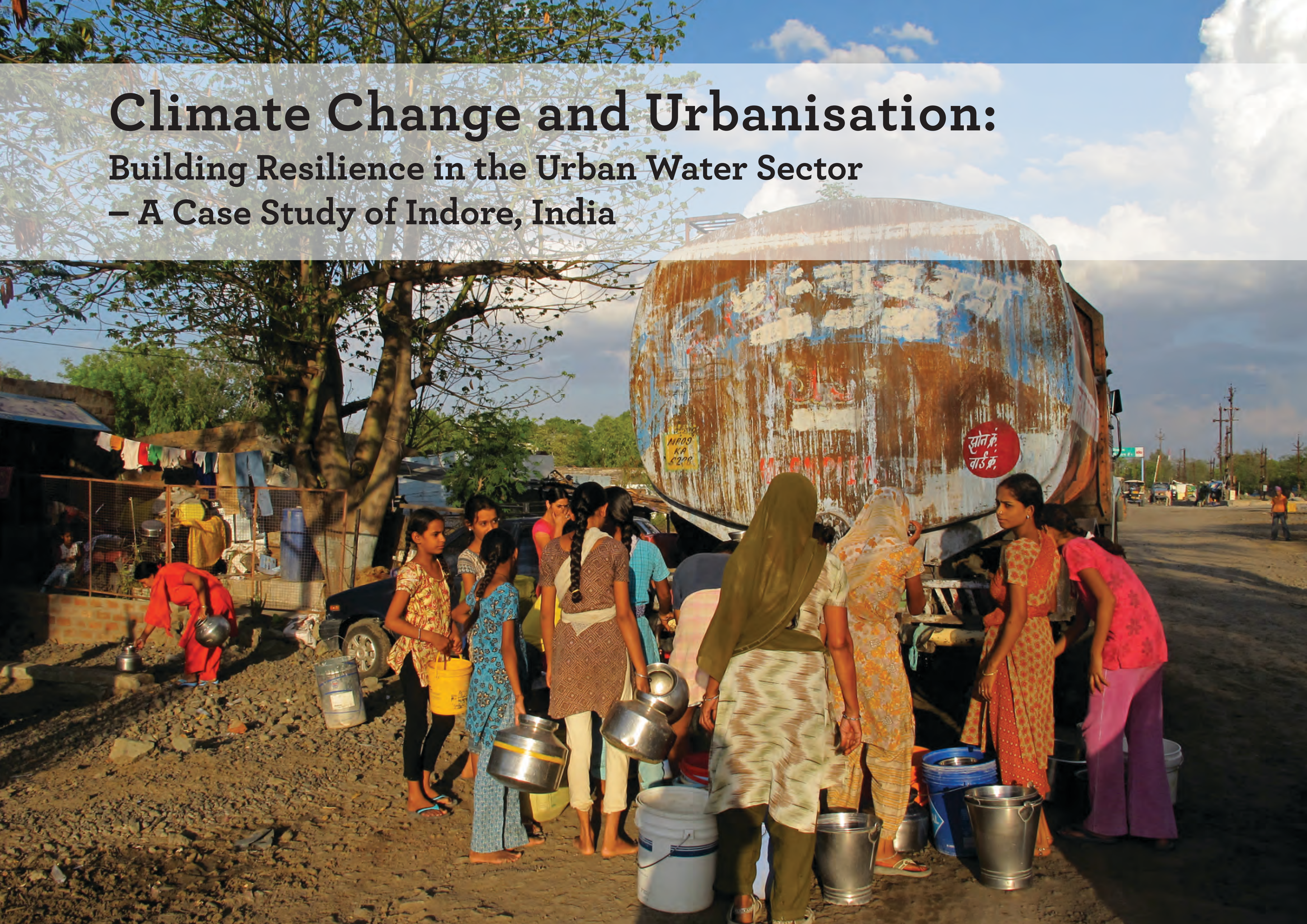
Climate Change and Urbanisation:

Building Resilience in the Urban Water Sector – A Case Study of Indore, India



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Building Resilience in the Urban Water Sector
– A Case Study of Indore, India

NOAA Indore Research Team and their Institutions

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Eva Saroch, Meena Palaniappan, Dilip Singh, Laura Seraydarian

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LIST OF ACRONYMS

ACCCRN	Asian Cities Climate Change Resilience Network
ADB	Asian Development Bank
CDP	City Development Plan
CGWB	Central Ground Water Board
CSAG	Climate Systems Analysis Group
CRU	Climate Research Unit
DfID	The Department for International Development
ENSO	El Niño Southern Oscillation
GCMs	General Circulation Models
GDP	Gross Domestic Product
GHCN	Global Historical Climate Network
GIS	Geographic Information Systems
IDA	Indore Development Authority
IAS	Indian Administrative Services
IMC	Indore Municipal Corporation
IMD	Indian Meteorological Department
ISET	Institute for Social and Environmental Transition
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
MPUSP	Madhya Pradesh Urban Services for the Poor
NGO	Non-governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
MGI	McKinsey Global Institute
RCMs	Regional Climate Models
SAM	South Asian Monsoon
SARP	Sectoral Applications Research Program
SLD	Shared Learning Dialogue
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UN-HABITAT	United Nations Human Settlement Program
VA	Vulnerability Assessment
WHO	World Health Organization

EXECUTIVE SUMMARY

This is the story of Indore, a city in the center of India, but it is also the story of thousands of cities in the developing world. These cities face rising pressures on institutions and infrastructure due to population growth and urbanisation, and are now beginning to experience the added impacts of climate change.

This is also a story about water in urban areas: where it comes from, where it goes to and who uses it along the way. It is the story of the hundreds of thousands of people globally who wake up wondering where they will get water from that day, how long they will wait for it, how much they will pay for it, what the quality of that water will be and whether that water will be there tomorrow.

Unique to developing country cities is the predominance of informal actors in the water sector. The formal, or government sector, which often exclusively manages water access and distribution in developed country cities, is only one among many players in the water sector in developing country cities. In these cities, thousands of people directly access the water source itself from self-supply through private boreholes. There is also a private water market, where water vendors supply water to meet demand through water tankers and through treated drinking water, where the public sector fails. These multiple water managers are at the center of this story.

In this environment, with already existing pressures on water availability and use, the impacts of climate change on water will be strongly felt by all these water managers. Climate change is already having impacts on temperature and the hydrologic cycle, changing when, where, how much and how often water falls. This complicates planning for water supply and demand and increases water insecurity. For those, particularly the urban poor, who barely meet their water-related needs, climate change is likely to increase already high levels of water insecurity.

This report is the outcome of research in Indore carried out by the Institute for Social and Environmental Transition (ISET) and the Pacific Institute, supported by TARU, over a period of three years. The purpose of this research was to understand the complex dynamics of the water sector, to investigate the needs of urban water managers and ultimately to suggest strategies and tools that can help these managers meet ever growing needs in the face of climate change and increasing water insecurity.

Over three years, we conducted literature reviews, downscaled climate models for Indore, performed a vulnerability analysis and conducted intensive stakeholder engagement through one-on-one discussions, focus group disscusions (with the formal sector, private providers and households) and Shared Learning Dialogues (where all sectors were brought together). We also conducted a survey of households and private water vendors to understand these two sectors in greater depth. The project team then brought together the research findings to suggest a set of resilience strategies and process tools that could assist managers in better managing and planning future water supply.

The four-step resilience planning process that we conducted in Indore can serve as a model for other communities integrating climate impacts into planning. The steps are (1) scoping to identify emerging problems; (2) synthesis and localised analysis of climate information; (3) vulnerability assessment focusing on the systems, the likely stresses on those systems due to climate and other change processes and the highly differentiated groups that depend on these systems; and (4) identification of potential strategies for building resilience.

Climate Change Vulnerability

Climate change poses unique threats to the Indore water supply system. Downscaled climate information suggests an increase in surface temperature of 2 to 4 ^{0} C, and a range of rainfall amounts of -4% to +8% by 2046-2065. The uncertain and wide range of possible futures complicates resilience planning efforts.

In the absence of useful high-resolution climate change projections, we chose to focus on the potentially increasing variability in water availability. Because water resource variability is already an issue that is perceptible to stakeholders, we focused on water scarcity and variability and current approaches to addressing them as indicators of what is likely to be effective in addressing increased future climate variability.

Our analysis of Indore's formal and informal water sectors suggests that resource variability is exacerbated via climate-sensitive vulnerabilities in Indore's formal water supply system.

Indore's Water Supply and Use

Indore is the largest and fastest growing city in the central Indian state of Madhya Pradesh (3.27 million population in 2010). Indore has grown into an industrial, educational and medical center, housing automobile, textile and information technology businesses (Government of India 2011). The city is managed by the Indore Municipal Corporation (IMC) and some surrounding regions are administered by the Indore Development Authority (IDA). Because of the inadequate and unreliable water supply situation, residents supplement their needs via household and community self supply, installing in-house storage, as well as supply from water tankers and packaged water providers. However, the ability to make such arrangements varies, and this has led to significant differences in water use between lower income and higher income communities. Our survey shows use of water ranges from 178 litres per day (LPD) per household in low-income Goma ki Phel to a high of 320 LPD in the upper income Sneh Nagar. Some low-income communities such as Nayapura were using a mere 31 litres per person per day (LPCD). This suggests tremendous inequities in Indore's existing water supply conditions and also points to the absence of incentives for water conservation in areas that are well served.

Beyond this, many vulnerabilities were identified within Indore's water supply from single-source dependency and high energy usage to ageing infrastructure and insufficient and inequitable access of water in the city. These are discussed below for the formal water supply sector, the informal/private sector and households. Some of the governance issues that emerge are also briefly summarised.

Formal Sector

The IMC provides water supply to the population living within the city, and is charged with four functions: capture the natural resource, treat the water to improve its quality, transport this resource to the city and deliver water to users through pipes. The IMC, however, has almost no authority to manage the local surface or groundwater resource base. The majority of the water supplied to Indore city is from surface water sources: the Narmada River, the Yeshwant Sagar Dam and the Bilawali water storage tank. These sources altogether provide about 170 to 200 million litres of water per day (MLD). With an estimated distribution loss of 25%, the current available water sources only yield 75-85 litres per capita per day (LPCD) even in a normal rainfall year.

Water is distributed to the residents of Indore through piped connections, standposts and municipal tankers. However, currently the IMC only serves 54% of the city population (Mehta and Associates 2006). About 16% of residents in Indore live in informal settlements that lack adequate water supply and receive less than the minimum 40 litres per capita per day specified by the government of India. Piped water supply in Indore has two problems. First, supply is insufficient and highly intermittent, typically available for less than an hour each day. Second, infrastructure is inadequate and piped supply does not reach much of the population. Municipal water supply in Indore is largely single-source dependent (75-85% from the Narmada River) and delivery is highly energy-intensive (leading to very high costs for water).

Informal/Private Sector

The intermittent and unreliable supply of water from the IMC has led to the birth and the expansion of a private water market in Indore that sources its water primarily from privately-owned boreholes that directly tap groundwater resources in and around the city. These private water purveyors draw on the same groundwater resource that is also used by the IMC to provide water. These private providers are driven by profit motives and, while the resulting price signals to consumers contribute to inequitable water distribution use patterns, they also provide strong incentives for efficient water use. In addition there are thousands of households that use individual borewells to supplement their water supply, which also contributes to socially differentiated patterns of access to water. This reflects the current legal situation, as the rights to extract and use groundwater are attached to land under Indian law. This legal structure leaves a large poor population that has no land tenure rights bereft of groundwater access.

Household Sector

Through a detailed household survey in eight diverse communities in Indore, we documented water supply and water use among households, the coping actions adopted by residents, the current and future information needs of the community as they relate to the coping actions, existing complaint and communication mechanisms and what residents identified as necessary improvements to their water services. Households take three types of action in response to unreliability of supplies from the municipal agency: Access – making arrangements to obtain supplies independent of the water supply agency; Voice – complaining to make the IMC water supply more reliable; and Manage – increase their ability to store and utilise available supplies as efficiently as possible.

Governance Issues in Indore Water Sector

As the highly differentiated patterns of water supply access and use within the public system indicate, inequities are deeply entrenched. Overall, the functioning of both the municipal utility and private water markets raises questions of equity and equitable distribution of resources, especially given the scarcity of surface and groundwater in Indore.The public utility has major governance problems that go well beyond cost recovery and finance and that directly contribute to this inequitable distribution of water. These governance issues are endemic throughout the public sector and are almost certainly as culpable as the functioning of private water markets in contributing to inequity and poor climate resilience. While these issues are noted, it is beyond the scope of this report to address fundamental issues of governance in the public as well as the private system and the lack of a comprehensive and equitable framework for managing the resources. Addressing this would require fundamental changes in legal structures (such as the disaggregation of groundwater rights to land ownership) and other institutions that are beyond the capacity of cities to undertake.

A Resilience Strategy for Indore

The objective of this study was to identify a resilience strategy for Indore that could make Indore's water supply more sustainable and resilient in the face of urbanisation and climate change. Emerging from this comprehensive look at Indore is a set of core vulnerabilities. Based on the seven vulnerabilities identified through our process, the Project Team collated information from the Shared Learning Process in Indore and best practices in the urban water sector to identify resilience interventions. Together, these vulnerabilities and resilience interventions represent the first step in a resilience strategy for Indore's urban water sector and the first step in an iterative and ongoing Shared Learning Process to continually identify needs and vulnerabilities, evaluate previous efforts and identify and implement interventions that will improve the sustainability, equity and resilience of the Indore water sector. These vulnerabilities and interventions are shown in table 1.

What is unique about the water sector in developing country cities is the number of water managers that participate directly in sourcing and supplying water. The resilience interventions we identify and detail in this report are reflected through the prism of this complex water scenario, leading to approaches that can be useful for water managers in diverse contexts. Instead of providing tools for a centralised water utility to plan for and manage the impacts of climate change, we outline an

Table 1. Vulnerabilities and interventions in Indore water sector		
	Core Vulnerabilities	**Interventions to Improve Resilience**
I	Demand-supply gap in water and dependence on a single distant surface water source	• Diversifying water supply sources at the household and community scales • At the city scale: cleaning existing water bodies, sustainably managing groundwater resources (conjunctive use) • Increasing storage capacity • Water conservation and efficiency (greywater reuse, water-efficient fittings, reducing system water losses, etc.)
II	Lack of access to water by the poor	• Implementing credit mechanisms and strengthening local communities to help them demand better services and equitable cost structures
III	Poor management of water utility: finances, infrastructure, complaints	• Infrastructure improvements and leak detection programmes • Metering and volumetric pricing for wealthier consumers • Improved complaint redressal system
IV	Lack of groundwater management	• Increase groundwater recharge through rainwater harvesting, dug wells and artificial recharge • Monitor groundwater levels in and around the city
V	Lack of water quality monitoring and regulation	• Water quality monitoring at household and community level
VI	Lack of information and understanding of climate change impacts	• Sharing of climate information and data with water managers to build capacity of city water managers to understand and incorporate climate information in urban planning and development processes
VII	Lack of networking and information flow between different water managers	• Development of a Citizens' Water Forum • Water tanker registration • Education of formal water sector employees

approach the variety of water managers in developing country cities could use to meet the demands of their shared water management future through communication, information exchange and transparency.

As documented in this report, processes for shared learning represent an overarching tool that can facilitate identification, refinement and implementation of many of the above strategies. The Shared Learning Process outlined in this report involves an iterative multi-stakeholder engagement process that would be suitable in most situations that need consensus-building and participation from all sections of society. This tool needs to be supplemented by other decision support techniques to improve communication, and generate and use information to build capacity.

Conclusion

Climate change and rapid urbanisation are taxing the ability of urban water systems to meet the water needs of populations. This presents both a threat and an opportunity. Through three years of detailed engagement in one city in India, we have arrived at a set of key resilience strategies for water managers in developing country cities to cope with water insecurity as a result of climate change. Through these studies it became clear that the urban poor are the most vulnerable to climate change impacts and water supply variations, and have the least resources to cope. Giving all water managers the necessary tools to manage in a new water future will require efforts at national, state and local levels. Policies and tools are needed to diversify water supply, promote water storage at all levels, promote effective water management policies, implement equitable water rates, improve water quality, reduce energy dependence and improve connections among all stakeholders in the sector. Climate change adaptation presents another opportunity to implement a shared vision for a more sustainable and equitable water system.

This report contains seven chapters. Chapter 1 and 2 provide an introduction to the study, processes, approach and methodology used in the study, respectively. The resilience planning process called the Shared Learning Process used in this study is also described in detail in Chapter 2. Chapter 3 provides information about Indore and its water supply situation, including a brief description of the climate forecast in and around Indore. The three water managers in Indore – Formal sector, Household sector and Private sector – are discussed in detail in the next three chapters: 4, 5 and 6, respectively. The results of the stakeholder consultations, vulnerability analyses and surveys for each of these water managers are also provided in these chapters. Finally, in Chapter 7 we discuss specific vulnerabilities within the water supply system in Indore city, the resilience interventions to address these vulnerabilities and tools to support overall resilience.

CHAPTER 1: INTRODUCTION

The National Oceanic and Atmospheric Administration-Sectoral Applications Research Program (NOAA-SARP) Project

The Institute for Social and Environmental Transition (ISET), the Pacific Institute and TARU Leading Edge (TARU) partnered to develop a project that would assist water managers in urbanising Asian cities in developing coping strategies to improve their ability to manage water supply in the face of an uncertain water future due to climate variability.

This project focuses on investigating and understanding the complex urban systems – specifically water delivery systems in the mid-sized but rapidly growing city of Indore, India. Indore was selected due to ongoing water scarcity issues and the city's stage of development as well as synergies with ISET and TARU's involvement in the Asian Cities Climate Change Resilience Network (ACCCRN) programme, also being conducted in Indore.

A slum in Indore. © ISET

Our extensive research, through dialogues with key water actors in Indore, provides a way of understanding the specific needs of all urban stakeholders in a manner that is highly relevant to urban contexts in many developing countries. The research, in turn, will help guide the development of a framework of action, consisting of a suite of climate-change resilience tools and techniques that enable the urban water sector to flexibly respond to a variety of uncertain climate and socio-economic scenarios. It is envisaged that the resilience tools developed under this project can be adapted for applicability in other Asian cities undergoing urbanisation, helping them to be more resilient to the impacts of climate change on water security.

Challenges

The Challenge: Urbanisation and Climate Change

In the developing world, population growth and the demographic shift from rural to urban areas are challenging the ability of urban governments/systems and other actors to provide for the basic needs of people. In many cities, residents lack access to adequate infrastructure to meet their transportation, water and sanitation, education, health care and housing needs. These sectors are all components of the urban system; their capacities and functions are interwoven and interdependent.

Climate change presents additional challenges for urban areas and the complex systems within them. General Circulation Models (GCMs) project a range of possible changes in global- and regional-scale climates and Regional Climate Models

(RCMs) or statistical downscaling techniques are frequently employed to downscale projections of temperature or precipitation to a resolution more suited to local-level adaptation initiatives. Though there are uncertainties in projections from climate models, they do provide unambiguous information on the general trends of warming and variation in precipitation.This variation in the timing, frequency and intensity of precipitation, coupled with rising temperatures, will have myriad impacts on urban systems that cannot always be easily anticipated or measured.

Fig. 1.1 depicts typical urban vulnerability that is very much a consequence of fragile systems, marginalised populations and negative climate change impacts. In other words, the urban poor are the most vulnerable group due to the combined effects of negative climate change impacts (as they do not have adequate resources) and fragile urban systems (which often do not serve the poor).

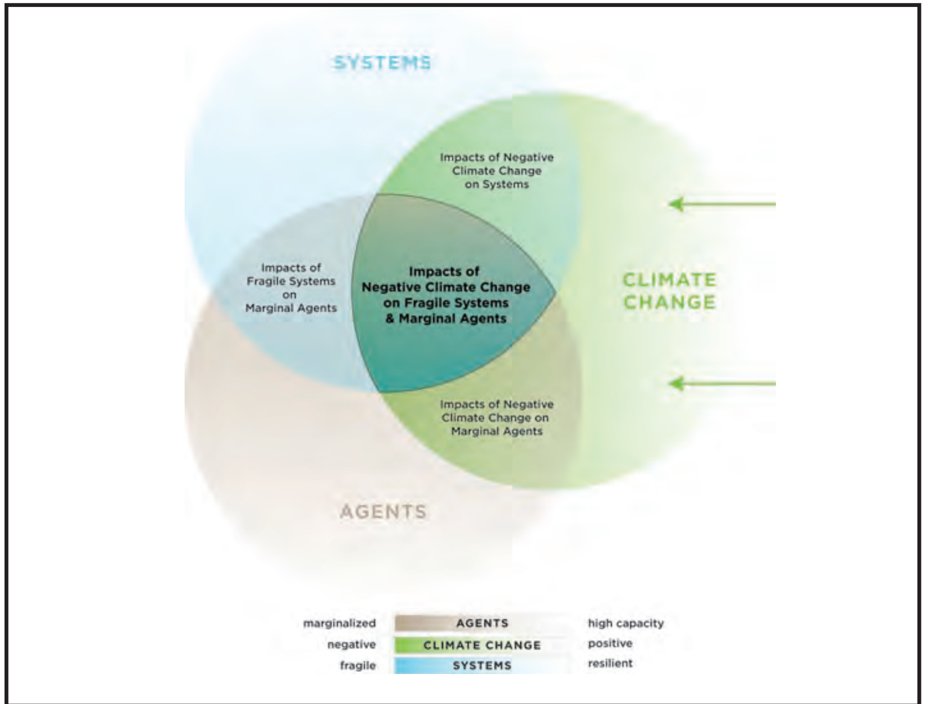


Figure 1.1: Urban vulnerability. © ISET

The Opportunity: Sustainable and Resilient Cities

Cities are complex socio-ecological systems and therefore are arenas where both demographic and social transformations are taking place. The current period of urbanisation in developing countries has been characterised by a wide range of disciplines as a transformation or an "urban transition" rather than a simple process of increased and concentrated urban population (Spencer 2007). This suggests that two processes are taking place in urban areas: one is population concentration and the other is the impact of this population growth on socio-physical infrastructure and the challenges therein to manage the stress and conflicts associated with higher-density living (Spencer 2007). These stressors include an increase in demand for water without a parallel expansion in the source, supply and/or management systems and capacity to dispose of pollution waste streams without contaminating urban and peri-urban sources – with similar challenges in the energy, education, health, transport and housing sectors (Desakota Study Team 2008).

Given the current state of transition in most urban centres in the developing world and in the face of climate change, there is an urgent need to ensure that the systems and the infrastructure for the provision of basic services are managed in a more environmentally-, socially- and economically-sustainable manner. As cities develop, the introduction of strategic tools in management and planning methods is crucial to enable the change necessary to build robust urban systems that are resilient to climate-and social-change impacts.

With the projections of increased variability in the timing and amount of precipitation and temperature increases due to climate change, flexibility, redundancy and fail-safe structures[1] are key factors to incorporate into water systems. For example, a sudden and untimely increase in rain could create issues such as

[1] Fail-safe structures are those that are designed in such a way that in the event of failure, they do not damage other structures.

high flows causing dam overflow and over-capacity for treatment plants. On the other hand, temperature increases coupled with drought could result in higher evaporation rates that deplete water supplies, particularly in reservoirs, leading to low availability from reservoirs affecting distribution networks. In the event that the system is unable to deliver water for a period of time, a secondary or supplementary system that is flexible and can respond quickly – such as the capture and reuse of greywater – could alleviate a looming crisis. Diversification and redundancy expand response options when dealing with the multiple levels of uncertainty associated with social, environmental and climate change. These components are critical for integration on an infrastructural and institutional basis in an effort to promote resilient adaptation.

The Indian Context

India is urbanising rapidly with about 7 million people added to the urban population annually (MGI 2010). Urban areas account for 60% of India's GDP, a primary reason why more and more individuals are choosing to reside in urban and peri-urban areas (iGovernment Bureau 2008). The Report on Indian Infrastructure and Services estimates that by 2031, approximately 45% of the total population in India will be living in urban areas, and its share of GDP by that time would have increased to roughly 75%. The same report also points out the dismal state of urban service delivery with infrastructure, investment and planning deficiencies in transportation, affordable housing and water and sanitation (Govt. of India 2011). With growth occurring in an unplanned manner, municipal governments are struggling to keep up with the rapid pace of urbanisation.

Water supply and distribution are inadequate in most of the developing world and remain a pressing issue in Indian cities. Some households receive water every other day for 30 minutes at a time. Water pipes tend to run directly next to sewage lines, where leaks resulting in contamination are a common occurrence. Adding to the inefficiency and insufficiency issues in water systems is the combined impact of decrepit infrastructure, poor or non-existent drainage and solid waste containment and inadequate municipal finances due to low recovery of operation and maintenance costs (only about 30-35% for Indian cities) (Govt. of India 2011). With no metering of piped connections, theft and technical losses, the non-revenue water in many Indian cities remains high.

The City of Indore

Indore is a mid-sized city in India with a population of approximately 2.5 million people. The city was self-sufficient in water supply from local sources until the 1960s, and with expansion, now relies mostly on water supply from the Narmada River, located approximately 70 km away, and which needs to be lifted (pumped up) by around 500 m. Despite augmenting of the Narmada-based water supply system, water scarcity has emerged as the city's highest priority issue, a perspective reiterated through a facilitated Shared Learning Process with numerous city stakeholders in 2009-10 as part of this project. Water supply and distribution in Indore are split between the formal, or government sector and the private sector.

The Indore Municipal Corporation (IMC) is the government entity responsible for managing water supply and distribution for the city. According to the City Development Plan (CDP) prepared under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2006, only 54% of Indore's population receives water through Municipal piped connections (Govt. of India 2006). The private water market emerged in response to the inadequacies in quality and delivery of water by the IMC. These two sectors operate separately from one another without effective mechanisms for communication, source management or joint planning. This divergence creates challenges and inefficiencies within the water sector. It also fuels social justice issues such as inequitable water distribution, with unmetered end-use and varying capabilities for storage creating disparities between water usage, access and payment across socio-economic classes. Weak or disconnected institutional and decision-making structures hinder transparency and communication, leaving many without a voice, inhibiting knowledge transfer and ultimately resulting in a fragile and (often) biased system.

In this study, we investigate the functioning of the formal and private sectors, the institutional and communication mechanisms and their relationship to the structuring and management of Indore's water supply system. We also explore various urban resilience frameworks and tools that can assist water managers, both formal and private, in more equitable and environmentally-sustainable management of the supply.

Figure 1.2: Indore, India.
Source: https://commons.wikimedia.org/wiki/File:Madhya_Pradesh_district_location_map_Indore.svg

Urban Climate Resilience: The Need for Tools

We introduce two key concepts to improving the resilience of cities to climate change:

1. Resilience Planning: Resilience planning approaches are methods of identifying, defining, prioritising, analysing, incorporating and addressing critical issues as a part of the planning process (for more details see Chapter 2).
2. Resilience Interventions: Resilience interventions are adaptive actions: investments, processes or institutions that can contribute to improving the resilience of urban systems in the face of climate, social and environmental changes. Typically, resilience interventions emerge from the resilience planning process mentioned above.

A key component of our resilience planning process is the development of a set of flexible tools and techniques that can be applied in different cities.

What are "Resilience Tools"?

In this report we define *tool* as something that can assist in supporting and facilitating the implementation of interventions that improve resilience to climate change. Tools can include process tools, guides/documents, decision-making support tools and evaluation tools. Tools could take the form of an educational brochure, on-line software program, a process guidebook or training kit with modules and pedagogy.

Tools could be used at all stages of the resilience building process. Some tools are used to evaluate climate impacts and identify mitigation and adaptation options, or are successful frameworks for organising information and developing effective approaches to evaluate the resilience of different adaptation strategies. Other tools enable water managers to visualise and understand the array of issues including resources, infrastructure, institutions and actors both from the formal and informal sectors – and the roles they currently play or could play in the future. Some tools are used to implement resilience interventions.

Why are Tools Needed?

Providers and users of any successful water system hold both information and power that affect the system. Effective regulations, monitoring, distribution and overall management hinge on the ability to see different facets of issues and systems. To ensure fair and effective outcomes, the use of information and dissemination of power must be transparent to all stakeholders. Communication and connectivity between stakeholders are important aspects in achieving this, bridging gaps between sectors, water agencies, government, communities and businesses by creating dialogue in which information can be exchanged and issues can be brought up and potentially resolved.

The primary purpose of tools is to enable proactive change agents to bring together the diverse sets of information and actors. Whether such change agents are the Municipal Corporation, an outside NGO (Non Governmental Organisation) or a coalition of business actors or communities, the goal is to engage key stakeholders and enable them to identify problems, opportunities and constraints; develop strategies and plan in comprehensive and inclusive ways; and learn from action in order to inform future plans.

A key component of comprehensive and informed planning is seeking out and incorporating both local knowledge (the bottom-up perspective) and the larger picture (top-down) perspective. A major challenge is that these two sources of insight and information are almost never brought together, yet this depth and scope is necessary to effectively plan and respond in a resilient way. The tools developed in this project seek to bring these perspectives together and to encourage and enable transparency and foster good governance.

A valuable tool will be an enabling vehicle for agents to accomplish their objective(s) and possibly aid in defining the objective itself. The gathering and dissemination of information on best management practices, planning and grievances is an important function for techniques within this context. As strategies and tools are accepted and utilised, they build capacity over time in ways that promote ongoing resilience. All of these components together work to improve the water-related decision-making process at both the action and policy level.

Who Needs Tools?

In developing countries, the urban water sector does not follow the “centralised water paradigm” of industrialised nations (Srinivasan 2008), where the water utility is the primary water manager. In these developing-country urban environments, the municipal water utility (formal sector) exists parallel to other water managers, including the private water market and individuals who self-supply through groundwater wells or other sources.

Each of these different actors is a water manager in his or her own right. The higher income homeowner makes daily decisions about how to manage water supply. For example, he/she determines whether and for how long to pump from the borewell, when to call for a water tanker during scarcity months and whether or not to purchase bottled water. The lower income resident also makes daily decisions about water supply, which include how far to go to fetch water, from which water vendor to purchase and how best to conserve limited supplies. Water utilities try to manage the needs of a growing population as well as make decisions about when to supply which areas of the city and for how long. The management decisions they make are influenced by numerous economic, political, cultural and other factors in addition to baseline technical and financial considerations. Private water providers are responding to the demands of the population and making decisions about which communities to serve, how much to charge for water and how to manage their water supply sources. However, decisions made in each sector affect the demands on and supply options for other sectors.

