Water Security in Peri-urban South Asia

Adapting to Climate Change & Urbanisation

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ISBN 978-81-929178-0-1

Citation: Prakash, Anjal and Sreoshi Singh (Eds). 2013. *Water Security in Peri-urban South Asia: Adapting to Climate Change and Urbanisation*. Hyderabad. SaciWATERs and IDRC.

This project was supported by the International Development Research Center Canada.

First Edition: June, 2013 (200 copies)

Second Edition: January, 2014

Published by: SaciWATERs, India

Book design: Somya Darshan Jee and Mohd Abdul Fahad

Cover illustration: Somya Darshan Jee

We would like to thank Dr. Kuntala Lahiri Dutt for critically looking at this report and providing valuable comments.

Editorial assistance: Karthik Seshan

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Abbreviations

APIIC	Andhra Pradesh Industrial Infrastructure Corporation
BBS	Bangladesh Bureau of Statistics
BPO	Business Process Outsourcing
CCA	Climate Change Adaptation
CGWB	Central Groundwater Board
CRIDA	Centre for the Research in Dryland Agriculture
DO	Dissolved Oxygen
DoE	Department of Environment
EC	E-coli
FGDs	Focus Group Discussions
FTI	Frequency-Time Index
GECIS	GE Capital International Services
GHMC	Greater Hyderabad Municipal Corporation
HMDA	Hyderabad Metropolitan Development Authority
HMWSSB	Hyderabad Metropolitan Water Supply and Sanitation Board
HUA	Hyderabad Urban Agglomeration
HUDA	Haryana Urban Development Authority
IAY	Indira Awas Yojana
IKP	ICICI Knowledge Park
IT	Information Technology
ITES	Information Technology Enabled Services
KCC	Khulna City Corporation
KPO	Knowledge Process Outsourcing
KWASA	Khulna Water Supply and Sewerage Authority
MCH	Municipal Corporation of Hyderabad
MNCs	Multi National Corporations
NGO	Non-Government Organisation
ORR	Outer Ring Road
PHED	Public Health Engineering Department
PRA	Participatory Rural Appraisal
REEDS	Research in Environment, Education and Development Society
SEZs	Special Economic Zones
TDS	Total Dissolved Solids
UA	Urban Agglomeration
VDC	Village Development Committee
VWSC	Village Water Sanitaiton Committee
WHO	World Health Organisation

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Acknowledgement

This report is the outcome of an action research project that explores the implications of rapid urbanization and climate change on water availability for vulnerable communities in four South Asian cities namely, Khulna (Bangladesh), Gurgaon and Hyderabad (India) and Kathmandu (Nepal). This three year project started in 2010 and was supported by IDRC's Climate Change and Water program. The project was led by the South Asia Consortium for Interdisciplinary Water Resources Studies (SaciWATERs) in partnership with the Institute of Water and Flood Management (IWFM) at the Bangladesh University of Engineering and Technology (BUET) and the Nepal Engineering College (nec). All the associated organizations and individuals who have contributed in a substantive way to this research effort are acknowledged. The contributors of this report express their gratitude to Dr. Sara Ahmed, Senior Program Specialist, IDRC- Asia Regional Office, New Delhi for her intellectual support and guidance through the process of project implementation. Generous support from IDRC grant for facilitating this action research project is also acknowledged.

We thank Dr. Kuntala Lahiri Dutt for providing valuable comments on this report. Karthik Seshan has assisted in copy editing of the first edition of this report, while design coordination has been done by Mohd Abdul Fahad. The layout and typesetting has been done by Somya Darshan Jee whose support is gratefully acknowledged.

Preface

SARA AHMED

Urbanisation is projected to be a defining feature of demographic change in South Asia. However, the rapid development of new habitations, infrastructure and services has been sustained through the growing acquisition of agricultural lands from the urban periphery. Additionally, this new development has often been built on traditional water sources, curtailing access to water and leading to greater competition between diverse water users. Growing urbanization has also affected the quality of water as wastewater infrastructure is non-existent, inadequate or poorly maintained.

Changes in land and water use have been further accentuated by the increasing impact of climate change on water availability and the increasing frequency of extreme events, particularly floods and droughts. Vulnerable communities, women, children, the elderly and physically challenged are typically the most affected but research on the differential impacts of climate change on water security is limited. Equally, there is little research on how vulnerable communities and individuals are adapting whether in terms of building social capital, adopting new technologies or seeking new livelihood options, including migration. Understanding the cost effectiveness of different autonomous adaptation strategies and how they intersect with or are strengthened by planned interventions is critical to policy on climate change adaptation, specifically the development of local and national adaptation plans.

In 2010, IDRC's Climate Change and Water program initiated support for an action research project on Water Security in Peri-urban South Asia: Adapting to Climate Change and Urbanization. Led by the South Asia Consortium for Interdisciplinary Water Resources Studies (SaciWATERs) in partnership with the Institute of Water and Flood Management at the Bangladesh University of Engineering and Technology and the Nepal Engineering College, the project sought to understand the drivers and impacts of urbanization and climate change on water security in four peri-urban locations: Khulna (Bangladesh), Gurgaon and Hyderabad (India) and Kathmandu (Nepal).

This report is an outcome of three years of research using a mix of qualitative and quantitative tools drawing on economic methods (cost benefit analysis), vulnerability indicators and an assessment of climatic trends likely to impact water security. Additionally, the project has supported capacity-building for key stakeholders in participating peri-urban communities, decision-makers at different levels of governance and a number of young researchers from India and overseas. The interdisciplinary project team includes several accomplished academicians and researchers who have been able to forge links with civil society networks; and important national and international policy forums on urban and peri-urban issues, resilient infrastructure development and equitable water management and governance.

On behalf of the Climate Change and Water team at IDRC, I would like to express our gratitude to the research teams, partner institutions and affected peri-urban communities who shared their life experiences with our project team in the hope that we could help them build a more sustainable future.

Sara Ahmed
Senior Program Specialist
IDRC, Asia Regional Office, New Delhi
June, 2013

Executive summary

Urbanisation is a defining process and characteristic of South Asia. South Asia is home to over 1.6 billion people in 2010 or a quarter of humanity, of which a third live in urban areas. This figure is expected to grow at an accelerated rate in next two decades. Water sources in peri-urban locations succumb to growing pressures from the cities as new and emerging claimants compete for scarce water; at the same time, the disposal of urban and industrial wastes into peri-urban water sources further compromises peri-urban water security. The effects of these are aggravated by climate variability and change. In 2010, Canada's International Development Research Center (IDRC) supported an action research project focusing on how urbanization and climate change shape peri-urban water insecurity and how water users adapt to these changes. This report is an outcome of the action research project that explores the implications of rapid urbanization and climate change on water availability for vulnerable communities in four South Asian cities of Khulna (Bangladesh), Gurgaon and Hyderabad (India) and Kathmandu (Nepal). Based on the gender and class disaggregated information, the report shows how people especially women and men from marginalised communities are coping with the changing scenarios and adapting to the new situation.

Further, this report documents the mobilization of affected communities and relevant line departments as key stakeholders in the process of building resilience to the process of urbanization, climate change increased water scarcity. It documents how a large number of stakeholders have been brought together that are affected by the process of urbanization and climate induced water insecurity or have potential to influence the issues at the ground level. This process was important in present research locations because peri-urban areas tend to be neglected both by urban and rural authorities – since some of their problems fall under the mandate of neither. Some of the intervention villages in peri-urban areas are largely characterized by traditional livelihoods where the population is hard-hit due to the rapid urbanization processes, whereby land is in greater demand for construction of buildings. Being nearer to the sea, climate change impact is very specific for Bangladesh, while in Gurgaon and Hyderabad in India, process of change has been induced by massive growth of the Information Technology (IT) sector. In Nepal, apart from the fragile mountain ecosystem disturbed due to urbanization process, the impact of melting glaciers due to global warming generates much concern for the future.

This report is divided into seven chapters. The introduction chapter is followed by four chapters dedicated to the issues and outcomes from each of the four research sites. Chapter 2 talks about issues of climate change, salinity intrusion and water insecurity in peri-urban Khulna in Bangladesh. Chapter 3 and 4 focuses on Gurgaon and Hyderabad in India discussing the issues of the growing city encroaching the peripheral areas (Gurgaon) and expansion of Hyderabad at the cost of its precious water resources. Chapter 5 presents the case of Kathmandu in Nepal showing how urbanization and climate change process in the Himalayan city is leading to water insecurity for the poor in its peri-urban locations. Chapter 6 focuses on the cost benefit analysis for drinking water by studying the Mayur River in Bangladesh. Using the economic tools of valuation, the study provides economic justification of reviving the river for Khulna city and its peripheral areas. Chapter 7 concludes this report summarizing the key findings and lessons from the study.

KEY LESSONS FROM THE STUDY

Climate variability, urbanization and peri-urban water insecurity: The research confirms that urbanization creates new claimants on water on two counts. First, fresh water flows from per-urban to urban uses as cities are not fully covered with formal water supply system and new demands are generated which utilities are unable to meet. Second, the increased demand for land leads to appropriation and contamination of land and water resources in urban and peri-urban locations. Climate variability and change brings in multiple stressors to this process of transformation. Planned urbanization that incorporates environmental planning, climate smart development and local resource use will help reducing vulnerabilities of peri-urban residents.

Disaggregating vulnerabilities: Gender, class\caste and access to water: The gender and class\caste disaggregated data collected in the research shows entwining of caste\class and gender issues that defines water allocation and access among users.The evidence of vulnerability and its impact on people lower in socio-economic hierarchy is evident from the present research. We found that there is no uniform gender disaggregated data in the water sector collected officially. Lack of data provides lack of evidence or status of the changing relationship between gender, class\caste and water access. This study, therefore suggests disaggregating vulnerabilities to reach the people who needs help the most.

Climate science verses local perception: Local adaptation at its best: The research found that, most of the climatic data analysis has been concentrated at aggregate level and is generalized to represent the country\ region. With extensive variations in topography and microclimate there is need of site specific climatic data analysis to understand the climatic variation at local contexts which this research has catered to. We also found that local perception is an important aspect of adaptation. People develop strategies to cope with the changes in the short run and to adapt to the long term changes based on their dynamic and evolving knowledge, whether or not they are consistent with meteorological data.Our research also shows that in most of the cases, local perception is very close to the climatic trends but there is a need to marry the science and perception for better adaptation outcomes.

Stakeholders' engagement is critical and paramount: Our research shows that local communities are struggling to find ways to prepare for the potential impacts of climate change while dealing with immediate pressures through changing agricultural practices, livelihoods and coping with water stress.Our engagement in this project shows that existing management approaches do not adequately incorporate changing stakeholder preferences. Affected communities are mostly aware of the trade-offs but that is not reflected in the planning process because of the gap between policy and practice. This project tried to include stakeholders' participation at the local level and has shown initial success. The experience therefore shows that stakeholders' engagement is not only critical but also paramount for better urban planning aimed at sustainability of resources.

Introduction

VISHAL NARAIN

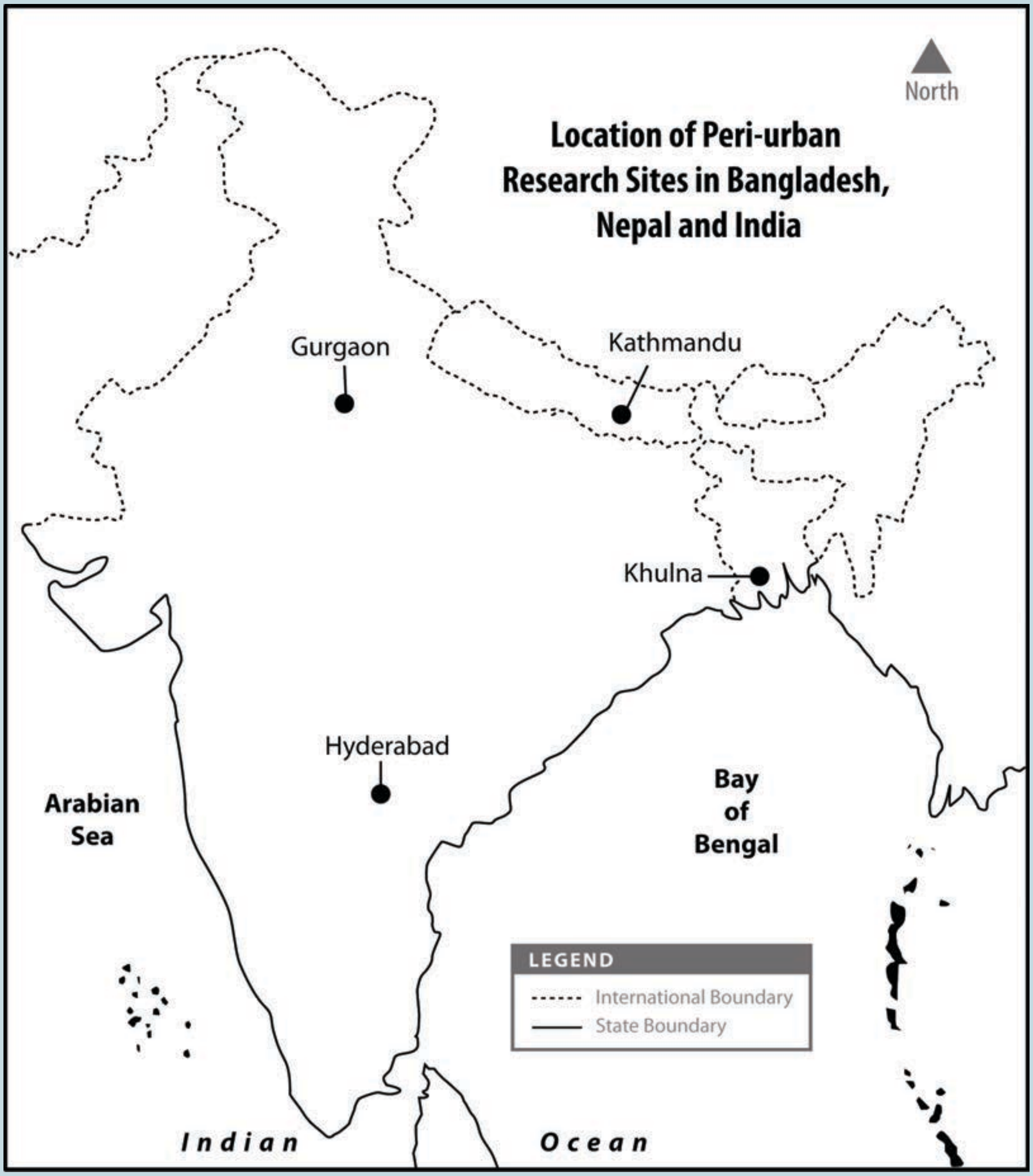

Fig. 1.1: Location of the project sites in South Asia

Source: Improvised from www.mapsofindia.com and research sites added

1 introduction

1.1 URBANISATION, CLIMATE CHANGE AND PERI-URBAN WATER SECURITY

Urbanisation has been an important trend of the 20th century. More than 50 per cent of the world's population currently lives in urban areas, a figure that is expected to increase to 70 per cent by 2050 (UN-HABITAT, 2007). Asian cities are likely to account for more than 60 per cent of this increase. In several South Asian cities, growth and expansion picked up after the 1990s. This growth was led by neo-liberal economic policies, policies favouring the growth of special economic zones and a real estate boom. Both local and global actors have had a role to play in this expansion. Most of these cities in South Asia expand horizontally over space, changing the use of land at the junction between the rural to urban areas, and the transformation of land and water resources at this urban periphery is an integral part of this physical expansion. These peripheral areas serve the urban centre as the sinks of its wastes, while providing the much-needed land and water resources for the urban residents. With changes in land use supporting urban expansion, changes in water use follow suit.

Within a short period, water sources in peri-urban locations succumb to the growing pressures from ever-expanding cities as new and emerging claimants compete for limited amounts of water. At the same time, the disposal of urban and industrial wastes into peri-urban water sources further compromises peri-urban water security. The effects of these are aggravated by climate variability and change. Climate change exacerbates the effects of the above through changes in the frequency, timing and intensity of precipitation, incidence of storm surges and extreme events, sea level rise and salinity intrusion.

This report shows how expanding cities in a scenario of climate change together create water insecurity in peri-urban areas and how water-users view and adapt to these changes. The report outlines the results of an action research project undertaken in four South Asian cities, namely, Khulna in Bangladesh, Gurgaon and Hyderabad in India and Kathmandu in Nepal. Figure 1.1 shows the location of these cities in South Asia.

These cities represent different institutional and agro-ecological contexts in which the combined effects of urbanization and climate change present themselves. Khulna presents the case of a coastal city facing threats of sea level rise and salinity intrusion. Kathmandu presents the case of urbanization disrupting the fragile hill environment. Gurgaon and Hyderabad have witnessed urban expansion after the neo-liberal economic policies were adopted in the 1990s. The growth of these two cities was led by information technology and

the business process outsourcing sectors.

1.2 CONCEPTUAL FRAMEWORK FOR THE STUDY

In this study, peri-urban water security is seen as being shaped by the twin processes of climate change and urbanisation. These processes act as multiple stressors on peri-urban water sources and create a situation of uncertain water supply for peri-urban communities.

The effects of urbanisation occur from changing land-use patterns that engender changes in water use through the links between land tenure and water security. The expansion of the city through new buildings and roads change the water flows. Moreover, the use of these water bodies to dispose of urban wastes further compromises peri-urban water security (Prakash and Singh et al. 2011).

Land acquisition and land use change, essential features of peri-urban contexts, directly affect the access of peri-urban residents to water, as they lose access to water sources located on those lands. At the same time, the presence of multiple claimants in the peri-urban locations increases the stress on water resources. Urban and industrial actors may be able to employ expensive technologies for water extraction such as submersible pump-sets that cannot be afforded by the local population, who lose out in the race for appropriating water. Rural-urban water flows to quench urban thirst, acquiring common property water resources for urban expansion and discharge of urban wastes into rural water bodies are other manifestations of peri-urban water insecurity. The effects of these pressures on peri-urban water sources are aggravated by climate change and variability. These take the form of changes in the frequency and intensity of rainfall, occurrence of extreme events such as floods and droughts, sea-level rise and salinity intrusion (IPCC 2007).

However, peri-urban residents are not passive recipients of these change processes affecting their water security. They adapt to this situation using a mix of technologies and institutions at both the household and collective levels. Their differential vulnerabilities are shaped by their exposure to these processes as well as their access to resources, technologies and institutions that

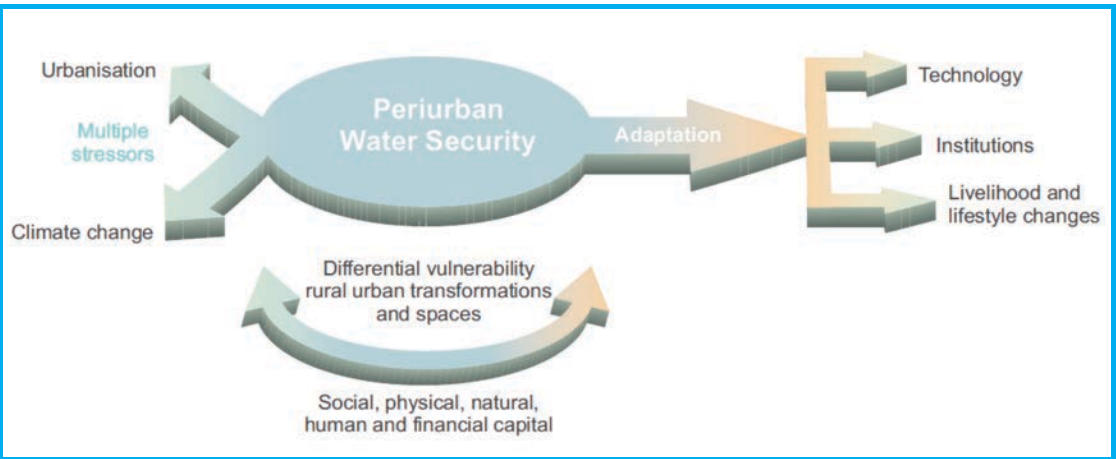

Fig. 1.2: Conceptual Framework for the study
Source: Author's compilation

help mitigate the pernicious effects. Figure 1.2 presents the conceptual framework for the study.

1.2.1 Defining the peri-urban space

While there is no unanimity regarding the meaning of the term peri-urban, there is a growing consensus in the literature that the definition of peri-urban goes beyond the definition of a geographic location (Iaquinta and Drescher 2000; Narain 2009; Narain and Nischal 2007; Simon and McGregor et al. 2006; Dangalle and Narman 2006). A focus on conceptual distinctions is appropriate for examining the physical space that lies within the continuum between the two poles of urban and rural, and for understanding the dynamics of change as they affect particular parts of the peri-urban zone. Additionally, it has been noted that'no single definition will fit all circumstances and situations unless couched in broad and functional terms' (Simon and McGregor et al., 2006: 10).

Therefore peri-urban space is defined here in terms of processes and features rather than a fixed distance or location away from the city. Thus, the word 'peri-urban' has been used not so much in its narrow, geographical sense, but more widely as an analytic construct to study the relationships between urban and rural activities, processes and institutions, especially as they pertain to water. The specific research locations were selected on account of the presence of certain characteristics, rather than their distance from the nearest towns or cities. In particular, the project teams focused on the evidence of changed water flows between rural and urban areas and other land use changes in peri-urban contexts that had a bearing on the use and management of peri-urban water resources.

The fact that the peri-urban areas are always in a flux, in a process of transition, renders it futile to draw precise spatial boundaries around them. Some common features, however, can be identified: peri-urban areas are situated within the metropolitan areas but are often outside of the formal urban jurisdictions; both agricultural and non-agricultural activities exist simultaneously, though the agricultural and rural characteristics are gradually replaced by urban landscapes and attendant changes in people's lifestyles; the continuous flow of people both from the urban core and the rural hinterland results in a complex social fabric (Dangalle and Narman 2006). Peri-urban areas are also spaces where the process of social exclusion is experienced by some people, particularly the inhabitants of informal settlements who are poorly served by infrastructure and services (Ranjan and Narain 2012; Narain 2012 a, b; Mycoo 2006).

As demonstrated in the subsequent chapters of this report, understanding aspects of peri-

urban water insecurity requires attention to the changing flows of water between villages and urban centres. These flows are often two-way: water flowing from the villages to cities to quench urban thirst and also the reverse flows of wastewater from the city to the village, widely used in agriculture but with adverse long term health impacts. Besides, these flows are not necessarily physical, as marked by the physical flows of water from the village to the city or vice-versa (for instance, through tankers), but they may also be in the same location; for example, groundwater in a village being used by urban residents or industry, and industries discharging their wastes into rural water sources.

1.2.2 Adaptation

The IPCC (2007) defined Climate Change Adaptation (CCA) as an adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploit benefit opportunities. The concept of adaptation is rooted in the role of human agency in dealing with environmental and physical stresses. It emphasises that humans are not passive recipients of adverse environmental changes, but exercise ingenuity and creativity in minimizing their negative impacts or exploit them to benefit themselves. The subsequent chapters show how peri-urban water-users innovate both technologically and institutionally to reduce their vulnerability to water insecurity. These responses occur both at the household and collective levels.

1.3 METHODS AND APPROACHES

The researchers involved in this project have used a mix of both qualitative and quantitative research methods in the project. In the field,PRA (Participatory Rural Appraisal) tools such as time lines, trend lines and seasonality analyses were used to capture local perceptions of climate change and variability. People's narratives of a changing climate were used to capture their lived experience of climate change. These were juxtaposed with quantitative analyses of secondary meteorological data on key climate parameters across the research locations.

Semi-structured household interviews and focus group discussions were used to assess and understand their adaptation strategies and responses, the implications of the interface of urbanisation and climate change for water security, factors shaping the differential vulnerabilities and changing gender relations around water. A structured household survey was also conducted to collect gender-disaggregated data on water consumption at the household level as well as to capture inter- household variations in water access. Cost-benefit analyses of adaptation strategies in place were carried out in one of the locations.

1.3.1 Engagement with stakeholders and communities

The project team members used a wide range of methods to engage with the community, civil society organisations and state agencies. A wide range of stakeholders were involved in the project from the very beginning to sensitize them to peri-urban water security issues and to garner momentum for change. A wide range of intervention strategies were used, involving both the water-users and service-providers. These include stakeholder meetings to promote dialogue between government agencies and water-users, lobbying for the protection of water sources with government agencies and service-providers and mobilizing communities for the formation of water-user groups and committees.

Participatory Rural Appraisal in progress in peri-urban Gurgaon, India

Engaging with stakeholders and communities in peri-urban Khulna, Bangladesh

Semi-structured interview in progress - peri-urban Hyderabadm India

1.4 ABOUT THE REPORT

This report is divided into seven chapters. The introductory chapter is followed by four chapters outlining the issues and outcomes from each of the four research sites. Chapter 2 discusses the challenges of climate change, salinity intrusion and water insecurity in peri-urban Khulna in Bangladesh. Chapters 3 and 4 focus on Gurgaon and Hyderabad, respectively in India and discuss the issues of the growing city encroaching the peripheral areas (Gurgaon) and expansion of Hyderabad at the cost of its precious water resources. Chapter 5 presents the case of Kathmandu in Nepal showing how urbanisation and climate change processes in the Himalayan city are leading to water insecurity for the poor in peri-urban areas. Chapter 6 focuses on the cost benefit analysis of reviving the Mayur river as a source of drinking water in Bangladesh. Using the economic tools of valuation the study provides economic justification of reviving the river for the residents of the peri-urban areas of Khulna. Chapter 7 concludes this report summarizing the key finding and lessons from the study.

Climate change, salinity intrusion and water insecurity in peri-urban Khulna, Bangladesh

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M SHAHJAHAN MONDAL
UTHPAL KUMAR
REZAUR RAHMAN
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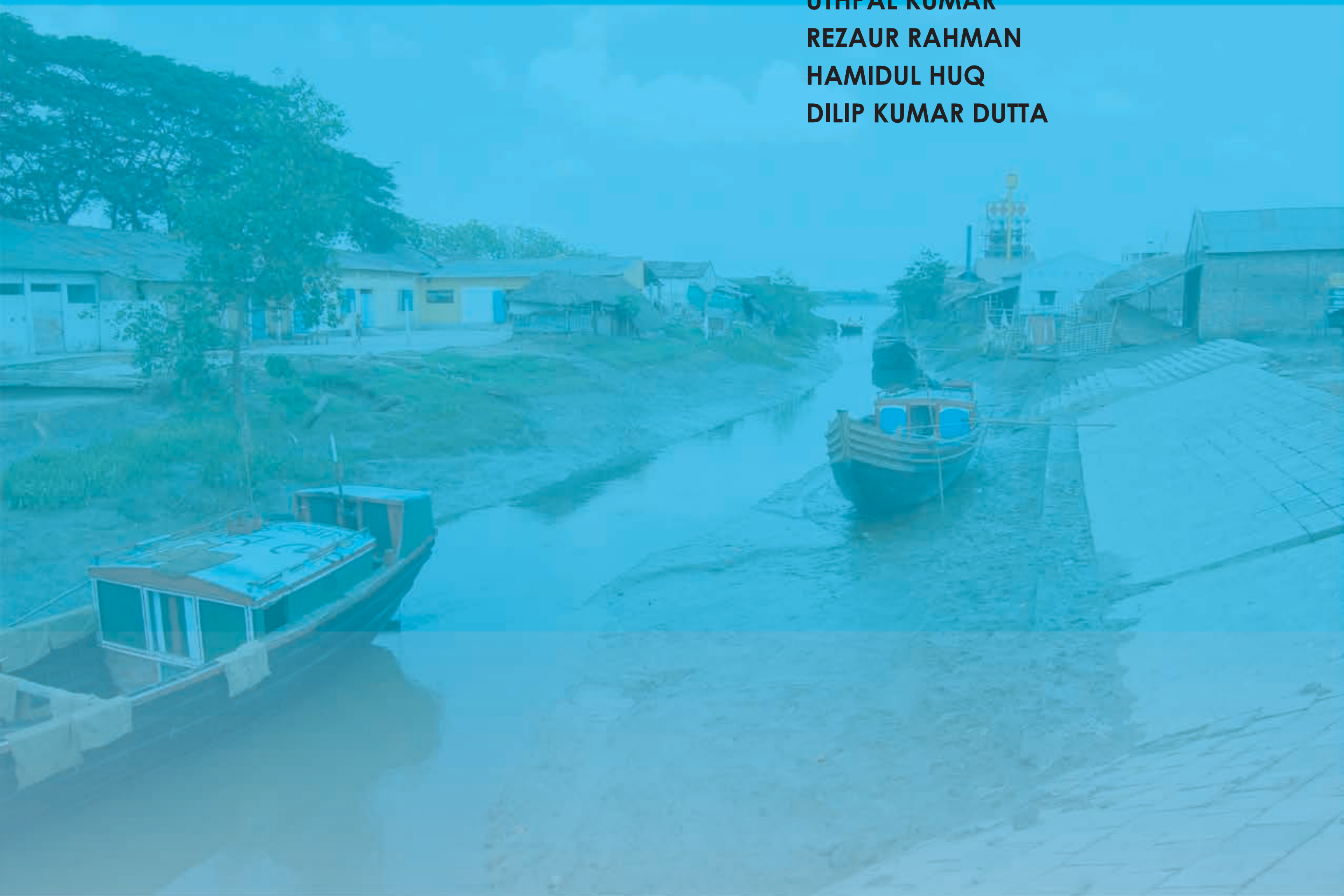


2 Khulna

BANGLADESH

2.1 INTRODUCTION

Khulna is the third largest metropolitan city of Bangladesh and one of the fifteen most climate change vulnerable cities of the world (BBS, 2011; IIED, 2009). Situated in the south-western coastal region of Bangladesh and in close proximity to the Sundarbans, it was once known as an industrial city with direct access to an adjacent large sea-port at Mongla. Khulna city is located along a natural levee of the Rupsha-Bhairab River on the Ganges tidal floodplain that is characterized by low relief, intricate river networks, tidal marshes and swamps. The land surface of Khulna is relatively flat with an average elevation of approximately 2.5 m above the mean sea level. The average slope of the land surface in the city is westward, whereas the regional slope is southward. This slope difference causes natural gravity drainage predominantly towards the Mayur River on the west, which is hydraulically linked with the Rupsha River. The upper aquifers of Khulna are prone to saline water intrusion because of their hydraulic connection with the Rupsha River. Khulna area lies on the Late Holocene-Recent alluvium of the Ganges deltaic plain in the north and Ganges estuarine plain in the south (Adhikari et al., 2006), within the foredeep part of the Bengal Basin. The surface lithology of the area is characterized by tidal deltaic deposits, deltaic silt deposits, and mangrove swamp deposits (Alam, 1990).

