capture its unique geography and specific requirements (INC, 2004). There are numerous research institutes supported by various governmental agencies in India that undertake climate and climate change-related research. Recognising the role of land, atmosphere and oceanic processes in modelling the monsoon variability, a multi-disciplinary, decade-long Indian Climate Research Program (ICRP) has evolved to study climate variability and climate change issues in the Indian context. Using various established climate models, different organisations are simulating climate in India. Institutions like Indian Agriculture Research Institute and others develop agricultural meteorological models for Indian crops. There are also water balance models that have been used for various river basins. The SWAT model simulates the hydrological cycle in daily time steps.

There are 22 types of atmospheric monitoring networks in India. There are also satellite-based meteorological observations performed by the Indian National Satellite (INSAT) series. The Central Water Commission (CWC) under the Union Ministry of Water Resources operates a national network of about 877

⁴⁴ Centro Nacional de Prevencion de Desastres

hydrological observation stations. The Central Ground Water Board monitors the ground water levels from a network of 14,995 stations.

The first flood forecasting station was established in the Yamuna River in the capital in 1958. Since then the total number of forecasting stations has now grown to 173. Flood forecasts are disseminated to the different agencies through all possible communication means for the benefit of the likely flood affected population. Daily flood bulletins are also hosted on the website: www.india-water.com for quick disseminations. The information is comprehensive and reasonably accurate (± 15 cm) with suitable advisories. On an average, 6000 forecasts at various places in the country are issued during the monsoon season every year. Special arrangements have also been put in place for sharing the river flow data of the international rivers passing through the neighbouring countries of Nepal, Bhutan, Bangladesh and Myanmar.

However, to be effective the forecasting systems need to be improved. Currently the forecasting system in India gives no information about the extent of the areas likely to be affected and the corresponding mitigation strategy. Moreover, all the potentially flood affected areas have high population densities of resource poor people. The existing flood forecasting methods can also be improved by incorporating comprehensive catchments modelling, using real time and remotely sensed data and GIS. The present lead-time of 12 hours to 72 hours in India needs to be enhanced for better preparedness and evacuation/ relief operations. The water level forecasts (which makes little sense to the user agencies) need to be converted into potential area inundation forecasts so that relief and rehabilitation response is better targeted.

Discussion. To prepare for climate change that will most likely result in more frequent and severe flood and drought episodes in the examine countries, governments, at the appropriate level, with the support of the relevant international organisations, should strengthen regional and national warning systems, with particular emphasis on the area of risk-mapping, remote-sensing, agrometeorological modelling, integrated multidisciplinary crop-forecasting techniques and computerized food supply/demand analysis.

Data and information as the basis for risk assessment and management should be government-funded and made available as a public good. The extent to which a hazard becomes a disastrous event has much to do with the planning, early warning and protective measures taken. An efficient forecast and warning system should deliver accurate information on likely events in a timely manner. It requires a rapid and people-centred distribution system for forecasts, advisories and warnings to all interested parties, and a prompt and effective response to warnings from both the government and public.

WMO has been providing assistance in flood forecasting through regional workshops with meteorologists and hydrologists and by fostering cooperation and networking. It has also been disseminating flood-hazard mapping technologies, mainly through Hydrological Operational Multipurpose System, a technology transfer system on hydrology and water resources (WMO, 2005b).

Better river basin information sharing also needs to be promoted. Argentina, for example, as a downstream country, is affected by the hydrometeorological events that occur in Brazil, Paraguay and the south-east of Bolivia. The devastating floods in Mozambique in 2000 when hundreds of thousands of people lost their homes were caused by heavy rains upstream in Zimbabwe. However, there was no system in place between these countries for sharing information about raising water levels⁴⁵. Co-ordination of information and efforts is needed among all countries sharing a river basin for flood mitigation and accurate forecasting.

Due to the lack of funding, meteo-hydrological networks in many developing countries are declining, with closure of some gauging stations. If this trend continues it will contribute to a further reduction in some countries' capacity to prepare for extreme weather events and implement adaptation measures.

The following recommendations have been proposed by the developing countries experts:

⁴⁵ <http://news/bbc/co/uk/1/hi/world/africa/662847.stm>

- There is a need to develop and disseminate risk maps.
- Early warning systems need to be integrated into governmental policy decision-making processes and emergency management systems at the national, provincial and local levels.
- People and community-based institutions should be well informed on forecasts, disaster risks and protection options, and motivated towards a culture of disaster prevention and resilience. The information on forecasts and protection options should also incorporate traditional and indigenous cultural knowledge and behavior.
- The networks among disaster experts, managers and planners should be strengthened across sectors and between world regions. Procedures need to be established for using available world-wide expertise when agencies and other important actors develop local risk reduction plans.
- The dialogue and cooperation among scientific communities and practitioners working on disaster risk reduction should be fostered.
- Cooperation among stakeholders at all level should be promoted. Institutions dealing with urban development should be requested to provide information to the public on the risks and disaster reduction options prior to constructions, land purchase or land sale.

In the four developing countries forecasts are mostly used to predict floods. Drought forecasts are less developed. Warning systems to forecast drought will make possible the implementation of drought-preparedness schemes.

For adaptation to take place there is a need for formal mechanisms that would link scientific information with policy development and water management. Climate projections and associated uncertainties need to be explained for policy makers and presented in the right format. Closer cooperation between scientists and policy makers is critical for effective adaptation to projected long term climate change impacts.

7. Conclusions

Adaptation to climate change is not yet prominent in the water management agendas of Argentina, India, Mexico and Zimbabwe. Moreover, the existing legal, institutional and technical frameworks are not strong enough to cope even with current climate variability and extreme weather events. While the basic elements of policy frameworks in the water sector of the four examined countries are there and similar to the Annex I countries examined in the Part I study, their performances are far from satisfactory. There are many legitimate reasons for this, such as wide-spread poverty in India and Zimbabwe, lack of infrastructure that provides drinking water and sanitation to rural communities in all four countries, weak institutions, lack of governmental funding for water management, high sensitivity to climate change, and others.

The four elements of domestic policy frameworks – legal, institutional, water management and information – therefore play very different roles in adaptation to climate change in the two groups of countries. Policy frameworks in Annex I countries are quite well developed: they are based on strong and enforceable legal provisions, rely on sophisticated institutional structures and involve water management measures and policies that are constantly adjusting to address changing climatic and hydrological conditions. While in some countries the arrangements are not flexible enough to incorporate adaptation and need to be modified to allow certain adaptation actions, others provide a good basis for adaptation in the water sector. The analysis of four non-Annex I countries demonstrates that domestic policy frameworks for management of water resources in these countries are very weak and contribute to these countries' vulnerability to climate change.

The analysis of the developing countries' policy frameworks in the water sector and their abilities to facilitate adaptation revealed that adaptation to climate change in these countries should first of all start with strengthening institutional, legal and technical capacities at all levels.

To adapt to climate change in the water sector, the developing countries need to focus on the following actions:

1. Review and update (or as necessary establish) their water legislation with a view to incorporating adaptation to climate change;
2. Where feasible, implement a fair and flexible system of water abstraction permits;
3. Assess the adequacy of traditional institutions with the aim of streamlining decision-making while building on their strengths;
4. Develop and improve water management strategies, drought and flood plans;
5. Create formal systems for information sharing among agencies at all levels, among related sectors (for example, agriculture, energy, environment, etc.), and between scientific and governmental communities.

The lack of a fair and functioning system of water abstraction rights in developing countries leads to water conflicts, inefficient use of water in areas with abundant water and famine in areas with water scarcity. The absence of a system that accounts for all water users contributes to the inefficiency of the management of water resources. Introduction and improvements of systems of water abstraction permits, with specific requirements for the amount, timing, purposes and period of water abstraction will allow governments to have greater control over water resources and their management, and will provide flexibility in adjusting water abstraction depending on water availability. Lack of institutional co-operation and a good institutional structure further contributes to inefficient water resources management. Many government agencies also lack the capacity to manage the water resources effectively.