The development of tools that aid communication and facilitate more comprehensive and inclusive water management (anything from a regular series of meetings to a website to a cell-phone-based information-gathering system to a formal and responsive complaint-redressal process and more) will help build resilience to climate change by strengthening the systems and helping cities prepare for the uncertain. The most proactive users of resilience tools largely depend on incentives and the level of organisation. In many cases, users are likely to be within the government and/or NGOs. In areas where businesses, communities and households are organising themselves for action, they may be just as, or even more, proactive. Governments, NGOs or business coalitions may have more capacity to deploy tools, while communities and households are more likely to be the end user. However, tools tend to be deployed and utilised at various levels, and while they may be initiated at a higher level (government, NGOs), communities and households can serve as both the deployer and the user.

Women and children queueing up for water. © ISET

Summary

Developing countries are witnessing rapid urbanisation and Indore, a tier II city,[2] is one of the fastest growing urban centres in India. The water supply system in Indore includes multiple service providers, which necessitates an integrated and comprehensive approach to water management for Indore, one that also takes into account changing climatic conditions and rapid urbanisation. There is a critical need to bring together diverse types of information and stakeholders in order to identify effective water management and planning. The urban poor in the city are more vulnerable to system/service deficiencies as compared to the higher income groups. In light of these conditions and in order to optimise the provision of services from the multiple service providers, there is need for a set of tools or processes that can help evaluate climate change impacts and frameworks for adaptation strategies.

This report outlines the resilience planning approach used in this project and in the ACCCRN study in order to provide a conceptual basis for the framework of process tools and techniques developed, including the study methodology. Chapter 3 provides details on the city's background, climate projections for Indore and a brief description of the formal and informal water sectors in the city. The three water managers in the Indore context – formal, private and households – are discussed in the following chapters, based upon the empirical surveys and discussions with various stakeholders. Finally, the information and data from these studies and stakeholder consultations are synthesised to document the challenges faced by different water managers in the city and the types of resilience strategies that can help alleviate water management issues in Indore. The approach documented in this report will be applicable and useful to other similar urbanising cities in the developing world.

[2] Tier I, II or III are categorisations of a city based upon population and infrastructure facilities available in the city.

There is an urgent need to respond to the multiple threats posed by climate change and its impacts on water availability, quality and supply. In order to be able to identify and quantify threats and adapt, ecologists have proposed the concept of "resilience," which has been defined as the capacity of a system to absorb disturbance and reorganise so it retains its essential functioning, structure and identity (Walker et al. 2004). Thus, building climate-resilient cities requires building adaptive capacity to respond to threats, both at the systemic level – the city water supply system as a whole – and at the scale of individual agents. The capacity to anticipate, as well as the flexibility to react and maintain critical functions and system linkages during stress, is essential to creating resilience.

The Shared Learning Process

In this chapter, we describe the process we used in Indore to incorporate climate resilience into planning. There are a number of adaptation frameworks and resilience planning processes that have been proposed and developed to assist institutions at multiple levels with decision-making processes associated with climate change (for example, Burton et al. 2004; Carter et al. 2007; Willows et al. 2003). Under the Asian Cities Climate Change Resilience Network (ACCCRN) programme and this National Oceanic and Atmospheric Administration (NOAA) project, we developed our own approach to climate-resilience planning that we call the "Shared Learning Process," which was originated by ISET. The Shared Learning Process creates an opportunity to develop deeper understanding, analysis and prioritisation of climate-related issues and the ability to respond to them.

The core principle of the Shared Learning Process is the iterative sharing of information between various actors on a mutually respectful equal footing, rather than a top-down imposition of "scientific and/or technical knowledge" from experts to "local communities." This sharing of knowledge and experiences among water managers is particularly critical for sustainable urban water management, especially since there is a paucity of information on the state of the urban water system. Moreover, the information is fragmented, located among multiple sources including the water utility, private water providers and residents.

Shared Learning Dialogue, December 2010. © Pacific Institute

Although it was implemented in Indore under the ACCCRN and NOAA projects, the Shared Learning Process is designed to be broadly suitable for all communities integrating climate impacts into planning. Because of its general applicability, the Shared Learning Process is presented as an "overarching process tool" which could be applicable anywhere (as described further in Chapter 7).

The Shared Learning Process consists of a number of iterative steps involving knowledge generation and exchange between various stakeholders. The Shared Learning Process in Indore involved three broad phases (table 2.1), all of which were undertaken in parallel with a *Stakeholder Engagement Process:*

1. Scoping of Problem
2. Vulnerability Assessments
3. Identification of Resilience Interventions

In the following sections, we describe each phase of the Shared Learning Process and then detail elements of the overall *Stakeholder Engagement Process* used in every phase of this project. Each of the three phases involved activities that engaged stakeholders such as consultation, knowledge sharing and exchange of information with stakeholder groups, as well as analytical activities undertaken by the implementing agency: data analysis, literature review and scientific assessments. The problem scoping, vulnerability assessments and resilience interventions each entailed both stakeholder engagement and analytical activities.

Table 2.1: Shared Learning Process elements in Indore

Phase	Month/Year	Objectives
I	August 2008–January 2009	Reviewing climate, water resources and social change information: literature review under NOAA primarily done by Pacific Institute. Climate change study for Indore conducted as part of ACCCRN by TARU and ISET. Information shared and used under both projects.
II	December 2008–March 2009	Scoping study: overlapping ACCCRN/NOAA. Semi-structured interviews (one-to-one meetings) and focus group discussions conducted to identify key stakeholders in the formal and informal urban water system.
	March–June 2009	Vulnerability analysis study under the ACCCRN project: outcomes used in the NOAA project to shortlist vulnerable communities across socio-economic classes.
III	May–June 2009	Development of tools (questionnaires, checklist) for household and community under the NOAA project. Inputs taken from ACCCRN questionnaire.
	July–August 2009	Semi-structured interviews conducted with formal water system managers: IMC, Zonal officer.
	July–August 2009	Household survey conducted in eight selected communities belonging to different socio-economic sectors.
	August 2009	Shared Learning Dialogue conducted under NOAA with representatives of 8 household survey communities.
	September 2009	Shared Learning Dialogue conducted by ACCCRN with 35 representatives from eight different communities belonging to lower income groups and slums to broadly capture the qualitative aspect of the differential understanding of risks, vulnerability and coping mechanisms. Climate change information shared with the communities.
	March 2010	Series of meetings with the Madhya Pradesh Urban Services for the Poor (MPUSP) project coordinator and other team members.
	June 2010	Scoping study for informal water market survey.
	July–August 2010	Informal water market survey conducted with 50 business owners selling water for drinking and other domestic uses.
	December 2010	Shared Learning Dialogue with representatives from IMC, Zonal office, eight communities surveyed and the water market. Focus of dialogue was to disseminate results from household and private water market studies, validate results and create a platform for stakeholders to discuss issues and propose solutions.
IV	January–August 2011	Final report writing.

Scoping of the Problem

The scoping phase is the starting point of the Shared Learning Process. It begins with the identification of major urban systems in the city, key stakeholders and the main risks the city may face based on various scenarios of climate change. The populations and/or systems that may be vulnerable to a specific risk are mapped. Because the process is iterative, these risks may need to be updated or revised as the project progresses.

The city's water management system was mapped through discussions with stakeholders from various sectors. The responses generated in semi-structured interviews (one-on-one meetings) and focus group discussions gave the project team a better understanding of the complex water management system, including water supply and management by formal and informal water managers, as well as highlighted specific examples of community-based initiatives being implemented in the city. Based on this initial review, the project team developed a set of survey instruments (checklists and questionnaires) that could be used to get a more detailed understanding of the roles, responsibilities, capacities and interdependence among various water managers in the city.

Synthesis of Climate Information

Key to scoping the needs in Indore was the synthesis of climate projections. The appropriate role of climate information in urban resilience planning, both historical data and projections, depends significantly upon the goals, priorities, capacities and timeframes of the various decision-makers involved in the process, as well as the resolution and credibility of the climate information. To be useful, climate information at the appropriate geographic scale and time scale would be needed in vulnerability assessments at city levels. Ideally, assessment of climate risk would be conducted in two steps:

1. **An assessment of current vulnerabilities (baseline conditions) and current risks.** These baseline analyses use available historical climate information to identify *exposure* (a critical component of vulnerability) to a particular climate hazard, such as droughts, and the *likelihood of occurrence of that hazard or the outcomes of that hazard*, depending on which definition of risk was selected. Analysis of historical climate hazard events and their resultant impacts assists in the identification of critical thresholds at which certain urban systems, livelihoods or populations are adversely affected. For example, due to lack of solid waste collection and sewer maintenance, a city may begin to experience significant flooding after 15 mm rainfall in 24 hours, even though the historical 95th percentile of extreme rainfall events for the city is 35 mm in 24 hours.

Water logging in Indore - Lavkush Awas Vihar. © TARU

2. **An assessment of future vulnerabilities and climate risks.** Scenarios of plausible future vulnerability and risk are created by using multiple climate projections (to account for uncertainty) to develop new scenarios of exposure, in conjunction with scenarios of changes in socio-economic, political and environmental conditions that might either enhance capacity or increase sensitivity. In particular, analysis of shifts in the frequency and timing of extreme climate events and variability in seasonality or key variables like rainfall, when coupled with the baseline sensitivity/threshold analysis, allow estimations of future risk. For instance, TARU notes that most of the flooding incidents in Indore in the past decade are predominantly due to poor drainage, compounded by rapid road construction and the increase in impermeable surfaces throughout the city (TARU 2010).

Explaining climate change to low income community during Shared Learning Dialogue. © TARU

TARU assembled climate information pertinent to Indore under the ACCCRN programme, with technical assistance from ISET. At the inception of the vulnerability assessment, both location-specific historical and climate-projection data were extremely limited. Only one data source, the Global Historical Climate Network, provided station-wise data; the remaining data sources were grid-interpolated and ranged from a scale of 0.5 to 1. Reliable historical climate information was available on a monthly time-step from:

- Climatic Research Unit (CRU) 2.0 of the University of East Anglia
- Global Historical Climate Network (GHCN)
- Gridded rainfall and temperature data from the Indian Meteorological Department

The lack of reliable daily station data made it difficult to be precise with defining areas of exposure throughout the city and for extreme event analysis. Additionally, the lack of historical data made it difficult to validate and undertake more than a simple bias correction of the climate projections available for the city. TARU used climate projections for the Indore area produced by the Climate Systems Analysis Group (CSAG) of the University of Cape Town. The projections were produced via a statistical downscaling technique (Hewitson and Crane 2006) from eight General Circulation Models (GCMs) running the A2 emission scenario[1] for 2046-2065 and the B2 emission scenario for 2081-2100. Only four of the eight models were retained in the analysis because of the inability to reproduce key climate statistics, such as precipitation seasonality. Additional projections produced by the Indian Meteorological Department (IMD), which used the Regional Climate Model PRECIS running three emission scenarios – A1B, A2 and B2 – became available in the middle of 2010 after significant portions of the vulnerability assessment were complete. Chapter 3 summarises the general climate projections for the city.

[1] GCMs informing the Third and Fourth IPCC Assessments were run using a set of greenhouse gas emissions scenarios known as the SRES scenarios. There were four emissions "storylines": A2, B2, A1 and B1, each with a family of scenarios. The concentrations of emissions in each storyline were different and depended on assumptions of future energy use, population and economic preferences. A2 was considered a high emission and B2 a medium storyline (Nakicenovic et al. 2000).

Due to the limited amount of climate information available at the time of the vulnerability assessments, only the baseline vulnerability assessment had a strong quantitative component. Scenarios of future vulnerability and the risk assessments were much more qualitative in nature. Additionally, and as discussed later in this report, the Municipal Corporation and other stakeholders identified under both ACCCRN and this project typically lacked the training and technical capacities to understand climate information, available projections and potential threats. In addition, current infrastructure and urban system conditions were already so poor that there was greater interest in addressing current problems rather than future ones. Therefore, the project team dedicated a larger share of our resources to relating climate change impacts to what people currently identified as issue areas of concern for the city, gradually building the capacity to understand potential climate change impacts.

During initial discussions in Indore, officials at the IMC were skeptical of the linkages between climate change and water scarcity in the city. Even during the interactions with communities and households, it was difficult to explain the climate change phenomenon and increasing levels of water scarcity in the future when they were already facing problems with water services. With the communities, an approach that worked well to bring in the climate change perspective was to prompt a discussion on past trends that they witnessed where changing climate conditions impacted water availability, especially groundwater levels. Most stakeholders from public and private sectors and the community readily acknowledged a perception that the climate has been changing in the past five-to-ten years. This acknowledgement was helpful in framing future climate scenarios and their impacts on quality of life, particularly regarding water services. It was only during the December 2010 Shared Learning Dialogue that climate change scenarios and their impacts were presented to the community. Toward the end of the project period, IMC officials also acknowledged the potential for climate change and its impacts on urban services, water resources and lives.

Vulnerability Assessments

The second phase of the resilience planning process involves vulnerability assessments.The concept of vulnerability and how it is defined have been an academic debate for some time, with different views from climate scientists, the natural hazards and disasters field and the development community (Brooks 2003). Who is vulnerable, to what/from what, where, when and how suggests the overlapping, complex and diverse geographies and timescales of vulnerability which cannot be captured by a simple definition. For purposes of this report, we define vulnerability as the susceptibility to suffer damage from an environmental extreme and the relative inability to recover from that damage (Mustafa 1998). Vulnerability is not a predetermined, chronic state; instead it is socially-constructed, contextual, scale-dependent and dynamic. Within any society the “susceptibility to damage” varies greatly among households depending on class, gender, location and other conditions shaped by economic, social and political processes (Moser and Satterthwaite 2010). This variance in vulnerability arises for two reasons: 1) exposure and the distribution of climate impacts vary greatly, and 2) adaptive capacity varies. Adaptive capacities, as described by Ahmed and Mustafa (2007: 82), “are the characteristics of communities and people which can be used to respond to and cope with disasters.”

Vulnerability assessments aim to identify and assess key issues for a specific geographic area, sector or demographic, ultimately indicating: 1) what the shocks and stressors are and 2) who is the least able to respond to these shocks and stressors. Each assessment is designed to collect specific types of information; the design is the key as it drives the direction and focus of the assessment, and therefore affects the results. In Indore, a city-level vulnerability assessment was carried out using a geographic information systems (GIS)-assisted technique to develop deeper understanding of existing vulnerabilities of populations across space and socio-economic groups.

ACCCRN-TARU Vulnerability Assessment

As part of the ACCCRN study, a vulnerability assessment was conducted by TARU. In conducting the vulnerability assessment for Indore, TARU utilised a sustainable livelihoods framework (DfID 2001) as a basis for analysis. Using this framework, we defined five resource capitals that influence livelihoods – human, social, financial, physical and natural capitals – and used proxy indicators to assess capacity, vulnerability or both within each capital. The proxy indicators (education, social networks, income stability, loans or lack of insurance, physical infrastructure and basic services deficiencies and water scarcity) were chosen based on household and community surveys (TARU 2010).

Geographic information systems (GIS) mapping was used as an important tool in this exercise, both to analyse infrastructure and service deficiencies and to present the results. GIS allows a large amount of data to be managed and displayed, providing a comprehensive spatial perspective of the city and its vulnerabilities. Supplemental stakeholder consultations were essential to ensure a representative and substantive assessment in order to understand city-specific vulnerability patterns and to validate methodology. Flood/water-logging maps of the city, limited climate projections and historical temperature and precipitation data were all incorporated into the vulnerability analysis (TARU 2010).

For Indore, water scarcity was found to be the highest priority issue for the city to address. An index was created displaying how much water each socio-economic class receives and how each class utilises that amount. Water scarcity index analysis suggests that all the socio-economic classes suffer from water scarcity. However, as vulnerability is highly contextual and scale dependent, those living in slums and the lower middle class were found to be particularly vulnerable, with nearly half the households facing acute water scarcity. The ACCCRN vulnerability results informed the development of Indore's city resilience strategy and provided information for this study. These results were utilised as entry points for the research and for identifying key geographical areas and demographic groups who suffer the most from water scarcity.

Sector Studies

To capture the systemic vulnerabilities within sectors like energy, water, transport, etc. in the city and the cross-sectoral linkages among them, specific sector studies were identified and commissioned in Indore as part of the ACCCRN project: Urban Health and Environment, Transport Sector, Water Security, Energy Security and Green Buildings for Indore.

Similarly, as part of the NOAA project, it was decided to undertake an in-depth study of three key water-supply-and-demand sectors in the city. They were:

(i) Formal water sector (Indore Municipal Corporation);

(ii) Water at the household level; and

(iii) Private water sector, including drinking water businesses and water tankers.

Woman carrying water jars on a bicycle. © ISET

These studies were carried out with the support of local city partners using various process tools. While the results from each of these sector studies are discussed in detail in the later chapters, the methods and general process employed in each is given below.

Formal Water Sector Study

The responsibility for sourcing and supplying water to the people living in an urban area rests primarily with the local city government, which is called the Indore Municipal Corporation (IMC). Discussions were carried out with the Municipal Corporation officials and Zonal officers to understand:

a. operation and maintenance of the water supply system;
b. procedure for new water supply connections;
c. complaints and redressal mechanism;
d. desired policy and institutional support for better management of water supply;
e. institutional and other bottlenecks affecting functioning of the water supply system.

Meetings were held with the elected representatives from wards (*Parshads)* to ascertain their roles in water supply delivery and management, as they act as a link between the IMC and the people, and to ascertain the effectiveness of their office in managing water problems of the ward. One-on-one discussions were also held with the Narmada Phase III[2] project officials to understand impacts of additional water supply and how that would affect the current water sector scenario in Indore.

Water at the Household Level

Eight communities were selected reflecting diversity in income groups as well as water supply sources for in-depth survey and investigation under the NOAA project. The methods used for the study of these communities included questionnaire-based surveys, focus group discussions and participatory appraisal tools. The household-level assessments helped in understanding the diversity of water supply arrangements by income group, the coping mechanisms for water scarcity currently in use, and the needs that residents had for information, communication or connection with the water utility and other water providers.

Private Water Market

The private water market in Indore consists of packaged water for drinking and water tankers. A survey of fifty private water businesses was carried out in Indore from these groups, using the tools of guided interviews and focus group discussions. In the guided interviews, the surveyors interviewed the business owner with the help of a checklist. These checklists posed questions on groundwater management, pricing structures, water sources, filtration methods, service areas, seasonal fluctuations in pricing and supply, consumer base, capital costs and challenges both within the market and internally. Focus group discussions gave a broad perspective and insights about the dynamics of the water market, while also enabling data verification and qualification of numerical data generated during the interviews. Additionally, web-based research was conducted to both verify and supplement the information, particularly regarding water quality standards and regulations.

Identification of Resilience Interventions

The third phase involved developing a comprehensive resilience strategy for Indore. Using the Shared Learning Process, the resilience strategy for a city is prepared by local stakeholders (usually with support from external resources) based upon a joint understanding of the vulnerability of people and sector(s) within an urban environment. Such a strategy and suggested interventions not only provide the context, information and analysis that can lead to identification of adaptation options, but also prioritise them and provide a roadmap for the private sector, civil society and government agencies. Since the Shared Learning Process involves the existing planning institutions and actors, the resilience strategy is embedded in the existing

[2] Fresh water for the city of Indore is sourced from the Narmada river, which is about 70 km away. The growing demand of the city has prompted the government to augment the water supply system from the river in phases. The first phase of Narmada water supply system was completed in 1984. Phase II was commissioned in 1992 and currently, with the Asian Development Bank support, Phase III of Narmada Water supply is under implementation.

planning process. It is hoped that the involvement of multiple stakeholders will ease the assimilation and implementation of the recommended resilience interventions.

In Chapter 7, we detail a Resilience Strategy for Indore, which examines the seven vulnerabilities identified through the Shared Learning Process and the Resilience Interventions to address these vulnerabilities. To address these vulnerabilities, the Project Team collated suggestions and ideas emerging from focus group discussions and Shared Learning Dialogues, and best practices in the water sector.

Stakeholder Engagement in the Shared Learning Process

Stakeholder engagement was core to every phase of the Shared Learning Process, from scoping and identifying vulnerabilities to identifying resilience interventions. A number of specific types of activities or tools were used as part of the Shared Learning Process, including multi-stakeholder discussions, focus group discussions with households and formal and informal sectors and one-on-one discussions.

The Shared Learning Dialogue, for example, links different types of stakeholders and aims at promoting learning *across* stakeholder communities. In contrast, focus group discussions are targeted to a single stakeholder group and aim to promote learning *within* a homogenous group of stakeholders. Finally, visioning exercises were undertaken – sometimes during a Shared Learning Dialogue event – with the specific objective of helping stakeholders understand scenarios and compare options. Each tool acted as a vehicle for information and engagement and action in the projects and is described further in the sections below.

Focus Group Discussions and One-on-One Meetings

Focus group discussions and one-on-one meetings are examples of basic supporting tools that facilitate the exchange of qualitative and quantitative data and also serve a networking function. Focus group discussions enable specific actors to be brought together to share information in a concentrated format. Focus groups could be utilised as part of a sector study or system analysis to bubble up specific knowledge, but may also be used somewhat independently to assemble actors based on demographics, geographic areas, marginalised populations or other groups of interest.

Focus group discussions were used quite effectively in Indore both for the household sector as well as for the private water market. Visits were made to all the eight selected communities for transect walks and focus group discussions – especially with women's groups. Various participatory appraisal tools were used, such as a ranking exercise and seasonality mapping. Questions and discussion points appropriate for each of the socio-economic classes were framed to be asked during the group discussions. With the private water tanker owners, focus group discussions were conducted subsequent to the individual interviews and included tools such as participatory mapping and ranking exercises. These discussions were conducted in the two localities where the majority of the water tanker owners are based.

Transect walks and focus group discussions were also conducted with the slum communities where a UK Department for International Development (DFID)-supported project on improving services for the urban poor is being implemented. Under the project, the slums are being provided with roads, drains and drinking water connections. This exercise was undertaken to see alternative methods in which active community participation has resulted in successful implementation of development projects in the city and what lessons can be learned and applied under the NOAA project. Examples such as the role of Resident Community Volunteers and Community Development Officers under Madhya Pradesh Urban Services for the Poor (MPUSP) can be replicated in other communities for improved service delivery.

Shared Learning Dialogue

The Shared Learning Dialogue is one of the activities conducted as part ofthe Shared Learning Process. In a Shared Learning Dialogue various stakeholders are brought together to share information in a multi-directional way that crosses scale and community and organisational and disciplinary boundaries.

The concept of Shared Learning Dialogue is straightforward: by fostering iterative deliberation, sharing of sector-or group-specific knowledge and experience and knowledge from both local practitioners and from external experts, the quality and effectiveness of decision-making will be improved (ISET 2010).

Multi-directional sharing of information dictates that actors from different sectors or perspectives share information in an attempt to develop mutual understanding. Successful and effective shared learning hinges on this coalition of local knowledge and scientific expertise. The nature of the dialogue needs to be open; so having an appropriate platform in place for individuals to speak freely and with enough time to ingest and process new information before attempting to utilise it is important.

Focus group discussion with Bijalpur water tanker © ISET

The iterative component is also critical: bringing individuals together repeatedly over time allows new information to be exchanged, relationships to build, questions to be answered and overall understanding to grow (ISET 2010).

Shared Learning Dialogues were strategically positioned throughout the resilience planning process to move information and partnerships forward to the next step. Utilised in the initial scoping phase, they set the stage for the project in determining what needed to be done, who should be involved and what resources will be needed. Ideally, these aspects will continue to change and build throughout the engagement process, using the Shared Learning Dialogue as a catalyst for bridging information and stakeholders, allowing for process modification, introducing new players and reframing where necessary.

The core goal of Shared Learning Dialogues in this project was to bring together different water managers within Indore to improve the management of the system while simultaneously minimising negative impacts on health, livelihood and the environment. At the city level, adaptation to climate change will require solutions that are locally generated by water managers.These adaptation strategies must effectively respond to particular "local" vulnerabilities and capacities in order to lead to appropriate actions and strengthen the development capacity of local organisations and communities (Satterthwaite et al. 2007; Danilenko et al. 2010).

The specific Shared Learning Dialogues conducted in Indore under this project, including one under the ACCCRN project and two under the NOAA project, are discussed below.

Shared Learning Dialogue - NOAA August 2009

While the NOAA project was in progress, a Shared Learning Dialogue comprising 24 participants representing the eight selected communities was conducted. For the dialogue, we sought to capture the various perceptions among water managers at each of the socio-economic classes and their understanding of diverse patterns of water supply: normal/scarce; months/rainy season; duration/frequency; ranking

Vision exercise template used in Indore. Source: TARU

quality and reliability; defining water scarcity; coping strategies at the household and community level; grievance redressal mechanism; and the kind of information they need to better manage their water and from whom. The qualitative information generated from the Shared Learning Dialogue provided a way to cross-check the household data gathered from surveys. It also provided support for generating an in-depth understanding of the different perceptions of water self-sufficiency and water scarcity among the groups, as well as of the differences and commonalities in their understanding with the formal water managers of how the water supply system functions and what they consider the key problems and solutions. A matrix was developed that provided a comparative analysis between the different groups on water supply availability and quality in normal and scarce months.

Shared Learning Dialogue - ACCCRN September 2009

In September 2009, we brought together 35 representatives from eight communities under the ACCCRN project belonging to lower income groups. The Shared Learning Dialogue was conducted to capture the qualitative aspect of differential understanding of risks, vulnerability and coping mechanisms. This was done to understand and cross-check issues and problems related to basic services such as water access faced by communities across Indore. The outcomes of this dialogue were also shared with the representatives from Indore Municipal Corporation (IMC) and from the Zonal offices by the community representatives. Though the communities present in this Shared Learning Dialogue were not studied as part of the NOAA project, the information and understanding of issues generated were also used for the NOAA project.

Shared Learning Dialogue - NOAA December 2010

The December 2010 Shared Learning Dialogue was held primarily to disseminate results from the household and private water market studies, to allow those results to be validated and to create a platform for stakeholders to discuss issues and propose solutions. There were 41 participants including representatives from the communities involved in the household survey, Madhya Pradesh Urban Services for the Poor (MPUSP), *Parshads*, the IMC and the private water industry in Indore.

Shared Learning Dialogue at Indore: December 5, 2010

The focus of the Shared Learning Dialogue was to disseminate results of the household water survey and informal water market to be validated by the participants and to create a platform for water managers to discuss issues and propose solutions.

Methodology:

Step 1: Ensuring participation of key stakeholders from both formal and informal water sectors: The core of a successful Shared Learning Dialogue lies in active participation of different stakeholders from different user communities and both formal and informal water sectors – hence timely dissemination of information about the agenda, place date and time is important. During this Shared Learning Dialogue, a total of 45 representatives from eight communities (those selected for the household water survey), representatives from the informal water sector, Indore Municipal Corporation, Zonal Office and MPUSP project participated. The majority of the participants were women.

Step 2: Facilitating the Shared Learning Dialogue: The dialogue was facilitated by team members from ISET and TARU, and opened with an informal introduction of the participants and facilitators. Information on the NOAA Urban Water Markets project and the climate context was presented briefly, followed by the results from the household survey and from the informal (private) water market survey.

Step 3: Dividing into groups: The presentations provided a basis for two group exercises that were conducted using various participatory learning and action tools. The participants were divided into five small groups based on socio-economic class, private water sector and IMC for group activities. Each group had a facilitator and note-taker from the facilitating team of AAS, TARU and ISET.

Group Activity 1: Validating the surveys: Each group was asked to discuss and respond to the three questions: *What feedback do you have on the information that was presented? Are there any additional points you want to add? What changes have occurred in your community (or informal) water situation?* Responses were then synthesised by the facilitators and note-takers and presented to the larger audience.

Group Activity 2: **Focusing on coping mechanisms and resource needs:** For the second group activity, the participants were divided into three larger heterogeneous groups. Each group was asked to discuss and respond to three questions: *We are all powerful water managers that can improve water management in Indore. How can we move from coping to management?* Results were synthesized on the flip charts provided. Each group then presented their main points to the room.

The dialogue was heavily focused on communities and began with presentations on climate change projections and implication for Indore, an overview of the NOAA-SARP project, specific results from the household-level study and a summary of results from the private water market study. The presentations provided a basis for two group exercises. The first focused on data validation of the surveys, dividing participants into five small groups, with community groups based on socio-economic class, private water sector players and government officials and staff. The second focused on coping mechanisms and resource needs, dividing the participants into three larger heterogeneous groups. Discussion points were provided in both activities so that group members could discuss, ask questions, raise issues and provide suggestive solutions. Each group chose a team leader who presented the information to the larger group. Participants filled out feedback forms regarding the structure and content of the Shared Learning Dialogues, and the findings were consolidated.

Visioning Exercise

A visioning exercise was used in the ACCCRN project as one of the tools to strengthen engagement, create awareness and improve understanding of the possible future scenarios. The scenarios are based upon current development challenges and current climate-change-related risks, addressing ranges and trends of climate change projections regarding critical climate variables such as temperature and precipitation. They also address two contrasting potential scenarios of the city's future as climate change manifests: the business-as-usual scenario and a positive future scenario, thus painting a picture of maladaptation compared to resilience. Vulnerability assessments and sector studies were key inputs to develop these scenarios in conjunction with the city stakeholders. The business-as-usual scenario typically projected a influenced by specific factors of the change process, such as improper planning, low institutional capacity or lack of shared learning and integrative management. The positive future approach emphasised the possible positive outcomes highlighting the key characteristics of a resilient city.

Focus group discussion with community at Scheme No. 114, Indore. © ISET

After the generation of scenarios, the resilience strategy for the city, including the specific action points or plans, was developed in conjunction with the city stakeholders.

Summary

To help identify and develop frameworks needed for building climate-resilient cities – from the individual to systemic level – resilience planning based on a Shared Learning Process was used in Indore to allow inclusion of multiple voices and information and knowledge from various types of water managers in the city.

The Shared Learning Process consisted of three phases: Scoping of the Problem, Vulnerability Assessments and Identification of Resilience Interventions. The Scoping Phase involved the synthesis of climate information into vulnerability assessments as well as detailed sector studies on water management by the formal (municipal utility), informal (tankers and bottled water operators) and household sectors.