Urbanisation and climate change have had serious impact on water resources in the urban and peri-urban areas of Khulna. The effects are evidenced by the fact that the hydro-meteorology of the area is changing, that salinity in the surface water and groundwater has been a major concern in the Khulna area, and flooding and drainage congestion have become difficult to deal with. In most places fresh water is available only from deeper aquifers or from a few surface water bodies, thus limiting access within the urban and peri-urban areas. At the same time, the city has grown rapidly in recent decades. Sea-level rise along with rapid urbanisation is also likely to aggravate the rainfall flooding, water logging and drainage congestion situations in the area. Urbanisation is diminishing and polluting the open water bodies, and threatening their subsistence uses including washing, bathing and livestock rearing in the peri-urban areas. The Mayur River, flowing through the western fringe of the city and its peri-urban areas, has been a major source of fresh water for both areas over a long time. Natural tidal flow in this river has been obstructed due to the construction of salinity control structures, transforming it into a closed water body. Encroachment and disposal of urban wastewater and solid waste have reduced the carrying capacity of the river and severely degraded the water quality. This has resulted in adverse impacts on ecosystem services,

livelihoods and water security, affecting women, the elderly and children most. The Mayur also links the urban and peri-urban areas, and plays a key role in reducing the vulnerabilities of the peri-urban communities. The degree of vulnerability varies among different stakeholders, and peri-urban residents adapt to these situations using diverse strategies.

2.2 THE RESEARCH LOCATIONS

Based on a scoping study, three peri-urban sites were identified from the initially-selected twelve sites for further detailed study, vulnerability assessment and action input mobilization (Figure 2.1). These sites were selected based on heterogeneity in land use, mixed institutional arrangements, diversity in livelihood options and issues of dependence on urban resources, urban/peri-urban hydrological linkages, the urban/peri-urban water use nexus, and vulnerability to water stress. These criteria were selected on the basis of issues identified by stakeholders, and information gathered from the literature.

Three sites, namely Alutala, Labonchara and Chhoto Boyra, were finally selected for the research. Table 2.1 shows the general characteristics of the three selected peri-urban communities. A central focus of this research was on promoting a participatory multi-stakeholder platform and policy advocacy to save the Mayur River.

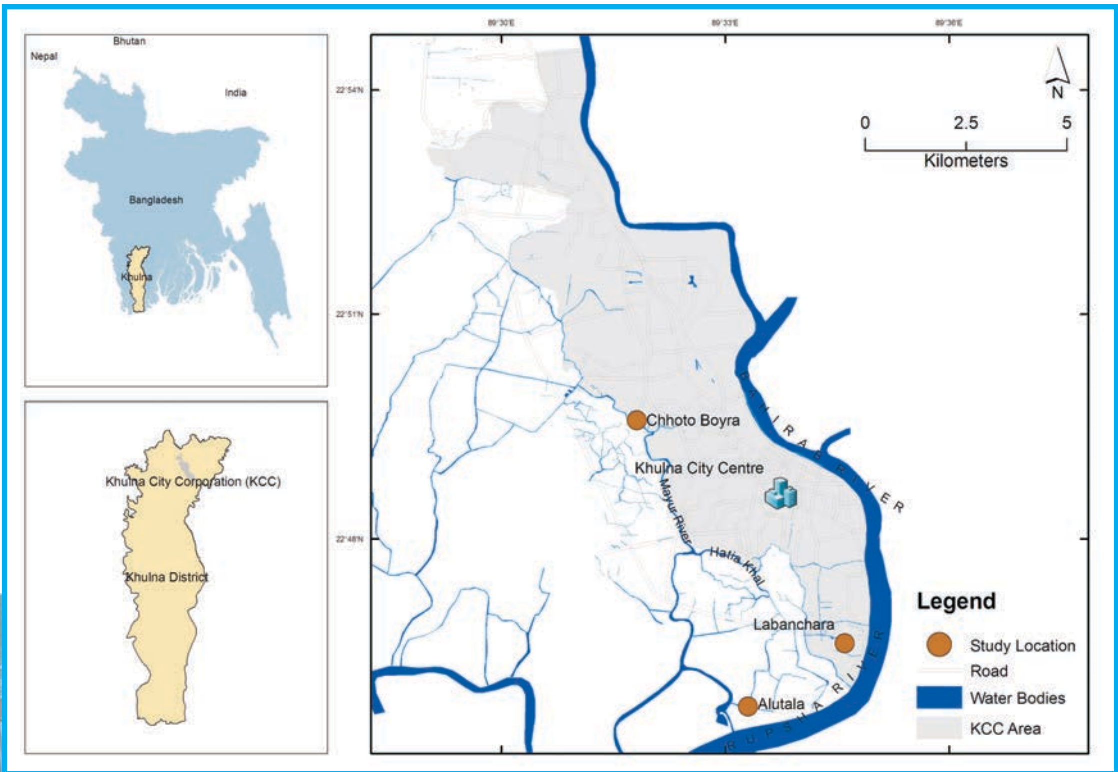
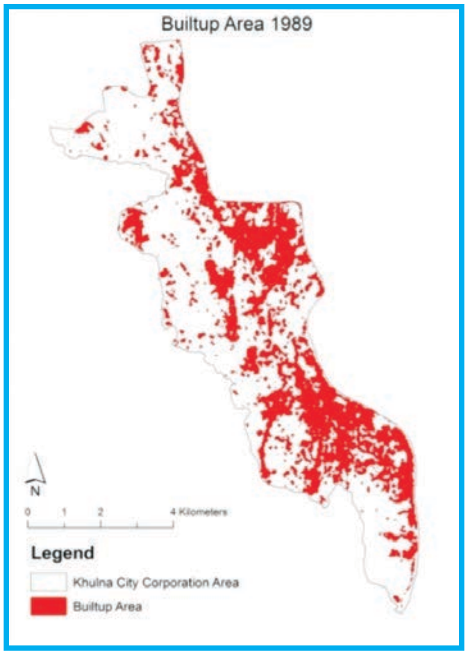
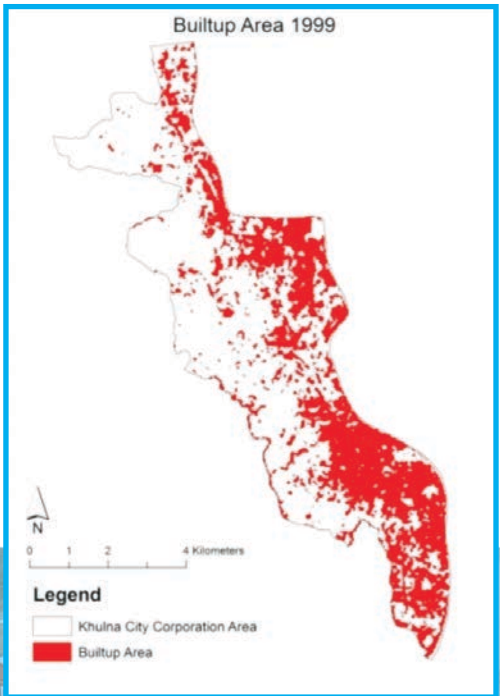


Fig 2.1: Location of the peri-urban research sites in Khulna, Bangladesh
Source: Developed by the authors using GIS

Location	Socio-economic characteristics	Issues/problems identified
Alutala	Alutala is 2-3 km away from the Khulna City Corporation (KCC) boundary. It is located in Botiaghata upazila of Khulna district. Agriculture, fisheries and livestock rearing are the major livelihoods options of the local communities. Some are also engaged in the city's informal sector.	Conflict between urban and peri-urban water users of the Mayur. Vulnerable to climate change and sea level rise. Vulnerable to flooding and water logging due to rainfall. Salinity ingress and arsenic contamination in groundwater. Absence of participatory regulator operation.
Labonchara	Labonchara is located near the Rupsha bridge within the city boundary with thousands of households in North and South Labonchara. Most of the people are dependent on informal business in the city and adjacent peri-urban areas.	Acute water scarcity for drinking, washing and sanitation. Vulnerable to water logging due to absence of drainage system. Salinity and water pollution limits access to safe water for drinking and sanitation. Absence of any institutional framework. Existing natural channels are not properly functional.
Chhoto Boyra	Landuse in Chhoto Boyra is still agriculture dominated. Thousands of farmers are dependent on the Mayur river's water for irrigation. A significant number of people are engaged in formal and informal businesses and service sectors in the city.	Acute water scarcity for irrigation. Conflict in water use between urban and peri-urban users. Vulnerable to rainfall flooding and water logging. Solid waste dumping in the Mayur river. Lack of institutional arrangement for saving the Mayur river.

Table 2.1: Characteristics of the selected peri-urban sites of Khulna
Source: Field survey- 2011





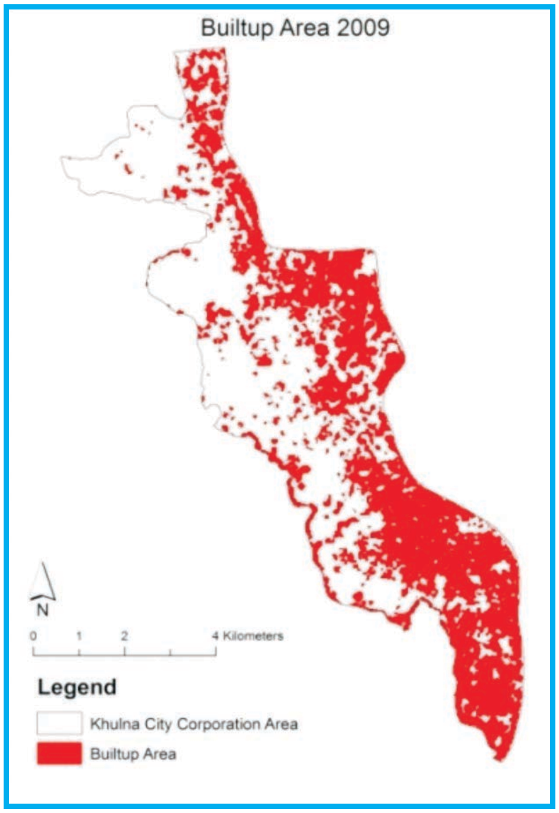


Fig 2.2: Growth of built-up area within the Khulna City Corporation boundary

Source: Developed by the authors using GIS

2.3 URBAN GROWTH TRENDS IN KHULNA

Khulna serves as the central urban corridor of the southwest coastal region of Bangladesh. Historically, Khulna was a market town and the seat of regional administration. During the early days, tobacco and sugarcane were traded at the river port with extended trading links with Calcutta (now spelt as Kolkata). Khulna was declared a municipality in 1884, and was connected to the regional railway network in 1885. Industrialization accelerated in Khulna in the 1950s and 1960s mainly due to jute processing and trading, and the establishment of newsprint and match factories (Murtaza, 2001). After an interim economic stagnation during the 1970s and 1980s, the local economy has been re-strengthened due to shrimp export processing activities.

Continued urban growth and socio-economic development have changed the land use pattern of the region. Figure 2.2 shows that the built-up area within the Khulna City Corporation (KCC) area has been gradually growing during the period 1989-2009.

Substantial growth took place in the south-eastern part of the city where a bridge over the Rupsha River was constructed in the early 2000s. This increase in built-up area within the city has been accompanied by a resultant decrease in fallow land, low land and water bodies (Figure 2.3). The area covered by vegetation, however, has remained almost the same after an increase from 1989 to 1999.

Demographic characteristics indicate that the population growth in Khulna has been approximately 3.8% on an average with a present population of 1.05 million within the administrative boundary of the metropolitan area (BBS, 2012).

The population growth was significantly higher during the post-liberation (1971) period than the pre-liberation period (Figure 2.4); however, during the last decade (2001-2011), Khulna experienced negative growth within its city boundary according to Bangladesh Bureau of Statistics (BBS) data.

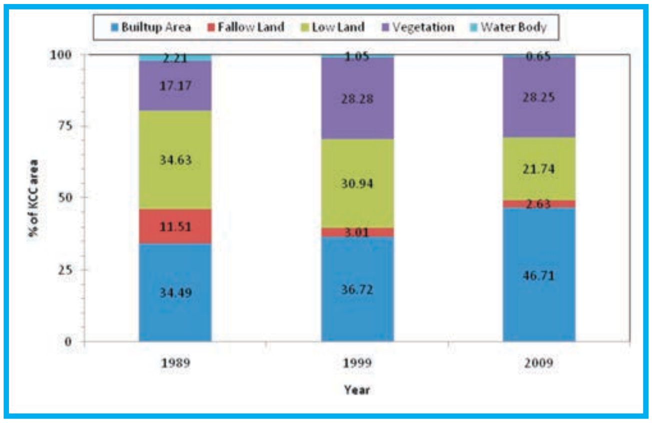


Fig. 2.3: Changes in land cover within the Khulna City Corporation boundary

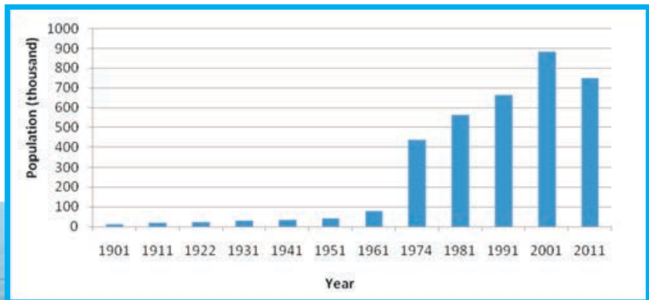


Fig. 2.4: Population growth in Khulna City
Source: BBS: 2001, 2011

One cannot be too sure, but this negative growth may possibly be related to the loss of livelihood opportunities resulting from climate change-induced disasters, and associated social, economic and environmental hazards.

2.4 CLIMATE CHANGE STRESS

The geographic setting of Khulna makes it sensitive to climate change stressors. The low-lying coastal topography and the rural people's dependence on natural resources for their subsistence make this region more vulnerable to climate change impacts. Temperature increase, sea level rise, changes in rainfall pattern, increases in cyclone frequency and intensity, and tidal saline water incursion are the principal climate change induced stresses having major ramifications on people's lives and livelihoods. In recent times, the frequency and intensity of climatic disasters, particularly those associated with cyclones and storm surges, have increased. Hydro-meteorological data of the region were analysed to identify potential stresses through determination of historical trends in climatic variables and tidal river water level, and by correlating the changes with regional hydrology. Trends in hydro-climatic variables such as temperature, rainfall, sunshine, humidity, fresh water inflow and tidal water level in the region were assessed. A correlation between the fresh water flow from the Gorai River, a major distributary of the Ganges River, and the salinity level in the Rupsha River near Khulna, was also investigated.

The results of our analysis indicate that the temperature of Khulna is rising very fast since 1980 (Figure 2.5a). The rate of rise is much higher than that reported elsewhere based on long-term observed data or climate model projections. The number of extremely cold nights is decreasing and the heat index is increasing. The sunshine duration shows a decreasing trend and the humidity shows an increasing trend. Rainfall is increasing in terms of both magnitude and number of rainy days (Figure 2.5b).

However, the annual maximum rainfall and the number of days with high intensity rainfall

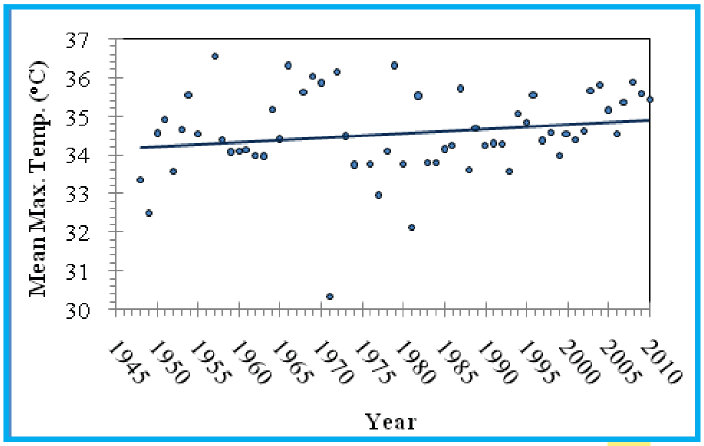


Fig 2.5a: Trends in mean maximum temperature in the month of May

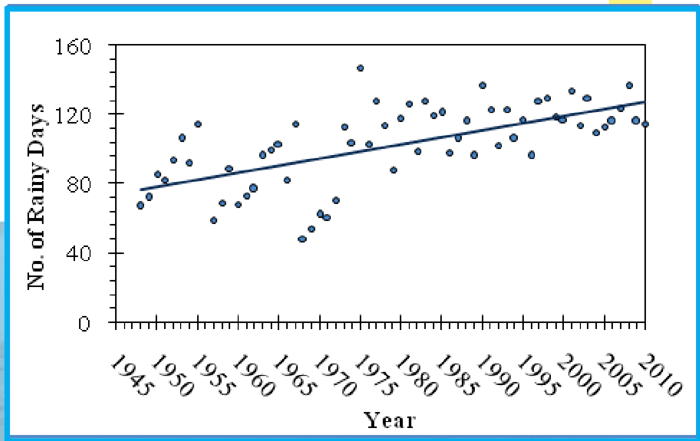


Fig 2.5b: Number of rainy days in a year in Khulna

Source: Authors' analysis using data from BMD.

have remained almost static. The annual maximum tidal high water level is increasing and annual minimum low water level is decreasing at a rate of 7-18 mm and 4-8 mm per year, respectively. There is a negative correlation between the Gorai flow and the river water salinity around Khulna. The dredging of the Gorai during 1998-2001 resulted in improvement of the salinity situation in the Khulna region. Variation in water salinity, tidal water level and fresh water flows in different time periods indicates that human interventions through upstream diversion and coastal polder construction have contributed more to hydro-morphological changes in the southwest than climate change

The gender-disaggregated baseline survey conducted among 125 households with 250 respondents in three selected peri-urban sites indicates that there is variation in the local perception of climate change across the three sites (Figure 2.6). Temperature related manifestations (i.e. warmer and frequent hot days, warm spells, etc.) of climate change are, to some extent, perceived more by the female respondents. Other manifestations, such as drought, cyclone, flood and salinity intrusion, are perceived more by the male respondents. Such difference in perception may be due to the fact that the male respondents are more exposed to the external environment than the females. Such perceptions are also linked to the observed urbanisation rate of the respondents. Those who believe that urbanisation rates are high in their localities, also tend to perceive that climate change manifestations are more strongly felt.

Stakeholder interactions, interviews and participatory mapping exercises revealed that the peri-urban residents do not experience long winters these days. They now wear warm clothes only for a few days during the winter and experience hot and humid weather during the rest of the year. They perceive that in general the climate is becoming warmer. In the past, temperatures were not as high as they are today. Gentle breezes rarely blow in the summer season now. Peri-urban residents also perceive that heavy rainfall events are increasing and the frequency and intensity of natural disasters are increasing. The perception of changes in river water level varies among different livelihood groups. In general, there is conformity among

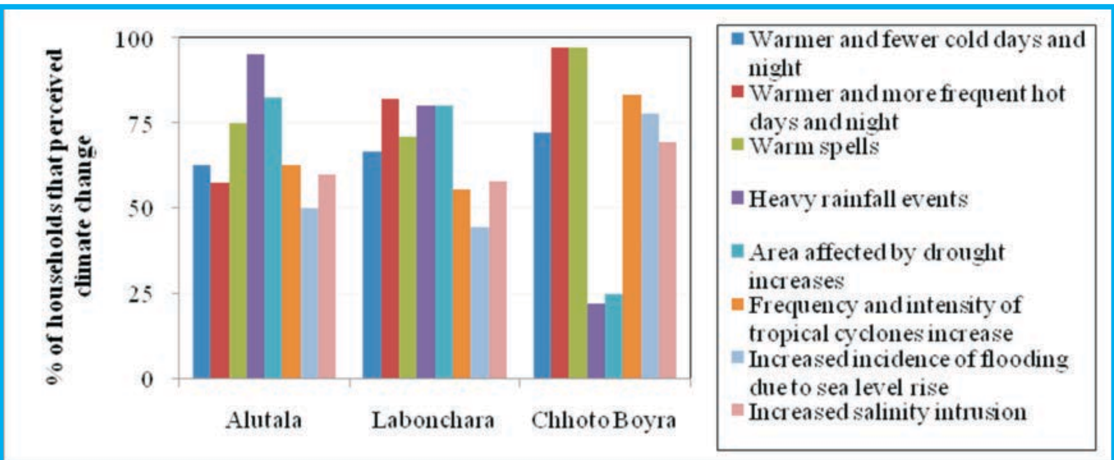


Fig. 2.6: Perception of climate change at the peri-urban sites in Khulna
Source: Primary household survey, 2011-2012

the results of hydro-climatic data analysis, baseline survey and stakeholder interaction regarding climatic trends, variability and stresses.

2.5 IMPACT OF CLIMATE CHANGE AND URBANISATION ON WATER SECURITY

Two processes are triggering change in the peri-urban areas of Khulna: the spread of urbanisation and climate change impacts. Urbanisation is sustained mainly by the acquisition and conversion of agricultural land and water bodies in the peri-urban areas. As the use of the land changes, the process of land conversion adversely affects the availability of water, the access to it and its quality in these areas. The effects of the changing peri-urban landscape are further degraded by climate change impacts including sea-level rise and salinity intrusion into the water bodies. Therefore, the peri-urban communities in this coastal setting are increasingly becoming vulnerable to uncertainties in the water supply, diminishing access, growing water conflicts and erosion of social capital. As these processes create stresses on the life and livelihood of the community, they try to overcome the vulnerabilities by using a variety of strategies.

The scarcity of drinking water is becoming more severe in the peri-urban areas due to the encroachment of water bodies and increasing salinity in surface water and groundwater. Khulna city and its peri-urban areas often face urban flooding from excessive rainfall and drainage congestion problems. This situation is likely to be aggravated in future with increased rainfall and sea level rise due to climate change and unplanned urbanisation. At present the Khulna City Corporation (KCC) area generates about 240-280 tons of solid waste daily, which is disposed of in the unplanned landfills and low-lying areas around the city, causing yet another severe problem in the peri-urban areas. The wastewater generated in the city is also randomly discharged in the Mayur River, which is an open water body shared by the peri-urban residence, through 22 open drains. The pollution of the river's water limits the livelihood opportunities based on agriculture and aquaculture that previously existed in the peri-urban areas.

Peri-urban communities of Khulna are also vulnerable to frequent natural disasters such as tropical cyclones and storm surges. Such extreme events are likely to occur more frequently in future due to climate change. It is also likely that climate change will trigger processes to reshape the dynamics of the resource base, processes over which the poor households will have no control. The climatic changes will make them even more vulnerable because of the lack of resilience to cope with the effects of such changes. This is a serious concern and source of conflict over water resources in the area.

Water security is one of the key challenges for Khulna especially in the context of climate change and urbanisation. At present, the drinking water supply system in Khulna is entirely based on groundwater resources. Khulna Water Supply and Sewerage Authority (KWASA) serves only 30 per cent of the urban population through a piped distribution system, and the rest of the population depend on personal or community based hand tubewells. In the peri-urban areas, people are mainly dependent on personal or community owned shallow/deep tubewells for drinking and domestic uses. Surface water from nearby ponds, channels, khals or rivers is used for agriculture, fisheries and subsistence uses. Although the drinking water supply is groundwater based, the shallow aquifer of the region contains relatively high electrical conductivity (EC) and sodium ion concentration. Thus, the water quality of the shallow aquifer is quite unsatisfactory and does not meet the guideline values for drinking water recommended by the Department of Environment (DoE) of Bangladesh and World Health Organisation (WHO).

Although urbanisation brought new opportunities for some people who had lived in the peri-urban areas, urban abuses and unplanned development activities have downgraded the existing water resources through pollution, physical encroachment and quality deterioration. The peri-urban residents often complain that the urban wastewater and solid waste are the two major sources of water pollution in the natural channels and rivers. Indeed, discharges of wastes and wastewater from the city are polluting the surface water bodies in the city and its surroundings. In addition, salinity intrusion and arsenic contamination in groundwater are also reducing water access and security in the region. Figure 2.7 shows the major sources of water pollution as revealed by the baseline survey of the peri-urban households.

The pollutant load in the Mayur River is largely caused by urban wastewater and solid waste.

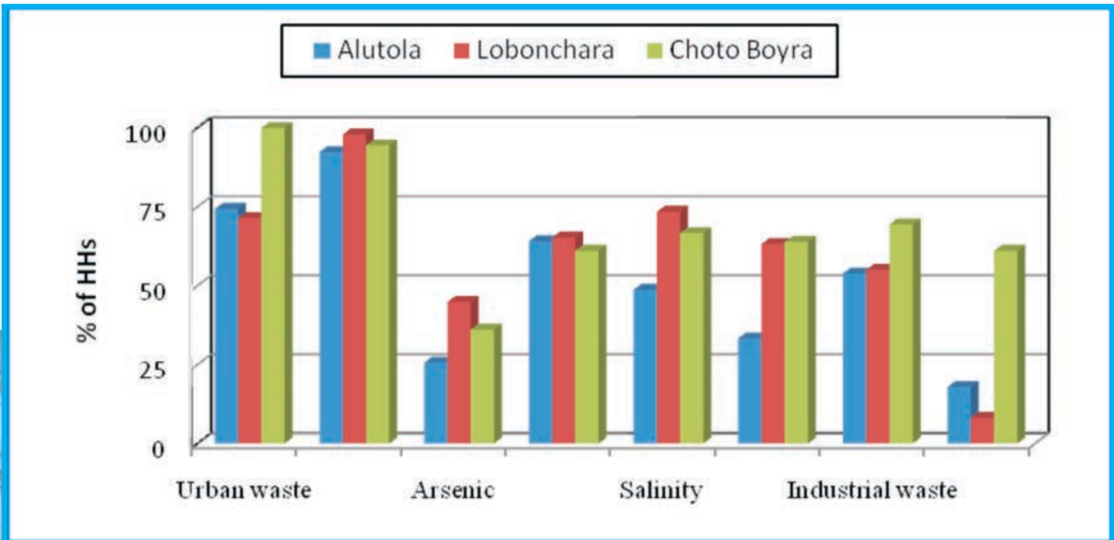


Fig. 2.7: Major sources of water pollution in peri-urban areas in Khulna
Source: Primary household survey, 2011-2012

An assessment of the physico-chemical characteristics of the wastewater flowing into the river from the KCC area through collection of wastewater samples from 10 spots on the drainage network at monthly intervals and analysis of 15 water quality parameters revealed that the pH values were within the permissible limit for reuse in agriculture. The Dissolved Oxygen (DO) levels were found to be below the permissible level recommended for irrigation. The EC and TDS values exceeded the irrigation water quality limits at a few spots. Some anion and cation concentrations were higher than the irrigation water quality limits. Thus, the wastewater is not totally safe for reuse in agriculture, and may pose threats for health, sanitation and the environment.

An analysis of the hydrochemistry of the Mayur River indicates that the river is overwhelmed with pollution, and the localized pollution is increasing rapidly due to stagnation and drainage congestion. DO in the river water ranges from 0.9 to 4.8 mg/L, whereas at least 5 mg/L is essential to maintain healthy aquatic life, and a DO level less than 3 mg/L is indicative of the absence of most fish species. Salinity in the river water shows high variation, from 5 to 14 parts per thousand (ppt), with an average of 9 ppt. This variation is highly correlated with the tidal variation when the Alutala regulator is open to the Rupsha River.

The baseline survey, which covered a wide range of issues including demography, socio-economic condition, water related vulnerabilities, urbanisation impacts and climate change implications, indicates that the people of Alutala expect urbanisation to improve their economic condition by accessing better income opportunities and civic facilities. On the other hand, the residents of Labonchara and Chhoto Boyra are already experiencing the adverse impacts of urbanisation such as pollution, detrimental land use change and encroachment of water

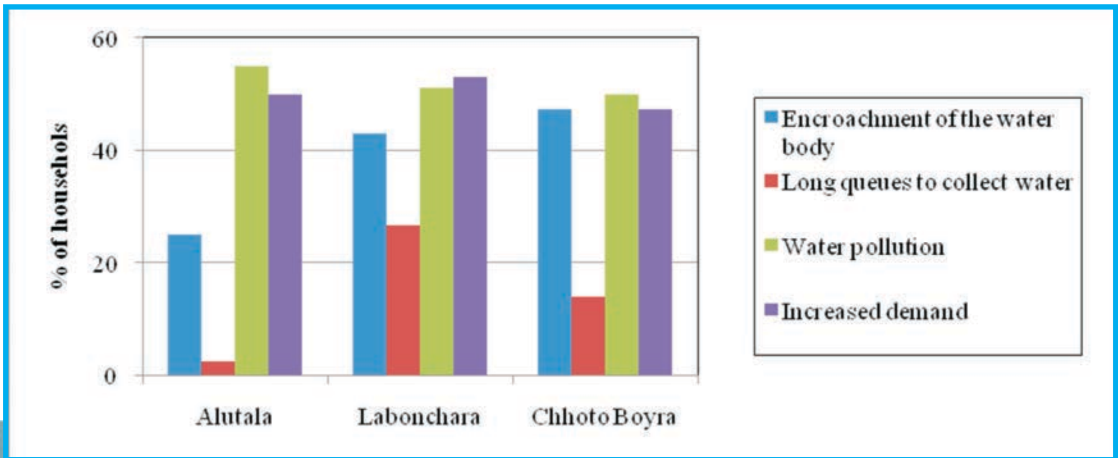


Fig. 2.8: Impact of urbanisation on water resources

Source: Primary household survey, 2011-2012

Box 2.1

Tea vendor Rashida Begum's plight

Rashida Begum is a shopkeeper at Labonchara. She is a widow and has a daughter. She came to Labonchara from Tootpara, an urban area within Khulna, after getting married. But her life has become miserable after her husband's death. She never went to school and could not find any source of income to support herself and her daughter. She somehow managed to start a tea stall at Labonchara. Now she is barely surviving with a daily income of Taka 50-100. Rashida suffers from drinking water scarcity on a daily basis. She collects water from about half a kilometer away from her house. It takes about twenty minutes for a single trip. She said that there were a number of private tube wells in the village but she did not have access to those wells. Sometime people are forced to use polluted water for washing and bathing. As a result, they suffer from frequent fever, diarrhoea and skin diseases. Rashida is also suffering from skin diseases. She said people were buying paddy fields to build houses. Road construction has destroyed the natural canals and drains.