Market mechanisms for water sharing might be as effective in non-Annex I countries as they are in the developed countries (California and the UK examples in the Part I report). There are several examples when local governments or community organisations in the examined developing countries in the absence of relevant regulations created ways for water sharing: water trading, renting/contract, decisions based on priority needs, demonstrating feasibility of such approaches. These methods should be incorporated in legal frameworks and made available for all.

The rule of law and transparency are essential preconditions for good water policy decision making. This might seem quite obvious, but it is often the missing component that leads to the marginalisation of certain groups of society and aggravates poverty and overall vulnerability of the population in developing countries to climate change.

Stakeholder participation in decision-making is a crucial issue in non-Annex I countries. In the countries where the majority of population is involved with agriculture and directly depends on water resources, participation of all the stakeholders, including small communities of farmers, in water management is especially important.

Poor communities in drought and flood prone areas are the most vulnerable to extreme weather events and will become even more vulnerable as climate changes. They are the ones who possess indigenous knowledge and might have skills and experience with adaptation to weather trends. They need to be heard by the government and need to receive help in implementing local level adaptation measures. These communities also need to receive information from the government of their weather/climate related risks and possible solution/adaptation strategies, like for example change of crop, timing of plantation, rain water harvesting, temporal and permanent migration from agriculture land. They should be trained to have other skills that would allow them to get other income unrelated to agriculture. Decentralising authority to the local level can help protect natural resources and improve livelihoods of people.

Community level adaptation projects funded by bilateral and multilateral organisations is an important component of building adaptive capacity in developing countries. These projects educate local stakeholders

on climate risks and possible adaptation tools; they bring knowledge and experiences of other communities with similar conditions thus sharing best practices. These projects also create links between communities and national and sub-national governments. Involving farmers in the irrigation system is one obvious remedy to address the problem of adequate water management. By entrusting responsibility for irrigation to a village or a group of villages, efficient use of available water can be promoted.

Water infrastructure is another critical component that would facilitate these countries' adaptation to climate change. Irrigation network systems are necessary to improve livelihoods of many rural communities in the case-study countries. Water reservoirs and small water harvesting pools are essential for making water available to the population at any time. In addition to water specific infrastructure, general infrastructure for basic needs is also necessary: roads, access to markets. Impacts from climate change should be considered in infrastructure development; building standards that incorporate climate change forecasts should be enforced for dams, bridges, roads, buildings, etc.

Information is critical to good decision-making and water management. In general climate change models, weather forecasts, climate projections and information on possible impacts are available to the governments of the case study countries. The challenge that these governments face is how to use this information. Early warning systems proved to be extremely important in avoiding large scale damages. However, lack of preventive measures and plans to address upcoming droughts and floods diminish effectiveness of early warning systems. More emphasis needs to be made on interpreting social implications of projected weather events. More research is needed in identifying and mapping areas especially vulnerable to climate change. Developing countries will also benefit from a wider dissemination of practical information on, for example, water requirements and demand for different crops; and indigenous knowledge of local level adaptation measures.

There are many adaptation measures for the water sector that have been identified by many organizations and documented in various literature, they include the following: increased water storage capacity; desalination; efficient water pricing; recycling waste water; increased irrigation water efficiency; reduced leakages; increased drought tolerance through drought tolerant crops.

The analysis, conducted under the auspices of the Annex I Expert Group, of policy frameworks in the water sector in the four Annex I and four developing countries identified other measures which are crucial for adaptation to climate change, such as:

- Development of a comprehensive system of water abstraction permits with specific time limits and other conditions;
- Allowing water trading;
- Coordinating land-use management with water management e.g., regulating development on flood plains; Use of risk zones maps;
- Development of flood and drought plans with clear mitigation measures; Better use of forecasts and warning systems;
- Creation of clear institutional arrangements for water and disaster management, with clear division of responsibilities and mechanisms for stakeholder participation;
- Development and re-evaluation of international water treaties with taking climate risks into account;
- Implementing demand-side policy measures such as water metering and pricing;
- In developing countries, development of such basic services as healthcare, education, and professional training will also facilitate adaptation to climate change;
- Incorporation of indigenous rules, knowledge and adaptation measures into decision-making and water management planning.

Implementing such measures would enhance adaptive capacity of countries vulnerable to climate change. However, they will require significant input of human and financial resources. Changing domestic legal and institutional provisions will take political will and initiative on the part of national governments. Implementation of specific instruments, such as techniques for water efficiency, improved flood and drought forecasting, may be facilitated by international cooperation. Information sharing, exchange of experiences and best practices on the national and international levels will continue to play an important role in formulating adaptation strategies and putting them into practice.

References

- Agrawala, S. (ed.) (2005.), *Bridge Over Troubled Water: Linking Climate Change and Development*, OECD, Paris, France.
- Alamo, U and Cifuentes, E. (2005.), *View of Mexico's Water, and Public Health Management Sector*.
- Bruns, B. R., Ringler, C., and Meizen-Dick, R. (eds.) (2005), *Water Rights Reform: Lessons for Institutional Design*. International Food Policy Research Institute.
- Department for Environment, Food and Rural Affairs (Defra), (2005.), *Impacts of Climate Change in India, Keysheet 5: Climate Change Impacts on Water Resources in India*.
- Garduño, H., (2005.), *Lessons from Implementing Water Rights in Mexico* in *Water Rights Reform: Lessons for Institutional Design* (Bruns, B.R., Ringler, C., & Meizen-Dick, R. eds.), International Food Policy Research Institute.
- Gleick, P., (2004.), *Water Conflict Chronology*. Pacific Institute for Sustainable Development, Environment and Security, (www.pacinst.org).
- Government of India, Ministry of Water Resources, 2002, *National Water Policy*, New Delhi
- Fourth World Water Forum, 2006, *Water and Climate Risks: A Plea for Climate Proofing of Water Development Strategies and Measures*.
- Gonzalez, F and Magana, V., (2006.), *Mexico Country Case Study on Domestic Policy Framework in the Water Sector*.
- Gumbo, D., (2006.), *Zimbabwe Country Case Study on Domestic Policy Frameworks for Adaptation in the Water Sector*.
- Hammer, J.H. and Wolf, A.T., (1998.), *Patterns in International Water Resources Treaties: The Transboundary Freshwater Disputes Database*, *Colorado Journal of International Environmental Law and Policy Yearbook*.
- India's Initial National Communication to the UNFCCC, 2004.
- Institute of Development Studies, (2005), *Vulnerability, Adaptation and Climate Disasters*. Volume 36, Number 4, October. IDS Bulletin.
- Levina, E., Adams, H., (2006), *Domestic Policy Frameworks for Adaptation to Climate Change in the Water Sector, Part I: Annex I Countries*. OECD.
- Linnerooth-Bayer, J., Mechler R., Pflug, G., (2005), *Refocusing Disaster Aid*. *Science*, Vol. 309. no. 5737, pp. 1044 – 1046.
- Magnani, C., (2001), *Derecho de Aguas. Instrumentos normativos y regulatorios de la gestión de los recursos hídricos*, *Curso Internacional de Posgrado sobre Gestión Integrada de los Recursos Hídricos*, Universidad Nacional de Buenos Aires, Secretaría de Ciencia y Técnica e Instituto Argentino de Recursos Hídricos, Buenos Aires.
- Mtisi, S. and Nicol, A., (2003.), *Caught in the Act: New Stakeholders, Decentralisation and Water Management Processes in Zimbabwe*, *Sustainable Livelihoods in Southern Africa Research Paper 14*
- OECD (2003), *OECD Territorial Reviews: Mexico*.
- Organisation for Economic Cooperation and Development, (2004.), *OECD Mexico: Progress in Implementing Regulatory Reform*, OECD.
- Organisation for Economic Cooperation and Development, (2005), *Measuring Aid For Water*, OECD. www.oecd.org/dac/stats/crs/water