Each phase involved activities that were conducted in parallel, both stakeholder engagement activities as well as analytical activities undertaken by the implementing agency or NGO: data analysis, literature reviews and scientific assessments. A range of stakeholder engagement tools aimed at building climate resilience were piloted in this project, including Shared Learning Dialogues, Focus Group Discussions and Vision-Sheets to help stakeholders visualise a range of possible futures.

The City of Indore

Indore is the most populated city in the central state of Madhya Pradesh, India. It is located near the drainage divide between the Chambal and Narmada Rivers at an elevation of approximately 550 metres. Situated on the banks of the Khan and Saraswati Rivers and centrally located on the Malwa Plateau, it is the core of the Indore Agro-Industrial Region, which consists of seven districts.

Formerly a major trading centre, Indore, along with its satellite townships of Pithampur and Dewas, has established itself as a strong industrial hub. The city is host to a number of industries including automobile, textile and information technology (IT), and in the last two decades, Indore has also emerged as a large educational and medical centre. The city has witnessed a decadal population growth of 41.3% from 1991 to 2001 and continues to urbanise at a tremendous speed. According to the 2001 Census, the city's population increased from 57,235 in the year 1911 to 1.6 million in 2001; the population for the Indore planning area was estimated to be 2.53 million in the year 2011 and to reach 3.67 million by 2021 (Mehta and Associates 2006).

Such a substantial growth rate has resulted in a significant increase in service needs, and particularly in the requirement of water for drinking, industry and municipal purposes.

Currently, only about 50% of Indore's population has access to formal housing, while the rest of the population resides in squatter settlements and unauthorised colonies. Only 20% of roads have storm-water drainage and roughly 55% of the population has access to the sewerage network, with nearly 80% of sewers underutilised and in various states of disrepair due to lack of maintenance (Mehta and Associates 2006).

Administration

The municipal area of Indore city is 134 sqkm, which is divided into 12 zones and 69 wards for decentralised planning and administration.The city of Indore is administered by the Indore Municipal Corporation (IMC), which was established in 1956 under the Madhya Pradesh Nagar Municipal Corporation Act in 1956, a government notification (Mehta and Associates 2006). The Municipal Corporation is headed by the Municipal Commissioner who is an Indian Administrative Services (IAS) officer appointed by the Madhya Pradesh state government. Parallel to this executive (or government) body, the city also has a Municipal Council that is an elected body. The Municipal Council constitutes elected corporators or *Parshads* – one from each ward – who, in turn, elect a mayor. The Municipal Council is responsible for running some of the city services, including the city bus service, the municipal hospital and the city library.

The Commissioner of the IMC is also the ex-officio chairperson of the Indore Development Authority (IDA), which is the main institution involved in planning and development of new residential areas in Indore. Until 1973, Indore had a City Improvement Trust to assist the IMC in its developmental activities, which was later converted into the Indore Development Authority following the Madhya Pradesh Town and Country Planning Act 1973. The IDA identifies areas for development of new residential colonies and is responsible for developing basic infrastructure, in particular water connections, sewerage and roads. After a sufficient number of plots or houses are occupied or sold, the IDA hands the area over to the Municipal Corporation, which then becomes responsible for the maintenance of infrastructure in the area (Mehta and Associates 2006). In Indore, the IDA has also taken up other developmental activities in the city, including the construction of major roads, traffic squares and parks.

Historical Climate Conditions

Due to its location in central India far from the sea (approximately 76 ^{0}E and 23 ^{0}N), Indore has a transitional climate that fluctuates between tropical savanna and humid subtropical. The city experiences three distinct seasons: summer, monsoon and winter. Summers typically begin around mid-March and last until the onset of the South Asian Monsoon (SAM), usually sometime in June. During summer, average daytime temperatures range from 35-40 ^{0}C with peak summer temperatures in May occasionally exceeding 45 ^{0}C, despite the low humidity. However, unlike other places in central India, the summer nights in Indore, on the southern edge of the Malwa Plateau, are much cooler, with a cool breeze (referred to as *Shab-e-Malwa)* in the evenings. The winter months (November to February) are dry, mild and sunny. Temperatures average from 4–15 ^{0}C, but can fall close to freezing on some nights.

Indore receives the majority of its annual precipitation, approximately 90%, during the monsoon season. The South Asia Monsoon (SAM) is an annual phenomenon over South Asia, bringing significant rainfall to the region from June through September. It is characterised by a shift in the direction of the prevailing winds from the northeast to the southwest. These southwest winds bring warm, moist air to the Indian subcontinent and trigger thunderstorm activity. The SAM experiences significant intra-seasonal, annual, biennial and inter-annual variation and is influenced by other large-scale climate phenomena such as El Niño Southern Oscillation (ENSO), the Indian Ocean Dipole and the Madden-Julian Oscillation (Webster et al. 1998). Analysis of extended (1901-2008) rainfall datasets from the Global Historical Climate Network by TARU indicates that annual variations in rainfall can deviate as much as 263mm, which is nearly a third of the average annual total. After 1973, annual rainfall around Indore appears to follow a decreasing trend (TARU 2011). However, this shift is still within the long-term average behavior for Indore and cannot yet be directly attributed to climate change.

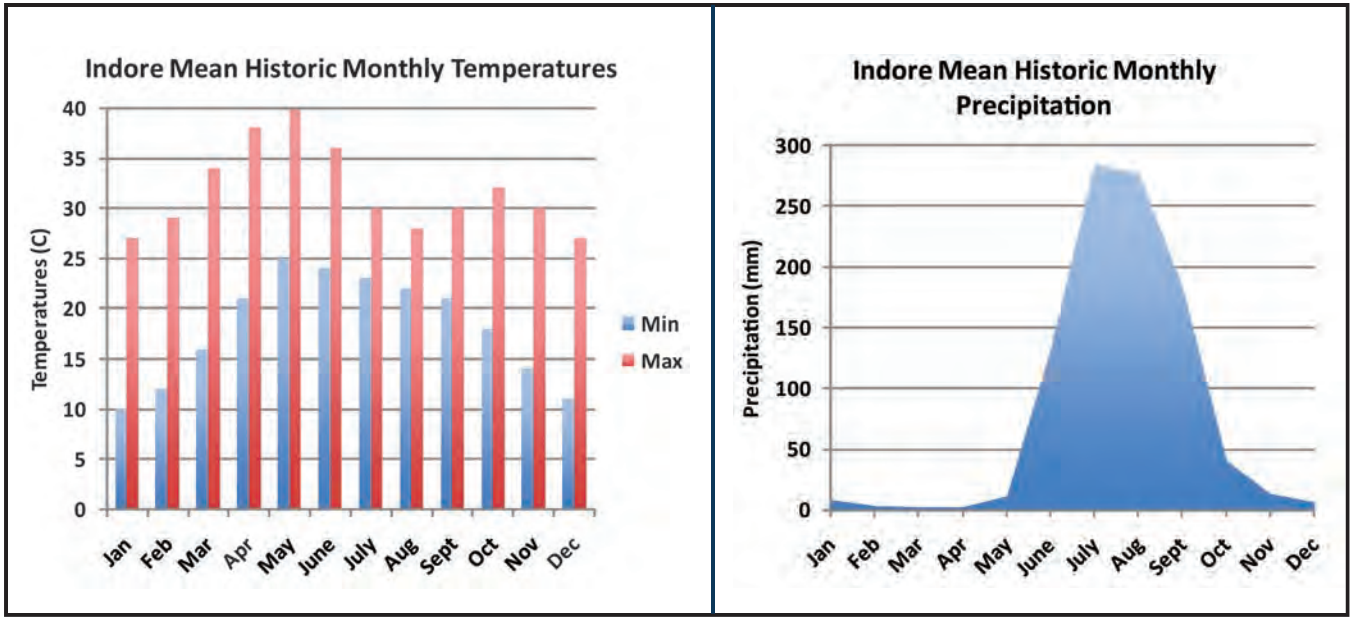


Figure 3.1: Average monthly temperatures and precipitation in Indore from 1951-1980 (IMD 2011).

Climate Change Projections for Indore

As discussed in the second chapter, this project drew heavily from the climate projection work done by TARU and ISET for the ACCCRN programme. Before this, no known location-specific climate projection work had been carried out for Indore, making aspects of both the NOAA and ACCCRN projects difficult to initially complete. Further more, as specified in Chapter 2, ISET and TARU interpreted and rescaled existing projection data for Indore, provided by the Climate Systems Analysis Group of the University of Cape Town and by the Indian

Meteorological Department (IMD). All climate-change projections presented here should be considered provisional. We strongly urge the IMD to begin developing suites of high resolution (~10 to 25km) climate-change projections for major cities in India, using multiple emissions and land-use scenarios and provide this data to the cities to aid them in their resilience planning efforts.[1]

The Asian-Australian monsoon system, of which the SAM is one branch, is one of the most complex large-scale climate phenomena on the planet. For a number of years, meteorologists and climatologists were fairly successful in producing seasonal forecasts about the onset and withdrawal of the monsoon system and whether it would produce below average, average or above average precipitation. However, since the late 1980s, the ability to predict the monsoon has decreased as the relationship between the monsoon and other large-scale climate features, such as ENSO, have changed in ways we do not yet understand. The scientific community's ability to project how the monsoon system might evolve under various climate-change scenarios may be weak, as General Climate Models (GCMs) and Regional Climate Models (RCMs) currently have a difficult time replicating key features of historically-observed monsoons. A significant amount of research is still needed to better understand certain monsoon dynamics and improve our ability to model the monsoon. Despite these challenges, projections from multiple models are starting to converge and agree upon changes in trends of temperature and rainfall for various regions of Asia (Christensen, et al. 2007).

Only projections from three GCMs, each running the A2 high emission scenario, were available for the future time period of 2046-2065. Results from a single RCM models, running limited emission scenarios for different time periods, does not capture the full range of uncertainty likely to be seen if multiple models, running multiple emissions scenarios, had been used. Therefore, we strongly caution against using the projection values for infrastructure planning without taking into account model uncertainties.

[1] Indeed, we urge all national meteorological departments or climate agencies to share both historical data and climate projection data with cities and educate decision makers on how climate information can be used in urban planning and development processes. Our call is not just aimed at the IMD.

Local Perception about Climate Variability and Change

According to Ms. Usha Vaishampayam (founding member of Utkarsh Mahila Samiti, a registered society that works on solid waste management and rainwater harvesting), "Due to variability in rainfall pattern witnessed over the past 5-8 years, water scarcity months can begin from as early as March. It's also not sure whether monsoon will reach Indore by mid-June; it can take longer. Looking at the rainfall pattern in recent years, even if Indore city receives rains, it could be scanty" (personal interview, 23 January 2009, Indore).

Compilation and interpretation of preliminary projection data[2] from a limited number of GCMs and RCMs for Indore indicate that annual rainfall amounts might range from -4% to +8% by 2046-2065 when compared with average annual rainfall amounts from 1961-2000 (TARU 2011). Minimum and maximum temperature change scenarios for the period of 2046-2065 show much greater agreement among the GCM projections available. Both minimum and maximum temperatures are likely to increase 2^0 to $4\,^0$C when compared with the average monthly temperatures from 1961-2000, as seen in the figure below. If these temperature projections actually occur, the city is likely to lose the *Shab-e-Malwa* night breezes and see a decrease in the diurnal temperature ranges.

Urban Water Supply System of Indore City

Indore is the fastest growing city in the state of Madhya Pradesh primarily due to its large educational, medical and commercial centres. It is a typical example of a city where rapid urbanisation has strained infrastructure and management capacities for addressing rapid growth in demand for city services, especially in the provision of safe, adequate and reliable water supplies. Climate change impacts may further challenge the water supply sources for Indore, thus aggravating water security issues

[2] Refer to Chapter 2 for a discussion on the methods and processes in ACCCRN for developing climate projections for Indore.

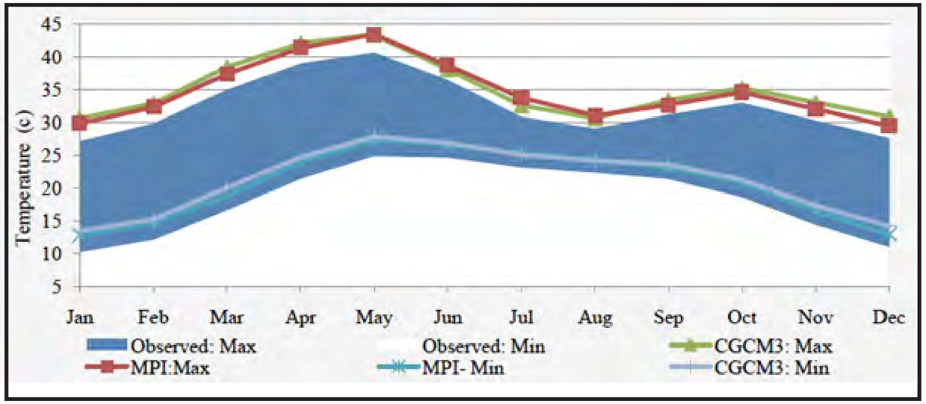


Figure 3.2: Indore future (2046-2065) minimum and maximum temperature projections compared with observed temperatures from 1961-2000. Observed data is from the GHCN. Projection data is derived from CSAG's Data Dissemination System, Asia2.2. Figure and analysis are copyrighted by TARU 2011.

in the future. Leakages in old and decrepit distribution systems, poor/inadequate sewerage systems and intermittent water supply can potentially affect the quality of the water supply system of Indore. Adding to these challenges, specifically in the private water market system, is the lack of effective regulatory mechanisms that adds to the risk to water quality in the urban conurbations (Koppenjan and Enserink 2009).

The development and operation of urban water supply systems and infrastructure in general is primarily the responsibility of the Indore Municipal Corporation. Municipal water is supplied in various forms, including the Municipal Narmada household piped connection, the Municipal Narmada commercial piped connection, the Municipal Narmada industrial piped connection, the Municipal Narmada standpost, the Municipal borewell and the Municipal tankers (drawing water from public borewells).

Water supply from the Municipal Corporation's Narmada water connections is not available to everyone, and in 2006 only 54% of the population in the Indore municipal area was covered. Nearly 16% of the population resides in slum areas where they lack access to municipal water supply and they receive less than 40 LPCD (litres per capita per day) from local borewells, community stand posts or public tankers. During the summer season, when supplies from the Yashwant Sagar Reservoir and Bilawali water storage tank and groundwater become scarce, hundreds of water tankers are contracted and operated by the government each year to provide water to various colonies and sections in the city.

> In the Shanti Nagar Slum, women emphatically stated that in the wake of water scarcity, more often than not it is the women who suffer the most. As per the societal norms, they have to take care of the children, complete household chores, fetch water and also (sometimes) earn livelihood. They struggle every day to access/collect water and though the politicians promise to provide relief from water scarcity during elections, they have not kept their promises. Even the men of the slum do not protest as the politicians keep giving them gifts, to get re-elected (Focus Group Discussion with women of Shanti Nagar Slum, 25 February 2009).

Domestic connections are non-metered and all households pay flat rate charges irrespective of consumption. The water supply system is in dilapidated condition and has a number of wastages/leakages and non-revenue water (Chauhan, et al. 2009). The formal urban service delivery system suffers from the following problems:

- Minimal regulation and enforcement of water quality;
- Over-exploitation of groundwater;
- No metering for household connections;
- No centralised regulations for groundwater extraction;
- Illegal water connections from the piped municipal water supply;
- Deteriorating water supply infrastructure – leading to leakages and instances of mixing sewerage into the piped water; and
- Growing water scarcity with climate variability adding to the above challenges.

Public stand-post, Indore. © TARU

Since this fragile formal water supply system caters to approximately only half the population in the city, a parallel private water market thrives in Indore. The private water market can be divided into two specific segments: water tankers and the packaged water industry. These multiple water supply arrangements and systems are interdependent and linked. In spite of the problems and stresses with water provisioning in the city, these private systems complement the formal system and help decrease the stress related to the water insecurity of a growing urban population.

Water Sources

The two major sources of water in Indore are surface water and groundwater. The surface water is mainly sourced from the Narmada River with some additional supplies from the Yashwant Sagar Dam and the Bilawali water storage tank. The sourcing and delivery of water to the city is done entirely by the Municipal Corporation or the utility.

Groundwater is used as an augmenting or supplementary source of water by the Municipal Corporation, through its borewells throughout the city, and is the main source of supply for the private water market system. In addition, many households and institutions in the city have their own private borewells.

Surface Water Sources

For Indore, the primary water supply source is surface water (Yashwant Sagar Dam, Bilawali Tank and the Narmada River), which contributes almost 90% of the supply. The Yashwant Sagar Dam, completed in 1939 to help overcome the water crisis of Indore city, was one of the major sources of water until recently. Due to the rapid growth of the city as a commercial centre, in 1984 the first phase of the Narmada project was commissioned by the IMC with support from central and state governments to bring water from the Narmada River to Indore. The Narmada Phase II was later commissioned in 1992. Approximately 75% of Indore's water supply comes from the Narmada River, which involves a lift of more than 420m and 70km in distance[3] (Chauhan 2009). This sourcing and delivery of water to the city is done entirely by the Municipal Corporation.

Considering the growing needs of the city and to reduce the stress of insufficient water supplies for the growing population, Phase III of Narmada water supply system[4] was planned and has been under execution since 2006. Presently, only a portion of the planned capacity has been operational, and Indore is being supplied with approximately 90 MLD of additional water, thus enhancing the total availability of water from the Narmada project to 230 MLD from the previous 140 MLD.

[3] However, the City Development Plan (Mehta and Associates 2006) reports that water is lifted approximately 500m from the Narmada River to a break pressure tank and from there transported to Indore city by gravity flow.

[4] Fresh water for the city of Indore is sourced from the Narmada River, which is about 70 km away. The growing demand of the city has prompted the government to augment the water supply system from the river in phases. Currently, with the ADB support, Phase III of the Narmada water supply is under implementation.

Groundwater Resources

Aside from the distant Narmada River, Indore depends primarily on local groundwater sources for water supply – either from the utility or from the private water tankers. As a result, it is important to understand the local hydrological context that determines groundwater availability.

Indore is located on the Deccan plateau. Geologically, the city is underlain by basalt formations known as the Deccan traps. These massive basalt flows have primary layers of high permeability in the vesicular inter-flow zones. These particular zones alternate with more massive sections where permeability is limited to vertical fractures. Above the basalt layers, black cotton soils with very low levels of permeability restrict the infiltration of water. As a result, the natural levels of groundwater recharge are quite low. Except in places directly linked with major fracture zones, water accumulation on the surface (whether from rainfall, natural streams, or urban runoff) probably contributes little to groundwater recharge. Instead, most water likely evaporates or runs off into streams. According to estimates from the Central Ground Water Board, the state of groundwater development is 172.5% with serious problems of groundwater decline (CGWB 2011).

Borewell in Indore Goma Ki Phel. © ISET

Prior to Indore's growth as a city, most of the area was agricultural. Irrigation was supplied from a few surface sources and more commonly from hand-dug wells that intercept vesicular zones between massive basalt flows. Dug well technologies have now been replaced by borewells, but the number of dug wells in most areas was probably between one and two per hectare. Although now either abandoned or partially filled in with debris, such wells can potentially be used for groundwater recharge.

With partial coverage of the sewerage system and leakages in the dilapidated water distribution system, the external supply to the core city adds significant amounts of groundwater recharge while also contributing to fecal pollution in groundwater. The total input of water to the 135sqkm area of the city, at the rate of 270 MLD, is approximately 9,755 ham (hectare-metre). Even considering conservative estimates of 15% of this water infiltrating into the ground, it amounts to about 1478 ham compared to the rainfall-related infiltration of 972 ham annually. This may be one of the reasons for continued availability of groundwater despite decline in the water table. Urban hydrogeological studies elsewhere indicate that such a phenomenon in urban areas is due to year-round influx of external water into urban systems (Hirata et al. 2006). This phenomenon is not well understood and needs further analysis, especially due to possible fecal pollution and buildup of heavy metals in groundwater due to urban recharge.

Groundwater is currently used by the Indore Municipal Corporation to meet approximately 10% of water demand in the city. IMC has more than 3,600 borewells in the city, and through the survey of households (see Chapter 5 for more details) we found that the main consumers of this groundwater supply from the IMC are people living in low-income or slum settlements. Also it is estimated that there are more than 50,000 private/individual borewells in the city, mainly owned by middle- and upper-class households (TARU 2010).

A number of new colonies in the city that have been developed by the Indore Development Authority also have not been transferred[5] to the IMC and do not have Municipal piped connections. These colonies either use borewells (community and Municipal borewells) or the Corporation supplies them water through tankers – both of which depend on groundwater as a primary source.

Discussion on Water Supply Sources of Indore

Overall, although groundwater currently meets a relatively small proportion of Indore's water supply, its importance should not be underestimated. It plays a significant role in meeting the needs of populations that are not connected to the municipal supplies. It is also the primary large-scale source of supply should any disruption occur, whether climate related or not, to water from the Narmada River.

As discussed in earlier sections, Indore is dependent on a single source (the Narmada River) for most of its water supply. Though this source has high reliability in terms of supply, Indore's dependence on a single distant source makes its water supply system vulnerable – both to power or source interruptions. If any disruption should occur in the Narmada water supply system, a major burden of water supply to meet the needs of the urban residents would be on local surface reservoirs and groundwater resources. At present, the municipality has only two or three days of water reserves from the Narmada to meet the needs of urban residents. A drought, major flood, earthquake or other event that damages the Narmada supply could disrupt water to the city for a period far longer than existing reserves would sustain. In addition, the competing demands on the water from the Narmada from within the state by other towns and villages are increasing. Keeping sufficient storage in local surface reservoirs and conservation of groundwater for emergencies will be key to building resilience of urban water supply in Indore. Unless these functions of local sources are incorporated in water management, failure of Narmada supplies can significantly impact the city.

In addition to recognising the role groundwater resources play as part of the overall water supply equation in Indore, it is important to recognise that these resources will be affected by climate and other change processes. The long-term replenishment of groundwater will be affected by climate conditions. Climate change may, for example, add to existing pressure on the groundwater resource base with: (i) changes in recharge rates; (ii) increases in demand as it is used to buffer water supply during periods of drought or high rainfall variability; and (iii) changes in water quality characteristics.

Summary

Management of water supply and use in Indore is undertaken at various levels and by different actors or managers. The term "water managers" is used here as an encompassing cross-scale term – from a community member to the IMC. These water managers can be classified into four different social-cultural environments or solidarities: (i) public or formal water system managed by local government bodies (Indore Municipal Corporation); (ii) water market system: water managers from packaged water and the local unregulated water tanker market of Indore; (iii) water supply and use systems at household and community scale where key water managers are the residents of a household or locality; and, (iv) the NGO and other non-governmental institutions such as engineering colleges who provide technical and information-based support to communities/households in managing their water supply arrangement.

We employed surveys, focus group discussions and Shared Learning Dialogues to study and understand in more detail the critical issues water managers from the formal system, households and private sectors face while managing water in Indore. The results are discussed in detail in Chapters 4, 5 and 6 respectively.

[5] Indore Development Authority (IDA) develops new housing colonies in the city. Once this development (laying of roads, streetlights, sewer pipeline, water pipelines, etc.) is completed, IDA then transfers this colony to the IMC. Only after this transfer does the IMC connect the sewer lines to the main sewerage line of the city, connect water from municipal supply to the colony pipelines, etc.

Formal Water Supply System

The development and operation of the formal urban water supply systems, and infrastructure in general, of Indore is mainly the responsibility of the Indore Municipal Corporation (IMC). This responsibility of providing water to the population residing within the Municipal jurisdiction is vested with the IMC in accordance with the provisions of the Madhya Pradesh Municipal Corporation Act of 1956 and Madhya Pradesh Municipalities Act of 1961. Municipal water is supplied to Indore's growing population in several different ways: pipes, tankers and Municipal borewells.

Management Structure of Indore's Water Works Department

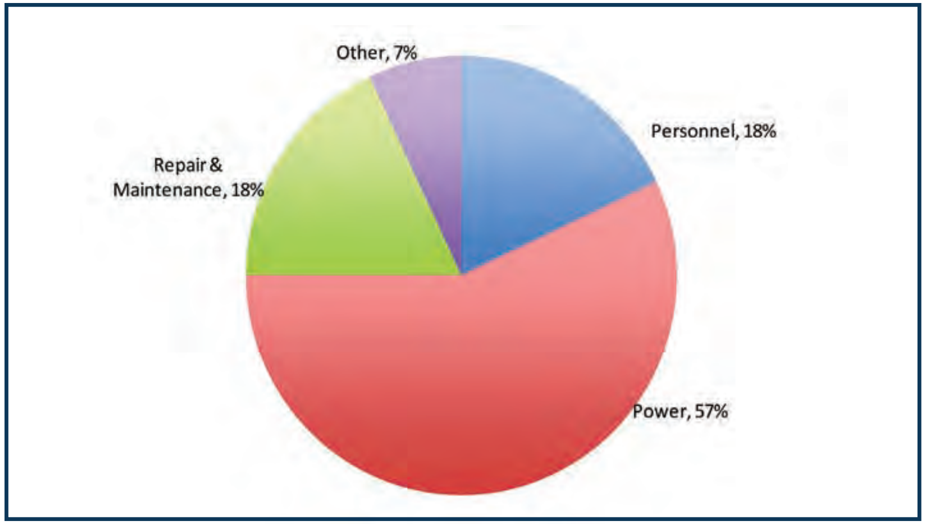
Until the enactment of the 74^{th} Constitutional Amendment in 1995, the Public Health and Engineering Department (PHED) operated and maintained all water projects and schemes within the municipal limits of Indore. Subsequently, the responsibility for management of both the water supply and the sewerage system was transferred to the IMC, with PHED giving the financial and administrative sanction for all projects. The commissioner is in charge of water supply operations for the IMC.

The Water Works Department of the IMC is headed by a superintending engineer on deputation from the PHED. The superintending engineer is further supported by two executive engineers handling the two Maintenance Divisions of Mandaleshwar and Indore, who in turn, are assisted by sub-engineers responsible for the various subdivisions within the jurisdiction of the Municipal Corporation.

In addition, staff from PHED are also deputed for maintenance of bulk supply lines. The Acts of 1956 and 1961 vested authority in the Municipal Corporation to collect water charges as well as the power to source, treat and distribute drinking water (Madhya Pradesh Municipal Corporation Act 1956). Other responsibilities of the Water Works Department include: operations and maintenance of water sources; operation and maintenance of intake wells, water filtration plants, storage and supply systems; operation, maintenance and replacement of main and distribution pipelines; maintenance of public standposts; arrangement for water and supplying it through tankers or other available means during times of shortage; registration of individual piped connection and its maintenance; maintenance of the IMC's private and public water sources, ponds, wells, etc. and construction and maintenance of drains and sewers, including their cleaning.

The urban water delivery system has four important components: (i) capturing the basic natural resource (diversions and reservoirs); (ii) transporting the water to areas where it will have an economic use; (iii) treating the water to improve its quality; and (iv) delivering water to users (through pipes, taps and borewells). Developing the water infrastructure of the city and continuous operation and maintenance of the water delivery system requires long-term investments of significant amounts of capital. In addition to these high capital costs, the variable expenses of operating the municipal water supply system in Indore are costly due to high energy costs for pumping from the water source to the city. Expenditures on operation and maintenance have a significant and direct bearing on service levels.

In Indore, the inability to recover costs (due to the lack of water metering as well as under-pricing) stands in the way of service improvement. The lack of adequate and reliable services further contributes to the public's mistrust and unwillingness to pay for piped water. Thus, Indore represents a classic example of a "low-level equilibrium" – a vicious cycle of poor cost recovery, decaying infrastructure and low service levels.



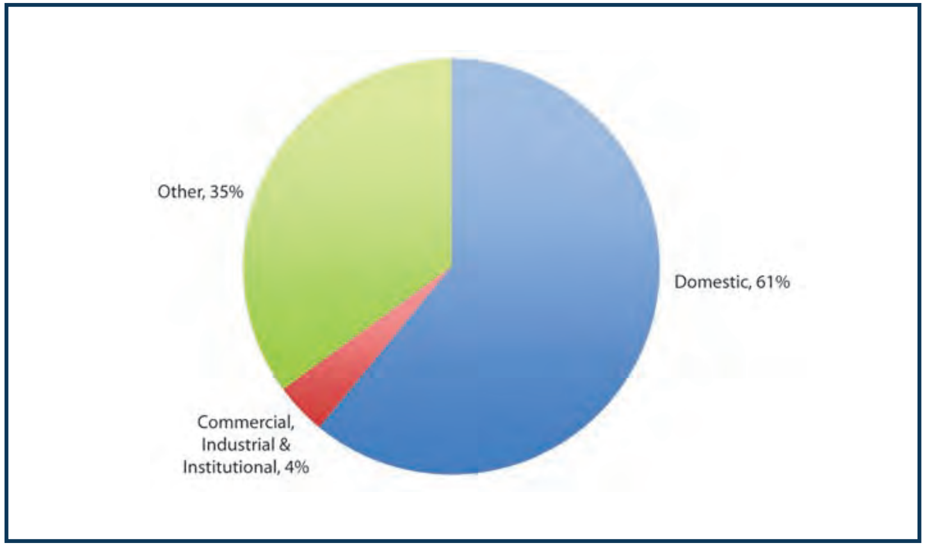


Figure 4.1: Operation and maintenance costs and annual billings of Indore Water Utility (ADB and Govt. of India 2007).

The annual billings of the Indore water utility and its operation and maintenance costs are shown in Figure 4.1 which indicates that annual water billings are approximately 21% of the operation and maintenance (O&M) costs and with increasing energy costs, the O&M costs are likely to increase further.[1] Secondly, commercial consumption is significantly low and contributes to less than 10% of the revenue, while domestic and "other"(institutional, bulk buyers and other large users) consumption forms the bulk of water usage.

Water Charges

The water that the IMC supplies to consumers is differentiated into three categories: domestic, commercial and industrial. A majority of the consumers, including households, have non-metered connections and are charged a flat tariff based upon the diameter of the piped connection. The rates are substantially higher for commercial and industrial consumers, as shown in the table 4.1.

In addition to the above water charges, the IMC also collects fees for providing specific services such as road cutting, authorising illegal connections and for registering new connections. For the bulk consumers, the water tariffs are INR 11/kl for domestic, INR 14/kl for commercial and INR 24/kl for industrial consumers. According to the study on water utilities, only 59 bulk consumers were metered and not all of the meters were functional (ADB and Govt. of India 2007).