Box 2.2

A Farmer's View

Harun-or-Rahsid is a local farmer at Chhoto Boyra. He grows rice and vegetables on his own land. Since prices of rice and vegetables have increased considerably, he now grows two crops, one for his own consumption and the other for selling in the market. Harun has been facing severe problems with irrigation water availability due to mismanagement of the Alutala regulator. He thinks the official gatekeeper operates the regulator as per instructions from the local elites and politicians who are more interested in fish farming in the Mayur river. He also believes that the Alutala regulator was constructed to make the Mayur river a closed water body to promote culture fisheries, business of the local elites and politicians. He claims that farmers who are dependent on the Mayur's water for agriculture are suffering from water shortage in the dry season. On the other hand, most of the agricultural lands are flooded during the rainy season due to the mismanagement of the Alutala regulator.

bodies (Figure 2.8). Box 2.1 presents the case of a widow in Labonchara struggling to meet her drinking water demands. Improper operation of hydraulic structures has added to the difficulties that local people experience. Box 2.2 presents a farmer's view on unavailability of water from the Mayur for irrigation during the dry season, and the flooding during the monsoon season resulting from improper operation of the Alutala regulator.

As urbanisation has increased domestic and industrial water demands and reduced access to surface and groundwater resources, the competition for these scarce water resources among different users' groups in the urban and peri-urban areas has also increased. This competition has created complex water use conflicts among the urban and peri-urban residents. The nature and dynamics of these complexities mainly depend on social, economic and political factors. An analysis of the complexities indicates that there are mainly four types of conflicts in the area: (i) conflict between agriculture and culture fisheries, (ii) conflict between urban and peri-urban users, (iii) conflict between urban and urban users, and (iv) conflict between peri-urban and peri-urban users.

Current trends and variability in climatic variables are perceived to have multi-dimensional effects on water security in the peri-urban areas. A significant portion of the peri-urban population depends on crop farming, daily labour, private service and small business. These people are relatively poorer, have smaller assets bases, lower education level and less access to political or social leadership. They are likely to be more vulnerable to climate change induced hazards and disasters. Heat stress during the pre-monsoon summer season is likely to bring discomfort to the lives of these people, particularly to the elderly and physical labourers.

Domestic water demand for drinking, bathing and washing-cleaning is likely to increase due to the rising temperature and humidity, particularly during the pre-monsoon season. The increased demand may add to the stresses for the women, who usually take the burden of household water collection.

The increasing trend in rainfall should help to reduce on-farm soil salinity and irrigation water demand. The increasing trend in rainfall towards the end of the monsoon season should also be beneficial for the aman rice which is a dominant rainfed crop in the coastal region. However, such rainfall may delay land and soil drainage and hamper the cultivation of rabi (winter) crops. Furthermore, the standing rice plant, when close to maturity, may not withstand the rainfall accompanied by wind during this time, and may wilt on the land surface resulting in huge yield losses, as witnessed during the severe rainfall in early

November 2012. The decreasing trend in sunshine duration is likely to affect the crop growth and yield.

Since the magnitude of rainfall has an increasing trend and the rainfall intensity is more or less stationary, it is expected that the groundwater recharge would increase in future. More local rainfall will increase the recharge primarily to the upper aquifer, which is saline. Moreover, with time, the peri-urban areas will experience more urbanisation and less recharge due to increase in concrete surfaces. The combined effect is likely to significantly lower recharge in future. As a result, water stress in the peri-urban areas may further increase.

The Mayur River is considered to be one of the potential sources of water supply for both urban and peri-urban Khulna. With an increase in concrete surfaces, increase in rainfall, and surface runoff, the fresh water flow to the Mayur is likely to increase. However, the river is currently, recipient of urban and peri-urban wastewater and solid wastes. Without adequate wastewater treatment and solid waste management, the situation will worsen and the peri-urban communities, particularly the poor, aged, women and children, will suffer from the direct and indirect effects of water pollution, unpleasant odour, loss of aquatic resources, etc.

Increasing temperature and humidity would create a more favourable condition for the formation of cyclones in the Bay of Bengal and, indeed, there were two recent devastating cyclones – Sidr in May 2007 and Aila in November 2009. These cyclones, accompanied by high storm surges, caused widespread damage to properties and loss of human and animal lives. Increase in soil salinity, due to the standing of saline water on farmlands for a long time or from storm surge inundation caused by these cyclones, has affected crop cultivation. In some of the affected areas, such as Koyra (nearby village), crops cannot be grown even today due to excessive salt content in the soil. Consequently, the lives and livelihoods of the people have been significantly affected. Many people from those areas have migrated to the urban and peri-urban areas of Khulna in search of new livelihoods. Since the Alutala area is under tidal influence, and the Mayur, the main drainage channel of the area, has been silted, malfunctioning of the Alutala regulator and/or any breach in or overtopping of the polder in the event of such a storm surge may have long-term consequences. These include water logging, increase soil salinity, and reduce farm productivity in the peri-urban areas.

Increasing water levels, accompanied by higher rainfall, may exacerbate the flooding problem in Chhoto Boyra and water-logging problem in Labonchara (Box 2.3). More

Box 2.3

Urban flooding from extreme rainfall

An extreme rainfall event occurred in Khulna during 25-26 June 2012. During this event, 171 mm of rainfall occurred in 2 days, and the highest rainfall intensity was 40 mm/hour which lasted for an hour. Khulna city experienced unprecedented flooding and drainage congestion during this event. Regular activities of the city were halted in these two days. Commercial activities came to a stand-still and people were stranded in their homes. This flooding caused huge damage to properties, infrastructure and businesses. This extreme event indicates a probable change in the rainfall pattern. On the other hand, the unprecedented urban flooding indicates the aggravating adverse impact of unplanned urbanization on the natural drainage system and urban drainage infrastructure. In Khulna, there are about 47 canals, locally called khals, which are encroached at many places by land grabbers. Most of these khals are hydraulically linked with the natural drainage system of the city. These khals are losing their efficiency and existence due to the lack of proper maintenance. Recently, Khulna City Corporation has initiated implementation of several development projects to mitigate urban flooding and drainage congestion.

agricultural lands in Alutala may come under tidal influence; the soil salinity of those lands may increase, the cropping pattern may change, and some of those lands may be converted for shrimp aquaculture. Thus, some of the currently cropped lands may become shrimp ghers in future and the share-croppers, small farmers and agricultural labourers may be adversely affected by such change in land use.

The anticipated changes in future climate are likely to have an impact on human health. There is already a prevalence of water-borne diseases, such as diarrhoea, cholera, typhoid, dysentery and jaundice, and skin and eye infections among the peri-urban communities in Khulna. The summer season is the peak time of occurrences of such diseases. The incidences of such diseases may increase in future due to an increase in flooding and water-logging from increased rainfall and river water levels. Water- logging, particularly in Labonchara and Chhoto Boyra, may increase the prevalence of mosquitoes. Outbreaks of cholera, typhoid and diarrhoeal diseases may occur after flooding as floodwaters in the peri-urban areas become contaminated with human and animal wastes. Informal interviews with the local people indicated that the rainfall pattern in the area has changed and the people are now suffering frequently from fever, diarrhoeal diseases, headache, allergy and nausea.

The baseline survey also revealed that about half of the peri-urban residents were not aware of the possible impacts of climate change. However, almost all the respondents, who were aware of the impacts, mentioned that crop yields had decreased, and pest attacks, physical stresses in work and human diseases had increased. Most of the people mentioned that the extent of saline water areas was increasing. These perceptions of the local people were more or less congruent with the results of secondary data analysis, indicating the general awareness of the respondents of the possible changes in climate and their impacts.

2.6 ACTION AND ADVOCACY

The peri-urban residents of Khulna adapt to the water insecurity caused by urbanisation and climate change through planned and autonomous responses and strategies. The planned strategies include infrastructure development and supply augmentation while the autonomous strategies include water harvesting and conservation practices, collective action, and changes in livelihoods and agricultural practices.

KCC and KWASA are formulating plans and programs to develop climate-resilient urban drainage infrastructure, implement a building code that would address the vulnerabilities, and protect the surface water bodies such as rivers and khals. Implementation of these plans and programs is expected to mitigate the

urban flooding and drainage congestion problems. KCC and KWASA are also taking up programs to augment urban water supply. However, successful completion of a project to import river water from a location some 40 km away from the city is facing uncertainty

Courtesy: Nuruddin M. Idris

Students participated in an art competition in Chhoto Boyra

since salinity level at the source is increasing rapidly. Another project of KWASA plans to construct a surface water treatment plant and an impounding reservoir to augment water supply in the city. These plans and strategies, however, address only the urban water supply and vulnerabilities therein. The peri-urban water security is not within the purview of such policy interventions.

Several autonomous adaptive strategies have been identified in the peri-urban areas that address the water vulnerability arising from urbanisation and climate change. Some households in the peri-urban areas practice rainwater harvesting for domestic uses. Rainwater is usually conserved in containers or small household ponds. However, this practice is not yet ubiquitous since rainwater is not adequate throughout the year, and there is a need for skill and support to build and maintain the infrastructure. Rainwater is also conserved in fields by building dykes around the agricultural lands for culture fisheries.

Innovative collective action strategies are emerging in the peri-urban areas of Khulna in response to water insecurity. Residents are collectively installing and maintaining deep tubewells that are shared by the community. Peri-urban residents are also collectively re-excavating privately-owned ponds to conserve freshwater for drinking and household uses.

Agriculture in peri-urban Khulna is dependent on surface water and rainwater. Cropping practices, however, are changing since the surface water bodies are diminishing because of the spread of urban built up area, encroachment by urban uses and urban wastewater pollution. Farmers rarely cultivate Boro(winter) rice and tend to grow vegetables that can be irrigated with wastewater. Salinity-

tolerant rice varieties are also becoming popular with an increase in soil and water salinity. Agricultural lands are sometimes converted to practice fish farming. In extreme situations, farmers sell off their agricultural land

Courtesy: Nuruddin M. Idris

Workshop being conducted to develop the village plan

to developers and move to non-agriculture based livelihoods.

Even with these changes, peri-urban residents experience water insecurity particularly during the dry season when the water in the Mayur and nearby khals is extremely polluted. Sometimes they are left with no option but to use this water for washing and bathing. In some areas, women and children have to walk long distances to collect drinking water. People are also forced to drink arsenic and iron contaminated groundwater from tubewells in the absence of a safe source of water.

Pollutant inputs into the Mayur River could be significantly reduced if solid waste is collected directly from the households, and then converted to compost. Based on needs assessment through stakeholder consultation for reduction of pollutant load in the Mayur, a pilot intervention for household garbage collection and compost production was supported in Chhoto Boyra. This initiative will, in the long run, reduce direct pollutant input into the Mayur River, provide an eco-friendly agricultural input option, reduce pollutant load in irrigation return flow, and create a source of earning from selling of compost.

Sustainability of this initiative was assessed through a 'willingness-to-pay' survey. About 90 per cent farmers said that they used compost in their agricultural field whereas only 32 per cent farmers used KCC waste-generated compost in their agricultural land. Low availability of compost (37%) and the lack of information about compost (51%) are the main reasons for low use of compost on agricultural land. Increases in rice and vegetable production were reported by 61 and 42 per cent farmers respectively, due to use of compost. On an average, rice and vegetables production increased by 201 and 310 kg per hectare, respectively. All the respondents believe that if producers sell

compost directly to farmers, then the compost price will be much lower and compost quality will be much better than the commercial brands available in the market, and they would prefer to buy more compost. Study results indicate that 15 per cent of the farmers are willing to buy compost at a rate of $1.3 per 10 kg, 44 per cent at $1.9 per 10 kg and 33 per cent at $2.5 per 10 kg. On an average, the farmers are willing to buy compost at a rate of approximately $2.0 per 10 kg.

Workshop being conducted to develop the village plan

Reviving the Mayur River, as an urban and peri-urban amenity as well as a supplementary freshwater source, has been a central point of discussion among all stakeholders. A cost-benefit analysis (CBA) was conducted to compare the economic justification for different options to revive the river. The study valued two options: (i) freshwater scenario, in which the Mayur would function as a freshwater reservoir, and (ii) tidal water activity scenario, in which the natural tidal fluctuation in the river would be fully restored. The study concluded that a freshwater scenario, having a higher benefit-cost ratio, would also provide substantial co-benefits for different sectors (see Chapter 6).

A climate change perception study conducted through stakeholder consultation and FGDs revealed a knowledge gap in climate change science at the local level, and a need for training and capacity-building in this area. Following a formal needs assessment, a training program was organized for the local professionals, NGOs, service-providers and academicians to provide basic scientific knowledge on climate change. Apart from this training, four climate change and adaptation training programs were organized at the community level to build local capacity for interpreting climate change impacts and vulnerabilities. The perception study indicated that people from most of the vulnerable groups are unable to fully relate to the gradual physical changes in natural systems supporting their livelihoods to the possible climate change impacts.

Nearly half of the households in the baseline survey mentioned that there was no specific

initiative in their neighbourhoods to address climate change vulnerabilities. The remainders were unaware about the existence of any such possible initiative. These findings indicate that the climate change initiatives, including awareness raising, capacity-building, risk reduction and adaptation measures, of government, non-government and inter-governmental agencies have not reached the grass-root communities living in peri-urban Khulna, though they are among those, most vulnerable to climate change impacts.

As a first step in building a multi-stakeholder platform, stakeholder workshops were organized to discuss the vulnerabilities and the actions required to mitigate them. These workshops brought all stakeholders closer together, and created an opportunity for combined action. Particularly, the project has generated goodwill and expectations for a positive change among the NGOs and civil society groups. On several occasions, the project objectives and activities were discussed with the city Mayor, who agreed to provide all possible support for the project. Local level awareness-building activities and national level policy interventions were carried out during the project. Art competitions were organized for local school children to depict their views on the Mayur River and how they would like to see it. Debate competitions were organized for the local youth to explore their ideas on how the river can become a safe water body. Quiz competitions were also organized for the college students. These programs have been quite successful in generating greater awareness among the younger people and their families about the importance of peri-urban water security, and the contexts of urbanisation and climate change. Three community level workshops were conducted at the selected sites to identify water-related vulnerabilities and to formulate action plans. These workshops were facilitated to develop participatory village development plans and to identify actions needed to reduce water-related vulnerabilities and improve water security.

The importance of reviving the Mayur River as a freshwater source and an urban amenity has been agreed upon by all stakeholders in the Khulna area. The project activities and stakeholder meetings have been instrumental in reaching this agreement.

Several multi-stakeholder meetings were organised to form a platform, called 'Save the Mayur Campaign', for water security of the urban and peri-urban areas. Eventually, a general consensus was reached to promote and advocate activities and programs that would revive the river. Research findings of the project were used in these deliberations as

supporting information. Different events including rallies and tree plantation programs were organized as part of the campaign. Together with the KCC Mayor, this campaign is in the process of formulating a comprehensive plan to save the Mayur.

2.7 SUMMARY

The findings of this action research indicate that freshwater is scarce in the Khulna area due to high levels of salinity in groundwater and surface water, and pollution of the Mayur River, an important freshwater body that can be saved to serve both the urban and peri-urban areas. This research also indicates that water insecurity of the peri-urban communities is likely to be further aggravated with the continuing trends in urbanisation and climate change.

The urban development plans for Khulna do not clearly spell out how the future water demands in the urban and peri-urban areas will be met with projected urbanisation and climate change. Plans to construct climate resilient infrastructure and augment freshwater supplies are meant for only the core urban areas. None of these plans address water insecurity in the peri-urban areas. On the other hand, peri-urban communities are adapting to their water insecurity through collective action, water conservation practices, and changes in livelihoods and agricultural practices. A formal or informal institutional arrangement could strengthen the adaptive capacity of the peri-urban communities. The Mayur River can be revived to create a freshwater source for the urban areas and mitigate water insecurities in the peri-urban areas.

This research facilitated a campaign, popularly called 'Save the Mayur Campaign', in which all major actors and stakeholders have joined in agreement to revive the river as an urban amenity and freshwater source while ensuring its ecosystem services and functions. A general awareness of the need to save the river has been created through several programs and activities. Knowledge gaps identified in consultation with the stakeholders were addressed through several short-term research components. Findings of these research components were shared with the actors and stakeholders in the consensus building process. It is expected that this campaign will continue to grow and encourage the policy-makers and service-provider organizations to consider peri-urban water insecurity in their plans and programs, and revive and sustain the Mayur River.

A growing city encroaching the periphery: water insecurity in peri-urban Gurgaon, India

VISHAL NARAIN
AMAN DEWAN
SREOSHI SINGH

3 INDIA gurgaon

3.1 INTRODUCTION

Gurgaon district is situated in the south eastern part of the state of Haryana, one of India's major food baskets - occupying an area of 3852 sq.km. Towards the north, it is bordered by Delhi, in the east by the state of Uttar Pradesh, in the west by the state of Rajasthan and in the south by the Mewat district of Haryana (Figure 3.1).

The research was carried out in four villages, namely, Budheda, Sadhraana, Sultanpur and Jhanjhrola Khera. Located about 15 kms from the Gurgaon city, these villages constitute a peri-urban zone that is characterised by rapid land use change, with wide implications for changes in the use of water. Budheda has had a history of land acquisition, as it has given land for the Gurgaon water supply channel. Sadhrana's land acquisition is led by an increase in the purchase of land for farmhouses by the urban elite due to its being very close to Gurgaon city, while in Sultanpur and Jhanjhrola Kheda land acquisition is a newer process brought in by the advent of Reliance Ltd. trying to set up industry in these areas. As noted in chapter 1, the peri-urban

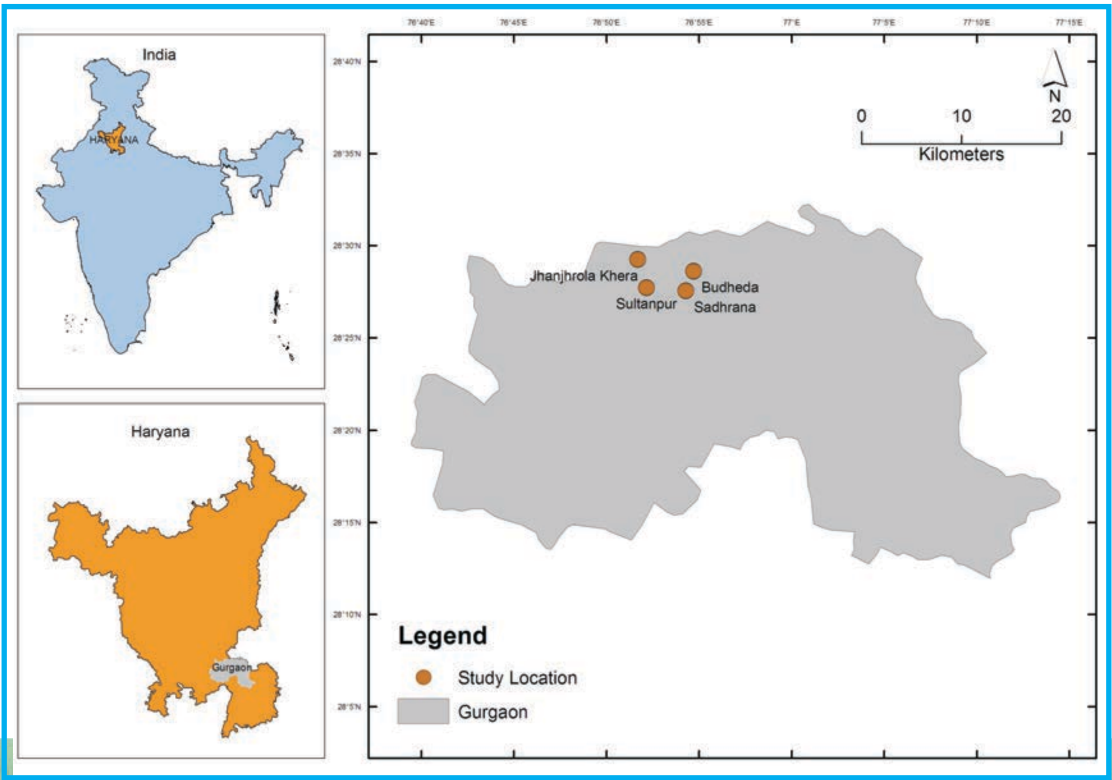


Fig. 3.1: Location of the peri-urban research sites in Gurgaon
Source: Developed on GIS using google earth and toposheets

space was not defined on the basis of distance but rather seen as an analytic construct particularly focusing on the two-way flow of goods and services between rural areas and urban centers- flows of labour, natural resources and agricultural products. Keeping this analytic construct in mind, features like the use of land acquisition as means to build infrastructure to support urban expansion, the flows of water between rural and urban areas, and the neglect faced by these locations while proximate urban locales were being favoured, were some of the main reasons for working in these four villages.

3.2 TRENDS AND DRIVERS OF URBAN GROWTH IN GURGAON

The present city of Gurgaon can be considered to be the metropolitan area encompassing settlements around the original city, and expanding even further with the establishment of new neighbourhoods and districts. A favourable tax policy by the Haryana government, improvement in city's infrastructure by the Haryana Urban Development Authority (HUDA) and the need of a business centre close to Indira Gandhi International Airport saw the emergence of Gurgaon as one of the most prominent outsourcing and off-shoring hubs of north-west India. The city is positioned as a millennium city marked by the presence of skyscrapers and glitzy malls, residential areas, gated communities and posh recreation and shopping complexes. Subsequently, there was a large influx of population largely from the surrounding states of Uttar Pradesh, Punjab and Rajasthan, as well as a sizeable spill over population from Delhi and the National Capital Region (NCR).

The migration to Gurgaon city led to rapid urbanisation and further expansion of urban outgrowths contiguous to the municipal boundaries of the city, better known by the Census of India as the Gurgaon Urban Agglomeration (UA). From 1971 to 2001, there was a decline in the growth of population. From 2001, however, there has been a sharp increase in the level of urbanisation (up to 68 per cent as per census, 2011). The Census of India 2001 data indicated interstate migration as the dominant nature of migration over the previous 4-5 years, i.e. 1995 onwards, and the reason cited in most of the cases was employment.

The NCR Planning Board as well as the Master Plans for urban areas and census for rural areas have projected the population of Gurgaon city to reach above 3 million by 2021. The projections for the 50 year period 1971-2021 are shown in Figure 3.2 illustrating the massive increase in urban population from 2001 to 2011

The most rapid phase of expansion started with the initiation of economic reforms in 1991 after the real estate firm, DLF Group, started buying farmlands owned by the local people to establish housing societies for the upper-middle class residents of Delhi. Further, the government removed the bottlenecks related to obtaining permits and provided special incentives to Information Technology/IT Enabled Services (IT/ITES) and Business Process Outsourcing (BPO) sectors as both attracted foreign investment. They were to receive preferential access to such resources and facilities such as land and electricity. Certain specific incentives provided were a relaxation in floor area ratio, rebate on registration, transfer of properties charges, and an exemption under the Haryana Shops and Commercial Establishment Act.

These factors made Gurgaon one of India's main outsourcing hubs in 1997 when GE Capital International Services (GECIS) was set up as the India-based business process services operations of GE Capital. Soon, a plethora of BPO and Knowledge Process Outsourcing (KPO) firms such as Genpact, Evalueserve, Dell, Accenture, Hewitt Associates, Copal Partners and Convergys expanded their operations into the city. Apart from the above, a few IT and pharmaceutical firms set up base as well, though their distribution has tended to be skewed. At present, Gurgaon is the regional head-office of Alcatel-Lucent, Niksun, IBM, Opera Solutions and Bain & Company. Gurgaon is also the headquarters of the two biggest automobile manufacturers in India, Hero Honda and Maruti Udyog. The Gurgaon Master Plan 2021 shows that the government aims to facilitate

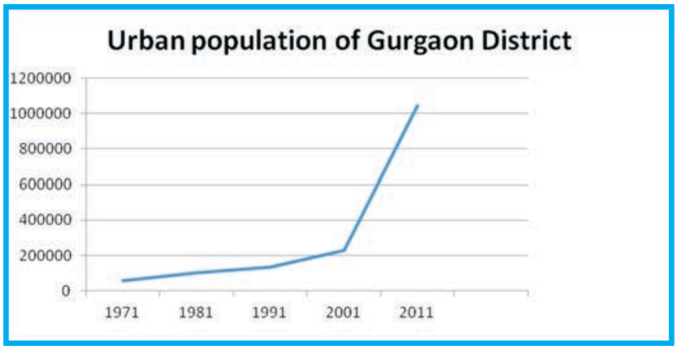


Fig. 3.2: Growth rate of Gurgaon's urban population

Source: Prepared from Census of India, 2001, 2011

endless urban growth for the benefit of those who can pay for it (Sustainable Cities Collective 2011). The Millennium City's development is best described as haphazard and taking place in an uncontrolled manner.

Public services like roads, local transport, electricity, sewage disposal and water supply are not functioning well (van der Woude, 2013). The growing urban population has led to conversion of agricultural lands to residential lands. The need for creating and increasing the number of residential colonies is also due to the fact that in Gurgaon, industry was growing at the rate of about 40 per cent which is much above the national average of 28 per cent (One India 2008), and this leads to the inflow of migrants. The lead that Gurgaon has in the process of industrialization is mirrored in the fact that the economic growth of Gurgaon district is estimated to reach 10 to 15 per cent during the next five years as compared to national growth of eight to nine per cent (One India 2008).

Social inequities are bound to occur when the lives of the people who were the original inhabitants of Gurgaon clashed with the people who work in these MNCs: migrant labourers, domestic help and industrial workers who constitute Gurgaon's poor. With no access to public transport, they resort to sharing auto rickshaws or comply with taxi drivers who flout norms, and stuff as many as 10 people into a single cab. Their children often fall into bore-wells sunk by citizens due to the inability of the government to provide water (Forbes India 2012). Thus although favourable tax regimes, government incentives, proximate locations to the national capital might have been drivers of growth for Gurgaon, the ability of the city to be sustainable is in doubt. The government is obliged to find ingenious ways of tackling problems of water scarcity, power shortages, and still be socially equitable at the same time, if the Gurgaon story is to continue to flourish.

3.3 CLIMATE CHANGE STRESS

3.3.1 Experiences of a changing climate

Since rainfall plays an important role in the day-to-day life of the farming community, a change or uncertainty in rainfall pattern works as a benchmark for them to perceive a changing climate (Ranjan and Narain 2012). As per the field interviews, rains were considered to be 'good' until the year 1977 and since then there has been a decrease in rainfall. The year 2010 has been considered to be an exception as it rained quite heavily that year (Figure 3.3). The villagers also perceive a changing climate in the form of increase or decrease in intensity as well as duration of winter and summer season after the 1980s. In general, the residents of the four villages studied have noticed a reduction in the intensity and duration of winter. Now, they say, winter is confined to only two months of December and January, unlike earlier when winter season spanned four to five months. Besides, people also perceive a changing climate through changes in the cropping pattern. Especially for farmers, their association with increase or decrease in the intensity of seasons is in terms of increase/decrease in number of summer/winter/rainy months and its corresponding impact on their cropping choices. Reduction in the intensity of winter has been perceived by villagers in a very interesting manner. A few mention that there was a time when a pot of water kept out in the open in the winters would freeze overnight; however, this does not happen anymore (Box 3.1). Another interesting way of perceiving climate change is to mark a specific year or a particular decade and say that the climatic parameters have not been stable since then. As noted above, this is the case with rainfall,

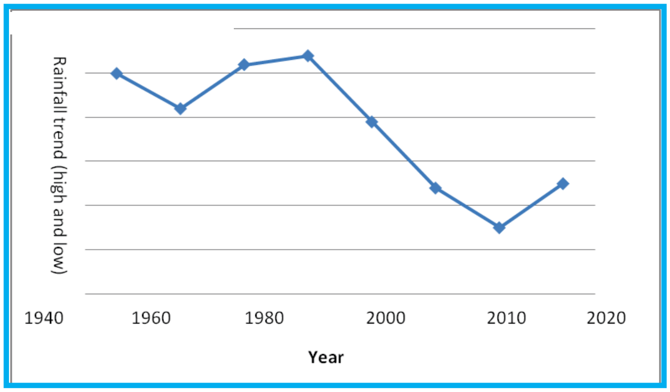


Fig. 3.3: Rainfall trend line
Source: People's perception

where people keep 1977 as the benchmark year. For the seasons, the 1980s is considered to be the period till which seasons were timely. In fact, winter season and fogs were considered to be more prevalent and consistent till the 1980s.

3.4 IMPACT OF CLIMATE CHANGE AND URBANISATION OF WATER SECURITY

The changes in land use in and around Gurgaon because of the expansion of the city have had a major impact on the use of water resources. It is important to note that most of this expansion has taken place in areas which are scrublands, pastures, water bodies, agricultural land, and lands with a high water table which is susceptible to water-logging. This urban expansion has in turn created huge demand for water. Figure 3.4 prepared from data obtained from the Central Groundwater Board (CGWB, 2007) shows the sector-wise

Box 3.1

People's perception of changing climate

"Rainfall has not only reduced but is also uncertain. "

"Earlier a pot of water left out at night in the open would freeze by the morning. That does not happen anymore. "

"If the kind of warm weather persists, then an acre of land that yields 50 mann now will be able to produce half that amount."

"Earlier we could sit together beneath the shade of a tree Now, that is not possible because of the intense heat."

"The weather is changing and is very erratic."

"Reduction in water table level is mainly because of reduced rainfall. 20 years back the water table was only at 5-6 feet."

"With less rainfall and moisture in the soils, there is now an increase in termite population, which harms our crops."

percentage gross groundwater draft in the four blocks of Gurgaon district in 2004; interestingly, Gurgaon block reveals the highest values in the domestic and industrial sectors. Tubewells in the depth range of 45 to 90 m BGL (below ground level) have been installed by different agencies in the block.

State policies for developing SEZs have also had serious social, economic and environmental impacts because most of the land acquired was previously fertile agricultural land or, in some cases, forest land (Basu, 2007). Land acquisition has been a subject of great discontent in the district (Narain, 2009). The acquisition of village lands for the construction of water treatment plants and canals to supply water to the city have also had impacts on water supplies; with the acquisition of these lands, peri-urban residents lost access to water sources located on them. The appropriation of rural water supplies by farm-houses owned by the urban elite and use of urban wastewater for agriculture are other aspects of changing rural-urban water flows in the district.