- Organisation for Economic Cooperation and Development, (2006.), Infrastructure to 2030: Telecom, Land Transport, Water and Electricity, OECD.
- Nemarundwe, N., and Kozanayi, W., (2002.), The use of Information institutions and social networks to access and manage water resources in a semi arid area in Zimbabwe, presented at the October 2002 meeting of the Beijer Institute and the Abdus Salam ICTP.
<http://www.beijer.kva.se/teaching/witness.doc>
- Orlov, B.S., and Tosteson, J.L., (1999.), Lessons From Australia, Brazil, Ethiopia, Peru, and Zimbabwe, Institute of International Studies, University of California.
- Pangare, V., Kulkarni, N. and Pangare, G., (2004.), An assessment of water sector reforms in the Indian context: The case of the state of Maharashtra, prepared for the United Nations Research Institute for Social Development Project on “Commercialization, Privatization and Universal Access to Water.”
- Pochat, V., Natenzon, C., and Murgida, A. M. (2006), Argentina Country Case Study on Domestic Policy Frameworks for Adaptation in the Water Sector.
- Rosenzweig, C., Strzepek, K. M., Major, D. C., Iglesias, A., Yates, D. N., McCluskey, A. and Hillel, D. (2004), Water resources for agriculture in a changing climate: international case studies, *Global Environmental Change*, 14, p. 345-360.
- Saleth, R. M., (2004), Strategic Analysis of Water Institutions in India: Application of a New Research Paradigm, Research Report 79, International Water Management Institute.
- Sharma, B. R., and McCornick, P. G., (2006), India Country Case Study on Domestic Policy Frameworks for Adaptation in the Water Sector.
- Sithole, B., (2001), Participation and Stakeholder Dynamics in the Water Reform Process in Zimbabwe: The Case of the Mazoe Pilot Catchment Board, *African Studies Quarterly* 5, no.3: [online] URL: <http://web.africa.ufl.edu/asq/v5/v5i3a2.htm>
- United Nations Environment Programme, (2006), UNEP Dams and Development Project, Confluence Newsletter, July 2006, No 9.
- UN Human Development Indicators, (2003).
- UNFCCC, (2006), Background paper for the African Workshop on Adaptation. Implementation of Decision 1/CP.10 of the UNFCCC.
- Water and Climate Risks, (2006)
- World Bank, (2000a), Argentina Water Resources Management: Policy Issues and Notes, Thematic Annexes Volume III.
- World Bank, (2000b), Argentina Water Resources Management: Policy Elements for Sustainable Development in the XXI Century, Main Report, Report No. 20729-AR
- World Bank, (2005), The Little Green Data Book.
- World Bank, (2005b), India’s Water Economy: Bracing for a Turbulent Future. Draft report. The World Bank, New Delhi, India.
- World Bank, (2006), World Bank Governance Indicators.
- World Meteorological Organization, (2005a), WMO Statement on the Status of the Global Climate in 2005.
- World Meteorological Organization, (2005b), WMO Annual Report 2005. Weather, climate, water and sustainable development.
- WRI, (2003), Earth Trends Country Profile.
- Zimbabwe Initial National Communication to the UNFCCC, (1998).

Glossary

Abstraction	The removal of water from any source, either permanently or temporarily.
Borehole	Well sunk into a water-bearing rock from which water will be pumped.
Catchment	The area from which precipitation and groundwater will collect and contribute to the flow of a specific river.
Groundwater	Water beneath the earth's surface in underground rock layers; can be within large cracks and openings in the rock layers or in inter-connected spaces between individual rock grains. Water within the saturated zone of an aquifer.
Irrigation district	A district formed by landowners to pay for the diversion and delivery of water to their land.
Policy framework	International and domestic legal frameworks, institutional landscape, water management policies and instruments and information that can be used in water management.
Appropriative right	A person may acquire a right to divert, store, and use water regardless of whether the land on which it is used is adjacent to a stream or within its watershed. The rule of priority between appropriators is “first in time is first in right”.
Riparian right	The right to divert, but not store, a portion of the natural flow for use based on the ownership of property adjacent to a natural watercourse.
Water project	Large infrastructure developments that transport water from the source to where it is required.
Water resources	A country's usable surface water and groundwater.
Water supplier	A public or private body that supplies clean water to households, industry, agriculture etc.

Acronyms

CGWB	Central Ground water Board (India)
CNA	National Water Commission (Mexico)
CWC	Central Water Commission (India)
IBWC	International Boundary and Water Commission (between Mexico and the US)
ICAR	Indian Council of Agricultural Users
LAN	Law for National Waters (Mexico)
MOWR	The Union Ministry of Water Resources (India)
NWP	National Water Policy (India)
NWDA	National Water Development Agency (India)
NWRC	National water Resources Council (India)
NWB	National Water Board (India)
RDC	Rural District Councils (Zimbabwe)
WUA	Water Users Association
WRPR	Water Rights Public Register (Mexico)
ZINWA	Zimbabwe National Water Authority

Annex A. Case Study Country Profiles

This Annex presents a country by country summary of information analysed in the main body of the report.

A1. Argentina

Climate change impacts and vulnerability: Major challenges for the water sector in Argentina will come from more extreme droughts and floods, and from the uneven distribution of water resources. Flooding will be exacerbated by changes in storm intensity from the Atlantic Ocean and sea level rise. Runoff is also expected to increase in some areas (e.g. La Plata Basin) but decrease in others (e.g. the Colorado, Negro, Senguerr, and Patagonian Rivers). Increasing temperatures will lead to decrease in snowmelt and runoff in the Andes, where an accelerated retreat of glaciers is expected in a timeframe close to 40 years. See Pochat et al, 2006, Rosenzweig et al, 2004.

About 71% of all abstracted water is used for irrigation, 13% for drinking water supply, 9% as livestock water and 7% by industrial uses⁴⁶.

Domestic legal framework: Water supply and sanitation management is decentralised into regional, provincial and municipal jurisdictions, showing a great variety of organisational modalities which reflects the organisation complexity of the sector.

There is no national Water Code or Law as the Argentinean Constitution gives provinces authority over their water resources. The Republic's civil code indicates that concessions should be used as means of acquiring the right to use water. All provinces require water-use concessions that are based on premises of beneficial and non-detrimental use of water to other users. Priorities for water use are commonly set via provincial legislation in accordance with the territory's economic use (World Bank, 2000a). Argentina has a riparian water rights system. Almost all provinces adopt regulations that are based on a rather rigid framework sponsored by the Legal Principle of Inherent Rights, which states that water may only be used on land from which it has been extracted (World Bank, 2000b). Since non-transferable water rights are assigned to a piece of land in a specific amount whether used or not, this system does not encourage efficient water use and does not provide for water sharing among various users through transfer or purchase of rights.

There have been calls for a national water law in Argentina. However, a recent Law N° 25688 'Regime for Water Environmental Management', promulgated at the national level and pending regulation, was criticised for being unconstitutional by taking over provincial competences on water (Pochat, V., et al., 2006). To address the issue of inconsistent provincial regulations regarding water resources a project was launched in May 2005 that calls for "Adopting the Argentina's Water Policy Leading Principles and other related matters as guidelines for the Nation's Policy".

Institutional set-up: Given the federal nature of the Argentinean government system, there is no single national water authority responsible for water management. However, several organisations intervene in the water resources management both at the national and provincial level. The main national organisation for water resource management is the Under-secretariat of Water Resources, in the Secretariat of Public Works in the Ministry of Federal Planning, Public Investment and Services. Its objectives, include: elaborating and executing the national water policy, proposing the regulatory framework governing water resources, coordinating the actions of the other jurisdictions and organisms involved in water policy; elaborating and implementing programmes and actions that manage shared international water resources and inter-provincial water regions; formulating and executing infrastructure, and developing water programmes and actions.

⁴⁶ Calcagno, A., Gaviño Novillo, M. and N. Mendiburo, 2000. Informe sobre la gestión del agua en la República Argentina, Comité Asesor Técnico de América del Sur (SAMTAC), Asociación Mundial del Agua (GWP) (www.eclac.cl/dmri).

Many other national organisations are involved in water resource management, including Ministry of Internal Affairs, Ministry of Foreign Affairs, International Commerce and Cults, Secretariat of Agriculture, Livestock, Fisheries and Food, in the Ministry of Economy and Production, Secretariat of Energy, Dam Safety Regulating Organism, Secretariat of Environment and Sustainable Development, in the Ministry of Health and Environment, and others.