The IMC's collection efficiency is quite dismal (UN-HABITAT 2006). The study indicates that in the years 2002-03 and 2003-04 only 43.03% and 66.30% of the billed amount was collected, respectively. Disconnections due to nonpayment of bills are not rigorously pursued by the IMC, although the Water Works Department launches periodic drives to collect unbilled amounts from defaulting consumers. In addition, the households resort to installing new connections, while the old connections with pending bills are disconnected.

[1] The 2008-09 study on service level benchmarking of public utilities reports that the cost-recovery of Indore water utility was only 34.8% (MoUD 2010).

Table 4.1: Flat-rate tariff chart for piped water connection in Indore (ADB and Govt. of India 2007)				
Serial Number	Diameter of Piped Connection (inches)	Residential (INR per month)	Commercial (INR per month)	Industrial (INR per month)
1	1/2	150	300	600
2	3/4	250	600	1200
3	1	500	1400	2400
4	1.5	1000	2400	5000
5	2	2000	5000	1000
6	3	4000	10000	20000
7	4	8000	20000	35000
8	6	14000	38000	76000

Description of Indore's Water Supply

The city is situated on the flat Malwa plateau on the basin boundary between the Narmada and Chambal Rivers and, therefore, does not have adequate catchment for reservoir sites or rivers with sufficient water resources in close proximity. Furthermore, due to the local geological conditions, groundwater resources are not adequate enough to meet a significant part of the urban drinking water requirements for a city of 2.5 million people located within 135 sqkm area. The quantum of water available to Indore from different sources is given in the table below.

The city of Indore receives about 160 to 180 MLD (million litres per day) from the Narmada River, Yashwant Sagar (reservoir-dam) and Bilawali Tank. The Municipal Corporation utilises groundwater as a supplementary source accessed through borewells within the city. The IMC has dug more than 3,600 borewells to augment the municipal water supply and extracts approximately 13 MLD from groundwater, capping the total water supply for Indore at 199.5 MLD. With the recent addition of 90 MLD from Narmada Phase III, the total water supply has increased to about 290 MLD. Assuming a conservative 25% loss in distribution, this translates to roughly 77 to 86 LPCD (litres per capita per day) water availability for an estimated population of 2.53 million in 2011 (Mehta and Associates 2006). This is much lower in comparison to the Ministry of Urban Development recommended benchmark of 135 LPCD supply in urban areas (MoUD 2010). The shortfall is partly met by the private borewells (estimated to be more than 50,000 in numbers) in the city (TARU 2010).

Furthermore, the water is not distributed in an equitable manner. It is estimated that about 400 km of additional distribution pipeline is required to reliably supply the whole municipal area (Chauhan 2009).

The city already suffers from low per capita water supply, inequitable distribution, large distribution losses or a higher percentage of non-revenue water (NRW), a

Table 4.2: Water supply sources for Indore as of December 2009 (Chauhan 2009)			
Serial Number	Source	Approximate Daily Supply (million litres per day, MLD)	
		Minimum	Maximum
1	Narmada River	140 (81.8%)	150 (75.2%)
2	Gambhir River (Yaswant Sagar Dam)	18 (10.5%)	27 (13.5%)
3	Bilawali Tank	00	4.5 (2.3%)
4	Municipal Borewells (approximately 3,600)	13 (7.6%)	18 (9%)
Total water available (MLD)		171	199.5

lack of sound demand management strategies and inefficient and inequitable cost structures (charging the same flat tariff for all households regardless of usage). Only 54% of the population has access to municipal water through various means (Mehta and Associates 2006), and the 2008-09 study on benchmarking of utilities reports that only 38.3% of the population was connected through Municipal piped supply (MoUD 2010). The population residing in slums (approximately 320,000) does not have access to the piped water supply and receives less than 40 LPCD from either the community standpost or Municipal tankers. Ironically, people living in the slum areas also constitute a significant part of the 30% of the city's population adversely affected by flooding and waterlogging in the city (Chauhan 2009).

Drinking water pipeline leakage. © ISET

While more than 150 MLD of sewage is generated in the city, Indore does not have sufficient treatment plants, resulting in twin problems of degradation of water quality of both surface and groundwater and unused opportunity for reuse. While there is demand for industrial raw water, most of the industrial units are located nearly 22 km away in Pithampura.

Water that is unaccounted for is the result of both leakages and illegal connections. Lack of metering makes assessment of leakage nearly impossible, while bulk tariffs make it difficult to assess non-revenue water. Losses in the distribution system (on account of leakage and wastage) are estimated to be about 25% of the water availability. Taking into account process losses (during treatment of water), transmission losses, unauthorised connections, etc., the IMC's estimated amount of unaccounted-for water is not less than 50% (Mehta and Associates 2006). The study on benchmarking of utilities indicates that the total non-revenue water in Indore during the year 2008-09 was about 58.5% (MoUD 2010). In addition to the financial costs to the water utility, these high levels of unaccounted-for water are also a reason for intermittence in the supply of water, since leaks and illegal connections reduce water pressure in the distribution system.

The consequence of underpricing and high levels of unaccounted-for water is that the IMC is unable to recover even operating and maintenance costs out of revenues from tariffs, let alone provide capital for the expansion and improvement of the network. While there are opportunities to build resilience and reduce dependency on distant sources, the city is unable to invest in resilience measures. At the same time, the households have to internalise coping mechanisms such as private borewells, household-level underground and overhead tank storage and household water purification systems and pay for tankers and bottled water. Considering about 70% of the houses (middle and upper class) invest an average of INR 15,000 for household-level storage systems, the total estimated capital investments are approximately INR 437 million. Also, with a conservative estimate of capital costs for a borewell and pump of INR 40,000, the estimated 50,000 private borewells are worth INR 1.6 billion. Additional direct costs including energy, and indirect costs including time wasted for water collection and health costs all contribute to the household-level coping burden. The conservative estimates of private investments on household-level coping mechanisms is not less than INR 2 billion (45 million USD), which is about one third the cost of Narmada Phase III (INR 6.4 billion).

Water quality monitoring

The Government of Madhya Pradesh Water Resource Department's State Water Policy clearly outlines the mandate of periodic quality testing and monitoring of both surface water and groundwater resources in the state by the concerned agencies/departments. The policy also mandates that industrial and urban waste needs to be treated before being allowed to flow into a stream (IELRC 2003).

Indradoot Cell at the IMC

The IMC established a water civic centre called "*Indradoot*" in 2003. This centre aims to redress complaints pertaining to the water supply arrangement, water quality or water bills within a stipulated timeframe. *Indradoot* registers and solves complaints regarding water supply, analyses complaints received for future actions, launches special water bills collection drives and tracks and converts illegal water connections into legal ones. The cell communicates directly with Municipal headquarters, all Zonal offices and overhead tank (OHT) distribution zones. All complaints related to water bills, short water supply, polluted water supply, illegal connections and bill-related issues are recorded and expected to be addressed within a prescribed time period. The *Indradoot* cell monitors the water quality in the distribution system and arranges for water quality analysis of water samples on consumer requests. It is also charged with creating public awareness through various initiatives including exhibitions, documentaries and pamphlets that are distributed throughout the city (ICMA 2004).

Drinking water being collected from a pipeline running through the open drain. © TARU

Although the IMC conducts regular testing of water samples from the water supply system, the results of these tests are generally not made public. The Corporation has its own laboratory situated on the IMC premises which tests water samples from different water supply outlets (i.e., overhead water tanks, public and individual water taps, etc.), however, it is reported that this laboratory is understaffed (Mehta and Associates 2006). There is no prescribed system of verifying water quality for private water tankers and chilled water suppliers. In fact, the Municipal Corporation does not have a record of the exact number of private water tankers and chilled water suppliers that operate throughout Indore. However, representatives from the Municipal Corporation organise water quality awareness campaigns during summer and monsoon months for the private water tanker suppliers to educate them on chlorination of water sources. Unfortunately, no inspection is performed and the IMC does not provide any form of certification to the water tanker suppliers for compliance with chlorination of water sources and of the tanker.

Challenges to Indore's Formal Water Supply System

Indore's water supply is heavily dependent on a single source, with 75% of the current supply being procured from the Narmada River, and a large part of the future requirement (augmentation in supply) also planned from this same source. Although the Narmada is a perennial river, it is rain-fed and dependent on aquifers in the upper basin for maintaining the base flow (Mehta and Associates 2006). The Narmada River has dams upstream which can aid in managing the continued flow in the river intake for Indore's water supply under current demand situations. Because the Narmada is an entrenched river (by the Narmada Rift Valley) with a narrow but long catchment, the possibility of increasing demand upstream for the agricultural sector remains low.

Secondly, there are competing demands from the Narmada River, both downstream as well as upstream from the Maheshwar Dam (the intake of Narmada Water Supply schemes). Since Narmada is an interstate river, Gujarat also has riparian water rights and the Government of Madhya Pradesh is mandated to maintain a specific annual flow downstream for use in Gujarat. There are many major and minor irrigation schemes upstream of the Maheshwar Dam and the government has to allocate Narmada water for these schemes. In addition, the development of other megacities in the state would require diverting some water to meet their demands as well. Given these demands and the changing pattern of rainfall, there may be insufficient water availability for Indore in the future (Chauhan 2009).

The other major source, the Yashwant Sagar Dam, is from a reservoir on the Gambhir River. It is expected that variations in temperature and rainfall due to climate change will affect the hydrology in both the Narmada as well as Gambhir Rivers. As described in the ACCCRN Water Security for Indore study, the number of rainy days is expected to decrease despite an expected increase in the total annual rainfall as well as the intensity in daily rainfall in the catchment. This will likely lead to instances of extreme floods and droughts. The study further states that the 90% dependable annual runoff, on which the water supply schemes are planned, will be reduced due to increases in droughts and will adversely affect water availability (Chauhan 2009).

The climate change impacts on hydrology, including fewer rainy days and increased intensity of rainfall, would also have a negative impact on local groundwater recharge. As discussed earlier, the geological formations in and around Indore are such that the higher intensity of rainfall would result in greater runoff and even less recharge of groundwater. In addition, urbanisation is likely to increase impervious areas, which can reduce the recharge of groundwater. The Municipal Corporation utilises groundwater as a supplementary source and many of its borewells are located in areas that are not served with piped connections. Since current groundwater extraction already amounts to more than 172% of annual recharge, drought conditions would lower the groundwater table, further aggravating water scarcity. Secondly, heavy floods would primarily affect poor populations living in slums and unauthorised colonies as well as impact the availability of safe drinking water.

Another important aspect of Indore's water supply system is its dependence on energy. The City Development Plan of Indore prepared under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) programme reports that sourcing water from the Narmada River requires a massive lift of more than 500m and transportation of over 70km from the river to Indore (Mehta and Associates 2006). The share of energy cost in the annual operation and maintenance costs of the Water Works Department of the IMC is approximately 57% at INR 502 million. This estimate applies to 2005-06 when the supply from the Narmada River was only 75% of the total (ADB and Govt. of India 2007). Currently, with 85% of the city's water being sourced from Narmada (including the 90 MLD of additional supply from Narmada Phase III), this energy bill would be much higher. With increasing energy costs, the share of energy in the overall O&M costs of the Water Works Department would undoubtedly increase in the future. This also highlights the fact that the water supply to Indore is heavily dependent upon the availability of power and is vulnerable to disruptions to the grid, which would result in the inability of the system to deliver water to most parts of the city.

The Municipal Corporation of Indore, similar to many Urban Local Bodies (ULBs) in other Indian cities, is overwhelmed with issues related to inefficiencies in service delivery and low consumer satisfaction. Some of the challenges faced by Indore Municipal Corporation with regard to water supply in the city are discussed below.

Insufficient Revenue

A study on the revenue receipts and expenditure of various departments of the IMC revealed that the Water Works Department's share of revenue expenditure constituted 30-35% of municipal expenses as compared to only 16-18% of municipal revenue. The study further projects that annual losses within the Water Works Department of the IMC would increase substantially over the years (UN-HABITAT 2006). These losses can be directly attributed to two factors: not charging for actual quantum of water use by different consumers along with significant distribution and transmission losses, also known as unaccounted-for-water. The total loss or unaccounted-for-water in Indore is more than 50%. In addition, this "flat rate" schema for pricing creates disincentives to conserve water and also creates inequities among the rich and poor. People from the low-income groups often do not have storage facilities and, hence, use much less water than those from the high-income groups – yet pay the same monthly charges for accessing piped municipal supply.

The IMC is beginning to take appropriate steps in this direction. The practice of charging a flat rate to all domestic consumers offers no incentive for water conservation and may also lead to higher wastage and leakage, in addition to inequities in consumption. Fixed charges for piped water supplied to households are steadily increasing. In addition, the tariff for the industrial and commercial consumers is moving toward a tiered structure rather than a standard unit rate for all amounts of consumption. Such changes that encourage efficiency are especially important due to of the high energy cost of procuring water. The total cost of production of water in Indore is the highest in the country, at INR 13.18/m^3 (ADB and Govt. of India 2007).

The Municipal Corporation is also considering having metered connections for all consumers including households. This would be a major challenge for the Corporation as there are several issues related to it. First, the distribution system would have to be further pressurised so that households toward the end of the

Low pressure in pipeline forces people to dig pits to collect water, Indore. © ISET pipeline also get enough water, even with meters. The current state of distribution infrastructure is not geared to handle higher pressures and would lead to increase in leakages. Secondly, installing meters in households suggests that the Corporation would have to have trained staff to collect meter readings from each household in the city, while meter calibration at regular intervals (once every 3 to 5 years) is also necessary to manage the metered supply. These steps would require additional staff and expenditure.

Inadequate and Ageing Infrastructure

Existing infrastructure is old and deteriorating and is becoming a technological and financial challenge to maintain and upgrade. There remains an urgent need to modernise existing infrastructure, especially water supply and sewerage pipelines, but the revenue deficit of the Water Works Department hinders investments needed to renew the infrastructure. With the number of illegal connections is estimated to be more than 20,000 (although no study has been carried out to verify this), the amount of non-revenue water is immense, estimated at around 50% (Mehta and Associates 2006). All this amounts to the debilitating revenue deficit of the IMC, hindering infrastructure improvement efforts.

Customer Service

One of the major challenges for the IMC is to improve its civil society interface. Although many workshops and *Jan-sunwai* (public hearing campaigns or on–the-spot hearings of the people's problems by the IMC officials and concerned departments) are underway, major communication gaps still exist between the people and the formal water system managers. People prefer to go through other means (*Parshads* or *Rehwasi Sanghs*) for registering their complaints. Even if complaints are heard, a linked issue here is that the Water Works Department lacks adequate technical manpower for effectively addressing the operations and maintenance of the water supply system. The delays in complaints redressal also result in a negative image of the IMC. Indore has set up a water civic center, *Indradoot*, to improve grievance redressal of water complaints.

Summary

The formal water supply system in Indore is facing multiple challenges including unreliable water connections, poor infrastructure, lack of full distribution coverage and inadequate management. These factors have contributed to the city's inability to recover operating costs, exacerbating the system's capacity to supply existing and growing populations. Only about half the population has access to water supplied by the Municipal Corporation. Moreover, due to the poor infrastructure and management, the proportion of non-revenue water for the utility is more than 50%. This is a significant loss to the utility since a major chunk of this water is from a distant source and procured at a high cost. As a result, the ability of the water supply system to remain resilient in the face of current climate risks remains low.

Depending on a single, distant and costly source of water also makes the formal water supply system vulnerable to several factors such as competing demands, power availability, natural hazards, etc., which could render the city waterless for a longer period than the city's reserves can sustain. There is an urgent need to develop, maintain and manage local resources such as groundwater, greywater and other sources that could be used to buffer against such vulnerabilities.

CHAPTER 5: WATER MANAGERS IN INDORE – HOUSEHOLDS AND COMMUNITIES

In the initial year of work in Indore, ISET, the Pacific Institute and TARU conducted a range of focus group discussions and one-on-one meetings with government officials, the utility, private companies and community residents. During our focus group discussions, which were held at various localities in Indore, it became apparent that there were a wide range of water supply arrangements in use, and that there were differences in water usage based on the water supply arrangements and the income level of the community. In our initial research, it was also clear that the women and men living in Indore, as in many developing country cities, were all making daily decisions to meet their water supply needs and that they were water managers in their own right.

In these discussions, residents who had formed community associations also expressed their desire to have tools to better manage their water supply. Certain community residents were also already employing coping mechanisms and strategies that proved to be an important model for other residents. To gain an in-depth understanding of the importance of these "water managers," a detailed door-to-door household survey was conducted in Indore by the Project Team. This was suplemented with additional focus group disscussions and Shared Learning Dialogues.

In addition to individual households, the project team also met private builders who develop residential flats (or 'Multi,' as they are commonly called in Indore[1]) in the city. Many builders in Indore are starting to provide value-added propositions with regard to water as a strategy to make their flats more attractive to the buyers, the most common of which is "certainty" of continuous water availability based on a combination of groundwater sources as well as large storage and pumping systems. These would be used and managed by the household community living in the flats and has been discussed as one of the models for coping with water scarcity.

In this chapter we present our survey methodology and describe the socio-economic profiles of the eight localities surveyed. We present our analysis of the water-supply and water-use data and then describe and classify the coping actions adopted by residents. Finally, we present the current and future information needs of the community as it relates to the coping actions taken. All information and analysis

Water collected and carried in plastic jars - Nayapura, Indore. © ISET

[1] In Indore (as in several tier II and smaller cities), people typically have individual/row houses. With an increase in population and lack of space within the city limits, the trend of living in multi-storied flats is fast becoming the new norm. Indoreans refer to these as 'Multi' – a short form of multi-storied buildings.

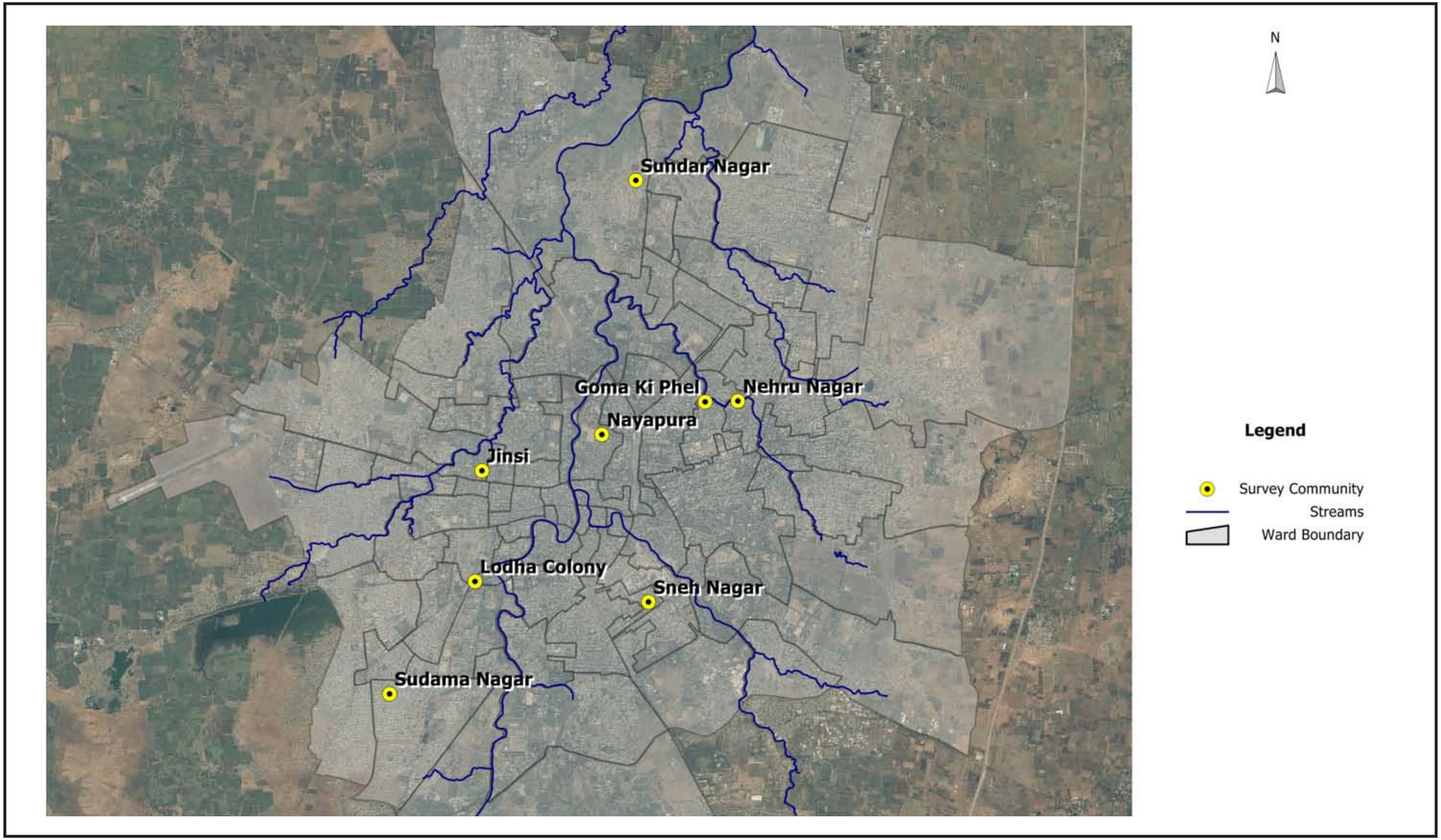


Fig. 5.1: Map depicting the eight localities where household surveys were conducted. © TARU

presented in this chapter are from the analysis of household survey data or from the discussions during the Shared Learning Dialogues and focus group discussions, unless otherwise cited.

Methodology

Study Design and Questionnaire Development

We developed the household water survey questionnaire based on the findings in the focus group discussions with various localities in Indore held during the initial phase. The questionnaire broadly focused on: different water supply sources, water storage capacity, variations of water supply from different sources in normal and scarce months, preferential ranking of the water supply in normal and water-scarce months, per capita usage of water by different communities, existing complaint and communication mechanisms and what residents identified as necessary improvements to their water services.

Selection of Communities

The project team selected eight localities for the water survey reflecting the diversity in income groups as well as water supply sources, including slums, low-income groups, middle-income groups and high-income groups: Goma ki Phel, Jinsi, Lodha colony, Nayapura, Nehru Nagar, Sunder Nagar, Sudama Nagar and Sneh Nagar. (See map of Indore in Figure 5.1.)

Water Supply Sources

There are different types of water supply sources throughout Indore. A majority of the population receives a portion of their water from various municipal water supply sources such as: Municipal Narmada household connections, Municipal borewell standposts, Municipal Narmada standposts or Municipal borewells used for filling public water tankers.[2] Private water supply sources that predominate throughout Indore are household borewells and private water tanker supply and community borewell standposts. Table 5.1 provides information on the different water supply sources and income groups for each locality.

[2] The water supply arrangements in Indore are defined using the following typology: Owner – Source – Distribution. For example, a Municipal Narmada household refers to municipally-provided water that is primarily sourced from the Narmada River and is provided through household connections.

Table 5.1: Household survey communities, water supply arrangements and income class

Community	Main Water Supply Source	Income Class
Goma ki Phel	Municipal borewell standpost	Low-income
Jinsi	Municipal Narmada standpost	Low-income
Lodha Colony	Municipal Narmada household and Municipal borewell standpost	Low-income
Nayapura	Open valve of Narmada pipeline	Middle-income
Nehru Nagar	Municipal Narmada household and Municipal borewell standpost	Middle-income
Sunder Nagar	Community borewell standpost	Middle-income
Sudama Nagar	Municipal Narmada household and Individual borewell household	Middle-income
Sneh Nagar	Municipal Narmada household and Individual borewell household	High-income

Training of Surveyors

The Project Team of members from TARU and ISET jointly conducted a one-day orientation on the challenges of conducting water surveys for slums/low-income groups, middle-income groups and high-income groups in Indore to the survey team from Aim for the Awareness of Society (AAS), a local NGO (Non-governmental organisation), which was made up of six surveyors and a team leader. The main focus of the orientation was explaining the reasoning behind each question on the survey, in addition to conveying how questions should be asked and who should be approached in the household to answer such questions.

Pre-testing of the Water Survey

Before conducting the comprehensive water survey in all eight communities, the questionnaire was tested in Lodha colony to assess whether the questions were

Water storage inside house in slum locality. © ISET

well understood by both surveyors and residents, whether the questions posed were generating appropriate responses, and also to ensure that each surveyor knew how to ask a particular question to women and men of the different localities. Furthermore, each surveyor was asked to brief the respondents on upcoming Shared Learning Dialogues. The surveyor would explain the Shared Learning Dialogue process and its usefulness and encouraged the participation of the surveyed household in the series of upcoming dialogues – which would bring together all of the surveyed communities, along with representatives from the government and private sector, in order to understand results and develop solutions.

Conducting the Household Water Survey

The household water survey was conducted in July and August of 2009 and involved 200 households in eight communities. In each community, 25 households selected through a random sampling method were surveyed. During the questionnaire session, women respondents – especially from low-income groups (Goma ki Phel, Lodha colony, Jinsi) and middle-income groups (Nayapura and Nehru Nagar) – were not only supportive, but were enthusiastic to learn more about the project and its outcomes, and were keen to be involved in upcoming Shared Learning Dialogues to develop solutions and interact with other sectors.

For the majority of respondents, regardless of income group, this project differed from others in that it was not strictly data collection, but also encouraged community participation in order to develop and implement tangible outcomes. The Shared Learning Dialogues offered these residents an opportunity to engage in constructive dialogue as well as share knowledge and experiences with formal water managers, the private water market and institutions. Such institutions include engineering colleges and local NGOs that could collectively develop viable solutions to water supply and management issues. The project team jointly analysed the survey data.

Profile of the Communities

The socio-economic profile and water supply conditions for each community are summarised in Table 5.2.

Household Water Supply and Water Use in Indore

Water Supply Conditions

Water supply in Indore fluctuates seasonally as well as from year to year. Therefore, households throughout Indore receive water from different sources. Municipal water supply comes from both surface and groundwater. The main municipal surface water source is the Narmada River and the supply is provided through household

Table 5.2: Water supply sources and socio-economic conditions of the surveyed communities				
Community	**Socio-Economic Profile**	**Water Supply Source**	**Water Quality Availability**	**Coping Mechanisms**
Lodha Colony	Lower income group colony. Residents are a mix of daily wage earners and service class.	The colony has Municipal Narmada household connections and Municipal borewell standposts.	Water supply is provided on alternate days for 20-25 minutes. However, during the rainy season, water supply extends to 30-45 minutes. The Municipal Narmada water supply duration is common in all localities. During the rainy season, the water is sometimes contaminated with drainage and unwanted pollutants, like worms. In addition, residents at times complain of the smell.	Most of the residents have underground water storage tanks with a capacity of about 2400 L. Households lacking space for water storage occasionally borrow water from the neighbors who have large storage capacity. Nearly all of the houses have installed water motors to pump water from the Narmada pipe connections.
Goma ki Phel	Lower income locality. Inhabited mostly by daily wage earners, such as rickshaw pullers and vegetable vendors, although some residents also belong to the service class.	The main source of water is Municipal borewell standpost, and its operation and maintenance is the responsibility of the IMC. A proper timetable is posted on a notice board alongside the borewell standpost and is maintained by the IMC representative in consultation with the community. Any change in the timetable is duly mentioned in the notice board.	Water, at times, is hard and not potable.	This community has a history of effective community intervention. Complaints concerning the water are addressed to the locality's caste leader, as the leader is easily accessible and has proven more responsive in addressing and solving problems related to water than the *Parshad*. During the summer, seasonal public tankers are made available to the locality by the *Parshad* when the local caste leader makes a request.

Community	Socio-Economic Profile	Water Supply Source	Water Quality Availability	Coping Mechanisms
Jinsi Colony	Lower income group colony.	The main water supply is from Municipal Narmada standpost that is connected to the Narmada pipeline. Water supply timings are similar to the Municipal Narmada household connection. Water is collected from the standpost in large jars and drums mostly by women and children.	During the rainy season, the water can often become contaminated with storm water and sewage. During this season, water is boiled for drinking purposes.	During months of scarcity, water is occasionally transported, generally free of cost, from nearby colonies where there is a borewell.
Nayapura	Nayapura is a community located in the centre of the city and is made up of approximately 1500-2000 households. This is a middle-income group and is densely populated with large-size households (aproximately 8-10 members per household).	One of the Narmada mains for supplying water to the Indian Railways colony leaks at a particular point within the Nayapura locality. This open valve is the key water supply source for the residents of this locality. Few houses also have Municipal Narmada individual connections, though the water supply is highly irregular and often smells. As a result, residents largely depend on the water from the valve. This locality also has three community borewells. Due to continuous conflict over the management of the borewells, residents prefer the open valve.	Individual water motors are attached to the main valve to increase the water pressure. Water quality is poor at times, as the main pipe runs parallel to the drainage line and water often gets contaminated, especially during rainy season. As reported by the residents, the water supply is highly irregular. At times residents have to come at 2:00 am to collect water from the valve.	Some of the coping mechanisms adopted at the household level include helping neighbours transport water from nearby sources: water is available in Municipal standpost in nearby locality; at times transporting water from nearby localities who have Municipal Narmada individual connection free of cost, especially for drinking purposes; getting water from nearby localities' private boring at times free of cost or at times on payment.

Community	Socio-Economic Profile	Water Supply Source	Water Quality Availability	Coping Mechanisms
Nehru Nagar	Middle-income group locality.	The locality has access to Municipal Narmada household connections as well as a Municipal borewell standpost that is operated by the IMC. If the Narmada piped water supply system is not made available on a certain day, it is compensated by an extra supply from the Municipal borewell standpost.	Residents prefer Narmada water for drinking and cooking. Water from a Municipal borewell standpost is hard and only used for daily chores. In general, the IMC water supply is treated before it is supplied, while Municipal borewell standpost supplied water is not.	For households with individual connections, the water is collected in an underground pit (this is a small dug-up area that is plastered and has a depth of 2-3 feet), and is further lifted up with the use of electric-operated pumps to overhead tanks with a capacity ranging from 500 L-1000 L.
Sunder Nagar	Sunder Nagar is a locality with mixed socio-economic classes, with households of middle and low incomes.	Nearly 240 families are dependent upon community borewell standposts. In total, there are five standposts, but presently, only four are operational. These borewells were installed with support from the member of the legislative assembly and the *Parshad* and with active participation of the community.		The residents of the locality have a union (*Rehvasi Sangh*[3]) and by collecting Rs 1000 per household, they installed rain-water harvesting structures near three borewell standposts in order to recharge them. During summer months, private tankers are also contacted by most households. IMC tankers come only once a week and upon request by the *Parshad*. In the third phase of Narmada, there is a possibility of supplying piped water connections to the residents.