The new and competing land uses that have emerged in the four villages under study have altered both the demand for and the use of water since the 1980s. These include land acquisition for a SEZ by a corporate giant, the development of a National Park for conserving avian population and the springing up of several residential farm-houses that constitute an urban use of the rural land. In peri-urban locations, land and water have multiple claimants and the same sources of water are put to several competing uses. For example, inside the Sultanpur National Park in the vicinity of these villages, an area of about 70 hectares of land must be flooded with water for about five months to attract migratory birds. This water is obtained from the Gurgaon Water Supply Channel, which is the main source of water to the city of Gurgaon as well as to two of the four villages, Jhanjhrola Khera and Sultanpur, studied by the research team.

The owners of farmhouses in the vicinity also acquire local water sources. They require water to grow fruits and vegetables; to nurture their orchards and expansive lawns. They also need water all year round for these purposes, while local farmers irrigate

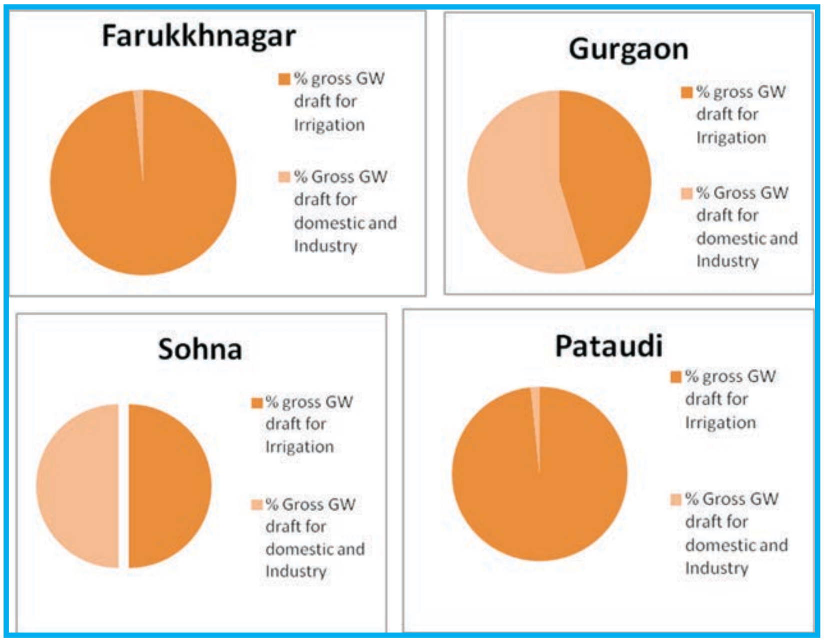


Fig. 3.4. Groundwater withdrawals in Gurgaon
Source: Prepared from CGWB, 2007

mainly for four months during the year, that is, during the Rabi (winter) season. The farmhouse owners pump water using expensive 15 hp submersible pump-sets that the locals cannot afford. There are several such farmhouses on the agricultural land of villages Sultanpur and Sadhraana, who compete with each other for local water; groundwater is thus sucked out of the reach of the small and marginal farmers who are unable to afford the high costs of extraction. The presence of these farmhouses, therefore, leads to sectoral, temporal and spatial competitions for water amongst its users.

Peri-urban areas often bear the ecological foot-print of urban expansion. Village Budheda lost private agricultural and common property grazing lands to the construction of a water treatment plant to supply water to the city. This loss of land to support the water requirements of the city is an indirect way in which the ecological footprint of the city is borne by the periphery. It is important to note that Budheda has a large livestock dependent population. Farmers who sell off their land or whose lands are acquired for emerging land uses lost their right to access water from the land since access to water is tied to land ownership. It is common among peri-urban residents to depend on tubewells owned by their friends or relatives and located in adjacent lands for irrigating their own lands. However, if the owner of the nearby land decides to sell it, the farmer who was dependent on this water source also loses access to water.

An important aspect of rural-urban water flows in the research sites is that of the use of urban wastewater. Urban wastewater is widely used in one of the villages, namely, Budheda especially for the cultivation of wheat and paddy. All of the wastewater irrigated produce is sold in the wholesale market, with virtually none being used for self-consumption. While it provides a cheap nutrient rich source of irrigation, it is known to have long term health impacts for the producers and consumers of the produce. These include, for instance, skin infections among the irrigators (IWMI 2003; IWMI 2006).

Due to saline groundwater and reduced rainfall since 1977, farmers now only grow one crop yearly. Also, if they

Urban wastewater being used for irrigation in Budheda, Peri-urban Gurgaon-India

grow a Kharif crop (the main monsoonal period), then the productivity of crops grown in Rabi season of the same cropping year falls (Narain & Ranjan 2012). Budheda has considerable low lying land, locally called jheels, which are proximate to flood prone areas. The year 2010 saw the destruction of crops in this area due to excessive rainfall and even in 2013 a portion of wheat crop was destroyed due to heavy and unseasonal rainfall in the month of February. As a result, farmers changed the crops they produce in these villages in order to cope with uncertain rainfall; they now produce more vegetables, wheat and mustard as compared to pulses in earlier times. This adaptation was demanded by the salinity of the groundwater in these villages, as mustard and wheat have a higher tolerance, but are not necessarily commercially beneficial for farmers.

3.5 RESPONSES OF COMMUNITY AND INSTITUTIONS

The Public Health Engineering Department (or PHED), supplies domestic water supply in all the four villages. A wide variety of technologies is used to access water for different purposes (Figure 3.5). Falling water tables in the research locations from rising demands and changes in rainfall pattern have led to a wide range of adaptive responses.

Technological responses include a switch in water extraction equipment in favour of tools that are able to dig deeper, and the adoption of sprinklers to economize on the use of scarce water. Water extraction technologies have changed from manually-operated pulleys (called rainths and animal-operated pulleys called lao chedas in the local language) to tubewells and submersible pump-sets to dig deeper into the aquifers. In Sadhraana, for instance, farmers have switched to submersible pump-sets over the last 7-8 years. 7hp pump-sets are commonly used. Another technological response is the use of sprinkler irrigation sets, seen very commonly in Sultanpur as well as in Sadhraana.

The choice of adaptive responses is shaped by local institutional and agro-ecological contexts. Sprinklers are found to be an adaptive strategy especially when the land is undulating and soils are sandy, making flood irrigation difficult to practice. The use of sprinklers enables farmers to apply water closer to the crops; besides, it also economizes the use of scarce labour. With occupational diversification, farmers spend lesser time on

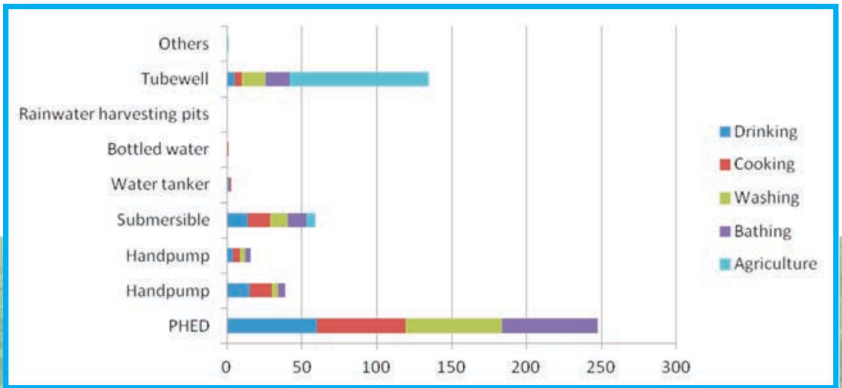


Fig. 3.5: Sources of water in the study villages
Source: Primary household survey, 2011-2012

the fields and to that effect automated irrigation technologies are a superior alternative to manual irrigation. In Jhanjhrola Khera, where there is greater salinity, sprinklers are not used, as providing water that close to the crops can prove harmful.

For the elite, acquiring a private submersible pump on their own plot of land is a way of improving water security. Another adaptive response seen especially in Sultanpur is that those whose plots of land are above saline water, buy plots of land over fresh water, install a submersible pump-set there and transport water to their houses. This highlights the links between land tenure and water security.

The most important institutional responses are reliance on social relationships and buying water from water tankers. A common adaptive strategy for drinking water is taking water from friends, relatives or upper-caste households in all four villages. Such reliance on community support is the case especially in Sultanpur among those who live in the region that is not served by the PHED. However, many of the upper-caste households who provide the lower-caste households access to the hand-pumps located on their lands are gradually selling off their lands. Besides, many lower-caste members suffer discrimination in accessing water and are often denied access when they request water from upper-caste households.

Buying water from tankers is yet another adaptive strategy especially in Sultanpur and Jhanjhrola Khera. This holds true for those who consider the PHED water as being unfit for drinking, whose lands are over saline groundwater, or those who cannot afford to buy water extraction devices.

There is some variation in the percentage of households purifying water before drinking across the villages (Figure 3.6). This difference arises mainly from water-users' perceptions of the quality of the consumed water.

With regard to cropping choices, farmers have responded by growing one crop instead of two. Many farmers now irrigate only one crop

Sprinklers are used extensively as adaptive response to water insecurity

Water tankers selling water to local inhabitants

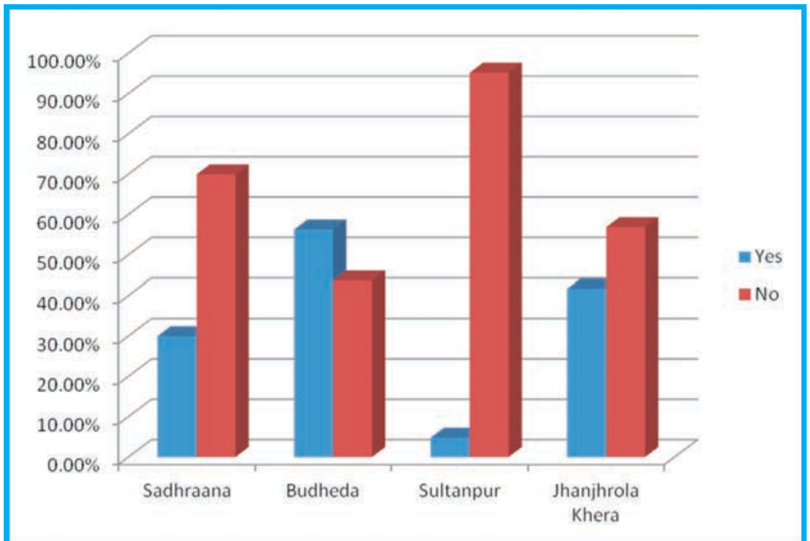


Fig. 3.6: Village-wise percentage of households purifying/not purifying water before drinking
Source: Primary household survey, 2011-2012

	Kharif Crops	Rabi Crops
Crops - 30 years back	Pearl millet, Gowar, Sorghum, Cholai, Dhaincha, Maize	Cucumber, Tomato, Peas, Wheat, Mustard, Chana, Potato, Fodder crops – Jai, Barsam, Kaasni
Crops - At present	Pearl millet, Gowar, Sorghum, Dhaincha	Wheat, Peas, Mustard, Carrot, Radish, Fodder crops – Jai, Barsam, Kaasni

Table 3.1: Seasonality Analysis of cropping in JhanjhrolaKhera

Source: PRA, 2011

and depend on the rains for one crop; thus, the decline in rainfall primarily affects the monsoon crop. They have reduced the cultivation of fruits, vegetables and flowers and concentrate now mainly on wheat and mustard in the rabi (winter) season and pearl-millet/fodder crops in the kharif (monsoon) season.

A seasonality analysis of the cropping pattern shows the changes in the cropping pattern over the years in one of the villages, namely Jhanjhrola Khera, in response to changing availability of water (Table 3.1)

3.5.1 Engaging with stakeholders and building adaptive capacity

In terms of building adaptive capacity, the research team in Gurgaon, India focused mainly on two components. The first component was to build and strengthen social capital by providing voice to peri-urban residents by getting them into direct dialogue with service-providers. Making service-providers responsive to water-users, breaking the distrust between the two and providing a forum especially to the underprivileged to express their concerns about service delivery were foci of the action research. This was accomplished through a series of stakeholders meetings between water-users and service-providers to promote dialogue and mutual accountability. In these meetings, the village representatives expressed their concerns and main problems with regard to water supply, and through discussion with the representatives of the PHED, devised solutions

Local stakeholders' workshop in progress and ways of improving internal water distribution.

The second component focused on developing human capital in terms of enhancing livelihood skills. This was accomplished by imparting the peri-urban residents' livelihood skills to facilitate occupational diversification in the face of land acquisition and climate variability. Uncertain rainfall patterns on the one hand and land acquisition on the other erode the base of livelihoods. Alternative livelihood skills can build community resilience. The imparting of vocational skills was accomplished through vocational training with the GMR group. This training imparted new livelihood skills to the village youth, and would enable them to diversify occupationally in the face of the erosion of their livelihoods.

3.6 SUMMARY

This research has documented various ways in which peri-urban communities lose access to water to the city. On the one hand, the emergence of new claimants on groundwater creates additional demands for this resource; on the other hand, changes in the rainfall pattern further accelerate the decline in the water table level. Peri-urban residents also lose access to water sources located on land acquired for urban expansion. While planners and policy-makers focus on providing for the needs of the growing city, conscious efforts are needed to turn their attention to peri-urban settings.

In this project, an effort was made to improve peri-urban water security by re-orienting state agenices and making them more responsive to the needs of peri-urban communities. This was accomplished through a series of stakeholder workshops and dialogues, that brought water users and service providers in direct interface with each other. A critical aspect of this action research has been building capacities of the communities and the local governments.

Vocational training imparted new livelihood skills to peri-urban youth whose livelihoods face threats from urbanization (mainly through land acquisition) and climate change (primarily through changes in the precipitation patterns). Alternative livelihood options and related capacity-building are seen internationally to be the most effective ways of enhancing adaptive capacity and thus reducing vulnerability (Nuorteva, P., Keskinen, M., & Varis, O. 2010).

Peri-urban areas are dynamic; they are seen by different groups through their own lenses, depending on where they fall in the rural urban continuum (Hilner 2010). It is thus imperative for the governments to look at peri-urban areas and their development as a whole and not as part of an exclusive urban or rural ecosystem.

Expanding city, shrinking water resources and vulnerability of communities in peri-urban Hyderabad, India

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ANJAL PRAKASH
SHAILI GUMMADILLI

4 INDIA

hyderabad

4.1 INTRODUCTION

Hyderabad is an historical city founded in the 15th century, a part of the Indian Union and capital of the state of Andhra Pradesh, mostly carved out of the erstwhile state/province of Madras. In the mid-1990s, when the Structural Adjustment Programme was initiated by the Government of India, Hyderabad became a node in the global web of economic flows and linkages. This has made Ranga Reddy district (of which Hyderabad is a part), the most developed district of the state.

This project has focussed on selected villages within four mandals of Rangareddy district, adjacent to Hyderabad, but outside the boundaries of the Greater Hyderabad Municipal Corporation (GHMC), not served by formal amenities like water, sanitation, solid waste management systems as they exist in the core city. These villages are governed by local governance bodies, known as 'panchayats' and are located within close proximity of selected development corridors around Hyderabad. The selected villages for this research are Mallampet (Qutubullahpur Mandal), Aliyabad (Shamirpet Mandal), Raviryala (Maheshwaram Mandal) and Peerancheru (Rajendranagar Mandal) where household survey has been conducted (Figure 4.1).

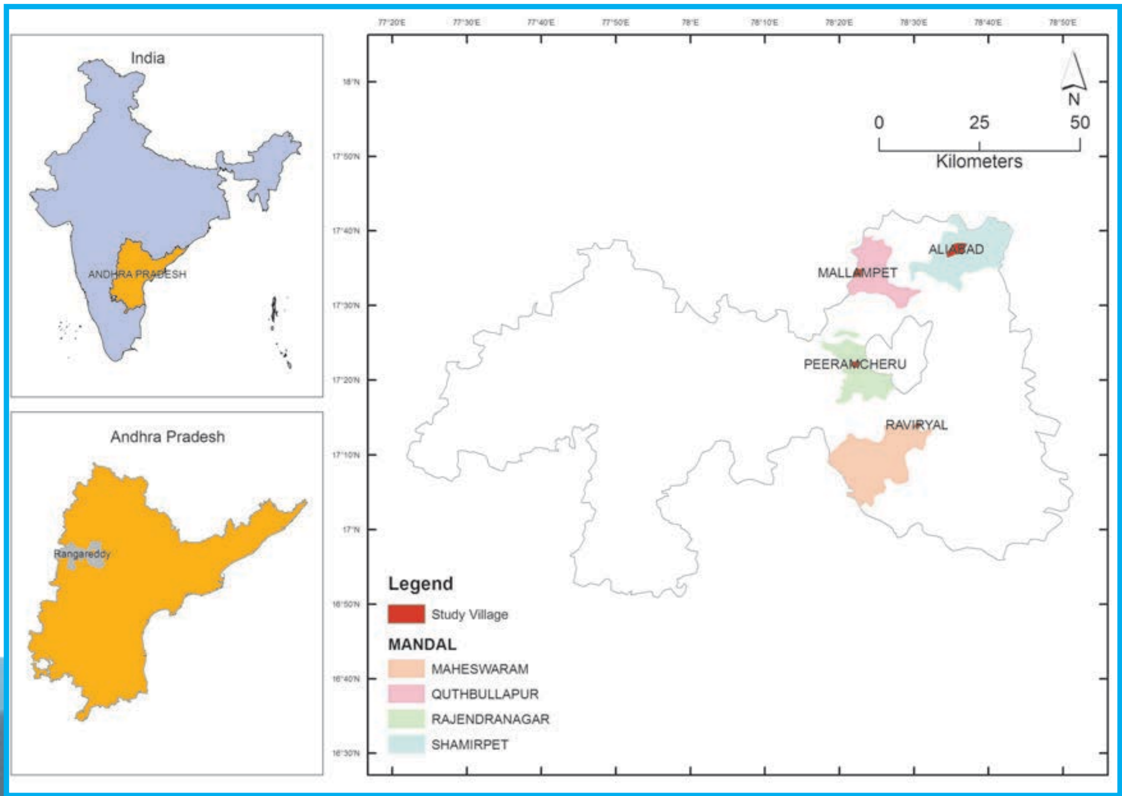


Fig. 4.1: Location of research sites in peri-urban Hyderabad

Source: Map prepared on GIS based on Google Earth and Survey of India maps

Sub district (Mandal)	Village	Dominant water uses	Distance from GHMC boundary	Nearest development enclave
Shamirpet	Aliabad	Agriculture-domestic-commercial/industrial	10 kms	Factories, Outer Ring Road, Genome valley, NALSAR, Prajay Water Front Gated Residential enclave
Qutubullapur	Mallampet	Domestic-industrial	6-7 kms	Outer Ring Road, Bollarum Industrial Area
Rajendranagar	Peerancheru	Domestic-commercial	7-8 kms	AP Police Academy, Shadan Hospital, Outer Ring Road
Maheshwaram	Raviryala	Agriculture-industrial-domestic	15 kms	Hardware Park, Fab City, Outer Ring Road

Table 4.1: Research villages and dominant water users in peri-urban Hyderabad

Source: Field Survey-2010-2011

A series of pilot visits were undertaken in 15 villages to select the study villages. The selected villages are at varying distances from the GHMC boundary, but lie within the jurisdiction of the Hyderabad Metropolitan Development Authority (HMDA). They are located across five mandals selected on the basis of the level of groundwater extraction as per a report by the Central Groundwater Board, 2007. The data collected from households in these selected villages is focused around the various aspects of water security/insecurity and their impacts on the lives and livelihood of communities. Table 4.1 gives a snapshot of the four villages and their water-user patterns.

4.2 URBANISATION

With a population of 7.74 million as per the 2011 census, Hyderabad is currently the sixth largest urban agglomeration in the country. The process of urban growth in the peri-urban zone has been significant with a shift over a span of 4 to 5 years from being rural to becoming urban, under the influence of the real estate boom. The city has experienced capital growth in high-technology manufacturing; financial and business related activities, etc. In 1996, the HITEC City project was inaugurated by the Government, with 64 hectares of land acquired by the Andhra Pradesh Government, with 90 per cent of the capital provided by Larsen & Toubro limited and a joint venture with AP Industrial Infrastructure Corporation. This has led to rapid urban growth, whereby the erstwhile Hyderabad Urban Agglomeration (HUA) which consisted of the Municipal Corporation of Hyderabad (MCH), 12-peripheral municipalities, Secunderabad Cantonment, Osmania University and eight gram panchayats (elected village councils),has been assimilated and the Greater Hyderabad Municipal Corporation formed in 2007.

A future projection of population for the HUA is shown in Figure 4.2 whereby the population of the surrounding municipalities is expected to grow very rapidly and match the population of the core areas of the Corporation. The observed growth, as well as the projections, indicates that the development will continue to happen in the fringe areas of the main city.

These areas have turned into growth nodes in

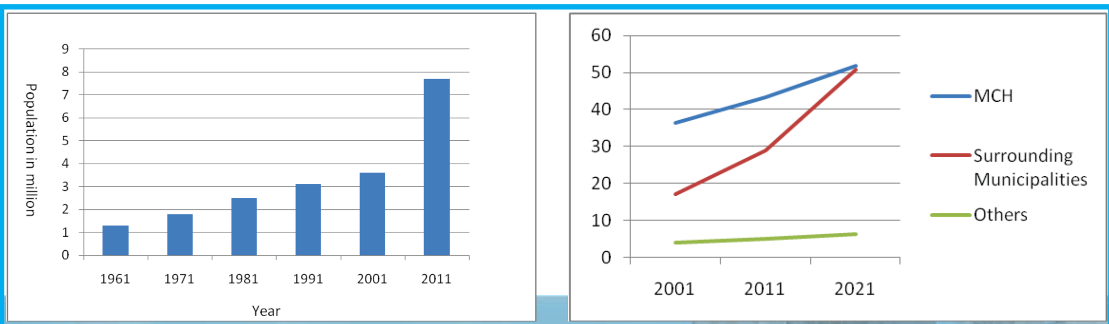


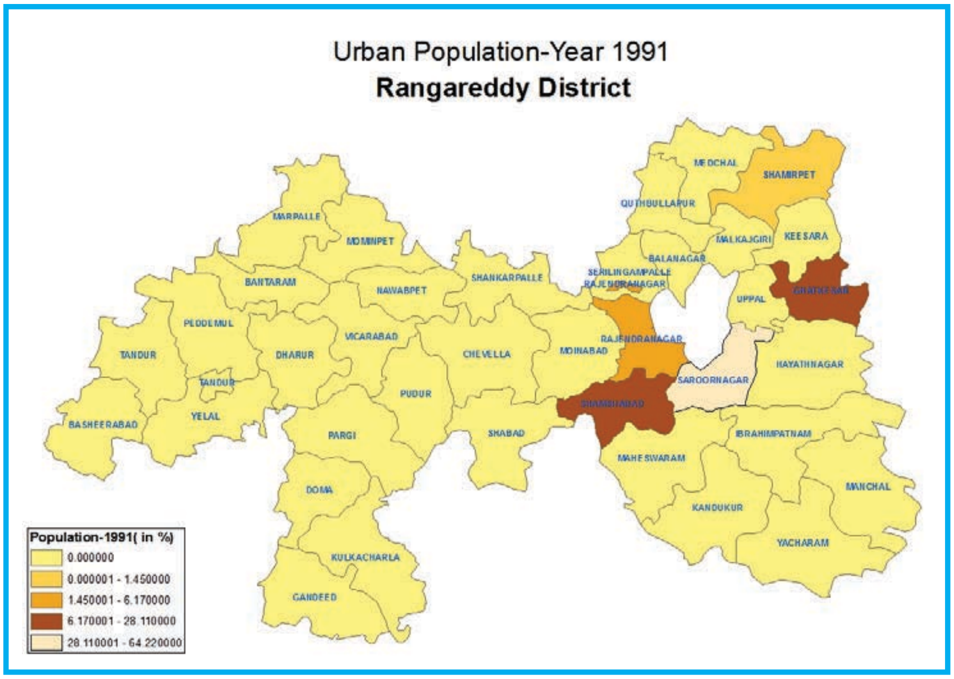
Fig. 4.2: Projected population figures (in million and growth in percent) for components of Hyderabad Urban Agglomeration (2001-2021)
Source: Calculation from data in GHMC Hyderabad City Development Plan, undated

recent years, and the real estate sector has boomed largely in these areas, providing housing facilities to the IT professionals coming into the city for new opportunities, as well as for further commercial expansion through SEZs, IT parks and so on. The changing rural-urban proportion from 1991-2001 is shown for the administrative divisions (mandals) of the Ranga Reddy district (Figure 4.3)

One can detect several growth corridors around the municipal boundaries, the maximum impact being felt in the Qutubullahpur and Rajendranagar mandals, located nearest to the HITEC city, which was the first and foremost initiative by the government to attract foreign investment and employment opportunities for the information technology sector. The Rajendranagar Mandal has also gained further importance after the new Rajiv Gandhi International Airport in Shamshabad became operational in 2008. Both these mandals are also very well connected to the Outer Ring Road which has been planned as part of the urban development activities by the (HMDA). The HDMA was formed in 2010 to undertake infrastructural development for the newly developed infrastructures outside the GHMC boundaries. The Outer Ring Road construction began in 2006, a year after the construction of the Rajiv Gandhi International Airport. The first phase has connected 5 locations, namely Gachibowli, Namakrama-guda, ORR link road Junction, the Andhra Pradesh Police Academy and Shamshabad. The second phase will connect the northern and eastern peripheries of Hyderabad urban agglomeration that covers the Shamirpet, Ghatkesar, Uppal and Malkajgiri mandals. In anticipation, lands have been already designated for urban development. Infact APIIC has set up an SEZ, Genome Park in Turkapalli, which is the driving factor for urbanisation in the Shamirpet Mandal. The IKP (ICICI knowledge park) has also been built in this area and HMDA has been engaged in infrastructural development in the Shamirpet mandal with the construction of the second phase of the Outer Ring Road.

In Shamirpet and Maheshwaram mandals, rapid urban growth combined with growth strategies adopted by the Government of Andhra Pradesh, has seen large scale impact from 2008 onwards, when the IKP started operating. Both these mandals are therefore still largely rural and are undergoing changes with large tracts of agricultural land being acquired for various developmental activities as reported from the field observations and interactions with communities. These landuse changes could not be captured and represented in a map, because of the lack of census data after 2001.

Maheshwaram mandal, in close proximity to the International Airport, has been an ideal location for several mega multi-national



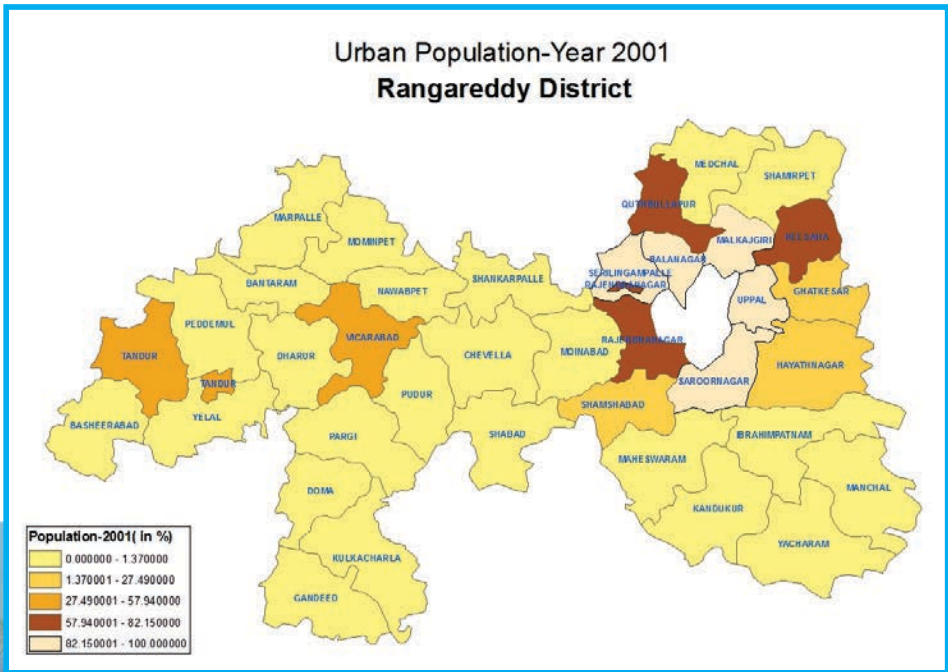


Fig. 4.3: Percentage of Urban population (in percent) of Rangareddy district, Andhra Pradesh (1991 and 2001)

Source: Computed and prepared on GIS from Census data-1991 and 2001

projects like Hardware park, Nano Technology Park, Fabcity, Gems Park, Industrial Park and IT Corridor Park, Nova Park, Apparel Park, etc., adjoining Srisailam Highway in the villages of Raviryala, Srinagar, Maheshwaram, Kandakur, Mansanpally, Nagaram, from which 190 ha of agricultural land has been acquired alone for the Fab City. While land acquired for the Fab city are scrublands, the Ring Road has been constructed by acquiring agricultural land, reported the local communities from Raviryala. These are the newly developing enclaves that govern the changes in the land utilization patterns while also influencing the occupation of the communities living in the villages. While the urban authorities are more concerned about the provision of basic services, especially water to the newly developing enclaves, the village communities are still dependent on water supplied by the panchayat through the Rural Water Supply Department, with systems not maintained properly. Lack of funds with the panchayat failing to replace the damaged pipelines, the flow of water to colonies away from the core areas of the village are disrupted, while surrounding development zones receive 24x7 water supply from the Water Board, through special pipelines.

4.3 THE VARIABLE CLIMATE STRESSOR: LOOKING AT SOME KEY TRENDS AND IMPLICATIONS

Urbanisation has shaped access to water for communities living in the peri-urban areas. However, changing climatic trends are likely to work as further stressors, making the situation worse. To understand what kind of changes the city has witnessed, with regard to its climate, analysis of basic meteorological data (of Hyderabad) revealed that there is an overall increase in 1.5°C in the mean maximum temperature in Hyderabad during the last six decades. Due to absence of data for the peri-urban areas, analysis was based on data available for weather stations in Hyderabad, located in Begumpet.