At the provincial level, there is a great diversity of institutions involved in the water resource management. Nonetheless, there are some common features. Submitting water abstraction licenses; overseeing reliable supply of safe drinking water; flood and drought predictions, plans, management and recovery actions, and the ownership of dams and reservoirs, among other issues, are in principle under the responsibility of the provinces. As water resources are generally shared by two or more provinces, large investments are required to deal with the frequently complex water problems and available resources need to be equitably distributed, the federal government has also generally played a very important role. For example, until the beginning of the 1990s it owned national companies that constructed and operated large works, such as dams.

Most provincial water resources administrations are branches of different ministries: including irrigation administration, departments of water, irrigation, drinking water and sanitation. Ten River Basin Committees were set up to help co-ordinate inter-provincial activities. These structures were initially successful but lost effectiveness due to the lack of funding. (Pochat et al. 2006)

In September 2003, most jurisdictions signed the *Federal Water Agreement*⁴⁷ through which they adopted the Water Policy Leading Principles and agreed to submit them to the Nation's Congress in order to get a set of rules and regulations through a National Framework Law of Water Policy. Jurisdictions also explicitly committed themselves to adopt these principles in their respective policies, legislations and management of water. The agreement of all jurisdictions on those basic guidelines constitutes a fundamental first step for the definition of future strategies and plans at provincial and national levels.

Despite the decentralised nature of governance, water users are not actively involved in water management. On the one hand, there is a lack of political willingness to carry out the actual transfer of powers (with associated administrative and financial autonomy) to user associations. On the other hand, there is some resistance from users who associate decentralisation with the loss of subsidies. However, there are several relatively successful cases of decentralisation and transferring powers to user association. For example, Mendoza River watershed Committee is comprised of 76 users' agencies that administer the irrigation network of the Mendoza River "oasis".

Water supply and sanitation services are operated by a total of 1,548 companies or organisations, with 70% private entities. The private concessionary companies serve about 61% of the urban population (V. Pochat, 2006).

Water management: Argentina does not have a national plan for water resources management, although actions have been initiated to move towards a Water Resource Management Master Plan⁴⁸. The first step, between 1994 and 1996, was to carry out a Preliminary Diagnosis of Water Resource Management. The government has also recently initiated the development of the Integrated Water Resources Management Plan for La Plata basin, the plan will include adaptation to climate change.

However, there is a Federal Plan for Flood Control, which consists of structural and non-structural measures. The structural measures contemplate works for the protection of urban areas, productive lands and infrastructure. The non-structural ones comprise activities such as, among others: a) technical assistance for establishing or strengthening of the capacity of each province to face flood problems, b) preparation of plans and regulations for land use in flood-prone zones; c) installation of an early warning system; d) coordination

⁴⁷ Acuerdo Federal del Agua

⁴⁸ Principios Rectores de Política Hídrica

of activities of the warning system and the civil defence; e) preparation of shelters for the probably affected sector of the population; f) organisation of education and public awareness campaigns⁴⁹. The autonomous city of Buenos Aires has a Master Plan for Hydraulic Management and Floods Control⁵⁰.

The country does not have long-term drought plans. The civil protection sector prepared some projects to address this situation. However there were no financial resources to implement them. Response plans to drought do exist, mostly involving the Civil Protection Agency and the agriculture industry giving money to those affected

Water infrastructure: 80% of the rural population does not have access to drinking water and a larger share does not have access to basic sanitation. The situation in urban areas is better, but even so around 50% of the urban population does not have access to sanitation. There are over 100 major storage dams in Argentina; most of them are for multiple uses (electrical generation, municipal and industrial water supply, irrigation, flood mitigation, navigation and recreation). Thirty-one of them are mainly for hydroelectric use. In the urban conglomerate of Buenos Aires more than 500 water supply wells had to be taken out of service over the past 30 years due to water quality problems caused by over exploitation.

Water policies: All organisations and companies which receive concessions for water withdrawals have their respective tariff regimes, directly established by the provincial governments - in the case of public agencies - or discussed between the regulatory entities and the private organisations, in the framework of their concession contracts. These tariffs are envisioned as the main source of income needed for investments in rehabilitation and maintenance of a generally old infrastructure and to expand the services. However, tariffs are sometimes established by taking into account social and political, as well as economic, criteria. These tariffs may thus not cover all operation costs and investment needs. Consequently, some kind of explicit or implicit subsidies are frequently involved.

Information availability: A Hydrological Warning Operative Center in Argentina which was established in 1983 after extraordinary floods of 1982 and 1983, collects and disseminates information on water flows in the rivers. A National Meteorological Service is in charge of observation and evaluation of the meteorological situation, with its own operative network of 114 weather stations, getting also 12 geostationary meteorological satellite images. Hydroelectric power stations jointly operated by Argentina and Uruguay and Paraguay, have hydro-meteorological networks of numerous stations that produce hydrometric and rainfall data. The inter-jurisdictional organisation of six Argentinean provinces and the Nation has Hydrological Information System with 12 hydrometric stations. The information is updated daily on the internet (www.corebe.org.ar). Research Centre on Water and Atmosphere analyses hydrological and meteorological data and develops forecasts of water flows.

The responsibility of the National Warning System is to provide early warning of strong floods or low flows to the national and provincial organisations in charge of water emergency control, of navigation, and of the population and environment protection. The Warning System collects information from various organisations from bilateral hydropower commissions (including their numerous hydrometric stations) and national meteorological service and National Commission for Space Activities to agro-meteorological stations and regional and provincial river basin stations.

A2. India

Climate change impacts and vulnerability: Floods, droughts and cyclones are the main extreme climatic events in India. Indeed, 12% of the land area is flood-prone (Sharma et al. 2006) and 19% (affecting 12% of the population) is drought-prone. Climate change is expected to increase the intensity of the

⁴⁹ http://www.corrientes.gov.ar/hacienda/entes-ministro/supce/web/supce_archivos/frame.htm#slide0074.htm

⁵⁰ Plan Maestro de Ordenamiento Hidráulico y Control de Inundaciones

hydrological cycle. This means that dry areas will receive less precipitation, wet areas will receive more, and the majority of the precipitation will fall over a shorter rainy season. The precipitation extremes associated with the El Niño South Oscillation could become more intense (Sharma, et al 2006). The retreat of Himalayan glaciers due to climate change will affect flows in several major rivers. Flows are likely to increase in the next 50 years as the glaciers melt giving rise to higher flood risk, then runoff will decrease leading to much reduced flows in the dry season, threatening the environmental use of the rivers. Given a wide diversity of current climate conditions in the country and various projected impacts of climate change, different rivers will be affected differently.

India has 16% of the global population but only 4% of global water resources (Defra, 2005). Water scarcity in many areas is exacerbated by inefficient use of water for irrigation (84% of the total water withdrawals) and unsustainable groundwater abstraction. India currently relies heavily on groundwater for irrigation purposes and is extracting at a rate much higher than the natural system can replenish supplies. Groundwater recharge is expected to decrease with climate change and is estimated to lead to a fall in groundwater tables by 6-8 m in some areas. This would increase the cost of water extraction by at least 3 to 4-fold by 2060.

Domestic legal framework: India does not have any separate and exclusive water laws, but rather water-related legal provisions dispersed across various irrigation acts, central and state laws, provisions in the constitution, orders/decrees of courts, customary laws, and various penal and criminal procedure codes (Sharma, et al. 2006). As most of the water-related legal provisions enacted in the past were characterised by water surplus conditions, they fail to reflect the current conditions of increasing water scarcity. A National Water Policy (NWP) formulated in 1987 following an unprecedented drought, laid out the central and state governments' approaches on water resources planning, development, allocation and management. The NWP did not suggest any major economic and institutional changes for better management of the resources and soon became redundant. A new NWP was declared in 2002, which in addition to the earlier provisions recognised the role of private sector participation and the need for a paradigm shift from resource development to efficient use of the developed resources. However, it did not fully incorporate the current level of thinking with regards to effective basin management. This policy also failed to address the economic and institutional issues that are constraining the water sector in India, (Sharma et al. 2006).