[3] *Rehvasi Sangh* is the Residents Welfare Association where all the households in a colony/locality are members and this body is elected/selected by the households themselves. The association works for the common causes of the locality. Sometimes these bodies are registered with the Municipal Corporation for better cooperation with the authorities.

Community	Socio-Economic Profile	Water Supply Source	Water Quality Availability	Coping Mechanisms
Sudama Nagar	Middle-income group colony.	The main water supply source of this locality is the Municipal Narmada household connection. Houses also have private borewells.	Water quality is worse during the rainy months than it is in scarce summer months. During the rainy season, pipes get contaminated from the sewerage. It has been reported that worms flow down the piped water and that it smells bad.	Most of the houses have installed water purifying systems, large sump storage and private wells, and a majority of the households have rainwater harvesting systems to recharge their borewells. IMC also sends water tankers, and in summer months residents can also buy water from private tankers.
Sneh Nagar	Sneh Nagar is the only high-income group colony that was selected for the survey.	The main water supply source of this locality is the Municipal Narmada piped supply. All the houses have piped connection and private borewells.	Municipal Narmada water supply in the household connection is 20-25 minutes and the supply is on alternate days.	As space is not a problem, all the houses have either installed underground water sumps or rooftop water tanks of up to 3000 L capacity. Most households also have private borewells. Sneh Nagar has a resident welfare association (RWA), which is highly proactive in managing water problems of the community.

connections and public standposts. Both of these distribution methods have the same supply source, and thus have similar durations and frequencies of supply.

With the numerous water supply arrangements and sources, the results for the household survey did not allow us to calculate with a high degree of confidence the exact amount of water supply to each household nor a precise community average. This was due to the fact that because underground sumps are supplied with water during early morning hours, the exact amount of supply was unknown to residents. In addition, although purchasing a water tanker during dry summer months greatly affected residents' water supply, the duration of time that households were provided water was often not tracked. Thus, this section provides an overall look at water supply conditions and variability in the different localities based on the household survey, focus group discussions and the Shared Learning Dialogues.

It is also important to note the duration of "normal" months (during the rainy season when water supply is less restricted) or "scarcity" months (during the hot and dry summer). Due to climate variability and change, the summer season can begin as early as March. Even during the normal or rainy season months, the rainfall can be minimal or irregular. For example, in 2008 Indore received approximately 21 inches of rainfall, which restricted the supply of piped water even during the normal monsoon months. Reduced rainfall also impacts groundwater levels, affecting private water supply. Although the Municipal piped water supply is highly inadequate and irregular, it is a valuable source of treated water and is used by the household for drinking purposes. As reported during Shared Learning Dialogues and in the water survey, households ranked the reliability of Municipal piped water at 3.8 on a scale of 1 to 5, with 1 being least reliable.

Municipal Water Supply

During normal water supply months (non-scarcity), approximately July to April, Municipal household piped water is available on alternating days for approximately 20-25 minutes[4] during the morning hours. Any change in the frequency of water supply is reported in daily newspapers and broadcasted through FM radio stations. Low-income groups have less of water storage capacity, and thus, each household can fill about 80 litres of water for a family of five or six members. The water supply is turbid for the first five minutes and the water pressure slowly decreases during the last five minutes. During the Shared Learning Dialogue, it was also reported that piped water supply at times is highly irregular, irrespective of the season. In some localities, Municipal Narmada piped water is supplied only once in every 3-4 days, even in normal months.

In months of scarcity (April-June), Municipal Narmada household water is supplied only on alternate days for 15-20 minutes. In these months, the water pressure is low. In some low- and middle-income localities, residents reported that occasionally there would be no water for more than 5 days, sometimes even 2-3 weeks. There are numerous reasons that the piped water supply is reduced during the summer months. A primary reason is that during this time the water level in the Yashwant Sagar Dam decreases significantly, leaving the burden of supplying Municipal piped water fully on the Narmada River source.

[4]It is interesting to note that the municipal sources maintain that the water is supplied for 45 minutes every alternate day. Since the pressure in pipelines is low in the begining and tapers off towards the end, the households usually report a lower period of municipal supply.

Using boosters (mini hand pumps) to increase pressure in order to get more water during the 25-minute supply period is a common practice regardless of economic class. Depending upon the availability of electricity, the middle- and high-income households will occasionally use booster pumps directly on the water-supply lines to increase the availability. Because the middle- and high-income households have more storage capacity, they can store large quantities of water acquired through the booster pumps, unlike households in low-income localities. In the rainy season (end of June-July), however, the piped water supply duration can sometimes extend to 30-45 minutes. During this season, water quality may be reduced due to flooding and stormwater runoff.

Municipal stand-post. © TARU

For low-income communities who lack a piped connection, the primary Municipal water supply source is public borewells, which are financed by the IMC (Indore Municipal Corporation). The community's role involves identifying where the standpost and borehole should be located and monitoring the timings when the standpost will be operational. In cases when groundwater is sufficient, the supply hours and frequency are higher than Narmada pipeline areas, since the borewells are operated by the community itself.

Jal Samiti

Jal Samiti is a local body whose main function is to manage water- and sewerage-related matters in Indore. Members of the *Jal Samiti* consist of 10 *Parshads* who are elected among all the *Parshads* representing their wards. *Parshads* who have not been elected as members of *Jal Samiti* give applications as well as proposals related to water and drainage work to the *Samiti* who then address them on a priority basis.

Roles of the *Jal Samiti* include:

1. installing new drainage line and replacing older ones;
2. managing water tankers as per the to recommendatiotns of the *Parshad.*
3. monitoring of water supply system; and
4. sending proposals for new infrastructure to the IMC for approval.

The *Parshad* (elected ward leader) facilitates a process to sanction a new public borewell to address the identified water needs of the locality. During months of scarcity, the *Parshad* may also request the IMC to provide a public water tanker. Water supplied by a public tanker can be provided to all localities regardless of socio-economic class. However, in some low-income localities and slums, financial constraints as well as reduced water storage ability often results in households depending primarily on public water tankers.

The Municipal Corporation formed a water supply committee, *Jal Samiti*, which manages the Narmada water supply as well as the Municipal tankers.

Private Water Supply

Throughout Indore, alternative sources for water supply are private borewells, community-operated and maintained borewells and purchasing water from private water tankers. In certain localities, such as Sunder Nagar, the municipal water is not the supply source. Sunder Nagar is dependent upon four community-operated and maintained borewells, although during months of scarcity, the *Parshad* will, at times, request public water tankers to supply water to residents. (See more on community borewells under Community Resource Diversification).

There are various estimates on the number of private borewells throughout the city, with figures ranging from 20,000 to 40,000 (Chauhan, 2009). Many of the residents of the high- and medium-income localities use their own private borewells, which provide water at different levels of reliability and quality.

Of the 25 households that were interviewed in Sunder Nagar, two do not have a community borewell supply or municipal supply, and their main water source throughout the year comes from purchased water from private tankers. The private water tanker market is an important water supply source in the Indore system as a whole. The rates for private water vary based on the season, the distance water is delivered and the income class of the locality. (See more on private water tanker market operations in Chapter 6.)

Water Use by Households from Multiple Sources

Among the eight communities surveyed, household water use showed a distinct increase in relation to income, ranging from 178 LPD (litres per day) in the low-income community of Goma ki Phel to 320 LPD in the upper-income community of Sneh Nagar. When aggregated by income level, water use per household averaged 190 LPD in low-income households, 225 LPD in medium-income households, and

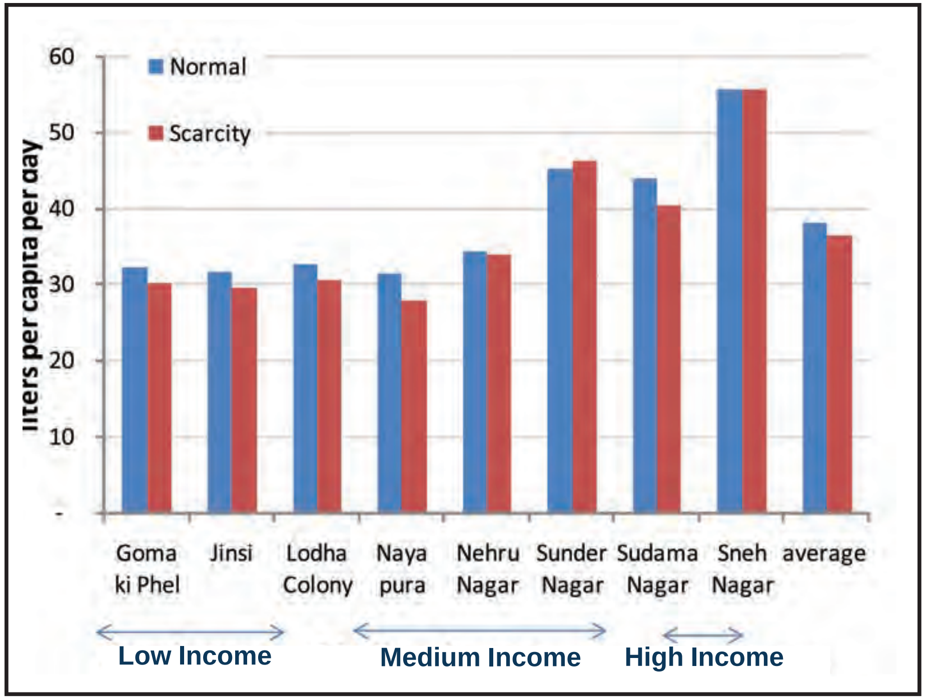


Figure 5.2: Variation in water use between normal and scarcity months.

390 LPD in high-income households. The average per capita water use by community (Figure 5.2) suggests that water use during normal months ranged from 31 LPCD (litres per capita per day) in Nayapura to 56 LPCD in Sneh Nagar. Sneh Nagar had both the highest reported water supply and the highest end-use, averaging per capita water use more than 50% higher than the other seven communities. The findings of the household water survey suggest that in several localities in Indore, water use per capita is below the level needed to meet basic human needs for water including for drinking, cooking, washing and sanitation.[5]

[5] The basic human need for water as defined by numerous sources stands at 50 LPCD.

Despite being a middle-income community, Nayapura has among the lowest water use per capita compared to low-income localities such as Jinsi and Lodha Colony. One of the reasons for this is that a majority of residents are dependent on their water supply from an open valve and some of the water use activities are done at the source itself. Even though some houses have Municipal Narmada household connections, this piped water has poor quality, as it often gets contaminated by the parallel-running drainage pipe. As a result, residents living within a 2km radius of the valve must transport water to their respective households. The houses that are located in close proximity to the valve have connected individual pumps to the valve, which allows them to get water directly in their house through the pumps. Households located at greater distances have to transport water in buckets and canisters which they carry by hand, handcarts or bicycles. The tedious task of transporting water from 1-2 km is both time-consuming and limits the daily water usage and consumption patterns of residents.

> "For the past 15 years, since I have got married in this household, I have been getting up at 4:00 am, transporting 10-15 litres of water from the valve to my house, which is on the second floor. This practice has not only generated health problems but also sapped us of the energy to make more than two rounds. Children too are involved in the transportation of water." (Reported by a Woman resident from Nayapura, Indore, India, August 2009)

An additional reason for low water consumption per capita is due to the larger household sizes in this locality. To make matters worse, due to narrow lanes, private water tankers carrying more than 4,000 litres of water find it difficult to navigate the roads, and hence, avoid delivery of water (Focus Group Discussion, February 2009).

In Nayapura, there are three community borewells, but due to poor operation management as well as constant conflict among the residents, the existing borewells are either nonfunctional or they dry up during summer months. As a result, residents have fewer options to alleviate their water stress. During the summer months when the water availability in the Municipal Narmada pipeline declines, it adds to the existing stress and vulnerabilities of the Nayapura community.

Different Community Perceptions of Water Scarcity

In the previous sections, we presented quantitative data and analysis on water scarcity. However, this data does not illustrate the complete picture of the different perceptions of people belonging to various socio-economic classes regarding "what is water scarcity?" This section presents the differential understanding of water scarcity across varying sectors as captured through narratives during focus group discussions, one-to-one meetings and Shared Learning Dialogues conducted throughout the project. Because the concept of water scarcity is a social construct among the economic sectors (low-, middle- and high-income), the understanding of water scarcity is not limited to litres per day (as understood in purely engineering terms); rather it extends to other indicators as well. For example, in a low-income group, water scarcity also implies disruption in normal water supply sources, poor quality of water, increased transportation time, searching out alternate sources, additional costs, changes in daily schedule, disruption in daily sleeping hours and/ or compromising critical water-based needs (bathing on alternate days). These differential patterns of water scarcity also have additional impacts on the health and livelihood opportunities of each of the groups. Water use of approximately 30 LPCD in low-income localities highlights the vulnerabilities that people face everyday and the challenges that water scarcity directly or indirectly has on their health, sanitation and livelihoods.

> "Everyday the greatest task for me is to run around for water. If I spend most of my time in fetching for water, then my source of livelihood gets affected. I am caught between water scarcity and my only source of livelihood." (Reported by a woman daily-wage earner (fruit and vegetable vendor) from low-income colony Goma ki Phel, Shared Learning Dialogue, August 2009).

Especially in slums, water scarcity has also been found to be a critical reason for the discontinuance of education, mainly among adolescent girls who generally bear the responsibility of fetching water for their households (Shared Learning Dialogue, August 2009).

For high-income groups, water scarcity has a different meaning. Given the financial and storage capacities at the household level, water scarcity does not have as much of an impact on their livelihood pattern because they have the ability to diversify their water resources as well as store large quantities of water purchased from water tankers. For both high- and middle-income groups, water scarcity constitutes cutting down on water usage, but not compromising daily water-based needs. As reported by women representatives of high-income groups during Shared Learning Dialogues, they wash the porch area only twice a week or use greywater for watering plants, etc., in their effort to reduce water consumption. This clearly illustrates how there cannot be a single definition of the term water scarcity, and also that the term is highly scale-dependent and contextual.

These diverse perspectives are key to understanding what coping mechanisms are employed at household and community levels or need to be deployed with support from the IMC, NGOs and other agencies such as academic institutions. They also help highlight the variability that needs to be reflected in policy solutions to water scarcity. Tools and new policies must capture these differential dimensions of water scarcity and water self-sufficiency as well as be flexible in addressing multiple needs and coping strategies.

Water Scarcity Coping Strategies

"Exit" Strategies

While residents reported a decline in municipal water supply during dry summer months, ranging from a decline of 65 LPD (28%) in Lodha Colony to a maximum of 218 LPD (90%) in Nayapura, water use did not decline to the same extent. Indeed, only modest decreases in reported water use were observed across all eight communities, indicating that most households had access to some kind of supplementary sources. Thus, an important way people cope with lack of supply and unreliability is by "exiting the system" – making arrangements independent of the municipal water supply system. Four coping levels were identified: 1) community source diversification; 2) household source diversification; 3) conservation actions by households; and 4) increasing storage.

(1) Community Source Diversification

Some localities have community-level coping mechanisms where a lack in municipal water supply is compensated for by other sources at the municipality level. For instance, in Nehru Nagar, a middle-income locality, if piped water is unavailable

People collecting water from open valve in Nayapura, Indore. © ISET

on any day, this shortage in supply is compensated by additional water from the Municipal borewell standpost. In most colonies, especially those of low-income, public tankers are made available by local leaders during summer months.

Sunder Nagar is an example of self-reliant community for water supply and management. It has a community borewell standpost that is managed by the local *Rehwasi Sangh* (Residents Welfare Association). As mentioned earlier, nearly 240 families are dependent upon five community borewell standposts, only four of which are operational. These borewells were installed with cooperation from both the Member of the Legislative Assembly (MLA) and *Parshad* (Ward Councilor), along with participation of the community. During normal months, water is supplied every other day for 2-3 hours, while in months of scarcity, it is available only for approximately 15-20 minutes every day. The *Rehwasi Sangh* has appointed a person for its operation.

The maintenance and operation of the borewell standpost is carried out by the *Rehwasi Sangh* which collects INR 150 per month from each household being supplied water. During months of scarcity when the water level goes down and the supply from borewells is affected, some residents buy water from private tankers. Generally, a 6,000 litre tanker costs approximately INR 350. In summer months, upon the request of *Parshad*, public tankers also supply water to the community residents. Some residents also have diversified their water supply by having private borewells. There are roughly 20-25 private borewells owned by households, in addition to their being members of the common borewell system.

(2) Household Source Diversification

High-income Sneh Nagar residents have the financial capability to diversify their water supply sources and as well as invest in storage. Coping mechanisms such as borewells explain the uniformity in water usage throughout the year in this community. Similarly, in the middle-income Sunder Nagar community, effective community borewell supply management by the resident welfare association has helped them efficiently manage water usage even during summer months of scarcity.

In addition, water conservation practices adopted at the household and community level allow certain localities to adapt to fluctuating water availability. Most of the high- and middle-income households buy water from private tankers, which is an additional method of diversifying water supply at the household level.

In lower-income areas, during summer months water pressure drops and residents can fill only 50-60 litres per day. A number of households use (hand) pumps to boost the pressure and collect up to 80 litres of water daily. Additional ways of augmenting water supply include purchasing water at INR 5 (for a 20 litre can) or procuring free water from nearby localities or households that have a private borewell. Private water tankers generally do not supply water to low-income communities, as they are unable to afford the cost of water and sometimes chaos/ clashes take place when water tankers arrive. To avoid conflict and non-payment, private tankers avoid going to slums (Focus Group Discussion, August 2010a).

(3) Household Level Conservation Actions

Many residents in the low- and middle-income localities reported adopting water conservation practices during the summer months. These include: washing clothes after two or three days; reducing water for bathing (bucket bath); pouring water with a mug for flushing toilets; collecting water in the tub while washing one's

A Community-managed Borewell Water Supply System

A group of residents from Goyal Vihar, a middle- to high-income locality in Indore, presents an interesting example of community-managed water supply. They have effectively diversified their sources for increased water security through collective water management.

This locality, made up of 600 households, receives water supplies from multiple sources including individual borewells, Narmada piped connections and, occasionally, private water tankers (during periods of acute scarcity). They also had a community open well that was used as a water source during shortages, however, due to an increase in residents, this well went dry (and soon became dysfunctional), as did the individual borewells.

In 2002, 12 households initiated the idea of starting a community borewell system that would cater to the additional water needs of these households while at the same time foster equitable distribution. They split the capital cost of installing a borewell, water meter and network of pipes to each house. Initially, each household attempted to maximise their own water availability, which led to significantly higher rates of extraction as well as conflicts between them.

Through dialogues and mutual consultations, the group decided on specific times that each house would be supplied water through this borewell. The borewell is operative for only one-and-a-half hours each day so as not to over-extract. Six of the 12 houses receive water every other day. Of these six houses, only two would open the tap (to receive water) every 30 minutes, and then it would be the turn for the next two houses and so on. All of the taps on this new pipeline have been installed outside the houses, and a member from the six houses operates the pump as well as regulates the taps. The next day the other six households manage the borewell in a similar fashion. This system has increased the availability of water in these 12 households to approximately 100 LPCD, which is higher than the average availability for Indore.

The Water Committee, which is an informal group made up of members from these households, keeps record of the expenditures on electricity and usage of water (according to water meter readings). All of the members of the community monitor each other to ensure that water is not wasted. In the event that water is overflowing from overhead or underground tanks, even for the municipally supplied Narmada water, that household is alerted. The community borewell is recharged by collecting rooftop rainwater from three nearby houses. The maintenance cost of the borewell is approximately INR 1,500 per year and is shared by all households.

This model of a community-managed borewell is gaining recognition from other households in the locality, and some are planning to replicate this model.

hands, vegetables and utensils, and then using it to water plants; and using wastewater from the washing machine to mop the floor or flush the toilets. Some households also reported using double tumblers for sinks, low-flow faucet aerators and dual-flush toilet cisterns (Shared Learning Dialogue, August 2009). It is noteworthy that a few localities reported increased water use for bathing and drinking in the summer, which made scarcity water usage higher than non-scarcity use. We assume that these localities were not in limited supply.

One household in Goyal Vihar (this household was not a part of the community borewell system) utilised a number of innovative practices for water conservation. For a household of four members, their only source of water supply comes from the Municipal piped connection, which is supplied only on alternate days. The supply of water varies and is less during the peak summer months. On average, they are able to collect roughly 13-15 buckets of water (about 300 litres in two days).With this limited availability, they manage their water usage by not using a washing machine and using the wastewater after washing clothes to mop the floor and wash the porch. Wastewater collected after washing hands, utensils, vegetables, etc. is used to water plants or even flush the toilets. The kitchen has double sinks and the tap has low-flow aerators. They (somewhat) proudly informed that they have managed to avoid calling private water tankers, and only when the water is not available from the Municipal piped connection for a longer period do they resort to private tankers.

(4) Community Level Conservation Actions

The residential flats developed by the builders are similar to gated communities but have only one or two high rises, each consisting of many floors. The builders provide a common borewell for the community as well as a Municipal piped connection. Water from both of these is collected in separate underground sumps from where it is pumped up to different storage tanks for use in the flats/apartments. Each flat has two separate pipelines – one for the borewell water (used for bathing and in toilets, etc.) that is connected to the bathroom and kitchen sink, and another for municipal water (to be used for drinking and cooking), which is connected only to the kitchen. Rooftop rainwater harvesting is also included in the design of these buildings and this water is used to recharge the borewell. The builders feel that these measures ensure better water availability in the flats.

Once all of the flats are sold and the respective owners move in, the builders hand over the systems to the residents. The residents of a particular housing society form a group and appoint a caretaker for the operation and maintenance of these systems. This dual system also provides the residents with flexibility and backup options for water availability in case there is disruption in the Municipal piped supply.

Such built-in arrangements and systems provided by the builders are becoming more prevalent in Indore and builders are beginning to recognise the need to conserve high-quality and high-cost water. Several of the builders also noted that although they have provided separate pipelines for grey- and black-water discharge, the Municipal sewerage system does not have provisions and currently both are discharged into the same sewerage line. They suggested that this greywater could be recycled for use in other purposes such as construction.

"Voice" Strategies

In addition to making private arrangements in order to cope with water scarcity, an important way in which households exercise control over their water supply situation is by complaining and by lobbying for a more reliable municipal supply. Residents register their complaints to authorities using a variety of intermediaries and communication channels. In addition the residents also use both organised and unorganised protests to voice their complaints.

Intermediaries in Making Complaints

Figure 5.3 maps the pathways by which complaints are addressed to the Indore Municipal Corporation Water Department. Broadly, there are two types of intermediaries: political intermediaries (including elected representatives and self-appointed caste leaders) and bureaucratic channels (complaint redressal cell at each of the Zonal offices of the IMC water department).

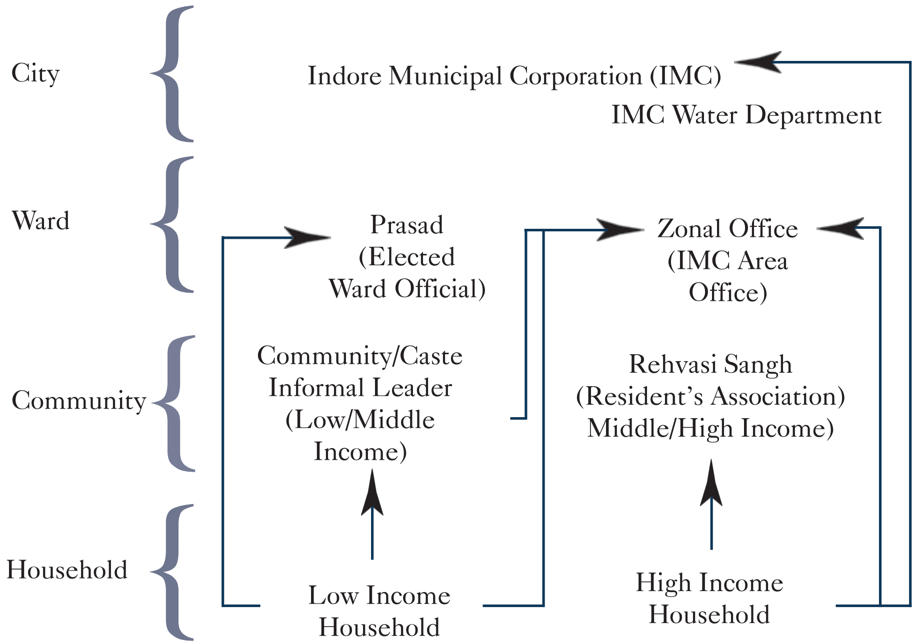


Figure 5.3: Intermediaries through whom complaints are communicated.

Throughout Indore, a predominant forum for registering complaints on water is through the *Parshad*, who receives by far the largest number of complaints. Low-income localities favored the *Parshad* as the primary mode of registering complaints, followed, in most cases, by the Zonal office.

In the low-income colonies of Goma ki Phel and Jinsi, residents preferred to address their complaints to the self-appointed local caste leader via phone calls or in writing. The caste leader is considered accessible and more responsive and acts as link between the complainant and the *Parshad* and/or the Zonal office.

There were several notable differences among the communities. In the high-income locality of Sunder Nagar, most preferred to register their complaints through the *Rehwasi Sangh*. In middle-income Sudama Nagar, the preference was to send their complaints directly to the IMC water department or the Zonal office. In these two communities, the elected representatives, such as *Parshad* who are ward councilors, were not considered as reliable as the *Rehwasi Sangh* or the Zonal office. Because both localities have active *Rehwasi Sanghs* (Residents Welfare Associations), the *Parshad* was regarded as an unnecessary and unreliable intermediary. Only two complaints reportedly were filed with the *Pani Samiti* (similar to the *Jal Samiti)*, both in Sudama Nagar.

Through the Shared Learning Dialogues, the lack of coordination across these multiple pathways became clear. Participants suggested that it is important to strengthen links between the IMC, Zonal office and community for effective complaint redressal (Shared Learning Dialogue, August 2009).

It was noted that in many communities, people preferred to report their problems directly thorough *Parshads* because of ease of access and paucity of time (in situations where the *Parshad* was responsive). In most cases, people use cell phones to report their problems, but in certain cases, they also give written notes/applications either to the local *Parshad's* office (often at the *Parshad's* house) or to the family members of the *Parshad* (Shared Learning Dialogue, August 2009).

Communication Channels

As shown in Figure 5.5, survey respondents reported four main channels or modes for lodging their complaints with the IMC or the *Parshad*. Approximately 53% of the respondents noted that *"hartal"* was the most effective means of getting complaint redressal, followed by in-person (29%), then letters (12%), and only 6% said that their complaints were addressed just by telephone calls. Through "*hartal*" the households make a collective representation in a large group regarding their problems at the *Parshad*'s office, Zonal office or even the IMC water department. *Hartal* /protest is usually the last resort for the affected community in addressing a larger cause, such as community demands for consistent water supplies. This situation generally arises only when people do not get water for more than four days, which happens almost every year during months of scarcity.

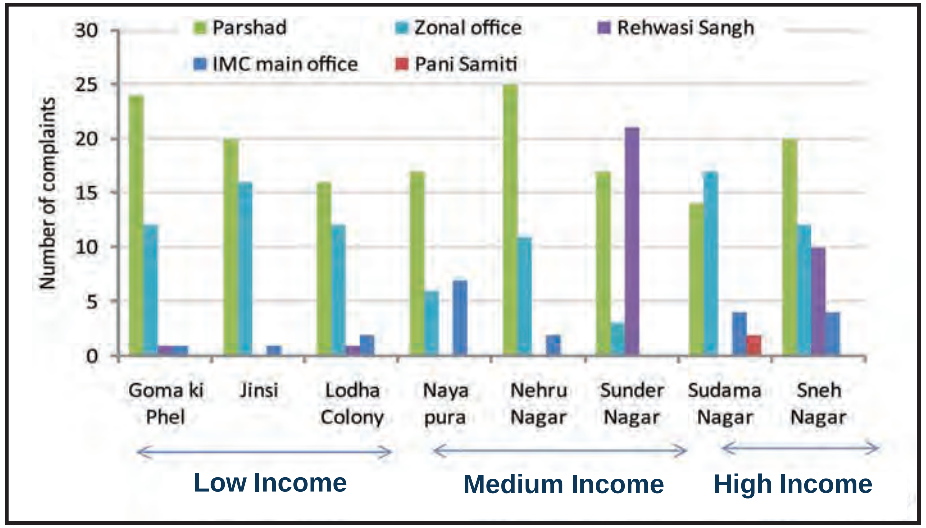


Figure 5.4: Water supply complaints by household and recipient.

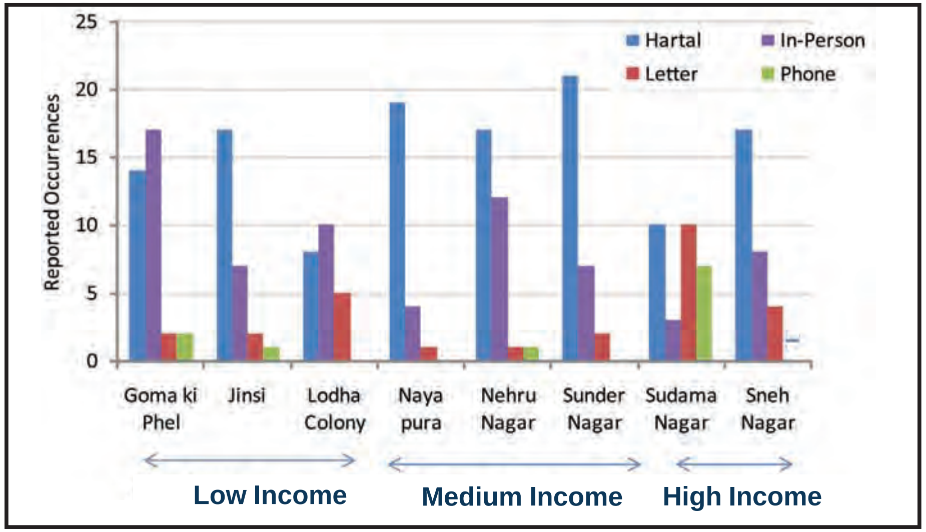


Figure 5.5: Mode of complaint made by a community.

The shift from formal complaints, which are addressed to the Zonal office, to elected representatives is now more efficient after the enacting of the 74th Amendment. This has established a strong patronage system, and political power is better linked with water supply/scarcity. The continued scarcity of water further strengthens these trends, and the formal system has lost its relevance in most of the urban services. In other cities such as Surat, the formal system is effective and the Surat Municipal Corporation has ensured prevention of power usurping by elected representatives. The Municipal tanker system in such situations is likely to continue unless radical reforms are taken up and users regain the trust of the formal system.