The number of rainy days within a year varied from 39-63 from 2000 to 2010. The year 2001

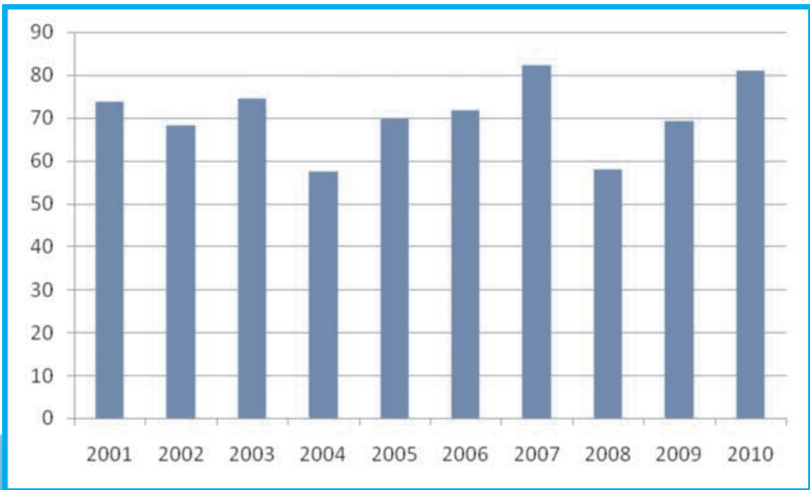


Fig. 4.4: Rainfall Trend in Hyderabad (2001-2010)
Source: Computed from IMD data, Hyderabad

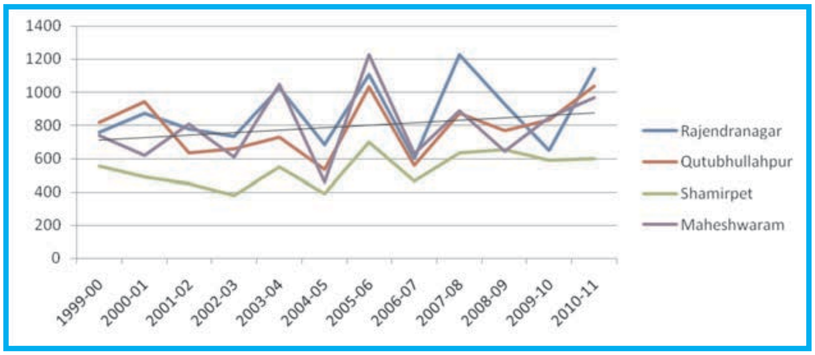


Fig. 4.5: Rainfall Trend in the four Mandals of Rangareddy District in Hyderabad (1999-2010)

Source: Data from Government of Andhra Pradesh, Hyderabad

experienced 42 rainy days whereas the years 2002, 2003 and 2004 recorded 47 days of rainfall. Only four years recorded rainfall above 50 days which was the average number of rainy days in the entire phase. The graph below shows that in 2002, 2004, 2008 and 2009, less than 70 per cent of the rains were experienced during the monsoon season, with 2004 and 2008 registering the lowest. This means that almost 30 per cent of the rains occurred during the rest of the year. Only in 2007 more than 80 per cent of the rainfall has taken place during the monsoon season (Figure 4.4).

A correlation was run between the total annual rainfall and the number of rainy days for the entire year and number of rainy days only for the monsoon season. The results reveal that neither the number of rainy days during the monsoon season alone, nor the number of remaining days of rainfall for the rest of the year alone had an impact on the total rainfall. This means that it is a combination of the two which contributed to total rainfall in the city.

The mandals selected for the study clearly show that, until 2002-2003, the total rainfall in the mandals was somewhat steady (varying between 700 to 900 mm). But after 2003, it seems to be taking an extremely erratic trend dipping to less than 500 mm and rising above 1000 mm every two to three years, except in Shamirpet mandal, which shows a consistent pattern as far as total rainfall is concerned. (Figure 4.5)

Box 4.1

Impact of Urbanisation and Changing Climate: Quotes from the Field

"There have been no heavy rains over the last few years, only slight drizzles",

"Process of urbanization led to rapid destruction of the forests in the watershed. The reduction in the forest cover has led to lesser amount of rainfall."

"Surface tanks have not been filled since last ten years, due to scanty rainfall."

"Everyone now has a borewell in the village for agricultural purposes, since rainfall has not been sufficient to cultivate through tank irrigation"

Responses from the field visits and focus group discussions have indicated the variability of the climate from what it was during the pre-development phase in Hyderabad. Some of the quotes that point towards these changes have been captured in Box 4.1.

4.4 IMPACT

4.4.1. Loss of access to surface water bodies for livelihood

Hyderabad has been receiving water since medieval times from surface sources like the Musi river, and later during the sixteenth century from the Mir Alam tank followed by the Hussainsagar Lake (located in the heart of the city of Hyderabad), both of which were being used as a drinking water source by the end of the 19th century for several parts of the adjoining parts of the city. Apart from this, several other tanks in all parts of the Deccan tract in and around Hyderabad were built during the early part of the twentieth century, to enable draining of floodwaters and to protect the city in future from floods and droughts and ensure water security throughout the year. There were 932 tanks in 1973 in and around Hyderabad; the number fell to 834 by 1996. About 18 water bodies (locally called tanks) of over 10 hectares and 80 tanks of below 10 hectares were lost during the initial phase of urban development in the HUDA area (Ramachandraiah and Prasad, 2004). 70 per cent of the largest manmade lake the Himayatsagar, used as a source of water for the city, has already shrunk due to drying up of the smaller lakes in the watershed areas, accentuated by reduced rainfall and low groundwater recharge, and construction of the international airport (ibid).

A GIS study of the watershed (2000 and 2012) of the surface tanks situated adjacent to selected peri-urban research locations shows changing land use and blockage of channels preventing water inflow to the lake. The impact has been accentuated by an erratic rainfall regime.

Figures 4.6 and 4.7 show the extent of urbanisation in the Raviryala watershed, whereby built-up areas have encroached on the main drainage channels, reducing inflow of water to the chain of water bodies within the watershed including the Raviryala cheruvu, marked in blue towards the north-east corner of the watershed, which has affected water security for the farmers and the dhobis (washermen). The dhobis consider themselves even more vulnerable since they have been dependent on the cheruvu directly. According to the dhobis "sewage from the surrounding villages of Mankala, Srinagar, Sardarnagar and Thukkuguda is being diverted into the feeder channels of the cheruvu. The flow of sewage is usually limited by the weeds in the channel, but only temporarily as it would only require a season of heavy rains to bring the sewage gushing into

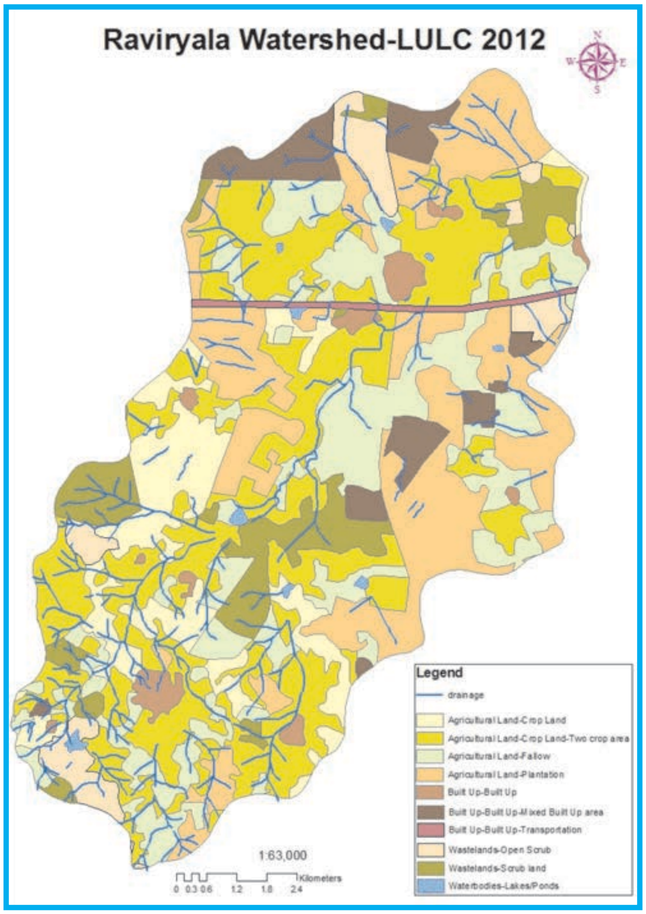
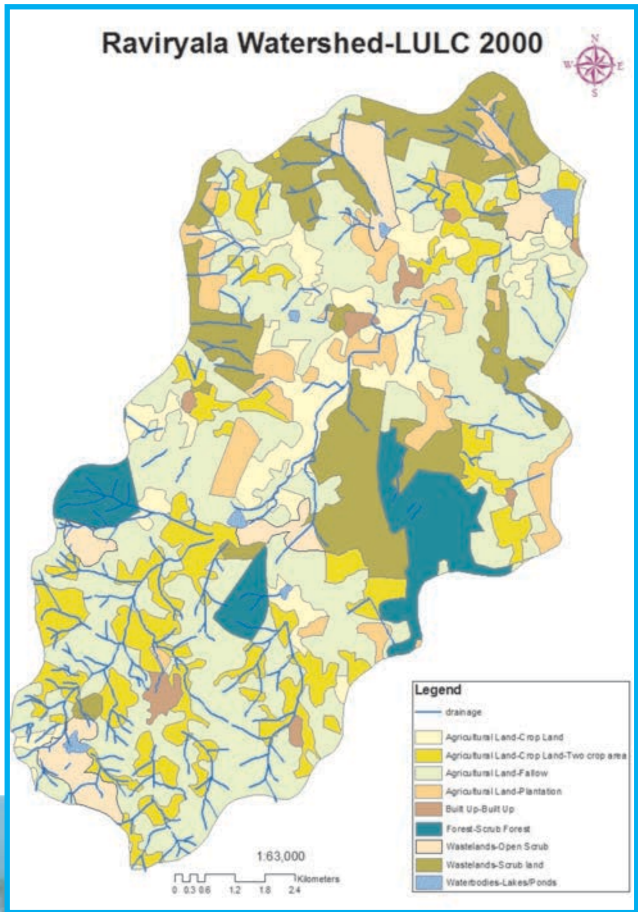


Fig. 4.6 & 4.7: Landuse/Landcover (LULC) in the Raviryala Watershed (2000 & 2012)

Source: Prepared through GIS mapping using satellite imagery and primary survey



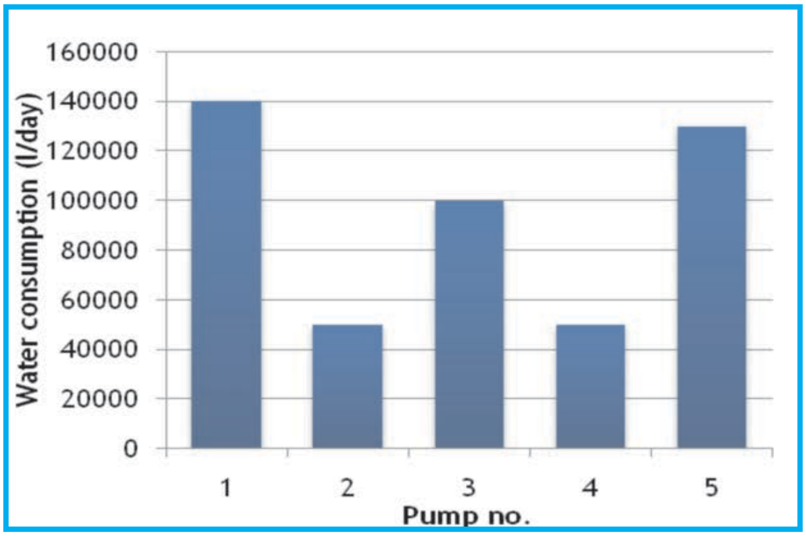


Fig. 4.8: Water Extraction by Tankers from Private Pumps in Mallampet

Source: Field survey in Mallampet village, 2011

the Raviryala cheruvu," as revealed from the PRAs and FGDs were conducted by the research team in Hyderabad.

4.4.2 Peri-urban to urban water transfers and water insecurity for communities

Increasing demand for water in the city of Hyderabad has encouraged private entrepreneurs to engage in the water market. Their activities are mainly concentrated in the peri-urban villages around smaller surface water bodies from where water is supplied through tankers to the city. In Mallampet, a peri-urban village, water is extracted rampantly to serve the industries and residential enclaves, which do not receive sufficient water from the Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB). These have affected the groundwater reserves. Panchayat borewells are often running dry during summers, transpiring into acute crisis for several days in a row, especially for households away from the borewells.

The quantity of groundwater has limited all the year round agriculture, profitable to the farmers. With the increasing demand for land for real estate and infrastructure development in the area, lands in and around the Mallampet village have been acquired by the (HMDA). The rising demand for water in the surrounding residential colonies and factories

PRAs and FGDs with local communities, Hyderabad peri-urban sites- 2011

Tankers extracting water from Agricultural Fields in Mallampet Peri-urban village in Hyderabad

around the village, due to the limited municipal supply has given famers a profitable business of selling water from their agricultural lands. This is an activity with least investment and much higher returns. Agriculture is only pursued by few households during the monsoon season if rains are satisfactory, when rice is grown, while vegetables may be cultivated during the rest of the year.

An estimate of the water outflow from the village by the tankers revealed that in a single day, approximately fifteen to twenty tankers, each with a capacity of 5500 litres, travel out of Mallampet, which extracts upto 100,000 litres of water from one borewell, though this amount partially varies across seasons (Figure 4.8). Five borewells are operating in the village and yield upto 500,000 litres of water. The constantly changing dynamics, but with new opportunities emerging, the village panchayat is finding it extremely difficult to meet the demand for clean water of sufficient quantity as pointedout a worried sarpanch (who is no longer in power because of delayed panchayat elections). During the survey in 2010, he mentioned that the supply of water is somehow being managed for the summer months but it is really difficult to gauge how this will shape in the coming years, considering the large number of migrants moving into the village because of the nearby Bollaram industrial area providing jobs. People report that water in the village was good even a few years back, drinking water is now purchased by over 90 per cent of households, from several filtration plants that have mushroomed all over the village over last three years during the project period, supplying water at INR 2-5 ($0.03-0.08) for a 20 litre can.

4.4.3. Water Availability at the household level: Caste and Class interactions

The primary source of drinking water for all households in the four study villages in Hyderabad is bottled water which is purchased (62%) by households from filtration plants or other commercial vendors located in the village, followed by the water supplied by the panchayat (21%),per cent and manjeera supply (13%)which is only available in Peerancheru occasionally, when payment is made to the Water Board. The Singur Manjira project is located 80 kms away from Hyderabad from where drinking water (upto 122 mgd) is supplied only to colonies within the boundaries of the Greater Hyderabad Municipal Corporation. This Drinking water project has been supplying water from 1965 since its inception till 1993. Peerancheru is one village, which although located outside the Municipal Corporation boundary receives intermittent supply from the manjira project on payment to the Water Board and hence not considered as a reliable source for drinking throughout the year. For other uses, households access water which is supplied through a pipe network or through public

stand posts, which are either small pipes sticking out of the ground along the main roads or by-lanes, or mini tanks (cement tanks) of approximately 100-150 litres, which stores water supplied by the panchayat from the overhead storage tank.

Across all the villages, 90 per cent of surveyed households in Peerancheru and 84 per cent in Aliabad have piped connection inside or in front of their house. The panchayat piped networks are connected till the lanes and by lanes, while the households pay a meagre amount of Rs 20 (less than half a dollar) to bring the connection into their premise through an additional pipeline. In Mallampet only 57 per cent of households and in Ravirala, slightly more than 60 per cent of the households have piped connections inside their homes. The frequency of water supplied every day to a household actually determines access to water for the households. In all the villages, the frequency of piped network supply varied from everyday to every fourth day and in certain cases, even more number of days, between supplies. The frequency of water supply across the four study villages and across the predominant caste groups is shown in Figures 4.9 and 4.10.

Despite the regular frequency in water supply, the number of hours or minutes of water supply plays a very critical role. In Aliyabad for example, water is available for limited hours only, as booster pumps are unable to supply water to certain portions of the village due to choked pipes and voltage fluctuations, although water is supplied daily. This feature has been a case for the scheduled caste colonies located in two different parts of the village. Hence a Frequency-Time Index (FTI) was created by combining the frequency and duration of water supply available in the household dataset and then examined across the households of the four study villages to identify proportion of households in different categories of FTI. Based on focus group discussions with the community, 90 minutes

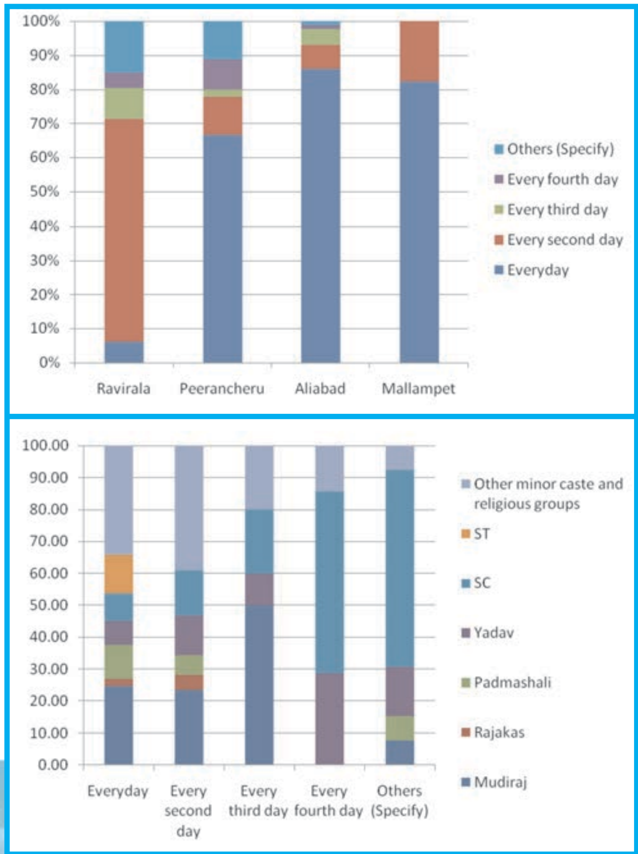


Fig. 4.9 & 4.10: Frequency of Water Availability Across villages and Caste Groups
Source: Primary household survey, 2011-2012

(one and half hours) of undisrupted water supply every day was reported as being satisfactory to be able to meet the household needs (not the best situation though). Keeping this duration and frequency as a benchmark, the index was prepared and categorized into medium to satisfactory, low to medium and poor to medium. Figure 4.11 shows that almost all the surveyed households in Raviryala and Aliyabad belong to the poor to medium FTI, which means, that the village as a whole is vulnerable to water insecurity irrespective of the caste or class of the household, although the scheduled caste community apparently seems to be more vulnerable, as blockage in the pipes have not been cleared and is likely to disrupt the water supply further if the panchayat is unable to replace the pipes.

In Mallampet, the larger proportion of households belong to the medium to satisfactory FTI category because the frequency of water supply is best amongst all the other villages. However, this village is extremely vulnerable as far as water supply in summers is concerned when a large proportion of households are likely to slip into the poor FTI category because pressure on groundwater table is very high as the commercial extraction increases and more frequent powercuts prevent booster pumps from supplying water efficiently to the farthest end of the village. Men and women in Mallampet have to make multiple trips to the core area of the village to fetch water from the standpost, when water is unavailable at the nearest standpost, a scenario that sometimes, lasts for 'almost ten days', reported by women from the low income colonies. The opportunity cost is also high and male members of the family, who have to collect water, at specific hours, thereby often getting delayed for work. As compared to the other core areas of the village which have a good frequency of water supply from the panchayat borewell, the migrant colonies receive erratic water supply due to their location at the farthest end of the village or in portions of the elevated tract, where panchayat supply is not available though government housing schemes for the poor have been uptaken through Indira Awas Yojana (IAY).

4.4.4 Water Insecurity for livelihood

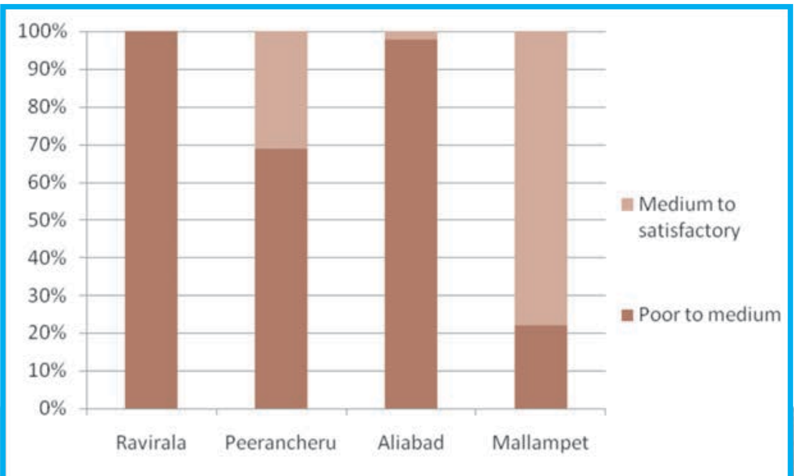


Fig. 4.11: Frequency Time Index Across Peri-urban Study Villages
Source: Primary household survey, 2011-2012

activities

In the peri-urban research sites of Hyderabad, Aliyabad and Raviryala villages exhibit more rural characteristics as agriculture still predominates. They are vulnerable to the effects of urbanisation and climate change, which have altered their agricultural calendar substantially. Raviryala has lost its main source of water for irrigation due to the shrinkage of the water tank, making farmers and the washermen community most water insecure. Shifting from their traditional sources of livelihood to find work in the city or to diversify their sources of earning has become a way of adapting to the water insecurity. In Aliyabad, the amount of water in the Shamirpet tank has drastically reduced the water being channelled into the irrigation canal, therefore making agriculture difficult to pursue, especially by those who cannot afford a personal borewell. Water from this tank is also shared by several villages downstream. The erratic rainfall regime has only worsened the situation further for the agrarian community. In Raviryala and Aliyabad, key informants from the farming community revealed changes that have occurred in their agricultural calendar shown in Figure 4.12. They attribute these changes to reduced groundwater availability, influenced by low rainfall.

The other community that has become vulnerable to inadequate water in the surface tank are the dhobis and the fisherman community (rajakas and boyas/mudiraj). In Mallampet, the fisherman community has been robbed of their profession, when lack of strong governance has been unable to protect their interests and their livelihoods which earlier had been quite profitable. The village has upto 94 members in a registered fishermen's society with the real count of fishermen crossing 130 to include migrant fishers, but no waters to fish in. The initial wave of development cordoned off the surface tank, the

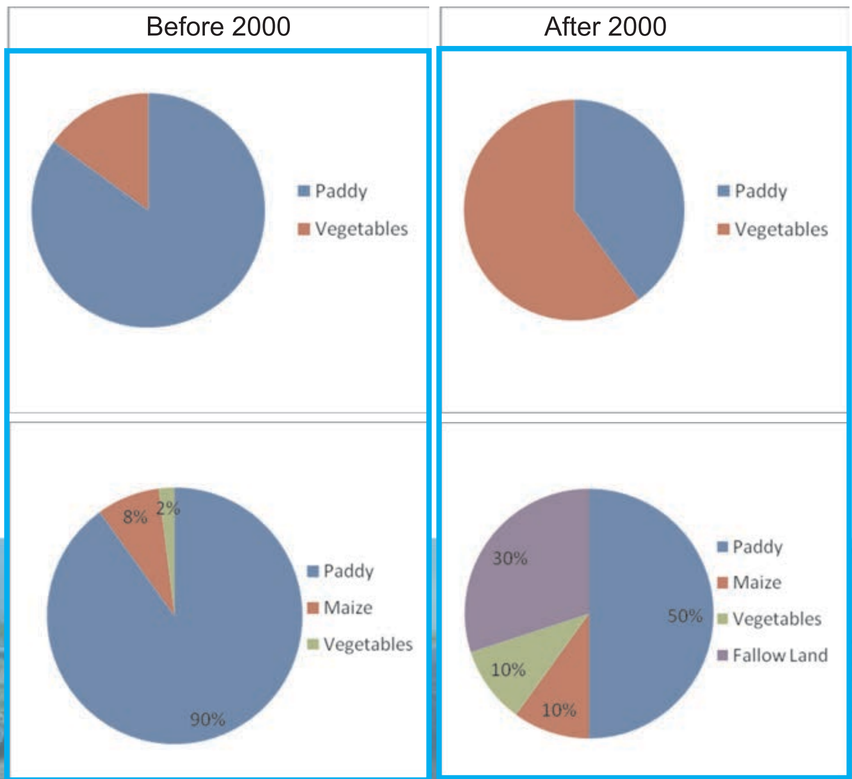


Fig. 4.12: Land allocation for paddy, vegetables and other crops before and after 2000

Source: Key informant interviews and FGDs with farmers

Khatua Cheruvu, towards the south, reducing the spread of the lake and the right to access for those dependent on it. This is clear when the fisherman community mention that a portion of the area that the nearby industry acquired has in turn been sold to farmers outside the village to develop orchards. Further, with the Ring Road being constructed, the tank has been reduced to half its previous size, with the channels being blocked which fed it with freshwater during the monsoon season. In Peerancheru, the pollution of groundwater due to waste disposal by the nearby hospital into the water body initially affected the groundwater and agriculture. Acquisition of lands for infrastructure and real estate development accentuated the problems, thereby robbing the farmers off their source of income. For all practical purposes, agriculture has ceased to exist in this village.

The dhobis in Raviryala have only seen the Raviryala cheruvu filled ten to twelve years ago. Since then, the watershed has been encroached and the water spread reduced to an extent, which limits the activities of the dhobis. To adapt to the situation they have installed a borewell, after pooling in resources, just to get groundwater to wash their clothes. Many of the rajaka households (dhobis) have migrated to other professions, due to low income levels that do not enable them to meet basic daily expenses. In some households, children have also dropped out of school, to support the family to earn a living.

4.5 Action and advocacy: building adaptive responses of the communities through the project

The state of water security in the four peri-urban research sites around Hyderabad city is dismal and calls for immediate attention in order to combat long-term water insecurity. The project has undertaken capacity-building initiatives at different levels- of communities and line departments, who directly or indirectly bear some responsibility for water security in these environmentally delicate terrains. Since they are in constant interaction with these terrains and alter the nature of activity been pursued therein, they in turn disrupt the natural environmental flow.

During the project period, the peri-urban villages of Raviryala and Aliyabad were selected for intervention for capacity-building

Peeracheru lake receives filth from the surrounding hi-rise apartments and other public institutions

Washerfolk in Raviryala struggle to make a living activities with men and women. Training programmes were organized in collaboration with MV Foundation, a grassroots organization working with farmer groups in Aliyabad village, on some basic aspects of water and hygiene. At a later stage, a technical training programme was conducted by scientists and trainers from Research in Environment, Education and Development Society (REEDS) and Centre for Research in Dryland Agriculture (CRIDA), who not only explained what climate change was but also some of its long-term implications that could affect water availability for pursuing agriculture.

Capacity building sessions with women

Drawing competition to create awareness about water and environment

The communities were trained in different kinds of techniques for long term adaptation. These included rainwater harvesting, different techniques to improve soil moisture and help cope with low rainfall regimes and the use of particular machinery to reduce the burden of agriculture while improving efficiency. The means to obtain these machines through subsidies with the government departments along with effectiveness of organic farming techniques were some of the most important components of the training. All the techniques were explained through theoretical sessions, followed by practical demonstration for ease of understanding. Field trips were organized by the MV Foundation which exposed the communities to

watershed development that can help rejuvenate the water table and improve the water security for the communities. The organisation along with the research team in Hyderabad engaged closely with the communities to convince them to form a Village Water Sanitation Committee (VVSC) that could uptake issues of water and water management in the village, a committee comprising individuals from all social groups, irrespective of caste/class. While a formal legal group could not be constituted, an informal group comprising 15 men and 5 women has been formed whose first initiative was supervising the construction and maintenance of a cement storage tank within the school for the children to use.

Apart from the above training sessions, education and practical training was undertaken in the Yadav colony of Ravirala village with regard to maintenance of water systems and organised garbage disposal to avoid contamination of individual household underground sumps (water storage tanks). These training sessions helped train the residents to maintain their water storage systems better, and prevent them from being polluted. The community was also trained about the benefits of segregating household waste, through the setting up of dustbins in specific locations, to prevent haphazard dumping of wastes. This initiative by the VWSC also involved women from the local self-help groups, to make them more aware of the linkages between water and health, and ways of purifying water before consumption, means to protect their storages from getting contaminated by the sewage, garbage and leakages from animal wastes. This initiative was undertaken through direct involvement of the VWSC that promises to improve the systems, even if it is in a small way. They helped with mobilisation of women and men from the colony to be part of this training programme and to further spread the practice to other colonies by way of constant engagement. The Committee has also been very pro-active in undertaking awareness programmes with the communities from all colonies in the village. With support of the project team, a painting and drawing competition on water and

Orientation program with HMWS&SB officials

environment was organized in the village school in Raviryala to generate greater awareness among children and the youth.

The VVSC in Raviryala pledges to work for improving the water security of its residents, against the impact of climate change and urbanisation. The committee has played a formidable role in involving the village community for awareness and training programme on solid waste management. The cement tank has benefitted school children by providing them a storage facility, which they can use for washing during the lunch break, when water is unavailable.

As part of the advocacy component of the project, the team members have been in communication with relevant Government departments, directly or indirectly involved in water provisioning and development activities, through stakeholders meeting where project outputs at different points have been shared, and discussions took place on ways to take forward, a more sensible and sustainable development trajectory. An orientation course was organized by the Hyderabad team and attended by the Engineers of the Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB), to sensitize them on climate change issues, its impact and the appropriate ways in which the Board could plan its supply systems without having to transfer water from larger distances.

Stakeholders meetings with citizen groups at different points of time during the project period have enabled legal follow-ups on protection and revival of water bodies around Hyderabad with respective Government Departments, to ensure that the city and its surrounding areas are water secured even in the wave of rapid urbanisation. At various forums, the activist groups have spoken about their intention to make Hyderabad and its surrounding areas more water-secure, by rejuvenating the tanks/ lakes and have appealed to concerned administrators for support. They have also sought effective policies that are robust enough to punish the perpetrators, who have been involved in the encroachment of water bodies for selfish gain without concern for the

Civil society groups discuss rejuvenation of water bodies in Hyderabad

environment and future of the city.