India has no explicit legal framework on water abstraction rights. Individual rights to both surface and ground water are recognised indirectly through land rights. Irrigation acts do not allow moving canal waters (surface water) to non-canal areas. So for groundwater a "water right" is similar to property right, while for surface water it is more of a use right. Control over groundwater at the field level is governed by a system of rights determined by farm size, the depth/number of wells, pumping capacity and economic power (Saleth 2004).

The central government has prioritised water use in order to provide a general framework for resolving inter-sectoral water allocation conflicts. The priority is as follows: drinking water, irrigation, hydropower, ecology, agro-industries and non-agricultural industries, navigation and other uses. Inter-state conflict resolutions in India often rely on past negotiated agreements for developing/sharing water among concerned states/regions. When there is a difficulty in reaching the agreement, the concerned parties can turn to the tribunal established by the central government under the provisions of the Inter-state Water Disputes Act of 1956. However, analysis indicates that existing legislation is not sufficient to resolve water quantity and quality issues between states in India (Sharma et al. 2006).

While no legal provisions exist for water trading, *de facto* groundwater markets exist between agricultural landowners. The system is unbalanced because there are more buyers than sellers, and the buyers tend to be small farmers without a strong bargaining position. In some areas it is estimated that 80% of irrigated land is irrigated by water from groundwater markets, (Saleth 2004). Since there is no system of water abstraction permits that would regulate the amount of abstracted water, groundwater markets encourage over-abstraction from aquifers. The markets also increase the inequity between large influential farmers and smaller, less resource-rich farmers (Saleth 2004). Markets could make water use more efficient if incorporated into the right legal framework, with water use quotas assigned to each abstractor that could then be traded.

Traditional structures and rules play a certain role in the water management in India. Micro-level water conflicts may be resolved through informal/traditional village level institutions, formal village councils and water user associations. There are examples when the irrigation canal authorities issue time-limited ‘water passes’ on a first-come-first-served basis. Priority is based loosely on their duration, and they are non-transferable and contain quantitative specifications (Saleth, M., 2004). These community-managed water distribution systems are generally good for adaptation purposes because they allocate the water using councils and after taking into account current water levels.

Institutional set-up: India has a federal system of governance. States are responsible for financing, cost recovery and management of surface irrigation and water supply related activities within their territory. The central government also plays a significant role by providing financial assistance to states and through undertaking the construction of irrigation projects of national importance.

The following institutions are responsible for water resources management at the national level: Union Ministry of Water Resources (MOWR) - the national organisation that is responsible for overall planning and management of the water resources in the country; Central Water Commission (CWC), the Central Ground Water Board (CGWB) and the National Water Development Agency (NWDA) – all under the MOWR – provide the overall monitoring and technical support; Indian Council of Agricultural Research (ICAR); and Planning Commission, which provides project clearance and approves financial allocation to various water (irrigation/ hydropower/ multipurpose) projects in different states. Pollution control boards are set up both at national and state level, and are responsible for water quality aspects.

In many states the administration and functional responsibilities for managing water resources are unclear and spread over a number of different government institutions (e.g. irrigation/ water resources departments, public works department, revenue departments, groundwater boards, minor irrigation corporations, pollution control boards, municipal corporations etc.). This impedes development of an integrated approach to water management. As with many countries, water administration is based on administrative boundaries and projects rather than on hydro-geological/water basin boundaries. This gives rise to several water sharing disputes among the states sharing a common river or other water resource.

Important organisational arrangements have been established to achieve inter-state and national-state coordination. These include various river boards created under the River Boards Act of 1956 and the National Water Resources Council (NWRC) set up in 1983, and the National Water Board (NWB) set up in 1990. The NWRC is an important policy organisation in the Indian water sector as it is the apex body chaired by the Prime Minister and includes the Union Minister of Water Resources and the Chief Ministers of each state. In order to achieve a consistent level of adaptation across the country and in order for large scale water projects (e.g. inter-basin transfers) to take place states must work together, and (more) central oversight/coordination may be required for this to occur.

India has many indigenous water management, irrigation and drinking water systems which have developed through-out its many diverse communities. Combining these indigenous water techniques with decentralised water decision making will provide India with flexibility, creativity and adaptability of the water sector in view of projected climate changes. However, there has been gradual demolition of the local traditional systems which further contributes to water shortages, (Centre for Science and Environment (1999) cited in Bhandari. and Khare 2006). Involving farmers in irrigation systems can help address the problem of inadequate water management. By entrusting responsibility for irrigation to a village or a group of villages, efficient use of available water can be promoted. There is an example of Orissa State in India where parts of irrigation system were transferred to farmers for maintenance and management. The farmers formed water user associations (Pani Panchayats) and they were registered as legal entities. This improved both infrastructure maintenance and agricultural productivity.

Water management: Planning for India’s water resources is included in the Five Year Plans. Priorities of the current Plan (2002 to 2007) include ensuring that all of the rural population receives a sustainable supply of water; increasing decentralisation of water supply management; mandatory water audits in order to

monitor water demand; efficient water use; increased storage of monsoon rains as ‘groundwater sanctuaries’ and maintaining historic minimum flows in rivers to help dilute surface water pollution. An increase in water user associations to manage irrigation infrastructure and charging for water at its true cost is also encouraged. The Five Year Plan also suggests forming a new integrated Flood Management Commission. All these measures will help adaptation in various practical and policy-based ways. The abatement of water pollution is also essential because a reduction in water quality makes available water unsuitable for use.

Flood management planning started in 1954 (after some devastating floods) with the establishment of the National Flood Commission (Rashtriya Barh Ayog)⁵¹. The major emphasis has been on structural measures including constructing more than 34,000 km of embankments and enlarging the capacity of more than 51,000 km of drainage channels. 4721 villages have also been relocated onto raised lands (CWC, 2004). The major non-structural measures have included (a) flood forecasting and warning (b) flood plain zoning (c) flood proofing (d) disaster preparedness and response planning and (e) flood relief. However, there is still an urgent need to develop an integrated planning for extreme climatic events/disasters at all levels from district to state and central government. This also needs to include the relevant communities and civil society organisations.

Government schemes to combat droughts include the Desert Development Program (DDP), the Drought Prone Areas Program (DPAP), the Integrated Watershed Development Program (IWDP) and the National Watershed Development Program for Rain fed Areas (NWDPA). These are area based development programs where certain structural measures like stabilising sand dunes, regenerating pasture lands, maintenance of traditional water resources and afforestation with region specific species is undertaken. Several research institutes in the country have been devoted to the development of technologies, practices and policies for better adaptation to droughts.

Traditional coping strategies in response to drought include migration of human and livestock population to wetter areas, sale of assets, dependence on government relief works, and water and food aid, sharing and cooperation, diversification in sources of income and borrowing from banks and money lenders. State government also makes arrangements to supply drinking water to the affected populations through water tankers and special water trains. Water harvesting at individual, community and state level has emerged as a strategic tool for effectively mitigating droughts and improving productivity and livelihoods (Sharma, 2004). Even in drought-affected areas storms can generate considerable runoffs and could be harvested in underground cisterns (drinking water for human/ cattle population); village ponds (cattle and domestic needs) and runoff-based farming systems. This would better help communities face droughts of different intensities.

The past efforts in drought management at the central and state government level have ensured that droughts do not trigger widespread food famines and epidemics. Medium and long range weather forecasts, creating food and fodder depots, providing employment and relief to the affected families, building resilience into traditional agricultural system appear to be good steps in combating low/medium-intensity droughts. However, most response measures and institutional arrangements are still ‘ad-hoc’, and while they provide some relief during droughts, they do not facilitate drought preparedness, drought management and drought-proofing of the vast areas which might be impacted as a result of climate change.

Water infrastructure: India has one of the lowest per capita dam storage capacities in the world. There is no infrastructure to adapt to changing hydrological regimes of rivers fed by Himalayan glaciers as much more storage will be required to capture glacier and snow melt and adapt to increased winter precipitation.

In India, different states have different economic development levels and therefore varying amounts of money to spend on infrastructure renewal. This could lead to different degrees of preparedness to climate change across India and will increase stress on water resources in inter-state basins. Inter-basin transfers are likely to become more important in future. If these are deemed necessary they will require large-scale

⁵¹ <http://planningcommission.nic.in/reports>

infrastructure development. These in themselves may increase or decrease the vulnerability of water supply to climate change but they also need to be climate-proofed and incorporate flexibility to climate change.