An additional method that communities use to catalyse complaint redressal is by not paying water bills. For example, during the Shared Learning Dialogue with low-income groups (especially in Lodha colony), multiple reasons were cited for non-payment of water bills: (1) non-payment was an acceptable norm where people do not pay when their neighbors do not pay; (2) reported complaints of not receiving bills for long periods; (3) many households feel justified in not paying because of poor supply. Interestingly, water connections are rarely cut off due to political pressures.

Collectively approaching the IMC officials is an additional mode of addressing complaints. From the Shared Learning Dialogue, it became clear that even with high-income residents (Sneh Nagar and Sudama Nagar), collectively approaching the IMC Commissioner was common.

The evidence from the household survey was supported during the focus group discussions with other communities. During the visit to Shanti Nagar slum (not included in the water survey), the women's group reported that they had registered complaints against the IMC with the local community leader because they had been promised individual household connections with the advent of Narmada Phase 3, but there have been delays in the process.

Redressal Time and Rate of Complaints

The speed of the complaint redressal depends on the nature of the complaint and the gravity of the issue, although external factors such as power politics or technical

Rehwasi Sangh (Residents Welfare Association)

Rehwasi Sangh is the Residents Welfare Association where all households in a colony/locality are members. This body is elected/selected by the households themselves. The *Rehwasi Sangh* works for the common causes of the locality related to water supply, drainage, sanitation, etc. Some of the *Rehwasi Sangh* are registered with the Indore Municipal Corporation to provide better access and cooperation with the local bodies.

In order to associate the residents in implementing and managing municipal services in their localities, the Madhya Pradesh State Government enacted *The Madhya Pradesh Nagar Pallika Mohalla Committee Rules* in 2008. According to its regulations, a Resident Welfare Association (RWA) can only be acceptable for designation as a "*Mohalla* (locality) *Committee*" if groups of citizens residing in a *Mohalla* are joined as an Association comprising at least 100 households. Section 4 of the Rules defines the structure of the Committee and Section 5 broadly deals with the roles and functions of the *Mohalla* Committee. According to Section 5, the Committee shall be the "eyes and ears" of the local body (IMC), and from time to time will advise the local body about the interests of *Mohalla* and its residents as well as help with structuring suitable policy measures, which will, in turn, enhance the quality of life for the residents. Apart from other responsibilities, the Committee is also entrusted with the task of maintenance, repair and replacement of common area facilities along with monitoring works related to sanitation, road, drain, water supply, streetlight, solid waste, etc.

According to Section 6, funds for the *Mohalla* can be received from the Central Government, State Government or Municipality. The *Mohalla* Committee, as stated in Section 8, would be entitled to undertake any kind of civil work or other works on behalf of the local body as an agency working for the local body (Govt. Of Madhya Pradesh 2008). Under Section 10, a Memorandum of Understanding (MOU) will be signed between the *Mohalla* Committee and Local Body defining their respective responsibilities, duties and obligations and this MOU will be reviewed from time to time.

Though not all the RWAs are registered with the local body, the possibility of recognising the residents associations as *Mohalla* Committees has opened up an opportunity to demonstrate the role of residents associations at micro-level planning.

difficulties in identifying the cause of problem also determine the time taken in redressal.

Responses to complaints varied by socio-economic group as well as the political power of each locality. Reported response rates to complaints ranged from 56% for low-income households to 63% for high-income households, although rates varied from 21% for Nayapura complaints to 84% in Nehru Nagar.

In the survey, 16% of households reported that their complaints were not recorded or otherwise tracked at all, ranging from a low of zero (all complaints were recorded and tracked) by Nehru Nagar households to a high of 38% by Nayapura households. Overall, almost three times as many low-income households (22%) reported that their complaints were not recorded or tracked, compared to high-income households (8%).

Although 84% of the households overall reported that their complaints were recorded, only 59% of households said that their complaint had received a response. Almost one-half of the total households (46%) reported that their complaints were addressed in less than one day, and approximately 37% of households said that their complaints were addressed within 1-3 days. There were households (approximately 11%) who reported that their complaints took more than a week to be addressed. The *Indradoot* cell, however, has the following (mandated) time-periods for redressal of grievances:

This poor complaint redressal rate and response time suggests the formal water governance system's apathy or inability (lack of capacity) to resolve water problems in a timely and effective manner.

Water Information Needs: Current and Future

Current Sources of Information

The survey data show that localities in Indore receive water supply information from a variety of sources (Figure 5.6). Moreover, these sources vary by sector, with higher-income households relying more on the water department and media,while lower-income households depend more on the *Parshad* and their neighbors for information (Figure 5.7).

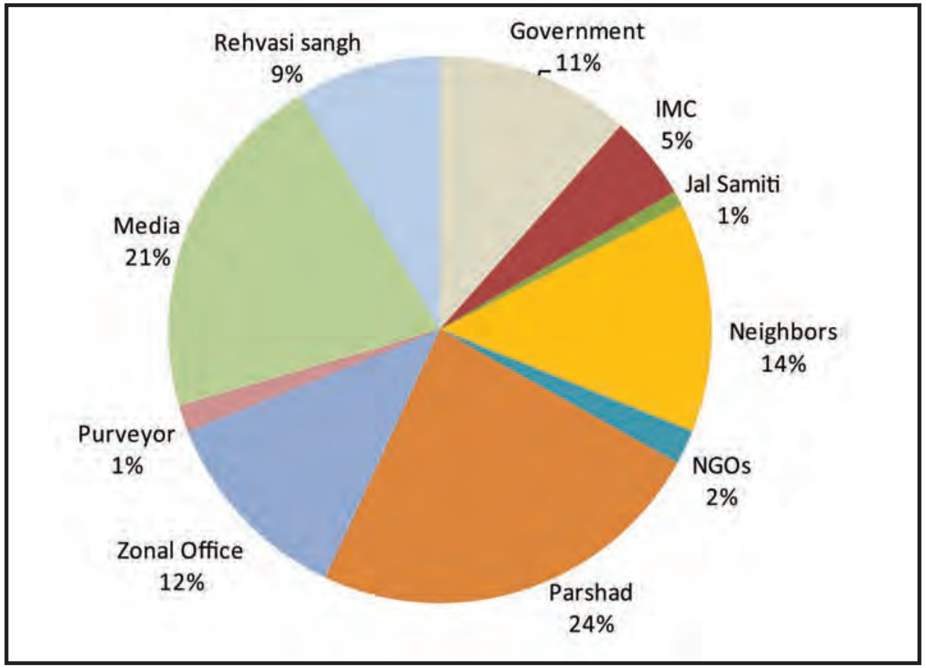


Figure 5.6: Overall sources of information on water supply.

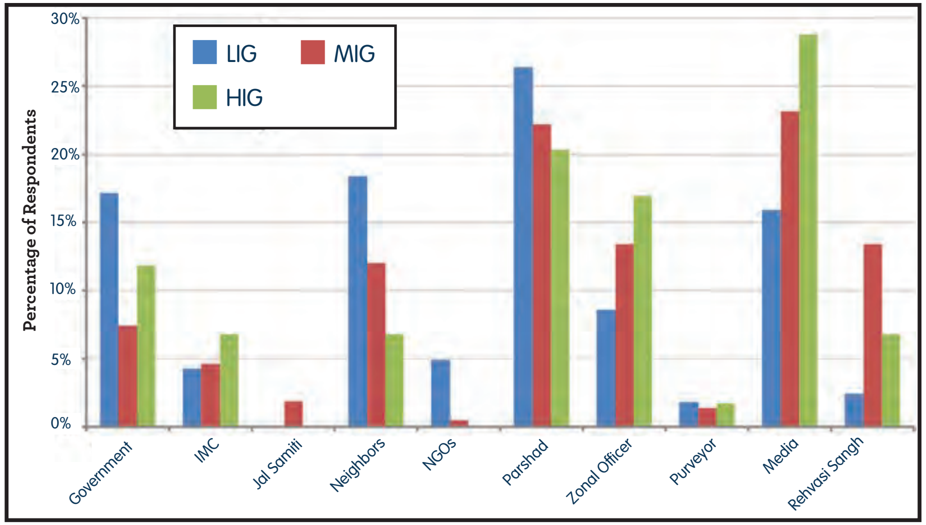


Figure 5.7: Current sources of information about water supply by economic group.

Types of Information Needed

The type of information needed by each of the economic groups varied based on their own perceptions of how to better manage their water at the household and community level. The types of information requested were consistent with the variety of "exit" and "voice" coping behaviors of residents. In general, the described information necessities were aimed to improve:

1) Government responsiveness to requests for improved municipal supply;
2) Community-level source diversification;
3) Household-level source diversification; and
4) Household-level conservation techniques.

Respondents ranked their interest for such types of information on a scale of 1 (lowest) to 5 (highest). Of the topics scored, community strategies ranked lowest, with an average score of 2.2, while household-level water conservation ranked

Complaint Registration Mechanisms – The Zonal Office

Zonal offices are area offices of the Indore Municipal Corporation (IMC). Each Zonal office covers roughly 3-4 wards. The Zonal office is in charge of the operation and maintenance of distribution pipes of up to 6 inches in diameter and deals with complaints regarding irregular water supply, water pollution, faults and maintenance of water pipes, water leakage, new connections, sewerage and legalising illegal connections. Complaints can be made to the control room of the Zonal office by telephone and/or registering the complaint in the complaint register at the Zonal office itself. There is, however, no toll-free number. While efforts to formalise the system have begun, it has not yet attracted the interest of users (see Chapter 4: *Indradoot* Cell).

The complaints made are with regard to: polluted water, water shortage, drainage choking and cleaning of drainage. Once the complaint is made by the concerned person, he/she is immediately given a complaint number. On the basis of the complaint number, he/she is able to track the progress of his/her complaint. Once the complaint is made, the Assistant Engineer informs the operations staff to take action. The operations team is then sent to the said location. Generally, it should take two days to rectify the complaint.

The majority of complaints are reported by the *Parshad*. The speed of complaint redressal depends upon the density of the ward, complexity of the fault point and political connections as well. For maintenance and operation of water pipes, it is difficult to track where the leaked sewerage pipe is polluting the water pipe as the system is not well developed and the sewerage line was laid way back in 1920. On the basis of the local knowledge of the lines-man, the team tracks the location of the leaked pipe or the fault point. General maintenance is done before the monsoons. Some of the institutional bottlenecks that the Zonal office faces are lack of trained staff and inadequate machinery.[6] The average number of operations staff at the Zonal office is 5-6 people (Focus Group Discussion, July 2009).

highest, with an average score of 4.4. Low ranking for community strategies suggests weak social solidarity among the communities. This social vulnerability can be turned into a strong social capacity through process tools such as Shared Learning Dialogues.

Figure 5.8 shows the interest communities have in receiving information regarding each of the seven topics. Information on saving water in the home and on reusing water scored highest across all households by economic sector. Households also gave the lowest scores to the perceived importance of "Combining with the community to create more water options."

The survey data were consistent with the narrative findings from the Shared Learning Dialogues. During these dialogues, residents in low-income localities were surprisingly interested in learning how to conserve water (best practices adopted by other households in Indore), how to purify water, how to keep water clean and prevent spread of water borne diseases, all despite how low their water usage already was. They were less interested in augmenting supply via rainwater harvesting. Indeed, rainwater harvesting appears difficult to implement in low-income localities due to lack of space and money. In contrast, for middle- and low-income localities, the focus was on water conservation. Space becomes a primary issue, and storage options that do not use extra space, such as buried PVC tanks, are a feasible solution for low-income groups. This could potentially be piloted through slum upgradation

[6]The staff strength of Indore water utility as indicated in the ADB study on Benchmarking and Data Book on Water Utilities in India, is 18.7 persons per 1000 connection which is quite high as compared to other cities studied (eg. Jabalpur has only 0.4 while Surat has 1.7 persons as staff per 1000 connections) Ref: (ADB and Govt. of India 2007)

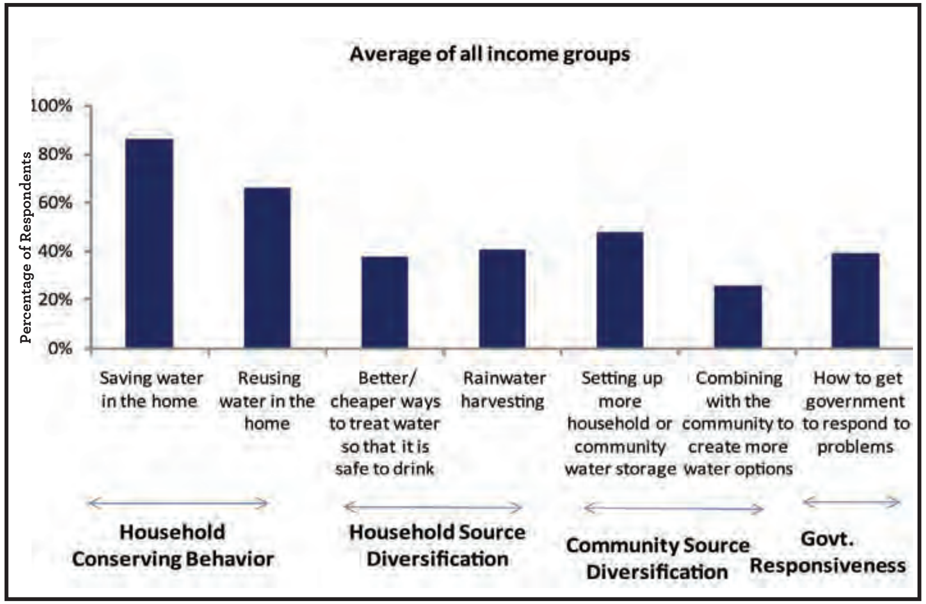


Figure 5.8: Ranked interest in new information on water.

programmes, such as *Rajiv Awas Yojana*, a Government of India programme, wherein property rights will be assigned to the urban poor living in slums. Introducing storage technologies into such programmes may be beneficial.

Summary

Data from the water survey documents the core strategies households use to access and manage water supplies in Indore. Households take three types of action in response to unreliable supplies from the municipal agency: (1) Exit – making arrangements to obtain supplies independent of the water supply agency; (2) Voice – complaining to make IMC supply water more reliably; and (3) Manage – increase their ability to store and utilise available supplies as efficiently as possible. The core strategies at the household level revolve around improving access to water and managing the way it is used. Key aspects of these strategies include:

Table 5.3: Time period for complaint redressal by Indore water utility (ICMA 2004)

Type of complaint	Time period for redressal
Leakage in water pipeline	5 days
Bad quality of water	7 days
Non receipt of water tax bill or complaint regarding amount	7 days
Any complaint regarding water supply	7 days
Illegal water connection	5 days
Regarding water suction through motors on supply lines	5 days
Water supply by tankers	1 day
Information regarding new connection	7 days
Regarding testing of private water source	7 days

1. Access: Given the limited availability of water in Indore, households at all economic levels invest substantial resources in improving their access to water. The ability to do this is heavily influenced by wealth and socioeconomic position. Municipal water supply is considered the most reliable source of water, even though it is supplied on alternate days for about 40-45 minutes. The most important reason for this is that municipal water is treated and then supplied (and hence it is used for drinking purposes only). In addition, this water is softer, compared to groundwater, and more palatable. Key access strategies that go beyond simple reliance on whatever supplies the formal municipal supply system provides include:

    a. Increase capture from municipal supplies: Apply illegal boosting (manual handpumps) to Municipal pipelines to increase their individual share of municipal supplies. For the poor, this may also involve capturing of water from leaks in the existing pipeline system. Wealthier households also have the ability to settle in areas that are well served by the municipal system.

Complaint Registration Mechanisms via the *Parshads*: a Case Study of Ward No. 62

In ward number 62, the *Parshad's* office is located in her house itself and office timings are from 9:00 am-2:00 pm. A complaint register is kept in her office and every morning she attends to the complaints. All ward members (households in this ward) have the contact numbers of the *Parshad.* An application for any complaint is preferred so that a complaint number can be given to the ward member and the application in written form can be used as a supporting document. A decentralised system of working enables the *Parshad* to attend to various problems of the ward. In each lane of the ward, a small number of active members act as the link between the *Parshad* and the community. These lane representatives meet the *Parshad* in the evening and report on new problems and the progress of the complaints already undertaken. Every Sunday, the *Parshad* visits the housing society in the ward to receive an update on the current problems and whether or not any solution has been provided so far. Generally, it takes 1-2 days depending upon the nature of the problem for it to be sorted out.

The *Parshad* gets a fund of INR 10 Lakhs to be spent each year on drainage and water-related works. Presently, the *Parshad* in ward 62 is using MLA (Member of Legislative Assembly) funds to construct a tank in one of the slums. Sometimes the employees from the Zonal office visit the *Parshad* in the morning to attend to the complaints made by the people of the ward. According to the *Parshad,* this is an effective and consolidated way to address the complaints made to the Zonal office. During summer months, at the demand of the people the *Parshad* will request the IMC to provide water tankers. Each tanker has a capacity of 1,600 litres, which provides water to 5-6 houses in a lane. On 14 November 2006, the *Parshad* organised a *Jan sunvai* (public hearing) programme in the ward, where officials from the IMC and the Zonal office were present and noted problems the people were having. Certain proposals on drainage were also presented to the IMC/Zonal officers. In collaboration with the IMC and an NGO, the *Parshad* has organised seminars in the past on water conservation and harvesting. The *Parshad* remains in contact with the specific cell in the IMC that disseminates information on rainwater harvesting. This information is then shared with the people at Sunday housing society meetings and even during religious functions. This is one of the best cases of the *Parshad* taking interest in water-related issues as well as proactive action.

b. Voice: Use complaints and similar strategies to improve the supply of municipal services to their area (this often complements direct capture strategies). Households use a variety of channels to communicate their complaints and they use a number of different intermediaries, however, these multiple pathways of communication are not proving to be that effective.

c. Self-supply: Drill wells or utilise wells on their own property to access common groundwater resources.

d. Community supply: Work with others in their community to develop and operate wells.

e. Purchase: Purchase water supplies from private tankers and packaged water suppliers. Purchase is also used to access higher quality water for specific uses (e.g. packaged water for drinking, tanker and well water for non-consumptive household and domestic uses).

2. Manage available supplies: Within the amounts households are able to capture or otherwise access, the survey documented a range of strategies used to manage water supplies to meet needs. These strategies include:

   a. Allocate: Within the supply households are able to access, they allocate water to different uses and will often use different quality water for different uses. For the least wealthy, allocation strategies are limited: they apply whatever water they can capture (regardless of quality) to basic domestic drinking, cooking and bathing uses. For the wealthy who are able to capture more water at higher quality levels, they will allocate increasing shares of water to non-essential uses, but may also differentiate the quality of water applied to different uses with lower quality being applied to bathing, cleaning or garden uses and highest quality to personal consumption.

b. Store: This involves the installation of cisterns, rooftop tanks and a diverse array of buckets and other storage vessels in houses. In general, storage is used to increase the ability to capture supplies from the municipal system, to reduce the variability of supply and, in the case of both tankers and the municipal supply system, to reduce the average cost paid for a unit of supply (large bulk purchases from tankers being lower average cost than purchases of smaller volumes). A similar issue applies in the municipal system where those who can afford large storage are able to carry over supplies from periods of high availability to other periods – but don't pay any additional cost. This strategy is limited for poor people because of lack of space and the cost of storage systems.

c. Treat: Installation of point-of-use treatment systems (such as aquaguard filters) is commonly used by middle- and upper-class households to improve water quality and thus enable allocation of water from low quality sources to domestic consumption. Even municipal water gets polluted mainly due to contamination from the underground drainage pipe that runs parallel to the Municipal piped water. During the Shared Learning Dialogue with eight representatives of the communities, municipal water was ranked at 3.8 on a quality scale of 1-5 where 1 is the lowest. As a result, treatment is important for municipal supplies to be used directly for consumption. Lacking the ability to do this, lower income groups probably pay a higher cost in the form of waterborne disease.

d. Conserve: This involves the use of different techniques to reduce the water requirement for different uses. Many households in the middle- and upper-income strategies will install low-flow taps, etc. Water reuse is also a common strategy at all income levels (greywater from washing clothes, for example, is commonly used for cleaning houses). Residents stated a high level of interest in accessing additional knowledge on water conservation strategies. Water use decreases in dry months, but not as much as water supply.

A core conclusion from the household survey is that higher income households are better positioned to both access additional water supplies and manage those they can access. Core strategies that would improve the ability of households to meet water needs should consider points of entry for improving the ability of households to manage existing supplies (such as the ability to source, treat and store available water) as well as diversify their access to water from the full array of municipal, community, individual and market sources. Improvements in information may help in this. Household information needs are consistent with the types of coping actions they take. In general, households expressed a strong preference for information to inform actions they can take at the household scale. Households currently receive information from various sources: media, IMC, *Parshad* and neighbours.

At present, just as the ability to purchase water in bulk or obtain maximum supplies from the municipal system reduces the average cost, many of the techniques for managing water (increasing storage, treatment, installation of water conservation devices, etc.) require investment.

CHAPTER 6: WATER MANAGERS IN INDORE – THE PRIVATE SECTOR

Indore's formal municipal water supply system is intermittent and unreliable, resulting in a significant portion of the city's population not being served at all or being served inadequately at best. This, in turn, has generated the birth and expansion of the private water market in Indore. Such instances are common across many cities in India where, even if municipal utilities functioned efficiently, water supplies are limited and would be insufficient to meet the full demands of the population.

Limitations on supply availability combined with the challenges utilities face from ageing infrastructure, high urban growth rates, extensive water pollution and difficult governance environments create conditions resulting in poor delivery of water supply services from the utilities. The utilities are unable to recover their operation and maintenance costs due to poor tariff structure, where the revenue collection of even subsidised water is low, further straining the utility. High household-level capital investments indicate the willingness/capacity of a significant section of users to invest in water, but in absence of users' trust in quality and reliability on the utility's supply, the systems are unable to function while the users are forced to search for alternatives, often at much higher costs. Under such conditions, water markets generally flourish as a major mechanism that urban populations utilise in order to meet both basic requirements and additional unmet demands. These scarcity dynamics have a tendency to create frustration among users who opt for alternate sources, since water is a basic need.

The water market includes a myriad of tanker and bottled water suppliers, borewell drillers, manufacturers of water purifiers, domestic pumps and pipes as well as water related service providers (formal and informal). Experience in other cities shows that once such markets take root, the system has a tendency to reinforce the market, and formal systems are unable to replace them even though the costs of privately-sourced water is much higher or the quality is uncertain. Markets thrive in this environment of scarcity and uncertainty, while water remains a live issue in the city's political and economic system. Water scarcity is able to significantly influence the dynamics of the water supply through forced "coping/innovation" mechanisms. It is estimated that the total investments on household storage alone is approximately one-third of the capital investments for Narmada Phase III.

In order to develop a more comprehensive approach to water management and planning (including groundwater) in Indore, the focus of our research aimed at bringing together information and issues from diverse types of water managers and stakeholders – those that manage and/or supply or sell water as well as those that consume or use the water. Through a water market survey, we attempted to explore the private water market as it exists in various forms and linkages (or the lack of them), along with formal water supply managers within the government system. The results are discussed in this section. All of the information provided in this chapter was obtained during the survey and/or focus group discussions, unless cited otherwise.

Water Market in Indore

The private water market in Indore consists of drinking water (in packaged form) and non-potable water delivered by water tankers and is intended to compensate for insufficient quantity, irregular availability, and at times, unacceptable quality of water supplied by the public sector. Water tankers supply a significantly greater volume of water than that from the packaged water industry. The packaged water industry is (to a large extent) regulated and has some degree of quality control, while the water tanker suppliers are unregulated and have limited connections to the formal water supply system. The market has grown rapidly, supplementing or in some cases replacing typical municipal water provision mechanisms, particularly in supplying packaged water to the commercial sector and tanker water to households. The main source of water for private water businesses is groundwater, primarily accessed through privately owned borewells.

Market History

The private water market has existed in Indore since the 1960s in the rudimentary form of water being sold in cans by vendors to the large cloth market in the central part of Indore city. A more systematic and organised private water market sprouted in the early 1990s with the emergence of private water tankers. The private water tankers of Niranjanpur and Bijelpur began selling water in response to the growing water needs of the people of Indore. The advent of the private water market in the city can be attributed to two main factors: 1) a rapidly growing population, and 2) the inability of the city's civic body to cater to the needs of this population despite the commissioning of Narmada Phase I in 1984.

Empty water jars carried back for re-filling, Indore. © ISET

Over the years, the sale of water in Indore has taken on various forms. In 1995, Easeau, the first packaged water company in Indore, opened for business selling water in pouches. Presently in the private water market, water is sold in tankers and in packaged form for drinking (in bottles, jars and pouches) both by national and local businesses. The current private water market and service providers in Indore are described in the section below, followed by the issues and challenges faced by this sector as well as those that emerge due to their operations.

Water Sources

The main source of water for private water businesses is groundwater, primarily accessed through privately owned borewells. Groundwater fluctuates seasonally, with a lower water table during dry or scarcity months due to lower levels of recharge from rainwater coupled with high levels of pumping during the dry season. During the normal months (including rainy season) of July–March, water is available in borewells at depths of 200 to 500 ft, whereas in scarcity months (April–June), the level of water in borewells drops to 500 to 800 ft. In recent years, weather variability has reportedly increased and occasionally, the scarcity months begin as early as February/March. Depending on how each borewell was constructed and whether or not the bore intersects major water-bearing zones within the basaltic bedrock, the drop in the water table could deny access to groundwater altogether. In some cases, borewell owners construct their primary wells deep enough to ensure water availability during the dry season or they may have a secondary well designated for utilisation only during dry months.

The survey of the water tanker market consisted mainly of tankers from Niranjanpur and Bijelpur, as they are the main water tanker suppliers to Indore. In Niranjanpur, nearly 25 individual interviews were conducted, whereas in Bijelpur, fewer families are involved in the water tanker business, and therefore only eight individual interviews were conducted. These involved borewell owners who sell water to tanker owners as well as water tanker owners who have their own borewells. Those who were not interviewed were encouraged to interact during the focus group discussions.

Market Structure

The private water market consists of businesses selling both drinking water and water for washing dishes, clothes, bathing and other domestic uses. The various water products available in Indore are outlined in the table 6.1.

According to interviews with locals, bottles and pouches are generally purchased while people are outside their homes. Individuals belonging to the high-income group purchase bottled water while traveling, as this is believed to be better quality than the pouched water. Although households in the middle- and high-income groups have in-house water filtration devices and do not purchase packaged water, many households have started using jars or bubble-top water for drinking purposes. In low-income localities and slums, drinking water is obtained primarily through either a borewell or (less frequently) through the Municipal pipeline. Tankers are pressed into service during the summer months to supplement the supply from the above sources.

> A woman living in Musa Khedi, a low-income neighborhood, opined that people drink pouch water when they go outside of the house, as pouch water is inexpensive and easily available.

The only existing private water market association in Indore is the Madhya Pradesh Packaged Drinking Water Association, which started approximately eight years ago

Table 6.1: Types of water purveyors and their products in Indore

Water Products	Product Type	Mandatory Bureau of Indian Standards Certification	Voluntary Bureau of Indian Standards Certification	Scale		Water resource
				National	Local	
Packaged drinking water	Bottles	✓		✓	✓	Groundwater, Narmada commercial piped connection
	Jars	✓		✓	✓	
	Pouches	✓		-	✓	
Drinking water	Jars		✓	-	✓	Groundwater, Narmada commercial piped connection
	Pouches		✓	-	✓	
Water for domestic use	Tankers	None	None		✓	Groundwater

(2003) in response to a government ban on water pouches. Members of the association include packaged drinking water manufacturers and suppliers having registered with the Bureau of Indian Standards (BIS[1]). One of the roles of this association is to provide its members information on new BIS norms and regulations.

Water Sold in Packaged Form

Packaged water for drinking in Indore is available both from national as well as local manufacturers. Nimbus Bailey, Kingfisher and Bisleri are the major national packaged drinking water brands sold in Indore. While Kingfisher and Bisleri have franchised to the local packaged drinking water manufacturers, Nimbus Bailey has its own bottling facility in Indore. Gautam Beverages and PD Food & Beverages manufacture both their local and national labels (Bisleri and Kingfisher respectively)

[1] The BIS, or Bureau of Indian Standards, is a national body set up under the Bureau of Standards Act 1986 of the Government of India. This body develops standards for products manufactured in the country so that various manufacturers maintain the quality and uniformity of products throughout the country. For more information, please refer to: http://www.bis.org.in/org/obj.htm.

in the same plant, utilising borewell water. Collectively, these three national brands sell approximately 85,000 litres of water daily in Indore during the normal months; this volume increases by 20-40% in the summer months. Some of the main local brands that sell water in bottles, jars and pouches are: Icebre, Easeau, Aqua No.1, Narmada, Gangawal beverages, Ego, Aqua Green, Blue and Aquashree. The collective sales reported by the 11 local manufacturers is approximately 90,000 litres per day during normal months, which increased by 30-40% during the summer season (Focus Group Discussion, August 2010b).

During summer months, there is a demand for cool drinking water and most of the bottled water and pouches are cooled in refrigerators and sold by the retailers. Chilled drinking water in reusable 20 litre insulated bottles, which keeps water cool for about five hours, is an innovative addition being provided by some locally-based purveyors to customers at an affordable price especially during summer months. Currently, there are approximately 15 local manufacturing units involved in this business with a combined daily sales of approximately 115,000 litres during the peak of summer season. Their main consumers are shops and small offices of traders in the city. Occasionally these are also used in small parties and social gatherings. Packaged water for drinking is also sold in pouches, primarily packaged and sold by local brands. Water available in pouches is mainly consumed in bakery shops, wine shops, grocery shops, and at roadside food stands. Each 250 ml pouch costs 2 Indian Rupee (INR), making them affordable to low-income groups.

Water Treatment Used by the Packaged Water Industry

Typically, reverse osmosis filtration is utilised by the packaged water industry so as to comply with the Bureau of Indian Standards (BIS), which is mandatory for packaged drinking water. The water is then packaged either in bottles, jars or pouches. While all of the national brands are registered with BIS and comply with its standards set for packaged drinking water, a majority of the chilled water service providers are not registered with BIS and at present there is no regulatory mechanism in place with regard to the quality of chilled water. However, chilled water is typically sold with a label declaring the Total Dissolved Solids (TDS) levels, as this is perceived to provide an idea regarding the taste and quality of the water. The primary reason cited for not registering with BIS is the high cost of the license renewal policy.