Although the project initiatives have been targeted towards building adaptive capacities of the communities in both the villages of Aliyabad and Raviryala, the communities in Raviryala have come forth and shown greater interest to bring change to the village and its people. While funds with the local panchayat are still limited, the VVSC wishes to undertake many such activities, the most important being rejuvenation of the water body adjacent to the village. Now that they are more equipped to negotiate with the higher officials at the Mandal level, this activity if successful, will help improve the water table and ensure water security in the longrun. This could also help to reduce the use of borewells by the farmers for irrigation. Although these have been a stepping stone, a larger change is in the pipeline with the project being able to set the ball rolling in this direction.

4.6 SUMMARY

Hyderabad has undergone rapid urban growth and the effects have been felt in the peri-urban areas which are subjected to severe stress for water and other environmental services. The villages, where research and action was undertaken, have been continuously impinged upon in different ways, either to serve the needs of the city or to provide homes and other means of income generation for the residents of the city. While the communities in this unique area lost their lands and therefore, means of livelihood, they also bore the brunt of water footprints of the city, making them most vulnerable.

In all the villages, the households have adapted to the poor water quality by purchasing water from the local vendors and filtration plants, set up by the panchayat or other local private entrepreneurs, although for many, it does appear to burden their monthly expenditure substantially. With regard to erratic water availability as depicted through the FTI, the households have either procured water from nearby villages or the city, while suffering the opportunity cost. While building larger storage facilities could be a way to tide over long drier spells during summers, income levels seem to be the deterring factor and only very few households have built underground sumps (underground water storage tanks within the household) to store water supplied by the panchayat. The strong social binding (despite social differences) prevailing in some of the villages enables them to access water from neighbours in times of crisis. On the other hand, they are also subjected to exploitation while being rendered a favour (of accessing water, only in times of crisis) against payment.

The lack of awareness of climate change and its impact makes communities even more vulnerable. They are able to relate to variability in the rainfall and temperature patterns and therefore either shifted towards the extensive use of borewells (as is the case of

Water markets are on a rise in peri-urban areas

Hyderabad and Gurgaon) or altered their cropping patterns from rice to vegetables and fruits. In an existing low rainfall regime and no access to surface storages, farmers reported that those who cannot afford a borewell have to leave their lands fallow, but nevertheless, rice cultivation has almost been reduced to only one crop in the year, while fruits and vegetables are preferred. They also reemphasize on the variability of climate that the region is experiencing when they speak of a recent year when soil moisture was not enough to even grow vegetables leading to the vegetable patches being dedicated to fodder crops.

The research conducted in the peri-urban villages of Hyderabad points toward the urgent need for the Hyderabad Metropolitan Development Authority to conduct a water audit and accordingly plan for the development of water supply systems in these areas without disrupting the environmental flows. Management of water schemes already prevailing in the villages need to be strengthened through repair and maintenance. The VVSC constituted in the Raviryala village for example, can take a lead role in this regard to work with concerned government departments to ensure that progress is made in this direction and that there is some accountability. More essentially, the urban authorities must critically review the development paradigm prevailing in peri-urban areas and means to modify existing plans for development that are environmentally sustainable.

Urbanisation and climate change: implications and responses for water security of peri-urban areas of Kathmandu valley

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ANUSHIYA SHRESTHA
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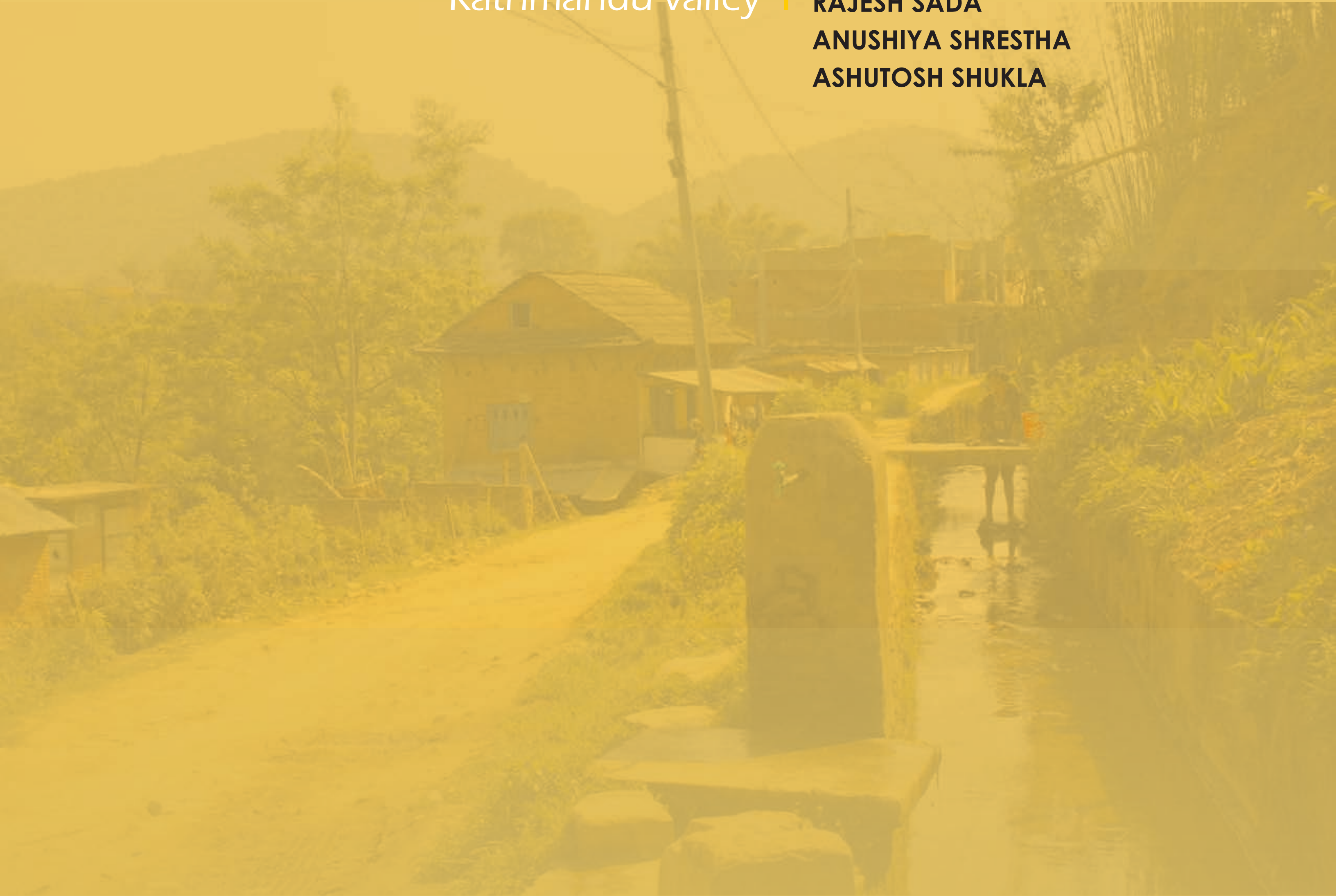

5 kathmandu
NEPAL

5.1 INTRODUCTION

In the pre-historic age, Kathmandu Valley existed as a lake, and was surrounded by hills and forests. The lacustrine sediments found in the valley give evidence to this geological ancestry of the valley. Myths described in Nepal Mahatmya, one of the important Nepali religious books, suggest that lord Krishna drained the lake. Swayambhu Purana, yet another Nepali text, tells of an earlier period when the lake Kalihrada, also called Naghrada, was full of snakes, and the lake was then drained out by a Buddhist Monk, leaving the Bagmati River flowing through it (Tiwari, 2005). Once the water was drained, the valley was settled by people at different phases of time (Jha, 1996). As the valley had a rich endowment of natural resources- water, forests and fertile lands - people started living along the river course where they grew agricultural crops and raised livestock with the river water as the source of irrigation. The Bagmati river and its tributaries were the major sources of drinking water for the people in the early days. Agricultural land was plentiful and there was an abundance of water that encouraged people to use land and water resources as their means of livelihood.

Kathmandu Valley comprises of three ancient towns, viz., Kathmandu, Bhaktapur and Lalitpur, which were once independent states ruled by the Malla kings from the 12th to the 18th centuries. During these periods, Kathmandu Valley itself used to be known as 'Nepal' and therefore many historians consider the early history of Nepal as the history of Kathmandu valley (Regmi, 1999) though there were several other princely states. In 1769 A.D, Prithivi Narayan Shah, the king of the Gorkha, conquered these three kingdoms in the Kathmandu valley and united the princely states into unified kingdom of Nepal. Kathmandu was made the capital city of the country.

Geographically, Kathmandu Valley lies between the latitudes 27° 32' 13" and 27° 49' 10" north and longitudes 85° 11' 31" and 85° 31' 38" east (Pant and Dongol, 2009). The elevation in the valley ranges from 1,100 to 2,700 metres above sea level, and forms complex topography within a small geographic area (Thapa and Murayama, 2009). The three valley districts are made up of 119 local administrative units (Village Development Committees or VDCs and Municipalities) and these altogether cover an area of 899 km^2 whereas the area of the Valley as a whole is 665 km^2. The Valley encloses the entire area of Bhaktapur district, 85 per cent of Kathmandu district and 50 per cent of Lalitpur district (Pant and Dongol, 2009).

Kathmandu valley is the most urbanized

centre of Nepal and includes five major cities, namely, Kathmandu, Bhaktapur, Lalitpur, Kirtipur and Thimi. The construction of Tribhuvan Highway, linking Kathmandu to Hetauda, in 1956 was the first transport corridor in the country that linked Kathmandu to Terai and to the Indian border in the south. People from other parts of the country started migrating to Kathmandu valley after 1960 with the development of transport and communication infrastructures. The urbanisation pattern in these cities is very haphazard and this flourishing urban growth has fundamentally changed the land use and land cover patterns of Kathmandu Valley.

The process of urbanisation and subsequent expansion of the built-up area into the peripheral rural landscape and the resulting transformation of the land use were largely spontaneous. The state did not either intervene or plan the urban growth, leading to the formation of an area with a mix of rural and urban livelihoods. This is the peri-urban zone, an area of on-going transformation of land use and livelihoods. These peri-urban communities are inadequately integrated into the city's society and its institutions. They also receive little or no benefits of urban infrastructure and urban services. This continual process of haphazard transformation in Kathmandu Valley has led to physical, social and environmental problems, and has created immense pressure on land and water services in the peri-urban landscape of the valley.

Besides unplanned urban growth, climate change is expected to worsen the availability of water in these areas and impinge on the quality of local water. One can expect that decreased supplies and poor qualities will cause stress on livelihoods and wellbeing of the people living in these areas, leading to water in-security.

It is in this backdrop of current difficulties around water security and impending enhancement of these, that this

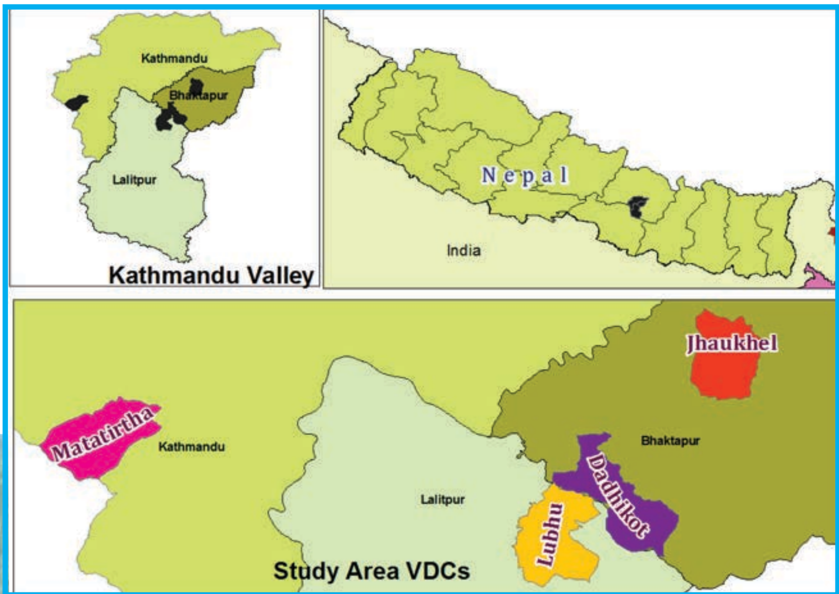

Fig. 5.1: Location map of the study area
Prepared on GIS using satellite image and maps

study in the peri-urban areas of Kathmandu Valley was undertaken. The aim was to understand the processes and changes brought about in the rural landscape as a result of urbanisation and climate change and its consequences for the use and management of land and water resources. Considering the diversity of water security concerns induced by the compounded effects of urbanisation and changes in climate, four different peri-urban sites viz. Jhaukhel, Dadhikot, Matatirtha and Lubhu were selected for the study to elicit how the water dynamics at the urban fringes have been influenced by the combined stress of the above (Figure 5.1).

This chapter identifies the water security concerns across the peri-urban areas of Kathmandu Valley and highlights adaptation practices and gaps, thereby assessing the differential vulnerabilities to which the peri-urban communities are exposed. The first section of this chapter provides a brief introduction and a description of the research sites whilst the second section describes the trend of urbanisation in Kathmandu valley and the peri-urban sites. The third section illustrates the perceptions and experiences of local people regarding changes in climatic variability, and section four describes their impacts on water security. The responses of the local community and institutions to the increasing impacts of compounding effects of urbanisation and climate change are described in this chapter.

5.2 Trends of urban growth in Kathmandu Valley

Kathmandu Valley is the most urbanized area in the country. Early settlement in Kathmandu and adjoining cities was limited to the historical city core. The process of urbanisation in the valley started only in the 1960s and accelerated after the 1970s (ICIMOD, 2007). This period of migration led to the expansion of the urban area beyond the traditional city core. The construction of a ring road around metropolitan Kathmandu during the mid-1970s further accelerated the pace of urbanisation that started reaching the adjoining rural areas post 1990s (Thapa et. al., 2008).

Rapid urbanisation has resulted in unprecedented land subdivision in the rural areas with the construction of houses, commercial buildings and other infrastructure facilities and services. The influx of internally displaced people, who started to settle in the valley after the start of the Maoists' armed struggle in 1992, rapidly accelerated the demand for housing plots and other services. Those who could not afford to buy land in the municipal areas preferred buying housing

plots in the fringe areas and adjoining rural areas. Excessive demand for housing plots in the land market motivated the rural landowners to sell their agricultural land for the development of houses at lucrative prices. The difficulties in cultivating the land - primarily due to shortage of labour led by increased opportunities for non-agricultural employment also fuelled land-use transformation. The absence of regulatory mechanisms or official restrictions also aided the change: besides getting cheaper housing plots, another motivating factor for new migrants to settle in rural areas was that there was no need to get building construction permits from the local authorities in these fringe areas. Thus expanding built-up areas engulfed what were previously predominantly agricultural areas.

This trend of rapid urbanisation, which started in the 1990s, continues unabated due to continued migration of people from the hinterlands. Even after the signing of a peace accord with the Maoists in 2006, the countryside has not regained its previous peaceful state, leading to a mass exodus of people from the rural areas. From 1955 to 2008, the population of Kathmandu valley grew five-fold and currently, it accommodates around 2.51 million people (Bhattarai and Conwan, 2010 and CBS, 2012). The push factors, responsible for this rural to urban migration are climate change-induced changes in temperature and precipitation regime resulting in adverse impacts on agricultural productivity and continued insecurity arising from lack of employment and livelihood opportunities. Increased flow of remittances sent by the family members employed in foreign countries, and a growing aspiration to live in the urban areas, have been the other determinants of rural-urban migration. In the absence of government-led land development, private land developers and land entrepreneurs are involved in land-related businesses. Buying tracts of low priced land, partially developing them and reselling for a profit, has been a characteristic of urban development in Kathmandu and in other urban areas in the country. Land speculation is prevalent at both individual and institutional levels. Land brokers and housing development companies hold huge parcels of land in the urban fringe areas for speculative purposes.

A study carried out by the Kathmandu Valley Town Development Committee in 2001 revealed that, between 1984 and 2000, land areas covered by urban settlements had

increased from 3,096 to 9,193 ha. Similarly, agricultural land has been declining on an average at 2.04 per cent per annum (Shrestha, 2006). In 1981, three fourths of the residents were involved in agriculture which in 1991 decreased to one third (ICIMOD, 2007). If this trend continues, by 2025 there will be no agricultural fields left in this once fertile valley. Bhattarai and Conwan, 2010 found a similar pattern which is depicted in Figure 5.2 a&b.

5.2.1 Peri-urban sites and the urbanisation trend

Jhaukhel Village Development Committee (VDC) covering an area of 5.41 km^2 is located at the northern flange of Bhaktapur Municipality. The VDC is inhabited by total of 7721 people in 1631 households (CBS, 2012). In the last decade the population in the VDC increased by 1.56 per cent with the addition of 435 (3.68%) households. This VDC lies in the northern ground water recharge zone among the three distinct groundwater zones in Kathmandu Valley identified by JICA (1990).

Dadhikot VDC, adjoining to the Thimi municipality, covers an area of 6.27 km^2 and situated at the southern part of Bhaktapur district. Over the last decade, the population of the VDC increased by over 60 per centrising to 11629 in 2011 (CBS 2012). During the same period, the number of households doubled. This shows the state of massive land use change and increasing built up areas in the VDC.

Matatirtha is located at the western part of Kathmandu District, approximately 5 km away from the urban area. It covers an area of 6.19 km^2 and is inhabited by 1413 households, with a total population size of 5982 people. In 1981, the population was artificially higher because of the possibility of over enumeration due to the highest monetary incentive given to the field workers compared to all other censuses (Karki, 1992 as cited in CBS, 2003). Though much more recently started, the population growth and land use change from agriculture to residential purposes has been expanding increasingly across the VDC.

Lubhu VDC, situated at the periphery of Lalitpur district, is a 700 year old traditional Newar settlement located at south-eastern

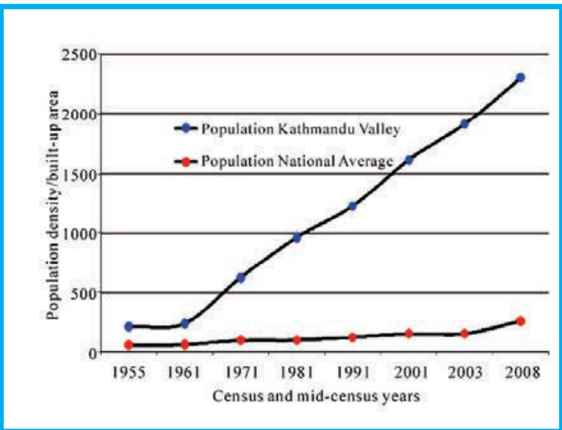

Fig. 5.2a: Comparison between Kathmandu Valley's population density and the national average

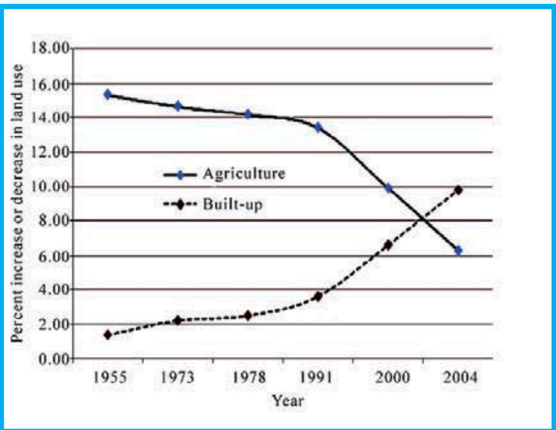

Fig. 5.2b: Comparison between changes in agricultural land and built-up area

(Source: Bhattarai and Conway, 2010).

part of Kathmandu Valley. The total population of Lubhu is growing at an average annual growth rate of 3.63 per cent. As per census 2011, the population of Lubhu is 10374 (CBS, 2012) covering an area of 4.76 km^2. The land pooling project was implemented in Lubhu from 1993 to 1996 which increased the selling away of the cultivable land resulting in increasing number of households reaching 2365 in 2011 from 1439 in 2001 (Figure 5.3).

5.3 CLIMATE CHANGE SCENARIO

The analysis of temperature records of Kathmandu valley showed that the number of days/year when minimum temperatures fell below 0°C is decreasing while the number of days with maximum temperature above 30°C is increasing (Figure 5.4). The maximum temperature is increasing at 0.05°C per year and minimum temperature is increasing at 0.04°C per year. The analysis of rainfall data showed no clear visible pattern both in monsoon and non-monsoon rainfall.

5.3.1 Changing climate as experienced by local people

Most of the respondents perceived an increasing trend of temperature-related indicators such as summer and winter temperature, extreme hot summer days, less cold winter and hot days across all the sites. Most of the respondents of Jhaukhel mentioned an increasing trend of extreme cold winter, which across the remaining sites is commonly observed to be decreasing. Similarly, most of the respondents across all the sites perceived a decreasing trend in precipitation-related indicators such as winter rain, spring rain, number of rainy days in monsoon and persistence in monsoon

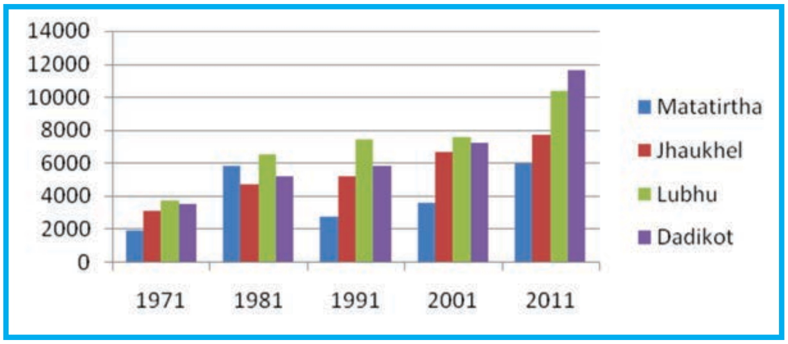

Fig. 5.3: Increasing population trend in four selected peri-urban sites
Source: CBS, 1971; CBS, 1981; CBS, 1991; CBS, 2001 and CBS, 2012

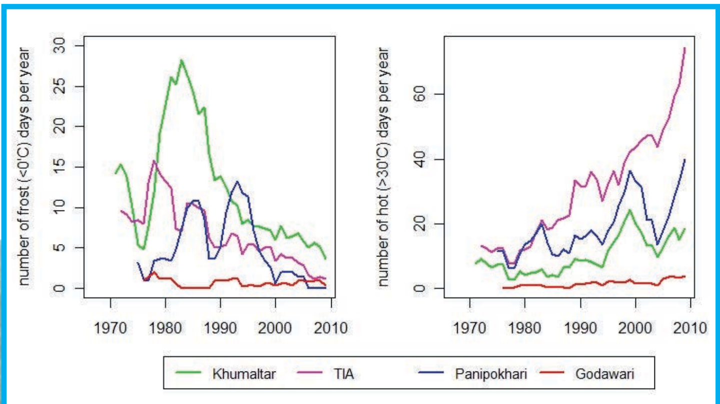

Fig. 5.4: Trend of number of days with Temp>30°C and days with Temp<0°C
Source: Analysis of the data obtained from DHM, 2012

rainfall.

Contrastingly, the majority of the respondents at Jhaukhel observed increasing rainfall intensity and occurrence of windstorms. An increasing trend of occurrence of dry spells is perceived commonly across all the sites. Perception of decreasing flash-flood during rainy seasons and decreasing occurrence of fog in winter is also common across all the sites. The graphical representation of the perceived changes in different climatic indicators is shown in Figure 5.5. Some of the narratives related to temperature and rainfall are given in Boxes 5.1 & 5.2 respectively.

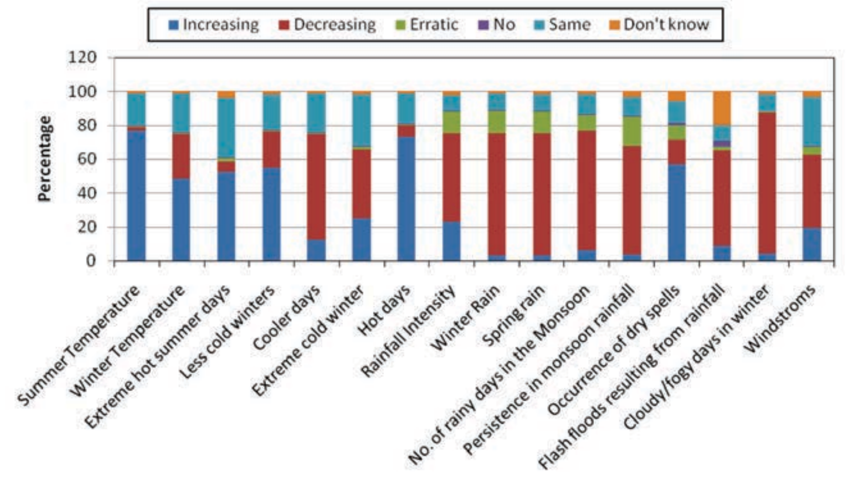

Fig. 5.5: Peoples' perception on changes in different climatic indicators
Source: Household survey, 2012

5.4 IMPACTS OF URBANISATION AND CLIMATE CHANGE ON WATER SECURITY

Water security at each of the four peri-urban study sites has been stressed by the increasing urbanisation and further accentuated by increasing climatic variability. The impacts that local people are facing due to the compounded effect of urbanisation and climate change are described in the following section.

5.4.1 Large scale groundwater extraction and declining water table

The water extracted in the peri-urban areas is either used to quench the thirst of urban dwellers or to meet the water demands of urban-oriented commercial services. Annually, around 90 million litres of groundwater are extracted by 12 brick industries operating within the Jhaukhel village development committee (VDC). Similarly, the volume of groundwater extracted from the 12 commercial wells of the same VDC during fiscal year 2010/11 was more than 90 million

Box 5.1

Local Statements indicating experienced changes in temperature

"Prior to 1980s, winter used to begin by Kartik (October/November) and the peak winter season months used to extend from November second week to mid February (Mangsir to Magh). In 2000s, winter began much later and ended earlier"

"Before 25/26 years ago, Thanto, icy film used to form above water level on the ditches but now it has been 10-15 years that winter is not so cold"

"The maximum temperature has been rising in such a manner; I assume there won't be winter season during my grand-daughter's period"

"Poush Fas Fus was said to due to passing away of the days of Poush (December/January) by the time fog got faded. But now there is no fog during this month."

"The nature has started being unsupportive since last 25/26 years. There was also drought and intense rain as periodic phenomenon, when I was young. So there is no way to blame nature for the production decline. The increase in population, carelessness towards agriculture and the improper application of chemical fertilizers are the major causes."

Box 5.2

Local Statements indicating experienced changes in rainfall

"Persistent rainfall lasting over days and nights (Sat din sat rat jhari, Shaune jahri , Shora Shraddha Jhari, Maghe jhari), were common prior to 1980s and has been declining with larger decline in 2000s "

"The rainfall pattern during June-July has started showing the intense rainfall which used to be characteristic of rainfall during August-September. The rainfall can no more be predicted. It rains in patches very intensely at a place and remains dry at a very short distance."

"The difference in the rainfall pattern and timing has reduced the hardship to work in the field. Before 10-15 years, I could transplant paddy only during July first week but recently I have been able to plant by third week of June."

"There has been decrease in the annual rainfall. The dry spells are getting longer. Had there been winter rain, it would have recharged the spring sources!"

"It has been 8-10 years with good rain. Before that monsoon used to start only during August and our paddy used to be only for straw."

litres. In Matatirtha, the massive commercial extraction of groundwater started in the late 1980s and is perpetuated through wells and springs in private land or leased in land, and springs in public land. At present, there are 14 commercial water extraction points in Matatirtha dispersed mostly along the northern part of the VDC. According to the Matatirtha VDC profile (2010), around 170 trips of water supply by water tankers, (approximately 1.2 million litres of water), are transported to different places of the Kathmandu Metropolis as well as to other parts of Kathmandu valley on a daily basis.

The implications of massive groundwater extraction have not yet been felt distinctly in Matatirtha but the lowering of the water table has been of increasing concern in Jhaukhel. The consequence of declining groundwater level has been the increasing need to deepen wells and bores. The study showed that the average annual groundwater drawdown in the area is more than 1 m. The depletion of groundwater is taken as the first indicator of water scarcity (Shah and Indu, 2004) and also indicates unsustainable extraction and lack of proper management (Shrestha et al., 2012). Three commercial wells in the VDC, two operated by bottling industries and one by a tanker operator, had to lower their submersible pumps by 3 to 8 m due to the lowering of the groundwater level. Those who are capable of bearing the cost for deepening the wells and bores adapt to the situation but the major victims of the competitive deepening of wells become the poor who are not able to afford, deepening of their wells. Chai et al., (2004) mentioned that the most important mechanism causing land subsidence is excessive groundwater extraction, which causes draw down of water table in the aquifer. In Jhaukhel, while the groundwater extraction has been increasing rapidly, the potential groundwater recharge zone in the VDC has been continuously declining due to massive sand mining activities and changing land use pattern (see below). The local people in the VDC anticipate acute water shortage in Jhaukhel, if the situation continues in the same way. Along with the increasing water insecurity, local people have additionally been stressed due to the threat of land subsidence that could be a result of excessive extraction of groundwater.

5.4.2 Sand mining and decreasing groundwater

Terrace sand mining in Jhaukhel started in 1978 during construction of the Araniko highway, linking Kathmandu Valley with China.

Currently, three sand mines extracting sand from hillocks are in operation at three different sites viz., Tajale, Devdole and Sundarthali area in Jhaukhel (see illustration). Sand mining has adverse impacts on groundwater recharge (Hemalatha et al., 2005; Rao, 2006 and Rodrigo, 2004). Local residents noted depletion of the groundwater table after terrace sand mining started in the area. They recalled a traditional stone spout known as Khujocha Hiti (Newari term for stone spout) located at ward number 8 with discharge of almost 2000 litres per minute disappeared in late 1980s due to the impact of mining sand required for construction of the highway. The stone spout used to be a reliable source of domestic water, required not only for the local residents but also served large number of households from Bhaktapur Municipality to wash their clothes. Additionally, the discharge from the stone spout was also used to help irrigate a large area of land. Similarly, a spring in the Nabala area had been a reliable source of irrigation for the farms located at Lukhondole area. Sand mining at Lakhaju tole since 1991 and unauthorized extraction of sand from underground till the level of water table has decreased discharge at Nabala spring. Farmers in this area have experienced decrease in discharge from Nabala spring to 95 per cent of its normal flow during dry season since 2010.