India has conducted three Minor Irrigation Censuses, the last with a reference year of 2000-2001. These are particularly useful for adaptation purposes because they look at those schemes that are under-used and. They also examine the water distribution devices, e.g. irrigation systems⁵². The most inefficient irrigation areas can then be targeted with more efficient technology.

Water policies: The prevailing cost recovery and water-pricing policies in India are inefficient. The Committee on Pricing Irrigation Water recommended the recovery of not only full operation and maintenance costs and one percent capital cost, but also a percentage of the depreciation cost. Unfortunately, despite widespread approval this policy was never implemented (mainly due to political considerations), as it would have led to an increase in water rates. Water charges for irrigation services are currently fixed by irrigation/revenue departments of the state and depend upon the crop and area to be irrigated. These charges are very low and vary by state and crop from US\$ 2 to US\$ 10 per hectare per season.

For demand side management to occur radical changes will be needed in the way irrigation and agricultural water is managed. In India irrigation uses over 84% of all water abstracted. Encouraging drip irrigation over spray irrigation, reducing evaporation from canals and reservoirs, charging the true price for electricity to slow the rate of groundwater abstraction and ensuring that irrigation systems work at the highest efficiency possible are the tools that can reduce the demand for water. Water demand might also be reduced if the unofficial water trading schemes that have become established are fitted into a regulatory framework. In urban settings water is wasted through illegal connections, faulty metres, high water losses and due to insufficient institutional and monitoring capacity (Pangare et al, 2004).

Information availability: India has developed a sound technical information base and expertise in many aspects of water development and management. However, the effective application of this information and knowledge at the practical level is constrained by a number of factors including the absence of appropriate organisational arrangements for enforcement and monitoring.

India has a strong basis for flood forecasting, having a network of 173 forecasting stations. Flood forecasts are disseminated to different agencies. Daily flood bulletins are also hosted on the website: www.india-water.com for quick disseminations. On an average, 6000 forecasts at various places in the country are issued during the monsoon season every year. Special arrangements have also been put in place for sharing the river-flow data of the international rivers passing through the neighbouring countries of Nepal, Bhutan, Bangladesh and Myanmar.

However, the forecasting systems need to be improved to be effective. Currently these systems give no information about the extent of the areas likely to be affected and the corresponding mitigation strategy. The existing flood forecasting methods can also be improved by incorporating comprehensive catchments modelling, using real time and remotely sensed data and GIS. The present lead-time of 12 hours to 72 hours in India needs to be enhanced for better preparedness and evacuation/ relief operations. Further, the information presented should be in terms of potential area inundation forecasts (rather than in terms of water levels). This would help to target relief and rehabilitation responses.

A3. Mexico

Climate change impacts and vulnerability: Mexico has nearly 150 rivers; most are small, non-navigable, and 70% drain into the Pacific Ocean. Most of the largest river systems are found in central

⁵² Government of India, Ministry of Water Resources, 3rd Census of Minor Irrigation Schemes 2000-2001 website, Results and Findings: <http://wrmin.nic.in/mi3census/chapter5.pdf>

Mexico. Less than a third of total runoff occurs within the 75% of the territory where most of the country's largest cities, industrial facilities and irrigated land are located (González and Magaña, 2006). Consequently, surface runoff and groundwater are increasingly insufficient to support the high growth rates and economic activity, resulting in disputes over surface water usage and the over pumping of aquifers.

According to the IPCC Third Assessment Report, Mexico will become warmer and drier with climate change. Mexico is heavily affected by the El Niño Southern Oscillation (ENSO) phenomenon, which already creates disruptive climate extremes on an inter-annual timescale. For example, there are positive precipitation anomalies during winter over northwest Mexico and negative summer precipitation anomalies elsewhere in Mexico. A strengthening of the effects of El Niño (the warm phase of ENSO) with a rise in the surface ocean temperature could have severe consequences for Mexico.

Domestic legal framework: Mexico has a Law for National Waters (LAN) that establishes the legal and regulatory framework needed to manage scarce water resources (González, F., et al., 2006). At present the LAN does not include clear statements regarding climate change, but its existence means that there is a framework into which adaptation can be easily incorporated. Through the LAN, special administrative and reserve zones can be established by decree where over-use, water quality or drought necessitates special action to be taken to preserve the environment or water supplies. The LAN also established a new water abstraction rights administration system. The stated objectives of the law are "to regulate the extraction, use, distribution and control of the nation's waters as well as preserve their quantity and quality in order to achieve sustainable integral development". Mexico also has state laws that regulate potable water and sewage.

The overall goal of a legal system of water rights that was introduced in 1992-1994 is a comprehensive accounting of all water uses. By December 2000, about 320,000 users had been granted abstraction permits in Mexico, which were recorded in the Water Rights Public Register (WRPR) (Bruns et al., 2005). However, the total volume of abstraction permits granted in many river basins and groundwater aquifers exceeds water availability. On the other hand, water abstraction and wastewater discharge levies that are incorporated into the system of water rights have contributed to increased water use efficiency. They also contribute substantially to funding of water management.

Various forms of markets are authorised under the legal system and have been introduced to facilitate access to water. Mexico sets a very important example for non-Annex I countries in allowing trading of water abstraction rights. Users are free to trade their rights within irrigation districts, they are also free to transfer their rights when the user changes. Other transactions are also possible but subject to approval. Areas where water rights could be transferred separate from land property were prescribed by a special decree. This flexibility is very important in resolving situations of mismatch between water demand and supply and will play an increasingly important role in conflicts over water that are likely to increase with climate change.

International agreements on shared water bodies: Mexico has a long history of water agreements with the US. In 1889 a special International Boundary and Water Commission (IBWC) was established to manage the boundary and water treaties between the US and Mexico and settle differences that may arise out of these treaties. The 1944 Water Treaty gives an example of how international water treaties might evolve with time depending on climate conditions. For example, additional provisions for protection from floods were added to the original agreement later and proved to be necessary. A possible reform of the treaty of 1944, is being discussed now in order to deal with issues (e.g., drought) that did not then exist (Alamo, U., et al., 2005). Both governments have recently signed an agreement regarding water conservation to address water scarcity resulting from population growth and frequent droughts.

Institutional set-up: In accordance with the National Water Plan and the Law for National Waters (LAN), the National Water Commission (CNA) was established to modernise and decentralise the management of the nation's water resources considering all uses and the preservation of the environment. The CNA was created to unite all aspects of water management. CNA is planning to reorganise CNA's regional dependencies into 13 regional offices along river basin boundaries. The Regional Offices will have principal

responsibility for water management, including: development of regional plans; promotion and strengthening of basin councils; co-ordination of water resources planning and management activities both by public and private sector participants; water quantity and quality monitoring activities; reservoir operation; the registry of water users into the National Public Water Rights Register; and dam safety.

One state, Guanajuato, took the lead in terms of requesting autonomous responsibility for water. This state has low and decreasing water availability per capita: from 1,500 annual cubic metres per person in 1970 to 750 in 2000. The State established a State Water Commission in 1991 as a decentralised public entity for the provision of drinking water, sewage removal and sanitation. The state was the first to pass a law on water in 2000. Following this pioneering example, 27 states have passed their water laws, and 13 have set up water commissions.

The decentralisation promoted by the CAN in Mexico follows the geographical distribution of water resources, with basins that cover several states. While this is the most effective approach to water management, it introduces discrepancy and conflicts between states in the absence of formal mechanisms for co-ordination and resolution of disputes.

Other public and private entities that cover various aspects of water management need to coordinate with CAN. For example, the Federal Electricity Commission (CFE⁵³), which operates reservoirs, must do so with CNA authorisation and oversight. CFE operates 64 dams with hydroelectric plants. The Director General of CNA presides over a Technical Committee for the Operation of Hydraulic Works. The committee makes overall decisions relative to the operation of the nation's reservoirs including considerations related to floods, droughts, multiple uses (irrigation, municipal and industrial, hydropower, navigation, recreation, etc.) and environmental protection.