Cost Structure of Packaged Water

While the cost of a 20 litre jar from one of the national brands between INR 50-60, the same jar from a local manufacturer costs about INR 30-45. The cost of various capacity water bottles in Indore are given in the table below:

Table 6.2: Bottled water sizes and rates in the Indore market

	Capacity (litres)	Price (INR)
National brands	200ml	5
	500ml	8
	1	15
	2	24-28
	20	50-60
Local brands	1	12
	2	18
	20	30-40

The price of chilled 20 litre water jars varies with season, and in peak summer months it costs between INR 35-45, whereas in normal months it is INR 25-30.

Water Sold for Domestic Use by Water Tankers

As discussed earlier, there is an extensive water tanker market in Indore that fulfills the unmet demands of almost all sections in the society. In comparison to packaged drinking water suppliers, the water tanker business has a much larger share at the household level. Here tanker water is mainly used for domestic purposes, including

Table 6.3: Typical price of chilled water jars in Indore		
Brand	**Selling price in normal months (INR)**	**Selling price in summer months (INR)**
Gold Aqua Chilled	30	35
Swati Chilled	25	40
Chanchal Aqua Soft	25	45
Shree Bhagwati	30	40
Om Chilled	30	40

drinking. During the interviews and discussions with the households we found that many households also use tanker water for drinking after certain processing procedures such as boiling, adding water purifiers or using water filters. The water in these tankers is mostly sourced from borewells and does not comply with BIS or other quality standards.

The water tanker business started in 1990s, initially as a response to the water demands of industries. However, driven by the burgeoning water needs of the city, water was then sold to various consumers including households, hotels, schools, construction companies, commercial centres, etc.

Most water tanker businesses are located in the peri-urban areas around Indore: Niranjanpur, Bijelpur, Palda and Sirpur Talab, Phuikoti, Khajrana and MR 10, with Niranjanpur and Bijelpur supplying almost 90% of the tanker water. Around 205 families residing in these areas are involved in the business, with the maximum number from Niranjanpur. Three categories of people are involved: borewell owners, tanker owners and those who own both water tankers as well as borewells. In Indore, the capacity of water tankers is 3000, 4000, 5000, 6000 or 12000 litres. Tankers supply water to various domestic, commercial and construction-based consumers in the city.

> For the past 2 ½ years, Mrs. Kaur, a resident of colony scheme No. 114, has been completely dependent on private water tankers to meet her household water demands. For a 4000 litre tanker she pays in normal months between INR 150-200, whereas the same capacity tanker costs her INR 400 in peak summer months. Every month she spends INR 1000 in purchasing water. (Focus Group Discussion, 29 February 2009).

The cost of water from a tanker varies according to the capacity, where larger storage implies cheaper water. However, there is not a significant price variation between 3000, 4000 and 5000 litre capacity tankers. There is variation in the price charged to the consumers depending upon the season, tanker capacity, distance, type of locality (high-, middle- or low-income or slums) and the type of consumer (household or commercial). Similarly, borewell owners also charge differentially toward tanker owners depending upon the season and electricity consumption. Typical costs of tanker water is given in the table below:

Due to lower groundwater levels in summer, the cost of electricity consumption is higher, and hence, the selling price for water is also higher. The summer season generally begins in April, but it can also start in March, and continues until June–July depending upon the arrival of the monsoons. The selling price also varies by the locality to which the tankers supply water. For high-income groups, such as those living in Saket or Ratan Bagh, suppliers from Bijelpur sell a 6000 litre capacity water tanker in peak summers for INR 500-1000, whereas the same quantity of water is sold in other localities (low- and middle-income) for about INR 350-400. Most of the tanker owners that were interviewed believed that selling water in slum areas is not convenient for several reasons. First, there is a lack of space to park the tankers; second, it is common to see clashes and quarrels among the people over water distribution. In addition, experience has shown that people living in slums do not fufill their payments on time. Tankers also provide water to construction sites at INR

Table 6.4: Variation in selling price of tanker water during different seasons			
Area	**Tanker Capacity (in litres)**	**Selling price, normal months (INR)**	**Selling price, summer months (INR)**
Niranjanpur	3000/4000/5000	100-150	200-250
	6000	150-200	250-350
	12000		1000-1200
Bijelpur	6000	200-250	300-350
	6000	200-250	500-1000 (cost for high-income localities)

200-250 per 6000 litres with the duration of supply continuing for 2-3 years until the construction is completed. Other consumers of tanker water are bottle and pouch water manufacturers, though these are only seasonal.

Niranjanpur has two types of electricity connections: permanent and temporary. When the demand increases, some borewell owners opt for the temporary connections for 2-3 months.

It was difficult to estimate the total quantum of water supplied by these tankers within Indore as these are not organised and no records are maintained. If we assume the average capacity of a tanker is 6,000 litres and each tanker makes six trips per day during the summer months of April and May, we estimate that the water supplied during this time is about 7.3 million litres per day, or a total of 442 million litres (there are approximately 205 tanker owners). However, there are many tanker owners who have multiple tankers of varying capacities and sometimes (during acute shortages) they even supply water 24 hours a day.[2]

[2] In addition to the private tanker businesses described in this sub-section, the Indore Municipal Corporation also hires private tankers to supply water to deficient areas or slums free of charge during summer months. However, the number of tankers hired varies upon the severity of the summer and the water supply available from surface water sources. For example, in 2009, IMC hired 250 tankers as early as in the month of April, while this year (as of May 20, 2011), they had not yet started the process.

Discussion

As with the formal municipal water supply system, water markets in Indore serve middle- and higher-income groups better than lower-income groups. Those purchasing the "high-end" bottled and packaged water supplies tend to be wealthier residents living in city centres. Similarly, those purchasing bulk water supplies from tankers tend to be businesses or households that can afford their own storage system (either a cistern or a water tank). In many ways the ability to store water is the largest single factor influencing the price of water. Since the cost does not vary greatly between 3,000- or 5,000-litre-capacity tankers, the larger the ability to store water, the lower the unit cost. Lack of storage facilities is, in fact, one of the primary factors limiting the ability of poor households to obtain water through such markets. In addition, poor households are limited in their ability to pay the INR 200-300 required price when purchasing a full tanker of water. Social conditions, specifically unruliness of crowds, also undermine the interest of tanker owners who serve poorer areas. Upfront costs, storage facilities and social conditions emerge as the primary factors determining why marginal communities are poorly served by water markets. These limitations also result in the poor getting differentially less access to private tankers compared to other socio-economic groups, but only reduce the scarcity faced by the middle- and upper-income groups.

Table 6.5: Cost of water for household consumers from various sources	
Water source	**Cost per litre for consumer (household)**
Municipal piped water (@ 80 LPCD for a family of 6 persons, the monthly charges are approx INR 180)	INR 0.0125 per litre
Tanker water	INR 0.02- 0.17 per litre
Packaged water	INR 2 to INR 15 per litre

Focus Group Discussion with Packaged drinking water suppliers, Indore. © ISET

The above limitations should not be used to dismiss the key role water markets currently and could continue to play as part of Indore's water supply system. Virtually all the water supplied in package form is ultimately used for direct consumption. Furthermore, most package water is treated in one manner or another and there is far less chance of cross contamination than in the municipal water supply system. Second, the level of water loss in tanker water markets is likely to be substantially lower than those in the municipal supply system. Direct water losses in transit, unlike the large leakage levels in the municipal utility, are minimal.[3] Tankers are generally filled from wells and deliver supplies directly to cisterns or other storage containers at consumer locations with relatively little loss. Third, in both the tanker and bottled or packaged water cases, consumers are actually paying for water services based on the amount they consume and the convenience with which it is made available. One-litre bottled water costs approximately INR 15/litre, larger 20 litre jugs cost INR 1-2/litre and tanker water costs between INR 0.02-0.17/litre.

[3] However, the process losses from reverse osmosis (RO) are likely to be higher than those from municipal supplies, as well as create pollution due to very high dissolved solids in wastewater generated from RO plants.

The water from municipal supplies is cheapest for domestic consumers and is treated/purified to potable standards. For packaged and bottled water, the motivations for paying costs that are as much as 375 times the cost of water from tankers probably involve a combination of quality, convenience, health and value-added coolness during the hot season. In the case of tankers, consumers are most likely meeting basic supply needs. In both cases, however, the cost of water probably assures relatively high levels of use efficiency by consumers. Increases in cost during the dry season also communicate the additional scarcity value of water. This is distinctly unlike the municipal system where the lack of an effective pricing mechanism undercuts incentives to conserve. In the municipal system, the unreliability of supplies – which in effect ration availability – is the primary incentive for water-use efficiency. Improving supplies from this source without stronger mechanisms for communicating the cost of water would likely lead to substantial inefficiencies in use.

Summary

Many questions exist concerning the role private tankers or bottled/packaged water suppliers play as part of Indore's water supply equation. Actual use efficiencies are unknown and little information is available on the quality of water at the point of delivery and at the source. Information – on the communities served by these water markets and on the potential health, water service and other benefits they receive – is also limited. While households are the main consumers for the tanker water, packaged water for drinking is primarily used by individuals when out of the home, in commercial establishments, offices and other institutions. Special events and social events such as marriages, workshops and business meetings are other major consumers of private water. What is clear is that the demand for both packaged/bottled water and the services of tankers is relatively high. The private sector water purveyors fulfill the services delivery gaps in Indore's water supply system. What is also apparent is that, just as with the municipal system, major problems exist. Water quality and management of the groundwater resource base is a concern as well as ensuring equitable access for poor and other marginal communities.

Many of the issues involved in reforming the municipal supply system involve finance reforms, grievance redressal mechanisms, massive upfront capital investments and changes in system delivery principles (such as pricing) that are politically and often technically difficult to achieve. Reducing leakage and improving quality, for example, would involve massive investments in new piping,

chilled water jars ready for supply. © ISET

therefore improving water supply availability to the point where the system could be pressurised and eliminating the incentive for consumers to take illegal connections and use other boosting devices. Given the rapid rate of growth of Indore, it seems highly unlikely that changes of this nature are realistic. As a result, while there are numerous reasons for improving the performance of Indore's municipal utility, the types of actions that could improve the equity and technical performance of the private water markets in the city are of equal importance. Considering the higher opportunity costs in urban areas, the improved water supply system can help with enhancing the household economy, especially for the poor who have limited access to both the municipal and private sector.

This chapter also highlights the extent to which groundwater is intrinsically linked to the private sector operators in Indore. In addition, there are thousands of individual borewells in the city and the Municipal Corporation itself has about 3600 borewells. All together the quantum of groundwater being extracted from within the city limits of Indore is at least 15% of the water consumed and it serves all sections of the society. Some of the key issues brought forth by this study of the private water sector in Indore are:

1. Lack of effective regulation of water quality

Improving the quality of water supplied by the private market and sustaining it, especially from water tankers, is a major challenge. Even though water tankers sell borewell water, these are not covered under the BIS list of products that require a specific scheme of testing and inspection against set standards. The methods for purification of the borewells' water are often hasty (rendering them ineffective), and there are no protocols for testing/monitoring of the source borewells to assess contamination levels. Water from the borewell is occasionally treated by adding alum – a chemical compound used specifically for the cleaning of drinking water (alum only helps in flocculation and sedimentation). In the past, the IMC tried simple measures such as the use of bleaching powder for chlorination, however, these efforts were discontinued later. Such measures are insufficient for improving water quality and are not performed regularly. Also, it is not clear how often the tankers are cleaned, and there are no monitoring mechanisms in place to check this. The costs of managing increased disease burden is much higher than improving the quality, but since these are invisible costs borne by the households, these measures are not considered by tanker owners or the IMC.

There is a lack of community awareness regarding the quality of water that is available from different sources and how/what to test for in ascertaining the water quality. The average person only considers color, transparency, smell and temperature when judging water quality. Since there are no concerted efforts to create awareness around water quality, and the IMC is not managing the community health (done by the state health department), the demand from the society has remained low and waterborne disease outbreaks during the summer and early rainy season are typical. The community associates these diseases with weather changes (heat, rain, etc.) and not bacteriological contamination. Regulation of water supply sources and tanker water suppliers could, as suggested above, help to address this, particularly if done in conjunction with community awareness programme on water quality coupled with provisions of easily-accessed testing facilities.

2. Declining ground water levels

High rates of urbanisation, a large increase in groundwater extraction and a decrease in permeable surfaces (leading to decreased infiltration) have contributed to the depletion of groundwater in Indore. The water table has receded from less than 10m in the 1960s, when the open wells were a common source of water, to about 135m at the present. Given such conditions where groundwater is depleting at a rapid pace within (and around) Indore, the city has instituted a ban on digging additional borewells within the limits of the Indore Municipal Corporation.

At present, there is a lack of established planning for groundwater or groundwater recharge (except for sporadic efforts toward rooftop rainwater harvesting). And although there is a ban on digging additional borewells in the city, the absence of any serious recharge efforts and continual abstraction is taking the groundwater levels deeper.

Neither the government nor the private water industry has made serious attempts to investigate possibilities for groundwater recharge. At most, users allow wastewater to collect in a pit, where it can seep into the ground. There is an urgent need for information and technical support for groundwater recharge so that both public and private water suppliers can sustain their supply source and avoid jeopardising this common resource. One opportunity for doing so may include utilising abandoned wells as cisterns and recharge points. The natural recharge of water through the highly impermeable black cotton soils in the area is significantly low and artificial recharge methods through wells and borewells need to be explored. If water quality can be maintained so as to avoid polluting groundwater resources, channeling runoff from precipitation directly into abandoned wells could contribute significantly to groundwater recharge. One option for this may be to collect water directly from rooftops and run it through closed pipes that lead to deep dug wells. Becsause these wells partially penetrate the higher permeability vesicular layers between basalt flows, this would address the problem of impermeable soils. It would also enable storage of substantial volumes of water at a local level since, in addition to functioning as points for recharge, wells could also serve as cisterns. Indore had a history of wells supplying most of the city's water needs in the past, and these can still be seen but are used as solid waste disposal areas. Such wells are widely available in both the peri-urban area surrounding Indore as well as within the municipality. An appropriately designed system should be able to ensure quality is maintained and also, because of the large volume of available storage in the abandoned wells, enable capture of large flows that occur in severe rainfall events. If done systematically, such a recharge system could also reduce urban flood problems.

At present, initiatives to recharge groundwater are just now beginning. Some proactive water businesses are installing rooftop rainwater harvesting (RWH) systems specifically for recharging groundwater. The government is providing a 6% tax rebate for qualifying RWH systems, and business owners are seeing the direct benefits of this water conservation. The potential use of abandoned dug wells as recharge points has not, however, been explored as far as we know.

3. Increasing use of energy:

Not only is the current situation of depleting groundwater alarming, but this also leads to another set of challenges related to the use of energy. The amount of energy used for extraction of water increases as the water table descends. The increasing cost of electricity will impact the individual (household) borewell owners as well, in addition to an increase in the GHG (Greenhouse Gas) emissions.

4. Absence of association:

Private water tanker owners do not have an association, and during focus group discussions, the desire to have a platform to discuss issues, receive support and obtain information did surface. One of the hindrances in forming an association is that the tanker owners are registered as truck operators and not as water tankers under the government authority. The issues related to quality, monitoring and regulation of this sector could be addressed more effectively if suppliers of tanker water came together and formed an association.

The presence of the above concerns highlights the need to identify effective strategies for strengthening service characteristics and the resilience of various components of Indore's water supply system. In the case of tanker water markets and packaged water, mechanisms for doing this may include:

1. Improving the level of information available on tanker water markets and bottled or packaged water suppliers. The types of information that would be useful in evaluating the role of such water markets includes efficiency, water quality, source protection and delivery issues.
2. Identifying regulatory or other mechanisms for managing private suppliers as part of the overall water system. This could include:
    a. Source regulation focused on both quantity and quality;
    b. Registration and certification and end point water quality monitoring for tankers;
    c. Public awareness campaigns regarding water quality;
    d. Formation, empowerment and knowledge support to (bottom up) local water management groups (water institutions) at resident welfare associations/colony committees in order to manage local water resources, including rainwater harvesting, groundwater recharge and management;
    e. The development of systems for groundwater recharge, perhaps utilising numerous abandoned dug wells that are scattered throughout both the urban and peri-urban areas;
    f. Establishment of service delivery standards (perhaps a requirement to sell a certain portion of water in underserved areas at a subsidised price);
    g. Encouraging the establishment of consumer and supplier associations;
    h. Addressing some of the specific factors that limit water access and increased price for marginalised communities, including issue of storage.

Private water tanker from Bijalpur © ISET

It is important to note that many of the above types of actions could be undertaken regardless of whether or not the municipal system is improved.

It is apparent from the study that the private water market in Indore serves a key function of diversifying sources of water that are available to consumers in addition to meeting demands that the municipal system is incapable of filling. The private water market will remain an important part of the total water supply system because the municipal (formal) water supply system in Indore has major system insufficiencies, which include insufficient and unreliable water connections, poor infrastructure, lack of full distribution coverage and inadequate management. Also, due to poor finances and capacities to manage these systems efficiently, the demand gap is likely to persist, especially with the growing population.

The private water purveyors provide a backup in the event that the fragile municipal system fails. Because water is priced and delivered in fixed quantities, unlike the municipal supply system, the private markets can ensure efficient use of scarce water by consumers. Similar to the municipal system however, the private water market does not adequately serve low-income communities. Quality issues and sustainability of the groundwater resource base are also major concerns. As a result, there is a need for proper regulation of the private water market and linkages with formal water managers in the city for better management of resources. Furthermore, because both municipal wells and private water purveyors depend primarily on groundwater as their source, it is imperative that proper management of groundwater resources and of local water bodies[4] in and nearby Indore is pursued seriously and in a planned manner. Groundwater also becomes important given the city's current dependence on a single, distant source (Narmada river) for most of its water supply.

[4]The city has three large tanks, Piplyapala, Bilawali and Shirpur, but construction in their catchment has drastically reduced the water inflow. The biggest locality in the city, Kathiwala Tank, stands on land reclaimed by filling the tank (Down to Earth, February 2009).

Rainwater harvesting at Goyal Vihar. © ISET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CHAPTER 7: A RESILIENCE STRATEGY FOR INDORE

Throughout the world, the goal for municipal water systems facing environmental change is to develop more sustainable, resilient and equitable systems to source and supply water. Water resources and their use are governed by a variety of political, economic and institutional systems. If these systems become hierarchical, non-inclusive, power-centric and disconnected, then governing the growing stress on water resources becomes particularly complex. Water problems are in many ways primarily governance issues. Technical solutions to many of these problems exist; the challenges to implementing these solutions lie in the political economy of water supply, use and management and regulation and enforcement – and the lack of political will and resources to get such solutions implemented. In this void of governance, formal water managers are not able to plan for the potential impacts of climate and social change through improving their own management or by better regulating the informal sector.

The objective of this study was to identify a Resilience Strategy for Indore that could make Indore's water supply more sustainable and resilient in the face of urbanisation and climate change. Indore's water supply system has three sub-systems: municipal utility or formal water system, private water market system (packaged drinking water and water tankers) and self-supply system (for example individual or community borewell). Addressing the challenges within Indore's water supply systems would depend upon a wide range of interventions to manage both social and climate shocks that involve all aspects of the formal and informal systems, including managing the resource base, supply systems and end-use. While some of the interventions would be technical in nature, many would need to address the processes and institutions through which water is governed. Each individual intervention would only address a small fraction of the management challenge. However, together, these governance interventions can help to build the capacity of water sector institutions to respond to both existing and emerging problems.

Technical interventions can often be handled within a water utility, community or household with little need for co-ordination among actors. In contrast, water governance is a political process; broad changes in water governance require a platform for conflict resolution, negotiation, social learning and collective decision-making. One of the key findings from this study is that there is near total absence of engagement and dialogue between and among the diverse array of groups belonging to the three sub-systems that are involved in managing water in the city.

As part of our project in Indore, we developed the framework of an overall resilience strategy comprising a multitude of different elements. The resilience strategy is meant to improve governance of the system as a whole through an iterative process of shared learning. We believe the multi-stakeholder "Shared Learning Process" approach piloted in this project serves as an overarching tool to address the shortcomings in the water governance system(s) in developing urban areas. While the core Shared Learning Process (described in detail in Chapter 2) needs to be supported by additional tools that address specific management or technical issues (such as leak detection and enforcement), it serves as an essential entry point to catalyse involvement, coordination, knowledge and capacity, particularly on the management of people and processes. It also contributes to transparency, accountability and inclusive decision-making.

Improving water sector governance in ways that will improve the sustainability, reliability and equity outcomes of water provision in Indore is a process that will take significant political and social investment and time. Through this project, we were compelled to identify solutions that were "doable" more immediately. During our interactions with daily wage earners and other low-income households, we were constantly pressed to find "doable" solutions as opposed to lofty ones. Many households struggle daily with obtaining and managing water; their water problems are immediate. Waiting for the overall structure of water governance in Indian cities to change may take far longer than these residents have. Initial steps toward solutions that build resilience are essential, and this chapter details some of the key resilience interventions that can be building blocks to improving water governance in Indore.

This chapter summarises the seven vulnerabilities identified in the formal, informal and self-supply sectors of the Indore water system. We also describe resilience interventions that help address these vulnerabilities, which were identified by the Shared Learning Process and through examining water-sector best practices. In the final section, we detail the key tools that support these resilience interventions.

Vulnerabilities and Resilience Interventions

We identified numerous vulnerabilities in the water supply system in Indore through the Shared Learning Process of one-on-one discussions, focus group discussions, surveys and multi-stakeholder dialogues over the course of three years with water-sector stakeholders including households and the informal and formal water sectors. The vulnerabilities identified included the *lack of access to water by the poor, lack of effective regulation of the informal water market and dependence on a single distant surface water source.* The household water survey highlighted the *differential access to water by the poor* and the ways in which the urban poor were the most susceptible to water insecurity as a result of climate change. Analysis of the formal water system through focus group discussions and literature review demonstrated the vulnerabilities associated with *poor infrastructure*, the expensive and distant water source and the lack of cost recovery at the utility level.

To address the seven vulnerabilities identified through the process, the Project Team collated suggestions and ideas emerging from one-on-one meetings, focus group discussions and Shared Learning Dialogues, and included water sector expert opinions on best practices. For example, in focus groups with communities, as well as in the household survey and in the December 2010 multi-stakeholder dialogue, community residents clearly expressed a desire for more information on how to conserve water at the household level. This was a clear finding, and was surprisingly unrelated to economic class of the household or even water use at the household level. Providing more information on water conservation and other opportunities for conservation and efficiency could help address the identified vulnerability of the *demand-supply gap in water supply*, using a demand-management approach.

Several of the vulnerabilities identified could be addressed by solutions emerging from the engagement sessions in Indore. Others could be addressed by looking to the international water sector and best practices in other areas. For example, the *lack of groundwater management* is an issue recognised internationally and would also be of particular importance in many Indian cities. Several Indian states and cities have implemented mandatory rainwater harvesting as a policy that has had a positive impact on groundwater aquifers. Taking from this national experience,

Municipal Corporation tanker supplying water. © TARU

Table 7.1. Vulnerabilities and interventions in Indore water sector		
	Core Vulnerabilities	**Interventions to Improve Resilience**
I	Demand-supply gap in water and dependence on a single distant surface water source	• Diversifying water supply sources at the household and community scales • At the city scale: cleaning existing water bodies, sustainably managing groundwater resources (conjunctive use) • Increasing storage capacity • Water conservation and efficiency (greywater reuse, water-efficient fittings, reducing system water losses, etc.)
II	Lack of access to water by the poor	• Implementing credit mechanisms and strengthening local communities to help them demand better services and equitable cost structures
III	Poor management of water utility: finances, infrastructure, complaints	• Infrastructure improvements and leak detection programmes • Metering and volumetric pricing for wealthier consumers • Improved complaint redressal system
IV	Lack of groundwater management	• Increase groundwater recharge through rainwater harvesting, dug wells and artificial recharge • Monitor groundwater levels in and around the city
V	Lack of water quality monitoring and regulation	• Water quality monitoring at household and community level
VI	Lack of information and understanding of climate change impacts	• Sharing of climate information and data with water managers to build capacity of city water managers to understand and incorporate climate information in urban planning and development processes
VII	Lack of networking and information flow between different water managers	• Development of a Citizens' Water Forum • Water tanker registration • Education of formal water sector employees

the Project Team proposed a rainwater harvesting intervention as one solution to the vulnerability of *lack of groundwater management.*

The full table of vulnerabilities and corresponding interventions are listed in the table 7.1. Each of the vulnerabilities and resilience interventions listed in the table are discussed in detail in the following sections.

I. Vulnerability: Demand–supply gap, dependence on distant single source

More than 80% of the water supply for the city of Indore comes from the Narmada River, making the city highly vulnerable to any disruptions in this source. Though the Narmada is a perennial river and its flows have been historically reliable, any future changes in the geo-hydrology in the catchment area of the river could alter its flow patterns. Water from the Narmada is lifted about 500m before it can flow by gravity to Indore, which is 70km away. Disruption in this long water transmission system would heavily affect water availability in Indore. In addition to the supply itself, this water transmission system is highly dependent on availability of electricity for the lift, adding another point of vulnerability.

Women from slum community going to collect water, Indore. © TARU

The water availability in Indore has always lagged behind the demand due to increasing population and lack of an effective demand-management strategy that addresses both end users and water losses within the system. The city has planned and implemented multiple phases of supply from the Narmada River to meet demands as they increase. The most recent Phase III of the Narmada supply programme was intended to provide an additional 360 MLD, but only about 90MLD is available to the city at present. This is not sufficient for Indore. The total water supplied by the formal system to Indore is equivalent to only about 80 litres per capita per day (LPCD) in comparison to the Government of India standard for urban areas of 135 LPCD. The supply-demand gap is also manifest in the lack of municipal water coverage to a large percentage of the urban population. As of 2009, only about 54% of the population in Indore had access to municipal water supply. A large part of this "unmet" connection is in poor areas or "unauthoris ed colonies" in the city. Furthermore, even those residents of the city who have access to a Municipal piped connection receive water only for 45 minutes on alternate days. As a result, a large part of the urban water demand is met by a mix of private wells, informal tanker-based water markets and other private suppliers.

Intervention: Diversification of water sources

Diversification in the source of water used, as well as diversification in the supplier of the water, is an important strategy for building resilience to climate variability. Diversification of water supply in developing country cities should incorporate multiple sources and adequate backup resources, including, where possible, conjunctive use (the management of both surface water and groundwater to increase the variety of water sources accessed) and a mix of local as well as distant water sources.

At the household scale, the middle- and higher-income populations in Indore are accessing groundwater directly though boreholes and tube wells to supplement their supply from Municipal pipes. These households also can call a water tanker when they need additional supplies of water. Low-income households, however, often only have access to one source of water, a local handpump or public standpost, and they often don't have the funds to pay for a water tanker. Although local sources will remain one of the fallback options for the poor (especially since they are currently under-served and the pipelines installed for them are often tapped/usurped upstream by other communities), establishment of community standposts in all low-income areas could increase access. Conjunctive use of water resources could also be an effective resilience strategy if propagated at household and community scales in the city. Use of high quality (and high cost) Narmada water for drinking/cooking purposes and lower quality water (groundwater is generally hard in Indore) for other purposes would improve the ability to deliver drinking-quality water to all groups. It could also reduce the energy bill of the utility, thus helping it gain some financial capacity, as well.

> The self-help group of Lokmanaya Nagar (a high-middle-income colony) started in 1994 by Ms. Usha Vaishampayan, a retired School Principal, has been a forerunner in community management initiatives. Her group, comprised of the residents of her locality, has been involved in projects such as garbage collection and management, recharging of old wells through rainwater harvesting and growing vermi-compost. With old wells being recharged, the water is being used for the plants and trees of the community garden. The group took charge of the community parks from the IMC nearly six years ago.

Community-managed water is an interesting and relevant coping mechanism that appears to increase the incentive of community members to implement water conservation practices and helps increase the reliability of supply. The proximity between users, system managers and technical infrastructure ensures better flexibility and user-responsiveness. These systems have the potential to foster new understanding and behavioural change that can improve system resilience. The idea of community-managed water was often put as a request to the formal water utility in Indore in the Shared Learning Dialogues and focus group sessions as well. There are several localities in Indore such as Goyel Vihar and Sunder Nagar that serve as models of community-managed borewell systems (for more details see Chapter 5).

Intervention: Increasing storage capacity at all scales: household, community and city

As climate change reduces the ability to predict precipitation patterns, increasing local water storage has become an attractive strategy to ensure supply during periods of drought. Water storage can help all water managers in addressing variations in precipitation intra-seasonally and also inter-seasonally. The urban poor, however, do not have the ability to store water, because they lack both enough land and land tenure. The Rajiv Awas Yojana[1] scheme aims to improve the quality of services and housing for the poor, and some progress is being made. The tenure issues are being addressed and ownership is being formalised under various slum improvement projects. With the land rights recognised, the poor can invest in storage options that did not exist even a few years back. Community tanks could be one of the options for poor people to collectively increase their storage. Community-level water storage could also involve establishment of large overhead tanks or large-scale underground storage. These systems would allow residents to collectively purchase water from tankers in bulk during low-water-supply months (which decreases the price paid per unit volume) and also store more water from the wet season to the dry season.

At the city scale there is a need for better management of existing surface storage and water bodies, such as ponds/tanks, waterways and lakes. In Indore, there are many such water bodies that have dried up due to mismanagement or neglect. For

[1] This scheme launched by Government of India for urban poor/slum dwellers under JNNURM on the lines of Indira Awas Yojana for rural poor. The scheme for affordable housing through partnership and the interest subsidy scheme for urban housing would be dovetailed into the Rajiv Awas Yojana which would extend support under JNNURM to states that are willing to assign property rights to people living in slum areas.