Similarly, after a spring located in ward no. 7 of Jhaukhel that served around 20 households for their domestic water needs went dry 3-4 years ago, the people previously relying on the spring for their water needs were compelled to depend upon the groundwater sources of neighbours to fulfil their daily water requirements. The spring was located between commercial extraction points in the upland area and a number of brick kilns in the low land within the ward. The decline in the recharge zone due to haphazard sand mining, scraping out of the top soil by brick factories and over extraction of groundwater for commercial purposes, especially in the southern part of the VDC, were considered to be the reason for drying of the spring.

5.4.3 River degradation and waste water irrigation

While the urban mode of life is expanding into the peri-urban areas, a visible consequence has been the river degradation from increasing pollution. The causes are diverse, including disposal of solid and liquid waste, encroachment upon the river waterway and

Terrace sand mining at Jhaukhel

water extraction. The deteriorating traditional irrigation practice and increasing dependency on waste water irrigation from Hanumante river in Dadhikot VDC shows a vivid example of urbanisation induced river degradation (see illustrations). Sada (2010) identified four important causes of degradation of the Hanumante River: i) disposal of untreated urban sewerage and solid waste, ii) upstream water extraction, iii) development of urban infrastructure and services with complete disregard of the river environment, and iv) insensitivity of the Bhaktapur municipality (and of other agencies), and lack of recognition of river conservation and restoration as an important part of urban development planning. The Godawari river flowing along the administrative border of Lubhu is increasingly being polluted due to the direct discharge of households' sewage into this river. The effluents from the increasing number of textile factories further add to the river pollution and intensified by the declining river flow due to upstream water extraction and irregularity in rainfall pattern. The pressure on the river system with increasing population and expanding urbanisation in Lubhu has been the cause of pollution of the Dovan river- the only reliable alternative water source within this VDC.

Across the sites, 23 per cent of the households were found to be practicing wastewater irrigation; pumping wastewater from the river for irrigation had become the common mode. However, the farmers reported the increasing pollution level in the river impeded them to its use during the dry period. The most common health problem resulting from exposure to wastewater irrigation, noted among the farmers across the study sites, have been skin diseases, followed by headache, cough and cold, fever, diarrhoea and eye infection.

5.4.4 Degradation of traditional water structures

Degradation of traditional water structures has been a common problem across peri-urban areas of Kathmandu (see illustration on page 82). People in Lubhu were traditionally dependent on dug wells, stone spouts, water tanks, ponds and the river to meet their domestic and irrigation water needs. Prior to the 1980s, nine traditional ponds existed in Lubhu which were used for the purpose of irrigation, washing hands and legs and also for groundwater recharge, but by 2000, many of these traditional water systems have,

Urbanisation induced river degradation and wastewater irrigation however, vanished due to urbanisation and rampant construction of physical infrastructures and human encroachment. Traditional stone spouts have suffered a similar fate. At present, there are five stone spouts- Sankhadevi Dhara, Amrit Dhara, Bhagbati Lachi Dhara, Gaphal Dhara and Jharu Dhara. But most of these spouts are either completely dry or only in partial use.

Similarly, negative impacts have been visible in irrigation infrastructures. Dovan Khola Rajkulo (historical state sponsored irrigation system) has virtually degenerated after being damaged by the flood in 1996 and this historical canal has now been covered for the expansion of the road network passing through Lubhu. Further more, local residents have been illegally draining the household sewerage into this underground canal. The irrigation systems in Lubhu lack maintenance and are further destroyed by land subdivision for construction and for town planning in the area. Other smaller irrigation systems in Lubhu have become increasingly dependent on rainfall due to decreased water supply at the source itself. With reduced capacity of irrigation systems, the agriculture in many parts of Lubhu is being rain-fed. Similarly in Dadhikot VDC, the historical Mahadev Khola Raj Kulo and Charkhandi Irrigation Canal were designed to irrigate 450 hectares and 250 hectares respectively for Dadhikot and neighboring Balkot VDC. The command area has declined due to, inter alia, decrease in water input from the source itself, encroachment and lack of proper maintenance. At present, approximately a

Degradation of traditional water structures

total of 356 hectares (7000 ropanies) can be irrigated in these two VDCs (Dadhikot and Balkot).

5.4.5 Growing grievances on rural-urban water flow

There have been growing equity concerns among the peri-urban residents over their rights to water and they have been increasingly opposing the excessive and unbalanced extraction of water from the VDC to quench the thirst of urban communities. The extent of water extraction around Matatirtha itself has changed the traditional practice of free water service from Matatirtha to neighbouring VDCs. The local government of Matatirtha started collecting revenue from the neighbouring VDCs except Satungal VDC, as water services were charged to compensate for the loss of its own water resources. The local government in the VDC also spearheaded regulation of commercial water extraction through a regulatory agreement between local community, water entrepreneurs and local government. However, the attempt at regulation within the VDC has hardly been implemented due to the economic, social and political reach of powerful water entrepreneurs. These water entrepreneurs have put forward the need for ending free water supply to Satungal VDC before the local authority enforces any regulation to control a water market operated by the local people.

Similarly, growing local opposition towards unregulated extraction of natural resources (water, sand and soil) has been emerging in Jhaukhel. Again, the voices of local people in this regard have been suppressed over time due to the involvement of those with money and influence in the extraction activities. The local government has been insensitive about the possible consequences on the local environment and has not made concrete effort towards implementing any monitoring and regulatory mechanisms. The growing concern among the local people over environmental degradation has been translating into conflict and continued apathy from the local government. This has raised questions about the prior-appropriation of water right, equity issues, water insecurity and vulnerability of these communities in the context of increasing urbanisation and climatic anomalies.

5.4.6 Social consequences of climate change

Literature shows that the increase in the daily variability of temperature can result in lower crop yields (Rai et al., 2011; Lal, 2011; Wheeler et al., 2000) and an increase in daily average temperature can enhance pests and weed attacks increasing the risk of diseases (Dukes and Mooney, 2000; Patz et al., 2000; Ziska et al., 2011). Literature also shows the direct relation

of rainfall intensity to destabilize a hill slope (Larsen and Simon 1993, Gabet et al. 2004). Therefore, an increase in extreme rain events increases the vulnerability of peri-urban areas to landslides and soil erosion thereby increasing the likelihood of affecting livelihood security.

The study found that declining water availability for irrigation has increased the dependency of peri-urban farmers on rainfall for growing crops. Agriculture was perceived to be adversely affected not only by a decrease in the overall amounts of rainfall, but also by shifts in the timing of rainfall. The increasing rainfall variability has been the major influence in determining the timing of crop planting and harvesting. Household surveys across the sites showed that most of the respondents perceived the decrease in crop production and changes in timing of crop planting and harvesting as major impacts of climatic variability (Figure 5.6).

5.5 RESPONSES TO WATER INSECURITY

5.5.1 Use of alternative sources and the reliance on market solutions

Fetching water from nearby public standposts/stone spouts, public wells/dug wells and buying water from water vendors are the primary responses of peri-urban residents to cope with insufficient water supply. In the event of extreme scarcity of water, fetching water from spring sources in the neighbouring VDCs and depending upon tanker supplies are the alternatives left to the people. Ferrying water in containers loaded on bicycles, motorcycles and push carts is a common sight at Lubhu, which is both time consuming and labour intensive. Often a number of households join to rent a vehicle to transport water in larger containers which is an easier and a more cost-effective alternative. Despite the increasing pollution, peri-urban residents have continued to depend on the nearby river water for bathing and washing clothes.

5.5.2 Increasing number of dug wells at households

The growing dependence on ground water is also evident from the number of dug wells commonly observed at the household level. The household questionnaire survey showed that 38 per cent of households across the peri-

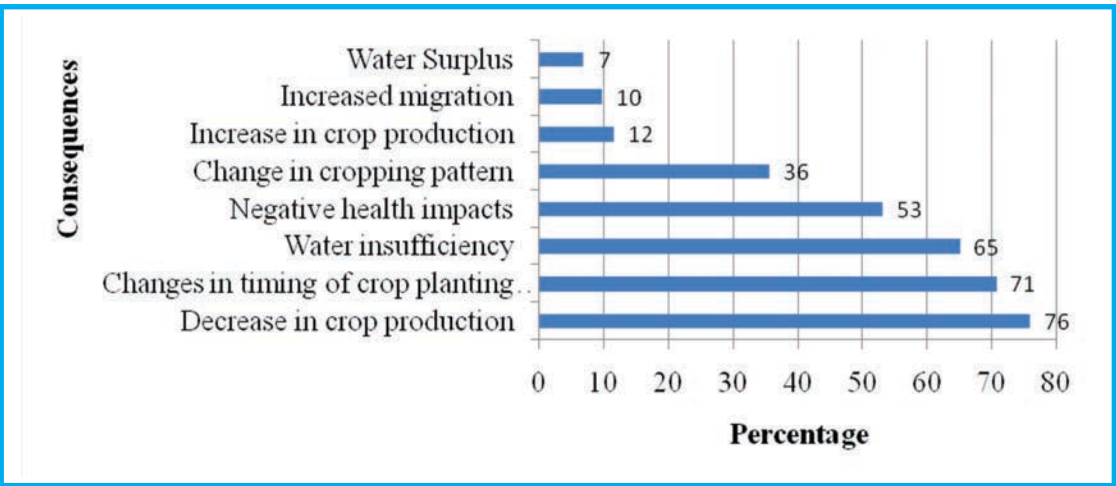

Figure 5.6: Perceived consequences due to changes in climatic attributes
Source: Household Survey, 2012

urban sites use ground water extraction mechanisms, the most common being dug wells (87%) followed by bores (7%) and tubewells (6%). In addition, the local people have started digging two or even more dug wells at an individual household level; 20 households were found to have dug wells that meet both the domestic water needs and supplement irrigation water needs. Water available in dug wells is insufficient for cereal crops so the peri-urban inhabitants prefer to grow vegetables in small gardens attached to the household.

5.5.3 Capturing the rooftop runoff

Peri-urban residents have started harvesting the rainwater that usually flows off the rooftop and storing the harvested water for uses in cleaning, washing and other sanitary uses. The findings from the survey showed that this was practiced by only 10 per cent of the peri-urban households. This is commonly done by digging pits in the homestead for storing rain water basically used for non-drinking uses and livestock watering. Some households have also developed roof-top and underground water storage tanks to store enough water to deal with periods of water scarcity.

Ferrying water in motorcycle

Bathing and washing clothes in river

5.5.4 Technological innovations

With increasing urbanisation, the lifting of water from the source (either spring or groundwater)using electric motor pumps, storage in reservoirs and then distribution through gravity flow has been a common technique used by community-based water supply schemes. These schemes have become more and more dependent on groundwater sources through deep bores or sump wells to meet the increased water demands of the local people. The shift towards

private water supply networks by the households has been a revolutionary change in water management across the peri-urban areas, where, a few decades earlier, fetching water from distant water sources used to be a disproportionate hardship for women. At household levels, the use of water pumps for lifting water from private taps or household-based groundwater sources and hoarding of water in larger polythene tanks at the rooftop have become common practices. The new households have started to construct large underground reservoirs in order to store water. Similarly, drip irrigation has been practiced in some parts of peri-urban areas.

5.5.5 Decreasing gender discrimination in water management

Declining availability of water, combined with increasing urbanisation and changing climate, has resulted in a gradual change in the culturally-rooted practice of water collection and management by women alone. This has been prominent across the peri-urban areas of Kathmandu. The increasing involvement of women in outdoor economic activities has also been instrumental in bringing the change in the gendered responsibilities to maintain household water security. In Jhaukhel, half of the respondents mentioned that both male and female are involved in household water collection whereas the other half only involved females. Almost two-thirds of the respondents agreed with the involvement of both males and females in household water collection in both Dadhikot and Matatirtha whereas for over two-thirds of households in Lubhu, water collection was the responsibility of a female.

5.5.6 Changing cropping practices

There has been delay in the rice transplanting across most of the peri-urban areas due to the delayed onset of monsoon while in Jhaukhel the farmers have perceived rice transplanting to be relatively easier. The traditional varieties of rice, Taichin-242 and Tainan-176, required more water and fertilizer. Khumal-4 was started in Lubhu around a decade earlier because it is more drought-resistant and needs less water and fertilizer compared to Taichin. With declining irrigation service and changing rainfall pattern, preference for this variety has been increasing among the peri-urban farmers.

Farmers have tended to turn away from cultivating wheat due to higher water requirement in growing the crop in comparison to other winter crops, lower economic return and higher input requirements and drudgery involved in crop cultivation. Many farmers switched from wheat to barley, red lentil (musur) and broad beans. In addition, the farmers have started to

sow peas prior to the paddy harvest so that the peas germinate using the soil moisture of rice field and grow to young plant prior to the harvest of paddy. The farmers believed that this had provided them dual benefits namely optimum use of soil moisture and the chopping of the growing tips of pea plants during paddy harvest which helped better growth of pea plants. Over the last few years, the farmers have been sowing the seed of winter crops immediately after the paddy harvest. The straw is then spread over the sown seed for drying them which also reduces the loss of soil moisture and helps for germination of the winter crops. In the areas where the preservation of soil moisture or arrangement of irrigation has not been possible, the farmers have no other option but to leave land fallow during winter.

5.5.7 Migrating from the upland to lowland

The availability of water has always been a constraint in the upland areas due to lack of dependable spring and groundwater sources and also topographic limitations in developing piped water supply systems. In Matatirtha, five per cent of the households considered the topographical position of their houses on the hills to be the cause of poor water supply at their private taps as did seven per cent in Jhaukhel and one per cent in Dadhikot. In order to avoid this difficulty, there is an increasing tendency to shift the location of their houses from the upland to lowland. This trend of shifting to the lower lands to avoid the water constraints has been a prime cause of changing land use pattern. Access to dependable water source was noted to be an important consideration when relocating their houses.

5.5.8 Increasing use of pesticide

Increasing temperature, declining occurrence of frost and variation in the pattern and amount of rainfall are the climatic variation factors that are perceived as the major causes of burgeoning pests and diseases in crops. With increasing occurrence of pests, farmers complained about the frequency and amount of pesticide use now needed. They noted that one bottle of pesticide costing 1.0 $ (NRs. 80) used to be sufficient for a ropani(approx. 0.05 hectare) of land during winter cropping but with increasing pests and diseases, the requirement of pesticide has increased three times over a decade for same growing period and same piece of land.

5.5.9 Occupational diversification

Peri-urban farmers are shifting to off-farm occupations, such as weaving traditional textiles, jobs in the government or private firms and industries as well as non-farm wage earning. In addition to the new avenue of

employment accompanying urbanisation, a very important reason for the shift in occupation has been the increasing scarcity of water for irrigation and the drudgery involved in farming. The usual practice at present is keeping a small piece of land for cultivation of economically more rewarding cash crops, such as vegetables, and selling the additional land and shifting to non-farm occupations for additional earnings. Increasing hardship of water management for agriculture and increasing urbanisation has attracted the peri-urban farmers to lease out land as a lucrative income source.

5.5.10 Commodification of water: The initiation of irrigation service fee

Following the renovation of the irrigation system, farmers in Lubhu have improved their mechanism for managing it. Traditionally, water in the irrigation canal was diverted to the lowlands only after the upland areas had been irrigated, which was provided free of cost. After the renovation of the Majha kulo irrigation system in 2012, the farmers in ward number 8 of Lubhu have started collection of an irrigation service fee. The irrigation water-users are charged on the basis of the area to be irrigated ranging from 1 to 2 $ per ropani(approx. 0.05 ha) of land irrigated depending upon the location of the field. The collected service fee has been used for remunerating two canal operators selected by the farmers' committee. This new system has helped farmers to manage the water in the canal based on the demand and hence free-riding of the limited water resource has been reduced.

Similarly in the next part of the same ward of Lubhu, the irrigation-users committee levied an area-based irrigation service fee of 4-5$for aprox. 0.05 ha. of land based on the location of field to be irrigated and here, this collected amount is used operating and maintaining the pump sets used in pumping water from the Godawari River.

5.5.11 Institutional response: preparing enabling environment for livelihood enhancement

Integrated Pest Management (IPM) was introduced in Lubhu in 1997 by the Department of Agriculture through Krishak Pathsala (Farmers School) meant for raising awareness on the negative effects of pesticides. However, this did not achieve the expected success. The Agriculture Service Centre, - Lubhu has been promoting the use of compost fertilizers and homemade pesticides and also been planning to organize capacity-building programmes on the preparation of compost and natural pesticides at the household level.

With the increasing occurrence of pests and

diseases as a combined effect of climatic variability and water scarcity, the preference towards organic farming has been growing among the small-scale farmers as well as commercial farmers. To this end, the Peri-urban Water Security Project at Nepal Engineering College provided a two days training on "Preparation of Organic Fertilizer and Soil Management" in 2012 which motivated farmers in adopting organic farming and enhanced their capacity in proper management of soil through the use of organic fertilizer. Through the training, farmers learned the process of preparing organic fertilizer and vermin-composting practically in the field which is supposed to play an instrumental role in increasing their productivity through proper soil management.

Farmers have also been requesting for training on "Preparation of Homemade Pesticides". Similarly, through the Peri-urban Water Security Project, Nepal Engineering College has been consistently involved with the local people in strengthening their adaptive capacities and enhancing their resilience to overcome water insecurity. In 2011, the project provided a technical as well as financial support for water source intake protection at Dovan River which benefited around 400 households of four different wards of Lubhu VDC. Besides, it also organized a two days training on rainwater harvesting, an exposure visit to different successful community water supply systems, consultation with experts, interaction with concerned government officials and organized different awareness raising programmes as well.


Capacity building programmes

5.6 Summary

Haphazard urbanisation in Kathmandu Valley has hastened the changes in land use and land cover in adjoining peri-urban areas. The increase in climatic variability across the peri-urban areas make residents apprehensive about their water security as has the unregulated extraction of natural resources. Peri-urban communities have been responding to these impacts differently on the basis of their access to resources, information and capability. These coping and adaptation responses include technological innovations, modifying the traditional practices of water collection, shifting agricultural farming practice and building new institutional mechanisms.

Institutions such as the Department of Agriculture, Agriculture Service Centre and Nepal Engineering College have also been involved with enhancing the resilience capacity of local people against the compounded effects of urbanisation and climate change by supporting through both hard and soft resilience measures. However the efforts from the responsible governing authorities to address the problem have been inadequate and inefficient. Thus growing water security concerns of peri-urban communities are gradually translating into conflicts and demands for advocacy for equitable water rights.

Cost-benefit analysis for drinking water: a study of River Mayur at Khulna, Bangladesh

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6 cba

6.1 INTRODUCTION

Economic consequences of losses in ecosystem services due to climatic change are increasingly being recognized. However, the measurement of the costs of such losses is not easy. Several challenges are involved in the process, due mainly to the unique characteristics of the ecosystems and the services they provide. Using the economic tools of valuation for assessing the value of services and a cost-benefit analysis (CBA), this study builds a case for establishing the economic justification for a program to revive the Mayur River in Khulna, Bangladesh in order for the peri-urban residents to benefit from it. The objective of this excercise is to explore whether the restoration of the river can be justified from the quantitative perspective in a CBA framework.

6.2 KHULNA: THE CITY AND THE RIVER

Khulna, the third largest metropolitan city in Bangladesh, lies on the coast of River Mayur and is potentially vulnerable to climate change induced stresses on its natural resources. Khulna City Corporation (KCC) covers an area of about 46 km^2. The population of KCC is about 1 million as of 2010 with a growth rate of nearly 3 per cent per annum and the population density exceeds 15,000 per km^2. The projected population of KCC is about 145,000 for 2030 (ADB 2010). The demand for drinking water for the residents of the city will predictably increase over time and will in turn lead to increasing exploitation of scarce ground water resources.

Embankments were constructed along the Mayur during 1982-1983 by BWDB (Bangladesh Water Development Board) to protect encroachment of saline water in the region. Since then, this intervention has blocked tidal water flow in the river from downstream (Alutola) to upstream (Hamidnagar) during dry seasons.

6.3 CONCEPTUAL FRAMEWORK OF THE STUDY

In thinking about the Mayur, two alternative scenarios emerge at first reckoning: freshwater and tidal water. Both scenarios are able to provide ecosystem services. The freshwater possibility refers to the absence of any tidal inflow (of saline water) in the Mayur from the Rupsha River in order to maintain the Mayur as a freshwater reservoir. The condition of the river will then be dependent on rain water and groundwater inflow (i.e., hydrological base flow) from surrounding aquifers. The tidal water option refers to the condition of the river as it was before 1982 when tidal fluctuation in the river was observed from upstream to downstream throughout the year. Khulna City protection embankment along the bank of the Mayur was constructed during 1982-1983.

It is recognized at the outset that if the river is preserved as freshwater source, then some new ecosystem services/benefits can be achieved which are absent in the present condition of the Mayur river. Some services will increase under a freshwater scenario such as flood regulation, disease regulation and so on (regulating ecosystem services). Table 6.1 provides taxonomy of the ecosystem services of the Mayur and to whom the benefits would accrue.

Given that this chapter focuses on the Mayur as a drinking water source to ensure peri-urban water security, the freshwater scenario has been evaluated in terms of CBA.

In the next step, the interventions or measures that need to be adopted and implemented to

Table 6.1: Taxonomy of the ecosystem services of Mayur River

Scenario → / Ecosystem Services ↓		Fresh Water Scenario		Tidal Water Activity Scenario	
		Losers	Gainers	Losers	Gainers
Provisional Services	Freshwater	Fishermen depending on culture fishery; Fishermen depending on capture fishery; Farmers	KCC people; People living along the river bank	x	x
	Bathing	People living along the river bank	KCC people; People living along the river bank	x	KCC people; People living along the river bank
	Domestic use	x	KCC people; People living along the river bank	KCC people; People living along the river bank	x
	Fish as food	Fishermen	x	x	Fishermen
	Boating	Boatmen	x	x	Boatmen
	Agricultural crops	Agricultural crop cultivators	x	Agricultural crop cultivators at downstream areas due to increased salinity	Agricultural crop cultivators at upstream areas

Cultural Services	Aesthetic values	x	KCC people; People living along the river bank; Land developers	x	KCC people; People living along the river bank (to some extent)
	Spiritual and Religious values	x	KCC people; People living along the river bank	x	KCC people; People living along the river bank (to some extent)
	Recreation and tourism values	x	KCC people; People living along the river bank including people from Khulna division; National Revenue Board (NRB) of Bangladesh	x	KCC people (to some extent)
	Cultural heritage values	x	KCC people; People living along the river bank including people from Khulna division	x	KCC people (to some extent)
	Educational values	x	Educational institution from KCC and Khulna division	x	Mainly educational institution from KCC (to some extent)
	Ecosystem services	Losers (Freshwater scenario)	Gainers (Freshwater scenario)	Losers (Tidal water Activity Scenario)	Gainers (Tidal water Activity Scenario)

Regulation Services	Flood regulation	x	KCC people; People living along the river bank	KCC people; People living along the river bank	Downstream people of the Rupsha River due to flood risk shifting in the KCC area
	Human disease regulation	x	KCC people; People living along the river bank	KCC people; People living along the river bank	x
	Waste assimilation	x	KCC people; People living along the river bank	KCC people; People living along the river bank (to some extent)	KCC people; People living along the river bank (to some extent)
	Climate regulation	x	KCC people	KCC people	x
	Erosion control	x	KCC people; People living along the river bank	KCC people; People living along the river bank	Downstream people of the Rupsha River due to flood risk shifting in the KCC area
	Sediment retention and transport	x	x	x	KCC people
Supporting Services	Water cycling	x	KCC people	x	KCC people (to a greater extent)
	Nutrient cycling	x	KCC people	x	KCC people (to a greater extent)
	Primary production	x	KCC people	x	KCC people

maintain the river as a freshwater reservoir are identified. This in turn requires that gainers and losers in the KCC area are identified so that interventions/measures, that need to be undertaken to maintain the river as a freshwater reservoir, can be meaningfully implemented in future taking into account the distributional consequences of the proposed interventions. The second step is to account for the cost of the interventions in terms of both investment and maintenance costs, alongside a complete listing of the benefits, to lead to a reliable cost-benefit exercise which can evaluate the economic rationale for the identified ecosystem service.

6.4 METHODOLOGY AND DATA

This study uses Cost–Benefit Analysis (CBA) for evaluating the economic rationale for the proposed project to restore the Mayur as a freshwater reservoir for Khulna. CBA finds its origin in welfare economics as a practical application of a decision-making rule, using utilitarianism as the basis, on a principle of greatest benefit for greatest numbers (Sen 1973, Little and Mirlees 1969, Dasgupta et al 1972). A benefit (B) is something that increases human well-being while a cost (C) is something that reduces human well-being. With this definition, a cost benefit analysis typically compares all the costs of a project with all its benefits, and if the project shows a net benefit it should meet with approval.

The information used in the current study comprises both secondary and primary data. Both qualitative and quantitative methods were used for primary data collection. The field work was done in two stages. An initial round of interviews and consultations with key informants was conducted in April 2012. Subsequently, over a period of two months, various techniques were employed for data collection. These are briefly detailed below.

Purposive randomized sampling was done for conducting interviews with households residing in the vicinity of the river. In selecting households, care was taken to ensure that the sample included the geographical location (upstream/downstream of the river), occupational profile (agricultural/non-agricultural; fishing; boatmen etc.) and the nature of tenure (legal owners of land and property/illegal encroachers; also known as bhumidoshshu). Focus group discussions were held with stakeholders who were likely to be impacted by the proposed interventions. These included farmers, boatmen, fishermen, Labour Contracting Society (soil cutters) and officials of the Khulna City Corporation. Four in-depth case studies were conducted, two with households located upstream of the river and two located downstream of the river, to gather data related to drudgery, time costs

and views regarding the proposal to maintain the river as a source of freshwater for the residents of Khulna. The case studies included two households which have access to piped water supply from KWASA and two which rely on only private sources such as tubewells or the river.

Monetary costing/valuation proceeds on the assumption of a representative household or decision-maker. Thus, to accommodate the heterogeneity among households and impacted stakeholders, care was taken in choosing key informants who are truly representatives of the concerned stakeholder community. Steps were taken to ensure that representation is all inclusive. Key informant interviews and expert opinion consultations were conducted with experts from academia (at Bangladesh University of Engineering and Technology and Khulna University) representing a range of expertise from both the social and the pure sciences, engineers and other relevant officials.

6.5 COST BENEFIT ANALYSIS

The perceived gains and losses for various communities which could potentially be impacted by a project that seeks to maintain the river as a freshwater resource for the residents of the city are given below. The perceptions on gains and losses are based on responses elicited during stakeholder discussions.

Farmers: If the Mayur is maintained as a fresh water reservoir, farmers on either side will no longer be able to irrigate their lands with water from the river. On this count they will need to make alternative arrangements. However, they will benefit from the sluice gate and all possible water entry points being closed to prevent saline water intrusion.

Fisher folk: To maintain the river as a fresh water reservoir, fishermen will not be allowed to pursue fish culture or capture fishing. In the present study, these losses are accommodated by including them in the resettlement and rehabilitation costs.

Boatmen: Boatmen will also not be allowed to ply their boats on the river for transportation purposes. There is a scope of their services being used for recreational purposes at a later stage. Thus, in the balance these losses are treated as having been neutralized.

Residents along the river bank: The people living along the banks of the Mayur River currently dispose of their waste into the river and do not pay for the negative externality caused by this activity. As more scientific waste management practices are implemented there is an apprehension that residents will be required to pay for waste

disposal services. The economic rationale that should be applied here is that the implicit negative externality costs are not taken into account by the residents, although these should in any case be accounted for in a complete accounting of the economic costs. Thus, this particular notion of loss is not a tenable one in terms of the current analysis.

Labour contracting society (LCS): This refers to a group of people who remove soil from the bank of the Mayur river basin, transport the soil to Gollamari and sell it for a livelihood. This community will need to look for alternative livelihood options. For the present study, these losses are included under resettlement and rehabilitation costs.

The assessment of the major interventions on which the success of the provision of drinking water and the economic rationale for opting for a freshwater scenario rests are given below.

Closing of the sluice gates

If the sluice gates of the river remain closed throughout the year, the river will turn into a freshwater reservoir. According to the Chief Executive Engineer of Bangladesh Water Development Board (BWDB), Khulna region, this will provide protection from flooding during monsoons which was the primary purpose of the sluice gate, although it may affect the fishermen community adversely. The feasibility of such an intervention would be high since the main objective of having a sluice gate is to control the tidal flow.

Solid waste management

Khulna City Corporation (KCC) is responsible for the operation and maintenance of municipal services, including solid waste management. Currently, a solid waste management service company organizes waste collection from approximately 1,200 bins of the city corporation, located on roadsides throughout Khulna City. As per one estimate, 50-60 per cent of the households have access to solid waste collection services (ADB 2009). The local NGOs are also involved in a community-based solid waste management program in certain wards of the KCC area. Consultations reveal that awareness creation will be important in overcoming the current obstacles to developing good management practices at the household and community level. In the long run, the sustainability of the intervention will hinge critically on this factor.

Waste water treatment

A central effluent treatment plant (ETP) or a number of small ETP units can be set up along the river so that waste water treated to the desired quality is discharged into the river. Consultation among the respective

authorities, who are already well aware of the importance and feasibility of both waste water and water treatment plants, can bear fruit in ensuring sustainable management of the water resource. Thus, the feasibility for the implementation of waste water treatment plants is relatively high given the high awareness and knowledge levels among concerned officials.

Removal of encroachments and illegal structures

Removal of all illegal structures along the river Mayur is likely to be a challenging task. The illegal structures along the river mainly involve grabbed land and a small number of housing constructions. Moreover, the upstream portion of the Mayur is under KCC's jurisdiction, whereas the downstream portion of the river is under Batiaghata Upazila of Khulna (Batiaghata is a sub-administrative unit under Khulna district) leading to a need for co-ordination between civic and administrative divisions. Due to these factors, removal of all encroachments and illegal structures along the river is likely to involve complex mechanisms of co-ordination, conflict resolution and stakeholder interactions.

Dredging

Dredging is essential for both restoring and maintaining the capacity in the river. At present, there are substantial stretches along the river where waste, garbage and sludge have raised the river bed substantially and incapacitated the natural flow of water. Agriculture is being practiced on some of the raised stretches of the river bed. Thus, the implementation of dredging activity is dependent on the success in removing encroachments to a large extent.