As part of the decentralisation effort, the Mexican government has been promoting farmer-managed irrigation schemes since the 1980s. Irrigation Management Committees (IMCs) have been established at the farmer level to help encourage management in small holder irrigation schemes. However, the IMCs have no legal standing and their effectiveness varies from scheme to scheme. On the other hand, by the end of 1996, the majority of medium and large-scale irrigation districts in the country (representing about 46% of the total area under irrigation) had been transferred to 386 Water User Associations. The Water Users Associations' (WUA) main function is the operation, maintenance, and management of the irrigation infrastructure. They can be established as civil associations and granted certain fiscal privileges. At a national level, a federation of WUAs called the National Association of Water Users (ANUR⁵⁴) has been established. It represents WUAs in negotiations with CNA, and Secretariat of Agriculture, Livestock, and Rural Development (SAGAR⁵⁵). CNA is the supervising organisation for the operation, maintenance, and management of the transferred infrastructure and equipment. CNA also provides WUAs with technical assistance in carrying out operational activities.

Water management: Mexico has a National Water Plan which is based on six major objectives:

- Encourage the efficient use of water in agricultural production.
- Encourage expansion of coverage and quality of drinking water, sewer and sanitation services.
- Achieve integrated and sustainable management in watersheds and aquifers.
- Promote technical, administrative and financial development of the water sector.
- Consolidate water user participation as well as the involvement of organized society in water management. Promote a new culture on good use of water.
- Prevent risks of floods and droughts and provide assistance after and during these episodes⁵⁶

⁵³ Comisión Federal de Electricidad

⁵⁴ Asociación Nacional de Usuarios de Riego

⁵⁵ Secretaría de Agricultura, Ganadería y Desarrollo Rural

⁵⁶ Taken from *Mexican Portfolio of Water Actions*, document from the 3rd World Water Forum
<http://www.worldwaterforum4.org.mx/uploads/documents/mexpowa.html>

The final stage of the National Water Plan involves the creation of Regional Long-Range Vision Water Plans for 2001-2025.

The use of seasonal climate predictions is limited, and no plans to prepare for drought exist. Recently, the Secretary of Environment requested academics to develop a National Project to produce climate information, including drought predictions. The Plan was produced but so far, there are no funds to finance this initiative, (Gonzalez, et al. 2006). Drought response plans exist in the Civil Protection Agency and in the Agriculture Ministry. In both cases, a monetary compensation is given to those affected by drought.

To address a present and future major threat of limited water availability and drought, a number of state level adaptation initiatives were defined through close interaction with stakeholders. For example, the state of Sonora that has been experiencing shortages in water in recent years due to population growth and prolonged periods of droughts proposed two adaptation measures: 1) a “culture of water” program to reduce water consumption and demands, and 2) an enhanced infiltration of water after extreme precipitation events. The “culture of water” program would include a home water saving kit (for the shower, toilet, sink, etc). This programme was partially implemented in a few homes, but due to the lack of resources it has been difficult to estimate its impact in terms of water savings. The objective of the “culture of water” programme is to reduce water consumption from 330 lt/person/day to 180 lt/person/day.

Recently, the Mexican Government decided to create a new fund to move from response to the emergency to preparedness to major threats. The so called National Fund for Preparedness to Natural Disasters (FOPREDEN) is intended to move to a “culture of reduction of vulnerability” to extreme events. FOPREDEN is at its early stages and there are no projects in the areas of major hydrometeorological disasters.

Water policies: Water pricing is differentiated and are actual costs of water covered only in a few states, including Mexico City. Low or non-existent payments for water services prevent governments for collecting necessary funds for infrastructure development, maintenance and improvements. The infrastructure has suffered dilapidation through the lack of maintenance, as much as 40% of the water is lost through leaks. Only 2/3 of the water used by customers is actually billed and only 4/5 of that is paid for. The water actually paid for represents 32% of water supplied (OECD, 2004).

Mexico is considering new regulations in housing projects that incorporate more carefully the characteristics of climate in a semiarid region in order to reduce energy and water consumption in cooling systems. Mexico is also implementing several projects on water conservation in the agriculture sector. Although it has been observed that when water-saving techniques are introduced, the tendency is to expand the irrigated land.

Mexican authorities are also giving a special consideration to insurance policies, and planning to reinsure their national catastrophe relief and reconstruction fund (FONDEN) with a catastrophe bond. This would give an investor an above-market return if a specific catastrophe does not occur within a specified time but sacrifices interest or part of the principal after the event. The government's disaster risk is thus transferred to international financial markets that have many times the capacity of the national reinsurance market.

Information availability: There are several governmental and scientific institutions in Mexico that participate in monitoring and generate forecasts and other information. The Civil Protection Agency interacts with scientific experts who work at the National Center of Disaster Prevention. There, a number of actions have been taken in order to diminish vulnerability to hurricanes and severe storms. An example is the establishment of a severe weather Early Warning System that alerts the authorities and the population of when to expect severe weather, particularly intense precipitation associated with hurricanes. The Early Warning System for Hurricanes has proven to be an efficient method to reduce the number of lives lost due to the effects of tropical cyclones. Since 2000, the number of deaths during the hurricane season has diminished from hundreds to only a few. The Early Warning System monitors and predicts the evolution of tropical cyclones and issues warnings, alerts, or emergency calls to take a preventive action (such as

requesting people to be informed, to be prepared for the impact of a hurricane or to move to a shelter for protection).

Only a few attempts to develop plans to reduce vulnerability to flooding have been implemented (as in Acapulco, Mexico, after Hurricane Pauline in 1997). There is still much to be done in terms of developing plans to reduce vulnerability to floods and droughts. The National Prevention Fund for Natural Disasters is aimed at financing pilot projects in various states of the country to prepare for natural threats.

A4. Zimbabwe

Climate change impacts and vulnerability: Drought is expected to be the biggest problem facing Zimbabwe. Recent projections of precipitation and runoff in Africa suggest a drop of up to 10% in precipitation in most of southern Africa (including Zimbabwe) by 2050 (Wit and Stankiewicz, 2006). This would reduce drainage by 17% in regions with 1000mm of rain per year, whereas in regions receiving 500-600 mm a year such a drop would cut 50% to 30% respectively of surface drainage. The country's average rainfall is 657 mm/annum.

Zimbabwe's economy is agro-based, and currently its economic development is tightly linked to a successful rainfall season as national agricultural production is mostly rain-fed. Only 37% of the country receives adequate rainfall for agriculture. Since some 80% of Zimbabwe's 12.5 million inhabitants are farmers, with 30% of them being city-dwellers but also engaged in agro-industry, the economic damage and human suffering associated with droughts are enormous. Also, 80% of Zimbabwe's electricity supply comes from the Lake Kariba dam, making not only agriculture but also electricity supply reliant on sufficient water.

Domestic legal framework: The devastating effects of the 1991/92 drought gave impetus for the reform of the water sector. The reforms culminated in 1998 with the passage of the National Water and National Water Authority Acts. The National Water Authority Act sets an administrative structure of water management and sets up the Zimbabwe National Water Authority. The National Water Act provides the legal bedrock for this sector and incorporates such provisions as time-bound water permits, their administration by catchments councils, polluter pays principle, and allocation of water for environmental purposes, drought preparedness, and others. The Environment Management Act (2002) provides a legal foundation for sustainable management of natural resources, prevention of pollution and environment degradation, and for preparation of national and other environmental management plans. The act also gives the Environmental Management Agency the authority to set and enforce effluent water standards.

By introducing a system of water abstraction permits, the National Water Act replaced riparian water rights by statutory rights that eliminated ownership or possession of riparian land as a prerequisite to the claim and exercise of water abstraction rights (FAO, 2002). Time-limited licenses increase flexibility and allow abstraction to be stopped when water levels become too low. Removal of the private ownership of water and the preferential rights of water owners should allow more equal access to water, which will be important as precipitation patterns change.