Shri Govindram Seksaria Institute of Technology and Science, an engineering college in Indore, has installed a water recycling plant within their campus. IMC supply for the college (for nearly 5000 people) is not sufficient. The college also has four tube-wells, but from January or February onward until June, the water table drops down to more than 500 ft and the availability is also reduced significantly. To meet the water demand, the college installed a water recycling plant and approximately 60 MLD of greywater generated is treated by bio-filters and collected in separate overhead tanks. The Narmada water (supplied by the IMC) is used only for drinking purposes after cleaning it further through an Aquaguard filter which is attached to the main pipe of the drinking water tank. This enables the provision of safe, clean drinking water. But drinking water supply is available only to the Institute, hostel and at the ground floor of residential areas. Nearly 10,000 litres are used for drinking water daily. Sometimes they call for an IMC 13000 litre tanker and pay INR 600 and a private tanker costs around INR 850. In the summer season the Institute needs four tankers. The combined usage of non-potable and greywater is 70,000 litres. Greywater is stored in a small tank and is supplied through a network of pipelines. Treated greywater is used for flushing toilets in the boys' hostel. Two Sintex tanks of 1000 litre capacity are installed in two hostels. In the newly constructed buildings of campus, rainwater harvesting is being practiced. (Meeting with Prof. Sandeep Narulker, Senior Lecturer at GSITS College, February 2009)

example, reservoirs like Pipaliya that served as a water source a few decades ago have dried up and are no longer in use. Even Bilaoli Reservoir now produces insignificant or no water during the summer season. Such water bodies can be dredged and cleaned to increase the surface water storage potential and groundwater recharge. Increasing water storage has also often meant large storage projects, yet better management of existing water bodies within the city can, as the accompanying box illustrates, have positive impacts in improving water supply and storm-water management.

Intervention: Conservation of water (Demand Management):

Considering the water availability situation in Indore and the fact that there will always be a gap in demand and supply, it is essential that water conservation and rational use of water is promoted in the city. The participants in almost all Shared Learning Dialogues expressed this as a felt need, as did the IMC, as they would have to procure less high-cost water from the Narmada. People wanted information on water conservation techniques and also on increasing their water supply by installing rainwater-harvesting systems. Demand management efforts would probably need to focus primarily on the wealthy and best-served sections of the city – the water use in these households approaches developed-world levels. Water use by the poorer sections of the population is likely to be relatively efficient due to the limited quantity and high labor cost of their water supply.

Because of the paucity of water available, water conservation at the household level is a norm in Indore. During our focus groups and Shared Learning Dialogues, women representatives mentioned common water conservation strategies taken during months of scarcity, with most households taking numerous steps to reduce water usage, reuse water when possible and avoid waste. Many households reported utilising greywater – the relatively high-quality wastewater generated from uses like bathing and washing utensils and clothes – for gardens, cleaning floors, etc. Such strategies can be effectively promoted and included as core climate change and adaptation strategies. In addition, examples from around the globe can also be shared by NGOs or government institutions as part of capacity-building for the citizens of the city.

II. Vulnerability: Lack of access to Municipal piped water by the poor

As of 2009, only about 54% of the population in Indore had access to Municipal water supply. A large part of this "unmet" connection is in poor areas or "unauthorised colonies" in the city. Our study clearly demonstrated that the urban poor in Indore are (and may remain) the most affected by water insecurity that could be further aggravated by climate variability.

The urban poor have a limited number of water access options. They rely primarily on inadequate municipal services and local sources, and they lack the political and economic power to demand access to Municipal piped supplies. The piped municipal supply in Indore is heavily subsidised, but it is the rich and the middle class who are the primary beneficiaries of these subsidies, since they are the ones with access to the piped system. In addition, while initial up-front connection fees are high, once connections are established there is only a flat monthly fee for water use. The problem is that these high upfront costs of Municipal piped connections serve as a barrier to entry for the urban poor, who, unless they can get a Municipal connection, cannot take advantage of the subsidy. Instead, the poor end up paying much more to buy water from private providers.

Intervention: Installment payment options and micro-credit schemes

One of the activities undertaken by the IMC is installing Municipal piped water household connections in those low-income localities where the households are willing to pay the monthly flat tariff of INR 180. The IMC has also recently decided that communities would be allowed to pay the one-time water supply connection charge of INR 2500 in four installments (Focus group discussions and discussions with MPUSP and Narmada Phase 3 project coordinators).

III. Vulnerability: Poor management of the water utility: finances, infrastructure, complaints

One of the key reasons why the water utility in Indore has been unable to meet demand and provide full coverage through piped connections is the poor state of the water utility's finances. While this is true in many cities in India, in Indore it is particularly important because of the high cost of water procured by the utility. The Indore Municipal Corporation provides water at highly subsidised rates to household consumers, yet continues to incur huge costs in procuring that water. The flat tariff structure results in this subsidy being captured by the wealthy, who have Municipal connections and the ability to store water in sumps, and leaves out a large poor population. Adding to the financial problems are issues related to water theft, distribution losses and low payment collection.

The poor finances lead to inadequate maintenace of the water supply systems of Indore Municipal Corporation. Most of the existing pipelines were laid in the 1970s with little investment in maintenance. As a result, there are numerous leaks in the system and unaccounted-for-water is estimated to be around 50%. Cross-contamination in the ageing infrastructure sometimes leads to mixing of sewage water in the water pipelines, and people have complained of foul-smelling water, dirty-coloured water, etc. coming from water pipes. There are also many unauthorised connections that add to distribution losses. Residents are dissatisfied with water services and often choose not to pay. This perpetuates the negative cycle: the water utility doesn't have the financial resources to improve services but cannot raise prices and improve its state because residents are unwilling to pay for unreliable services.

Old dug well being recharged through community efforts in Goyel Vihar. © ISET

Adding to the dissatisfaction of residents, the complaint redressal system in Indore is highly ineffective. Although there are multiple routes that residents take to complain about poor water services – they could address the complaints to the IMC directly or exert pressure through elected officials – the IMC lacks the capacity to address complaints properly. Communities consistently reported difficulties in getting information on the status of their complaints made to the Zonal office. This lack of responsiveness increases frustration with the IMC. As a result, many residents prefer to operate through political rather than bureaucratic channels as they feel that response time is faster when going through the Parshad (elected official). The problem is that reliance on political influence further undermines the formal system for resolving complaints.

Intervention: Reduction in unaccounted-for-water

During our focus group discussions with the communities, it clearly emerged that raising awareness and public involvement would be an effective means to control water theft and leakage. Information about the water supply system of Indore (the effort and costs involved and water conservation measures) should be given to the citizens at workshops organised by the IMC or NGOs at various venues: *Jan sunvai* (public hearings), schools, workshops, seminars, etc. The purpose of these events would be to generate awareness about the importance of water and how citizens can actively participate in reporting any leakage or theft they see in and around their locality to the Zonal office, and in turn strengthen the functioning of the *Indradoot* cell. An important component of this effort would be to ensure that all consumers know the phone number(s) to report leaks at the Zonal office. This can be achieved through a variety of measures such as providing calendars to all registered consumers with the necessary contact numbers. An SMS-based system (mobile phone technology) could also be utilised for this purpose.

Another intervention would be to deploy Geographical Information System (GIS)-based monitoring mechanisms to control leaks or breakages of water system pipe lines. This would require setting up a GIS cell within the utility and providing appropriate training.

Intervention: Metering and pricing

A key component of improving the IMC's finances on account of water supply is to remove Indore's untargeted subsidy (flat tariff structure) and impose new and more equitable water use charges such as metering,[2] block tariffs and the provision of a certain basic amount for free to the poorer sections of society. However, this is not an easy task, as has been experienced in other Indian cities. Involving non-profit organisations and community groups could help in publicising the real costs of water supply and the need to raise tariffs to the wealthiest consumers. One of the ways could be to link the flat tariffs to the floor area of the residence (linked to property tax being filed with the IMC).

The issues in reforming the municipal utility are much more complex than just financial challenges. The overall political economy of water supply improvements involves questions of competing jurisdictions, political interference, unions, endemic problems with getting quality work done even if investments are made: many such issues would need attention.

IV. Vulnerability: Lack of groundwater management

Private users, water suppliers in the informal sector and (despite access to imported Narmada water) the formal municipal system are heavily dependent upon groundwater resources. With ever-increasing demands on the local groundwater resource base this is leading to over-extraction in and around Indore. Demands on groundwater resources from multiple sectors (agriculture and industry as well as domestic supply) have severely depleted groundwater reserves, and the water table has dropped significantly in the last decade. In addition, increasing urbanisation

[2] Universal metering is a strategy that may lead to better management of the water system, reductions in wasted water and better targeting of water rates based on consumption patterns. Increasing block rates can promote customer conservation, because customers who can consume less are rewarded by a lower unit cost. However, looking at the success rate of implementing universal metering in other cities in India, this would take some time and effort in Indore. The utility would have to first improve its infrastructure and provide adequate supply to the consumers before they would accept the metering system.

and growth in Indore have resulted in increased pavements and built-up space – significantly reducing groundwater recharge capabilities within the city while, at the same time, increasing the threat of flooding (from inadequate storm-water drainage or choked drains). Neither the municipal utility nor the private sector has any effective groundwater management strategy in place.

Intervention: Increasing groundwater recharge through rainwater harvesting and artificial recharge

Many Indian cities are increasingly turning to artificial recharge as a way to address the groundwater depletion problem. Recharging groundwater will raise aquifer levels and will help municipal and other public agencies to have access to larger quantities of groundwater. Artificial recharge could include both household-scale rooftop rainwater harvesting to recharge structures as well as community/city scale efforts at directing storm water to urban lakes and recharge ponds.

The Indore Municipal Corporation established a separate cell called Rain Water Harvesting and Recharging Department in the year 2000. The function of this cell is primarily to create awareness and assist individual home owners in adopting rainwater harvesting techniques in the existing as well as new homes. Rainwater harvesting has been included as a separate head under the municipal budget, and a separate Technical Committee (with representatives from NGOs, institutions and the Municipal Corporation) has also been formed to guide the Rain Water Harvesting Department. There is a need to further strengthen this department in terms of its capacity to generate awareness and offer technical inputs on rainwater harvesting schemes. Policies mandating rainwater harvesting structures as part of the building code, similar to what has been done in Tamil Nadu, can ensure wider use of rainwater harvesting.

Community-level artificial recharge schemes involving the use of abandoned water bodies (such as dug-wells) in and around the city have been relatively underused in Indore. With increasing urbanisation, the permeable surface within the city has reduced drastically. Many water bodies that were once used for water supply before the advent of piped water supply have fallen into disrepair and become filled with garbage. These can be cleaned and used for storing the rainwater (for recharge). They can also be used as back-up storage for the communities in times of water shortages. However, management of water quality is always a major concern with this and other groundwater recharge techniques. If quality can be maintained, however, such techniques could significantly improve Indore's water security.

V. Vulnerability: Lack of water quality regulation and monitoring

Intervention: Water quality testing and monitoring mechanisms

Water quality is a key concern among residents in Indore and came up numerous times in our focus group discussions with communities, and also during Shared Learning Dialogues. Residents attributed numerous health effects to poor quality

Drinking water collected from low level. © TARU water. Though many households in the higher income households have RO (reverse osmosis) systems and/or use water filters, this is an expensive technology and is out of reach of a large population in the city. One of the issues raised at community level interactions was of a need for information on water quality testing methods and of water purifying techniques. As noted above, mechanisms for water quality monitoring and control are essential if any of the local strategies for rainwater harvesting or groundwater recharge are to be used.

Water quality testing at household level: An important tool to respond to the needs of communities is the availability of a low-cost water quality testing kit, as well as an information booklet that provides information on how to treat/purify water based upon the type of contaminants. Such water testing kits can be made available by the IMC at the community level in the lower-income groups. The Municipal Government in collaboration with the private sector should provide low-cost water treatment kits. Low-income communities having community-level water storage could also use a community-level water treatment facility.

Water quality regulation and monitoring of the borewell water used by private and public tankers: If formal linkages between the formal water utility and the private tanker water providers can be established, a citizens' forum on water quality regulation and monitoring could be formed. This forum could include representatives from the IMC, water tankers (borewell owners and water tanker owners), local engineering colleges, civil society organisations and consumer representatives from various parts of the city and could focus on the multiple factors that affect water quality at different points in the system.

The types of activities a forum such as this could support include periodic testing of borewell water, monitoring of tankers and building awareness on water quality at the household level. This could be carried out with support from state Groundwater Departments' laboratories that are already fully equipped with necessary analytical equipments to test water samples. A certificate on water quality noting the date of testing and the results could be provided to the tankers and borewell owners, which consumers could demand to ensure the quality of water being delivered. This forum should also monitor the checking of cleanliness of the tankers, and it could also provide information and technological support to borewell owners on how to recharge their borewells.

VI. Vulnerability: Lack of information and understanding of climate change impacts

One of the challenges in implementing resilience planning or resilience strategies in the cities (or even in rural areas) is the knowledge-sharing gap between the climate

Collecting water from public stand-post. © TARU change scientific community and urban communities. Our study found that the water managers in Indore lack knowledge and understanding of issues like climate variability and of climate impacts on urban water systems. In addition, climate change information and projections downscaled to a small area are not readily available. For cities to respond and adapt to climate change, it is critical to build capacities of urban water managers so that the climate change issues are adequately factored into and considered in planning for water systems.

Intervention: Establishing links to local scientific institutions to improve climate understanding

The formal water sector (or IMC) is the main institution responsible for planning and development of water supply infrastructure and water resources in Indore. There is a definite need for developing the capacity of the water managers at the IMC to enable them to incorporate climate change information into planning and management of water supply system, thus building the resilience of the city. The local engineering colleges and other technical institutions can be utilised for this purpose in conjunction with external experts.

VII. Vulnerability: Lack of networking and information flow between different water mangers

No single water manager has sufficient information on, for example, the condition of the different water sources or how much is being extracted or by whom to effectively manage water in Indore. There are multiple and conflicting authorities and jurisdictions over water, with different agencies charged with regulating groundwater, surface water and water quality. The IMC has little control over managing the resource itself. Surface water from the Narmada is allocated under state-to-state and central agreements, while groundwater is legally attached to land ownership and is regulated by the state and central groundwater boards. Water quality is a subject of the pollution control boards. Most of these agencies undertake little or no long-term planning and there is very little inter-agency coordination.

In addition, the informal water sector has also emerged as a key component of the water supply system. The informal private water sector works in isolation: water tankers are not recognised or regulated by the IMC. In addition to the formal and informal sectors, the vast number of consumers at household and community levels could also be defined as water managers. While this is typical of many developing country cities (Burke and Moench 2000; Moench, Caspari and Dixit 1999), the fact that all these actors in the formal and informal sector depend on the same resource base makes it critical to ensure coordination. Any climate-resilient strategy requires effective communication and partnership between these multiple water managers at the household, community and city scales.

Intervention: Development of a City Water Advisory Board of IMC, water tankers, other private actors, consumer groups

A City Water Advisory Board that brings together the formal and informal water sectors in Indore will assist in improving communication and planning among all water managers. In order to be resilient to climate and social change, water managers in all the three sub-systems need to understand the complex and contested terrain of the urban water system(s), account for the water sector impact of their systems and, most importantly, explore the thresholds or tipping points in each of the sub-systems and of the system as a whole. Thresholds are not only features of physical supply systems (groundwater over-extraction until it exceeds the natural recharge capacity of the system) but social systems also (no water quality regulatory standards).

For the formal sector, the networking could then provide the basic regulation of groundwater sources and tankers. It also might facilitate increased understanding of:

- how the private water market might shift in the face of climate change;
- which system(s) are most vulnerable or pushing toward a tipping point;
- how the formal water sector might adapt to fill in new gaps; and,
- how to address unsustainable or maladaptive practices among the informal water actors as well as within the formal sector.

Intervention: Development of a Citizen's Water Forum

A Citizen's Water Forum could bring together residents and water users throughout Indore through townhall meetings and on-line social networks to understand and address the water needs, challenges and questions of water users. The Citizen's Water Forum can bring together residents to speak with one voice to the IMC, water tankers and others to ensure that water managers in Indore are responding to the identified needs of residents, including on price, quality and reliability.

Intervention: Water tanker registration

Given that the water tankers are an integral part of the water supply system in Indore, there is a need to make sure that these tankers are managed as part of the overall water supply system. Better connections between this sector and the formal sector could lead to better regulation, monitoring and planning for the heavily overdrafted groundwater resources of Indore. Formal registration of water tankers would help the IMC to identify authorised operators. It may also make it possible to contact and periodically test and certify private tankers.

Woman collecting water from municipal pipeline. © TARU

Intervention: Capacity-building of formal sector employees

In order to be resilient to climate and social change, water managers in the formal sector need to understand the role of the informal water sector. This is a prerequisite for the basic regulation of sources and tankers. To do this, the formal water sector will need to undertake a process of communicating and understanding with the informal water sector providers in order to assess their role, their adaptive capacity and their strategies in order to incorporate the role of the informal water sector into the decision-making process of the formal water sector.

Resilience Building Tools

Through our work in Indore with communities, the informal water sector and the formal water sector, we identified and piloted several "tools" that could assist water managers in building urban resilience to climate change.

We propose the use of the **Shared Learning Process** as an overarching tool to facilitate the iterative resilience-planning process to help identify vulnerabilities and necessary resilience interventions. The Shared Learning Process is an iterative and multi-stakeholder engagement process with strong roots in participatory action research to aid urban water management in supporting and facilitating the implementation of interventions that improve resilience to climate change. Interventions to build resilience identified through the Shared Learning Process implemented under the project address specific problems and could become part of a much larger and comprehensive water sector reform effort.

In addition to the Shared Learning Process tool, we also tested a number "support tools" that were used for specific targeted objectives. Some support tools might form part of the Shared Learning Process in helping facilitate dialogue and communication between stakeholders. Other support tools may be used in operationalising and implementing some of the resilience interventions. We introduce four types of support tools: 1) information tools; 2) decision support tools; 3) communication system visualisation tools; and 4) participatory tools.

Overarching Process Tool: Shared Learning Process

The main idea behind the Shared Learning Process tool is to engage multiple stakeholders in the decision-making processes and empower them with the management, technical and financial skills to manage their water supply system in an effective and sustainable manner. The Shared Learning Process tool involves an iterative process of knowledge exchange between the various stakeholders. Each step in the Shared Learning Process requires consultation, knowledge-sharing and an exchange of information with stakeholder groups as well as data analysis and assessments by the facilitating agency. Often, the Shared Learning Process also involves external facilitating experts and/or researchers and practitioners who are not members of the community or group but fulfill key knowledge gaps (like climate change data). Since the basis of the Shared Learning Process tool is participatory action research, it recognises diversity and plurality of views and the importance of local knowledge alongside other forms of scientific and technical knowledge. The iterative sessions at multiple scales allow for sequential growth in understanding, which would lead to increased levels of comfort and meaningful dialogue among participants.

The Shared Learning Process tool can be tailored to the specific needs and objectives of many resilience interventions mentioned in the previous chapter. For example, in localities that do not have a community-managed borewell system, the Shared Learning Process can be utilised to bring together the community for source diversification at a community level (existing Municipal piped connection and having a community borewell system instead of individual borewells), thus ensuring equitable distribution to all households (some households may not have enough resources for an individual borewell) and putting a cap on extensive exploitation of groundwater resources. The structure and component of the process tool largely depends on the key goals and how to achieve them. The core idea is to empower communities with the management, technical and financial skills to manage their water supply system in an effective and sustainable manner.

Specifically, the Shared Learning Process would:

- Allow different water stakeholders, especially the marginalised communities, to articulate and present their needs, interests and expectations and to work through differences with others and develop long-term resilience strategies.
- Provide a platform for different water managers to interact. These interactions would facilitate breaking established disciplinary and psychological boundaries that cause groups to reject or discount information, insights and perspectives that challenge their views. They would also help in building trust, rapport and understanding between the formal and informal water managers.
- Provide technical input into the discussion by involving external facilitating experts and/or researchers and practitioners who are not members of the community or group but fulfill key knowledge gaps such as the possible impacts of climate change.
- Create opportunities for the communities and Municipal Corporation to debate and reflect upon a range of options and ways for building resilience.
- Ensure that the perspectives and realities of the intended beneficiaries of the various interventions are accurately recognised in planning.
- The structure and the composition of the Shared Learning Process Tool needs to be contextual and adaptable according to the needs of the community or group. The Shared Learning Process may choose to use any number of participatory and learning and action tools – such as focus group discussions, interviews with formal and informal sectors and detailed household surveys or surveys of informal sector operators.

Support Tools

While Shared Learning Process is an overarching process tool, there are many specific support tools that could be developed in the context of Indore. These are:

Information tools

Some of the resilience strategies suggested in this report have their genesis from the specific information need expressed by the communities/households. Some of these can be in the form of information booklets or brochures describing methods for water quality testing, water conservation techniques (e.g., greywater reuse), etc.

Toolkits can be designed for developing capacities at the city and community scales for specific issues like rainwater harvesting, conjunctive use of water, testing of water quality, etc. This would empower the communities to sustainably manage their water resources. Similarly a capacity-building toolkit for the water managers of formal and private sectors can also be developed for specific purposes like groundwater recharge, use of GIS technology, etc.

Decision-support tools

Decision-making support tools are needed in the water sector to help assess the numerous options available to meet water-related challenges as a result of climate change. Global climate change, with its dramatic impacts on water supply and demand, is forcing a reevaluation of traditional water planning and norms, and will require a shift to a more comprehensive set of water supply-and-demand management strategies and an incorporation of a variety of actors. New approaches to sustainable water supply dubbed the “soft path” emphasise efficiency, decentralised water supply, matching water quality to water demand, smart economics and better governance in water management.

A decision-making support tool can help water managers understand and compare the numerous options available including water supply potential, climate resilience, costs, energy use, etc. This will help all water managers make more informed decisions about water supply.

Residents in Indore requested more information on ways to conserve and reuse water in the household. A decision-making support tool could help residents evaluate their current home water use – such as making www.wecalc.org (see box) useful for an Indian context – and identify all the options to reduce this use and connect them to all the information they would need to implement these changes.

Decision Making Support Tools

The Pacific Institute has done a survey of existing decision-making support tools in the Water, Sanitation and Hygiene (WASH) sector and found much was missing in terms of ability to compare costs, an effective user interface or incorporation of community needs. We created a prototype of a decision-making tool called the **WASH Choices Tool**, www.washchoices.org, as an on-line computer program to provide an example of what might be possible in the sector. The current prototypes cover sanitation options and household drinking water treatment. The on-line programme goes through a series of questions to assess the community and the economic, environmental and cultural context and then proposes a few solutions. The example system also provides information on everything that is needed to build, maintain and implement the selected technology or approach.

We have also created a fully functioning computer program called **WECalc** to help residents in the United States calculate the energy and greenhouse gas implications of their household water use, www.wecalc.org. This calculator also identifies opportunities to conserve water and energy use in the home.

Communication (system visualisation) tools:

Residents, water service providers and the water utility in Indore need far more information about actions taken by each other so that they each can better plan. In order for water managers to meet communities’ water supply and sanitation needs, they require more information on the water arrangements of those they serve. During times of water scarcity, the formal municipal supply of Indore relies on the same groundwater resource base used by the informal water sector; the actions of each user group affect the ability of other users to access water. Currently, however, there is no communication between the municipal utility, private well owners who supply their own needs or those pumping groundwater for other uses. Longer-term concerns, such as climate change, are difficult enough to plan for even where the water utility has complete control of the water resource. In developing countries, where people access water sources directly, no single sector has control over the resource.

Water SMS

In Indonesia, the Pacific Institute is working with PATTIRO and Nexleaf Analytics to create a highly accessible communication and tracking mechanism relying mainly on mobile phones to develop crowd-sourced map data on the state of water services. This tool is intended to increase the exchange and monitoring of information among communities, water service providers and government, in order to improve water services and management of resources in Indonesian cities. By enabling information about water and sanitation problems to flow among communities, governmental entities and service providers, this platform will support rapid, informed decision-making on acute and chronic water problems and provide a tool for communities to advocate for water services, as well as a data-driven dashboard for utilities to better plan for needed new services and manage water sources. Governments can increase service provision to underserved and vulnerable communities; alert residents to service changes; aggregate data on informal water services; unserviced areas and aquifer levels; as well as assess and prepare for risks associated with climate variability and change. Using SMS, email or the web, residents can remotely report conditions such as poor water quality and sewage backflow, register lack of infrastructure to aid in network expansion and view information on the status of service provision and problem resolution.

A more effective tool for communicating about the water resource and water use among all sectors can improve the ability of each actor to better manage and plan for water. An effective system to allow information to flow among all of the water sector mangers could improve the ability of water providers to learn about and then respond quickly to acute, short-term problems their customers are facing and increase the ability of utilities and local governments to improve infrastructure and extend it to areas where there is need.

Resident Community Volunteer Programme, Indore

A notable initiative of the Madhya Pradesh Urban Services for Poor project is an effort to improve citizen access to government. Under the project each of the selected slums has a "resident community volunteer" (RCV), who is entrusted with fostering community participation in planning as well as operation and maintenance of community-based systems. The RCVs acts as a link between the IMC, Zonal office and the community. RCVs are trained at a zonal training centre, which acts as a platform where the RCVs can provide information on problems that the community is facing. (Meetings and focus group discussions with RCVs, March 2010)

A communication tool that creates actionable maps and is publicly available could help improve regulation and accountability of informal water sector providers and make all water providers more accountable to their customers. The ability to quickly communicate to get an overall picture of the system could help communities respond to disasters and plan for climate impacts and population growth. Such a tool could provide key information to enable marginalised groups including the urban poor to obtain improved water and sanitation services.

Participatory Tools

Another type of tool is for facilitating public participation in reporting water leakage and thefts, thereby reducing non-revenue water. This could be in the form of a help-line phone number or an SMS-based (mobile phone) system that would track the locality where leakage or theft is reported.

The use of Resident Community Volunteers under a project in Indore is an example of community participation in managing water at local level and improving the interface between community and the formal water sector. These community volunteers could also address the issue of weak complaints redressal mechanisms, wherein they could act as a link between the community and the *Indradoot* cell of the IMC.

Summary

The above sections highlight the wide array of potential actions that could be undertaken to build resilience in Indore (and potentially other locations) along with the sets of more specific tools that could contribute to the process. The Shared Learning approach represents an overall framework tool for building understanding and engagement by different water managers. Implementing this type of approach could incrementally begin a process that, by focusing first on "doable" steps that address current problems, could begin to address the larger communication and governance issues that block development of more comprehensive solutions.

THE WAY FORWARD

Globally, climate change will have profound implications for water resource supplies. Climate change impacts where, when and how much water falls – complicating long- and short- term planning for water supply. In developing country cities, the impacts of climate change are compounded by rapid urbanisation. The combination of these processes has the potential to seriously threaten urban water security in developing world cities. In this context, municipal water systems and water managers need a strategy to enact a more sustainable, resilient and equitable water system.

Water utilities in these cities must plan in the face of increasing populations, ageing infrastructure and unreliable water supplies. Private water suppliers are also water managers that source water and provide for the needs of residents where the public sector has failed. In cities where the urban water utility does not meet all water needs, individual residents also manage water: each household negotiates a complex set of water sources and prices, including self-supplied groundwater, water from the water utility, as well as private tanker water supplies. While all water managers need an approach to plan for resilience, the urban poor are particularly vulnerable as they have much lower capacity to adapt.

Over three years in Indore, we studied the needs and priorities of every water stakeholder, including water utilities, the private water sector and households. Emerging from this effort was a set of necessary resilience interventions to improve the water security of the urban water sector in Indore. While each city throughout the world will have its own set of resilience interventions, what is universally necessary in resilience planning is bringing all stakeholders together to discuss and agree on impacts, needs and interventions. This report presents a universally applicable *process* to arrive at these.

The resilience planning process conducted in Indore can serve as a model for other communities integrating climate impacts into planning. The project piloted an innovative process for resilience planning – the Shared Learning Process – to identify and understand the core vulnerabilities in the city's water supply system and sub-systems and to suggest a resilience strategy and interventions. The Shared Learning Process brought together all of the water managers in single and multi-stakeholder groups to learn from others as well as articulate their own needs. The study highlights the fact that multiple independent water managers sometimes have conflicting goals. Therefore, resilience-building measures need to be initiated at all levels. The project also developed a range of "tools" that could assist in the resilience-building process both in stakeholder engagement and implementation of the identified resilience interventions.

Core to improving resilience will be improving governance and the capacity of water managers in the urban water sector. Adaptive governance is the ability to manage systems that are accountable, transparent and responsive to change in the society, as well as those brought on by the uncertainties and unpredictability of climate change.

There is also a need for key paradigm shifts in how urban water is managed in developing country cities. Emerging from this project are some key lessons that are applicable in developing urban environments:

- First, it is important to catalyse awareness that water supply and management are the responsibility of not only the Municipal Corporation, but also of consumers and the informal or private actors involved in water supply. While resilience-building ultimately has to be a joint effort, most of the resilience measures could be started or initiated at the household or community levels and should have active support from the Municipal Corporation. In addition, there needs to be better coordination between the formal and informal sectors that are using the same resource base.

- Second, the urban poor are the most vulnerable to climate change impacts and water, and they have the least resources to cope; they merit special attention. Therefore, policies and tools are needed to diversify water supply and promote water storage at all levels, but particularly targeting the urban poor.
- Third, it is important to draw attention to the critical role of groundwater and the need for management of the groundwater resource base. In Indore, because of the Narmada Water supply system, there is minimal focus on local (or groundwater) resources. Local and regional governments need to create better systems of monitoring and conserving groundwater resources, including improving education on the importance of groundwater resources, rainwater harvesting and infiltration, and improving conservation and efficiency.
- Finally, water managers in urban developing country environments need ways to communicate and share information. Because of the numerous users that directly access the water resource, no single water manager has complete knowledge of the status of ground- and surface-water resources that serve the municipality. Climate change and urbanisation further compel water managers to develop methods of multi-directional communication and water system transparency and visualization that will help each water manager better plan in the face of constraints on water availability.

As climate change and urbanisation further limit water availability in urban environments, all water managers need the necessary tools to better understand their interconnections, the status of the water system and strategies to improve resilience. Connecting water managers through on-line and mobile systems and increasing information transparency in the urban water environment are key tools that can improve resilience planning in these cities. As each city develops a resilience strategy, the urban poor need special consideration as they have the least capacity and resources to adapt to water insecurity and are most likely to be negatively impacted. Key to improving climate change resilience will be improving governance in the water sector. National governments and local governments need to support water managers to diversify water supply, promote water storage at all levels, promote effective water management policies, improve water quality and improve connections among all stakeholders in the sector.

Climate change will have dramatic impacts on urban water sectors. By bringing all stakeholders together to plan in the face of increasing water insecurity and implementing improved governance and water management strategies, Indore and cities throughout the developing world have a chance to create water systems that sustainably and equitably meet present and future water needs.

Carrying water in plastic jars. © TARU

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