The 1998 National Water Act states that a permit shall be valid for a period of twenty years, or as decided by a catchment council. The Water Act also specifies conditions under which a permit may be amended or cancelled by the catchment council depending on how beneficial is the use to which the water is being put. This is a big step in levelling the playing field for all water users as it creates an opportunity to review the allocations to different users and adjust them based on an assessment of the usefulness of the water use and water availability. However, implementation of this system of water abstraction permits is still very weak due to the lack of institutional and technical/monitoring capacity.

There are also important land-use provisions that interact with the water sector management. The legislation both under the National Water Act and the Environment Management Act (2000) forbids the cultivation of wetlands (dambos) and stream banks. This is an important measure for mitigating floods and reducing their

socio-economic impacts. However, due to the variability in rainfall and the presence of fertile soils in these zones, subsistence farmers have continued to work in these restricted areas. The extent of enforcement is limited since there are conflicting provisions authorising these areas as food producing zones in cases of droughts. There has been a move to ensure that wetlands are sustainably managed, which would require a localised management of each particular wetland.

Indigenous institutions and rules also play an important role in the water resources management. For example, during water shortages, community-based structures regulate not only volumes but also the type of water use. For privately owned wells kinship (extended family) ties are used to access water.

Institutional set-up: The new institutional framework for Zimbabwe's water sector is dominated by the Zimbabwe National Water Authority, Catchments and sub-Catchment Councils. While these have compelling positions with respect to water management, there are several government institutions, quasigovernmental agencies, and non-governmental organisations that are involved in water management in general and irrigation in particular. Therefore the water system is very hierarchical in Zimbabwe with successively lower and more local levels having more 'hands-on' responsibilities in the management and allocation of water, but less or no (in the case of local water point committees) legal standing (Gumbo,2006).

The Department of Water Development, under the Ministry of Water Development, is responsible for policy formulation and standards for planning, water pricing, management and development. The Ministry of Water Development is custodian of water rights (Gumbo, 2006). The Zimbabwe National Water Authority (ZINWA), also under the Ministry of Water Development, is involved in the practical application of water pricing systems and the management of water resources. It also provides technical assistance to the Catchment Councils (Mtisi and Nicol, 2003). There are many other institutions at the national level that are involved in water management, however, their various roles are not necessarily complementary (Gumbo,2006) These institutions include Ministry of Agriculture and Rural Development, Agriculture and Rural Development Authority, the Ministry of Water Development, Ministry of Local Government, Public Works and National Housing, Ministry of Environment and Tourism, and others.

Catchment Councils are based on the seven major watersheds in Zimbabwe. Since they cover very large areas, Sub-Catchment Councils were formed as a smaller management unit. At an even lower level there are water user boards and local water point committees. Catchment and sub-catchment councils are responsible for preparing plans for the optimum development and utilisation of water resources in their areas, developing an inventory of water resources of their catchments, and major water uses within the river system, developing recommendations for water allocation. These functions are fundamental to the success of the management framework of water in Zimbabwe but are impeded by the technical capacity of employees. Furthermore, the boundaries of sub-catchment areas (ecological river catchment boundaries) and even the main catchments themselves do not coincide with district and provincial boundaries. This makes coordinated planning a difficult task and has inhibited decision-making at this level, leaving the ZINWA to make the major decisions (Gumbo, D., 2006).

Thus, while in theory the water structure is decentralised, it is unclear is the extent to which the central government has accepted to "let go" (Gumbo,2006). This is largely due to the limited capacity to generate revenues both at Catchment and sub-Catchment Council levels, as these structures rely on handouts from central government for survival.

There are also various types of water user groups in Zimbabwe. Some of them are formed by communal farmers, others by commercial farmers, there are also several small-scale farmers groups. Representatives of water user groups participate in the Sub-Catchment councils. The primate concern of water user groups and sub-catchment councils in Zimbabwe is regulation of access to water.

Local communities in Zimbabwe are not connected to the whole system of water management: legal provisions have almost no relevance to them; they are too poor and far away to have an access to relevant institutions, even Catchment Councils. On the other hand, their local concerns and tools that they use to cope

with water stresses (from unwritten ancient rules for conflicts resolution and water sharing to methods to use water efficiently and adjust crops) are not taken into account by government agencies.

There is also a lack of necessary capacity, especially within regional and local offices. Reduced funding from central government is unlikely to improve this situation. Village-level institutions are not strong enough to address issues of disaster management and cannot take the lead in the construction of flood protection measures. As a result, the institutional arrangements for disaster management in Zimbabwe may be in place but the extent to which they can deal with disasters is limited. Catchment Councils are not adequately resourced to meet the demands of their own mandates. Critical entities such as the local water point committees have a say in how water is shared and management and yet they do not have access to any professional training. Training is limited to pump minders but does not focus on efficient water use or minimising losses (Gumbo,2006).

Water management: Zimbabwe has moved towards more integrated water resources management through the Water Resources Strategy which led to the promulgation of the National Water Act and the National Water Authorities Act. The Strategy reflects the user-pays principle and suggests measures such as fair water sharing and full pricing of water. These measures, if implemented, will increase the resilience of the water and agricultural sectors to climate change. However, implementation is impeded due to the lack of capacity, funds and water users who are able to pay the full cost of water.

Some plans have been created to address floods. These include warning mechanisms/procedures, evacuation procedures, stock of resources available both material and human. These plans need to be reviewed regularly. Central to the plans are information dissemination and education about the dangers of floods. The current approach has been to limit these plans to flood-prone areas such as the Limpopo, Save and Zambezi.

The government set up a disaster management framework under the Civil Protection Organization to address an increasing threat of floods and storms. This framework includes several government departments: health, foreign affairs, water, mining, state security, and information. Other organisations related to floods may be co-opted as and when required. The Zimbabwe National Water Authority (ZINWA) and the Meteorological Department form the early warning unit and are responsible for the weather and flood forecasts. Zimbabwe Defence Force and Republic Police, Civil Aviation and Ambulance services may also be involved, e.g. to provide rescue operations and relocate victims of floods as well as provide security during flood crisis. Local government coordinates activities by these different actors. The important role of Catchment Councils in disaster preparedness in Zimbabwe should be further developed. These entities should be directly involved in the development of catchment level flood mitigation plans by involving communities and households. However, Catchment Councils lack capacity to implement these tasks.

The national government has developed the National Policy and Programme for Drought Mitigation. Implementation is facilitated through financial assistance from international organisations that have established the regional Early Warning System and the Drought Monitoring Centres. Drought Monitoring Centres issue bulletins that provide pre-seasonal forecasts. However, once the forecast is made, the government does not have a good system in place to use these predictions.

Water policies: In Zimbabwe demand-driven approaches include attempts to encourage more efficient water use through water pricing and by treating water as a commodity. Reducing waste through leakage control and improved irrigation efficiency is also a part of demand side management. In Zimbabwe, water demand exceeds or threatens to outstrip sustainable levels of supply – and this is likely to be accentuated under climate change. Conventional strategies to further increase water supply can no longer meet growing future needs, and are unable to cope with the uncertainty arising from increased climate variability and climate change. Thus, efforts are needed to reduce water demand and mobilise non-conventional water sources through appropriate policies, laws, incentives, and technical measures.

Information availability: Zimbabwe has a comprehensive data gathering and monitoring network which brings together government, universities, and research institutions. Meteorological information has been

collected on a regular basis since the 1950s and daily rainfall data are collected from 120 stations. Close to 1,200 rainfall records are submitted monthly but there is a delay in compiling this data (which are available at a fee). The meteorological service has a web page with current forecasts. Information is also available in the form of the SADC (the South-African Development Community) Water Resource Database on CD-ROM. Surface flows are monitored through a network of gauging stations that record dam levels and flow in rivers. Dam levels are recorded twice a week, and the corresponding amount of water in each dam is calculated and summed for each province. The change in water volume is monitored weekly for each of the important national dams. River water quality is monitored routinely and a network of sampling sites is visited at least every three months. Chemical analyses of water are performed by the Water Quality Analysis Laboratory. In addition, information is also captured by the Department of Water Development on groundwater which includes water levels and quality, the nature of the geological formation and the results of pumping tests. Groundwater levels are monitored on a monthly basis in order to optimise rates of abstraction by users.