Sewer line along the banks of the Mayur River

A suggestion was made by the stakeholders to construct a sewer line parallel to the river bank in a manner such that it can connect the twenty two KCC drains and eventually join the central effluent treatment plant (CETP). This will ensure that the quality of the river water is commensurate with the desired quality for drinking water. Studies conducted by Khulna Water Supply and Sewerage Authority (KWASA) have given considerable importance to the construction of sewer lines for successfully implementing plans for improving water supplies and transportation of water within KCC area (ADB 2011). Since these studies have already established guidelines on this matter, the feasibility for in-principle approval is high. However, costs of construction will be required to be looked into.

6.6 COMPUTATION OF BENEFIT COST RATIO

Data on various parameters that will feed into the CBA have been collected and analysed. In terms of benefit estimation, different techniques have been used. The benefit and cost estimations are presented in this section in which various techniques have been used. All estimates are in per annum and current prices in 2013. An inflation-adjusted real interest rate of 10.11% is used for discounting the benefits and costs over a period of 10 years in conducting the benefit – cost exercise. A real discount rate of 10.11% after adjusting for inflation has been used by previous studies on CBA for clean-up projects for rivers in Bangladesh based on recommendations of the Bangladesh Planning Commission (Alam 2008, Alam and Marinova 2003).

In the economic evaluation of development projects, several studies use the convention of a 10 year period for calculating costs and benefits, partly because the costs associated with the project tend to have an average length of life (of the interventions required) of about 10 years (Alam 2008, Hutton and Haller 2004). The majority of benefits can be expected to accrue by this time period (Table 6.2).

The costs for the analysis have been computed as including both the investment cost and the annual operation and maintenance costs (O&M) wherever applicable, which in turn includes equipment, labour and managerial costs. Costs have also been assumed to escalate at 5 per cent per

Table 6.2: Benefits from river restoration for drinking water purpose and methods of estimation

Benefit	Method	Explanation
Health	Secondary Data / Cost of illness	Costs of illness include preventive costs and treatment costs, lost wages and leisure (value) in a full estimation (Haque et al (1997), Baqui et al -1992, 1998)
Residential Water	Replacement Cost / Cost savings	Alternative expenses of procuring potable water for the household (Alam and Marinova, 2003)

Fish production	Benefit Transfer	These are estimates based on studies conducted elsewhere in similar circumstances (Hill and Hatchett, 1995)
Housing and Land Values	Secondary Data / Key informant interviews	These capture the increase in property values that experts project due to the river clean-up (Haque et al, 1997)
Recreation and Tourism	Survey / Adjusted Benefit transfer	Estimates from similar studies were taken and adjusted for tourism potential and population impacted for Khulna
Flood Control	Avoided Damages	Estimates on population affected in Khulna in floods in recent past, and the damage caused due to floods to income and property is computed and treated as the potential benefit from flood regulation
Commercial and Industrial Water	Replacement cost / cost savings	Alternative cost of procuring water supplies for these activities provides the monetary value of the service (Alam and Marinova, 2003)
Reduced Drudgery from water collection	Cost savings / Survey data	Survey estimates of the time spent in collecting water from alternative sources is valued at the average income level of working women in households – in most instances women collect water
Reduced water stress from climate change & other future benefits	Escalation factor – 5%	A conservative estimate for the impact of climatic change is assumed, based on a literature review

annum (in current prices). The costs for ensuring that the drinking water provision scenario can be achieved and maintained comprise of 5 major heads. These areas are removal of illegal structures and encroachments, rehabilitation and resettlement costs, solid waste management and sanitary landfill costs, waste water treatment plant costs, and river bed dredging costs. Note that these costs represent total costs over the entire intervention period corresponding from 7 – 10 years on average and would require annualisation in order to obtain the annual cost implications. The costs are presented in Table 6.3.

6.7 CONCLUSIONS

The cost-benefit ratio computed for the freshwater scenario for the Mayur is presented in Table 6.4. This would be compatible with the provision of drinking water from the river for the residents of Khulna city as well as its peri-urban

Table 6.3: Costs for restoring River Mayur as a freshwater source

Details	Bangladesh Taka(mn)	US Dollars (mn)***
Solid Waste Management	122	1.586
Removal of illegal structures & obstructions	115	1.495
Waste water treatment plant	2323*	30.199
Sanitary landfill costs	8	0.104
River bed dredging & landing facilities costs	796	10.348
Rehabilitation and resettlement costs	2170**	28.21

*Due to the lack of availability of data specific to this head for Khulna city, the estimate has been taken from the study by Alam and Marinova (2003). **These costs are on the higher side since the extent of encroachment is extensive in the river and along its banks. *** Conversion rate 1 Taka = 0.013 US $ in June 2013. Reference website http://business.westernunion.com/currency-converter/ [accessed on June 8, 2013]

counterparts, while helping them to cope, thereby, with climate change induced water stress. The estimates also take note of the increased population expected to create demand for water for domestic and non-domestic purposes in the years to come. A five per cent mark-up was added to the total benefits to capture the reduced water stress from climate induced impacts if the intervention is put in place in a timely manner. This is a conservative estimate of avoided damages from climate change impacts on water stress for the region. Finding alternative options to meet water demands in the long run, such as the establishment of de-salinization plants or the transport of water over long distances, could have social and economic costs that are prohibitive or pose challenges in quantification such as conflicts across communities. Some alternatives such as the provision of bottled water during periods of high salinity may have challenges related to social acceptability (ADB 2011). As is obvious, substantial co-benefits are also reaped from having a fresh water scenario in the form of better water supply for agricultural, industrial and commercial purposes.

As these estimates demonstrate, the net benefits from developing the river for purposes of provision of drinking water are positive, and justify such interventions. The benefits from such a program would extend beyond those

Table 6.4: Cost-benefit estimates

Details	Bangladeshi Taka	US Dollars*
Total Benefit (10 years)	12990.54 million	168.87702million
Net Benefits	7456.54million	96.93502million
Benefit Cost Ratio	2.13	2.13
Net Present Value (NPV)	61.81million	0.80353million

* Conversion rate 1 Taka = 0.013 US $ in June 2013. Reference website http://business.westernunion.com/currency-converter/ [accessed on June 8, 2013]

of drinking water, with additional benefits such as enhanced land and property values alongside the river banks, tourism and improved fish production. Non-market benefits are likely to far exceed the estimated ones, since specific non market benefit values such as those for biodiversity are not obtained. It is to be noted that even with these limited values, the benefit–cost ratio is positive and augurs well for the chosen scenario. The benefit cost ratio and the net present value (NPV) at a discount rate of 10.11 per cent for a period of 10 years, clearly shows the feasibility of the proposed scenario with the present value of benefits exceeding the present value of costs.

Summary and key lessons

ANJAL PRAKASH

7 summary

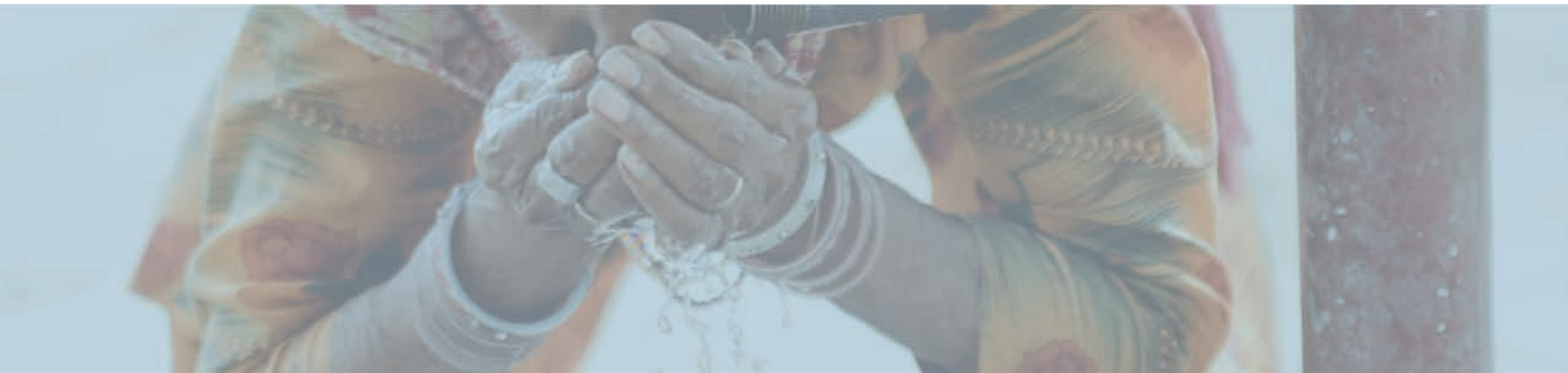
Massive urbanisation defines South Asia, which is home to over 1.6 billion people in 2010, or a quarter of humanity, of which one-third live in urban areas. Although the rates of urban growth in South Asia are considered to be slower than some other parts of the world, growth is predicted to accelerate in urban areas in next two decades. Further, statistics reveal that most of this urban growth will occur in the countryside, engulfing the rural landscapes surrounding existing metropolitan cities, that is, in the peri-urban areas. These cities grow in numbers and expand physically by acquiring land from the peripheral rural areas. These peripheral areas also receive the waste from the core cities. The peri-urban zones are therefore conceptualized as the transitional areas between the two conceptual extremes of rural and urban in the settlement continuum. These are areas of continuous transformations of the landscape, of flux of people and resources, and of dynamism in their social and economic interactions creating complex (and often contradictory) growth patterns.

Changes in the usage of the land also involve fundamental transformations in the uses of water, bearing significantly on the environmental health and the well-being of the residents of the peri-urban areas. The acquisition of water from a diverse number of sources, and the pernicious use of water by several users for different purposes, make its supplies unpredictable.

At the same time, the reality of climate change, the alteration of rainfall, temperature and other weather phenomena, has observable and adverse effects on water availability. In general, cities are particularly vulnerable to the effects of climate change because of the congestion and the fixed nature of urban infrastructure. The built up surface of cities increase runoff from rainwater and decrease the recharge of the groundwater during the spells of short and intense rainfall periods, and increase evapo-transpiration, and encourage groundwater exploitation. Extensive built up areas contribute to dangerous heat events and increase human vulnerabilities. Therefore, not only the cities but also the peri-urban areas become susceptible to the effects of climate change.

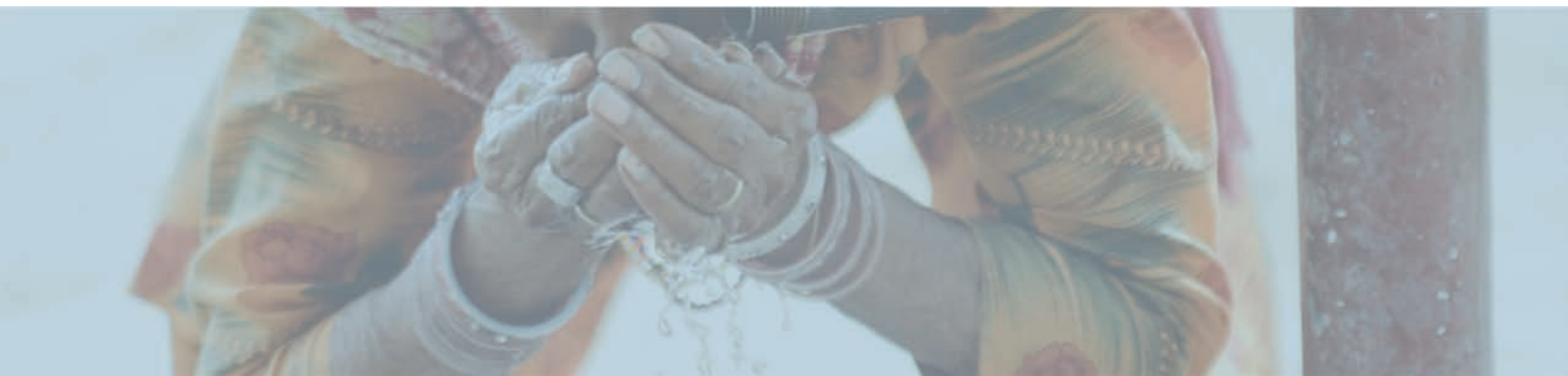
This report explored the implications of rapid urbanisation and climate change on water availability for vulnerable communities in four South Asian cities: Khulna (in Bangladesh), Gurgaon and Hyderabad (in India) and Kathmandu (in Nepal).

It shows how people who live in the zones surrounding the core urban areas are coping with the rapid transformations in the availability of water and its declining quality. Further, this report has documented how residents are adapting to the changes through community mobilization for building resilience. They are working together with the



relevant departments as stakeholders in the process of transformation from rural to urban, constrained by water insecurities induced by the expansion of the built-up areas and climate change.

Table 7.1 summarizes the key findings of this report. It provides a city-wise understanding of how the two processes of urbanisation and climate change intersect to produce water insecurity for the residents of peri-urban locations. It also shows the key adaptation responses to the deteriorating quality and declining amounts of water by the communities. The key responses centre on three main areas: the securing of drinking water through alternative sources and the use



summary

City	Urbanization impacts on periurban water	Climate change trends having implications for water availability	Key adaptation responses
Khulna	Acute water scarcity for drinking and other domestic needs Pollution of Moyur river Wastewater diverted to peri-urban areas	Sea level rise Salinity ingress Flooding and water logging Rise in average maximum temperatures Increase in heat index	Development of alternative water supply for city Shift in livelihood and agricultural practices (from rice to vegetable production) Collective leasing of water bodies for freshwater for irrigation Male migration and growing feminization of agriculture
Gurgaon	Change in land use pattern and appropriation of water commons Exploitation of groundwater resources leading to salinity ingress Receives wastewater that is used for irrigation	Huge variability in rainfall Rise in mean maximum temperature leading to evapotranspiration Variability in duration of summer and winter seasons	Investment in private borewells for accessing water Increase in purchase of water Use of sprinklers in agriculture Changing cropping patters due to salinity ingress – from pulses to vegetables to wheat and mustard
Hyderabad	Appropriation of water bodies as land prices are going up Loss of access to water bodies for livelihood Secular decline in groundwater Thriving tanker water economy in un-served areas	Increasing trend in annual mean maximum temperature Variation in total annual rainfall and reduction in number of rainy days	Changes in cropping pattern from rice to vegetable to adjust to water scarcity Diversification of livelihoods from agriculture to service sector Buying water for drinking from commercial vendors as water quality deteriorates
Kathmandu	Thriving tanker economy fetching water from peri-urban areas and supplying water to urban locations Declining groundwater table Increasing illegal sand mining due to rise in construction activities River degradation and wastewater irrigation	Decreasing trend in annual number of cold days Increasing trend in number of hot days with temperature more than 30°C Large variation in the yearly number of >50 mm precipitation events	Evolution of rotational water system Roof top rainwater harvesting is on a rise Changes in timing of crop sowing and harvesting Male migration to Kathmandu for wage labour – feminisation of agriculture

Table 7.1: Urbanisation, climate change, water insecurity and adaptation trends in four research locations

summary

of commercial ventures for better quality water; the adjustment of and changes in cropping patterns to address the decreasing quantity of water for irrigation; and the diversification of livelihoods through male outmigration in search of wage labour leading to feminization of agriculture. In this study, gender-and class-disaggregated information was generated to show the gender-selective nature of all these effects and responses, with special focus especially on women and men from marginalized and lower caste communities.

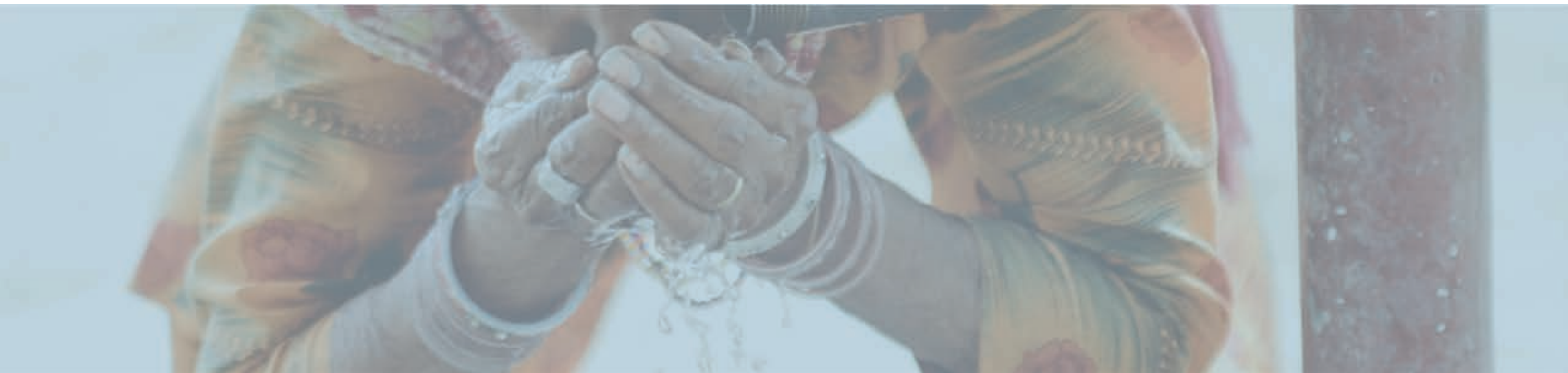
Geographical location of the city plays a crucial role in determining the relative weight of the two factors. Due to its location closer to the sea, climate change impacts are noticeable for Khulna, whereas in Gurgaon and Hyderabad, the main agent of change is the Information Technology (IT) sector. In Kathmandu, the impacts of climate change on the fragile mountain ecosystem and the melting of glaciers due to global warming seem to have disturbed local livelihoods and enhanced the rates of urbanisation.

7.1 ACTION AND ADVOCACY IN FOUR RESEARCH LOCATIONS

This project also involved a large number of local stakeholders who were affected by or concerned about water insecurities brought about by the twin processes of urbanisation and climate change. The report also outlines their thoughts and actions on water insecurity and documents the local actions being undertaken to influence change at the ground level.

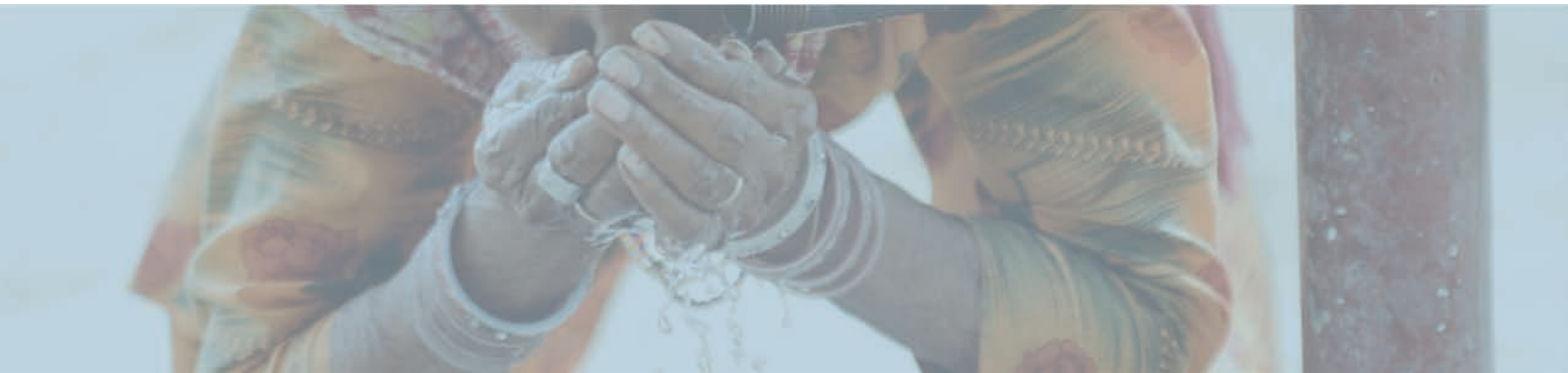
The process is important because peri-urban areas tend to be neglected by both urban and rural authorities as some of their problems fall under the mandate of neither of these. The villages studied, had at one time supported traditional livelihoods, many of which are under threat from the rapid urban growth due to rapid transformation of cropland into residential and commercial buildings.

The project undertook a stakeholder participation and capacity-building approach with both government and civil society groups, to assist them to rise to the challenges of peri-urban water insecurities. It built the capacity of stakeholders at the local level to address these concerns and brought in stakeholders to discuss and deliberate the issues for policy change in favour of the vulnerable communities. A series of interactions brought forth the nuances of urban development in South Asia – uneven impacts on a socially, economically and politically uneven milieu. The key approach and outcomes of the advocacy and action



Cities	Approach for grounded advocacy and action
Khulna	● Study of water pollution in river Mayur through student's involvement in collecting and analyzing data. ● Save the Mayur River' campaign built multiple stakeholders platform for informed dialogue between authorities and affected community. ● Dialogue with Khulna City Corporation for better provisioning of basic services in peri-urban areas. ● Knowledge gap identified that helped in building training and capacity building of local level officials.
Gurgaon	● Building and strengthening social capital through dialogues with service providers. ● Stakeholders engagement approach made service provider responsive to water users and bridged the implementation gap through dialogue. ● Orientation of junior officers of Public Health Engineering Department on peri-urban water issues. ● Enhanced livelihood skills and occupational diversification through vocational training.
Hyderabad	● Formation of village level water committee and investment in building cadre of people and leaders who can take up future intervention. ● Village level awareness program to save lakes and water bodies and undertake waste management program in the village. ● Training and capacity building program for villagers and associated line department officials on different aspects of water and climate change issues. ● Supporting advocacy forum – Save our Urban Lakes (SOUL) through knowledge management and research.
Kathmandu	● Working closely with farmers group supporting research needs for organic farming. ● Training of village volunteers on adaptive agriculture through organic pesticide, fertilizers and climate resistant crops. ● Imparting knowledge of rainwater harvesting, water supply.

Table 7.2: Key approach for advocacy and action in four research locations



component is summarized in Table 7.2.

7.2 KEY LESSONS

7.2.1 Climate variability and urbanisation interact to create patterns of peri-urban water insecurity

The research confirms that urbanisation creates new claimants on water on two counts. First, fresh water flows from peri-urban to urban uses as cities are not fully covered with formal water supply systems and new demands are generated which utilities are not able to meet. This demand is met by private tanker operators who find it easy to fetch water from peri-urban locations and supply this water in urban areas. Second, the increase in demand for land leads to appropriation and contamination of land and water resources in peri-urban locations. Water bodies such as cascading lakes of Hyderabad and traditional water management practices such as Khals in Khulna have been partially appropriated by increased demand for land. This has affected water security in terms of increased scarcity and floods in urban areas.

Climate variability and change aggravates the impact of urbanisation and increases

water insecurity through: rise in temperature; reduced intensity of rains, shorter seasonal duration; and sea level rise and salinity intrusion.

Urban sprawl and growth of peri-urban areas have been induced by low land prices that have attracted the investment in peri-urban zones. Although known for the abode of the less privileged, the peri-urban areas in four cities are witnessing enormous prospects of residential and commercial development owing to the increasing demand for homes in the city. This process has usurped lands and surface water sources to a large extent, resulting in the poor and marginalized population suffering the most, because of diminishing access and control over the environmental resources. Climate variability and change brings in multiple stressors to this process of transformation. Planned urbanisation that incorporates environmental planning, climate smart development and local resource use will help reduce vulnerabilities of peri-urban residents.

7.2.2 Disaggregating vulnerabilities: Gender, class/caste and access to water

While gender issues are well recognized in policy and research, assumptions continue to be made in the water sector that inequalities exist "only" at the household/community levels, ignoring the complex intersection of gender and class/caste which serve to restrict opportunities and access to critical resources including water in South Asia. This research finds parallels between the cultural logic of castes/classes and gender discrimination. The gender- and class/caste- disaggregated data collected show entwining of caste/class and gender that defines water allocation and access among users. Social relations of water are poorly understood and rarely implemented in policy and practice with a focus to reach the most vulnerable and marginalized. The evidence of vulnerability and its impact on people lower in socio-

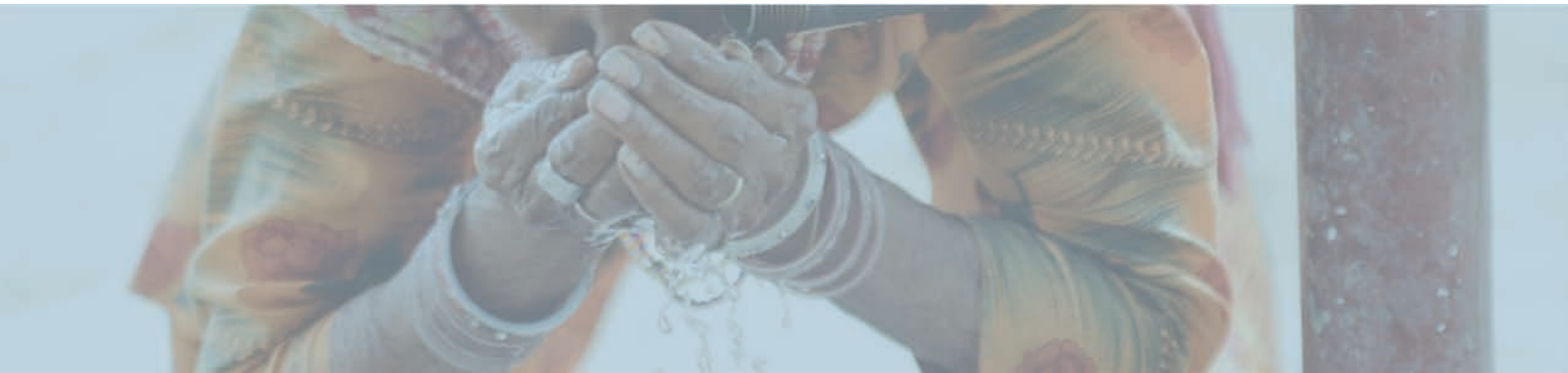
economic hierarchy is evident from the present research.

For example, documenting the plights of the victims of climate induced vulnerability in Bangladesh shows that one of the major stressors of urbanisation is the climate or environmental refugee displaced by increased cyclones and floods in the area. In India, increased groundwater pumping due to the sale of water is disenfranchising the poor who earlier had access to water. As the local groundwater table has fallen, women now walk further to collect water as local taps and hand-pumps have dried up. However, an important point that emerges from this study is about the impact of changes underway for women and marginalized communities. In peri-urban contexts generalizations are indeed difficult and one needs to look at the local contexts, gender, caste and class relations along with the flows of goods, services and resources across rural and urban areas to come to any conclusions. The problem occurs because there is no uniform gender-disaggregated data in the water sector collected officially by agencies responsible for data collection and analysis. Lack of data provides lack of evidence or status of the relationship between gender, class/caste and water, and hence one relies on smaller studies which cannot be extrapolated to understand larger gender relations with respect to water. This study, therefore suggests disaggregating vulnerabilities to reach the people who need help the most.

7.2.3 Climate science verses local perception: Local adaptation at its best

The research found that most of the climatic data analysis has been concentrated at the aggregate level (national, regional or state level) and generalized to represent the entire country or region. With extensive variations in topography and microclimate, there is need of site-specific climatic data analysis to understand the climate variation at local contexts. Ongoing climate variability and change are projected to impact a variety of sectors in all three south Asian countries studied in this research.

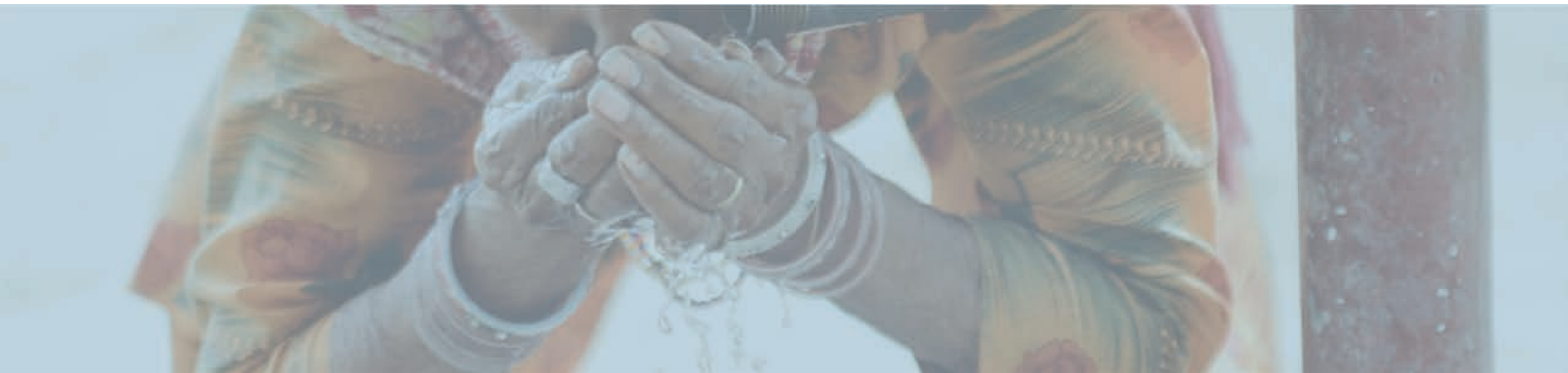
Impacts on water resources include anticipated water shortages in dry seasons and more weather-related disasters such as droughts, floods and landslides expected in the future in India, Bangladesh and Nepal. However, this study finds that, barring a few



summary

indicators of climate variability, scientific analysis is rarely available at the community levels in all four peri-urban areas. Farmers and residents are relying mostly on their own observations and subjective interpretations. These interpretations are based on a long-standing experience and familiarity with seasonal patterns of rainfall and a set of local climate indicators that constitute the climatic perceptions.

It is important to be aware of these perceptions since people frequently act on their perceptions, change their behaviour, and develop strategies to cope with the changes in the short run and to adapt to the long-term changes based on their dynamic and evolving knowledge, whether or not they are consistent with meteorological data. This research has tried to bridge the gap between climate science and local action in a peri-urban context. It has observed that the two sectors – water resources and agriculture-are going through changes due to climate



variability. Local people and farming communities in peri-urban locations are the most vulnerable groups. The groups are adapting to the changing climate through their own perceptions without any help from the local authorities or informed knowledge. This process may exacerbate risks.

For example, a wide understanding in all research locations was that rainfall has decreased. The scientific analysis showed variability in rainfall distribution but average rainfall has not changed significantly during the last 50 years. Local perception on this subject, therefore, is guided more by water stress due to the poor- or mis-management of water and is a non-climatic factor.

The research also shows that in most of the cases local perception reasonably approximates the climatic trends. However, there is a need to marry the scientific data and the perceptions of local communities in order to achieve better adaptation outcomes. Local actions, therefore, must be part of the larger resilience strategies that are based on analytical foundations where both science and local perception come together.

7.2.4 Stakeholders' engagement is critical and paramount

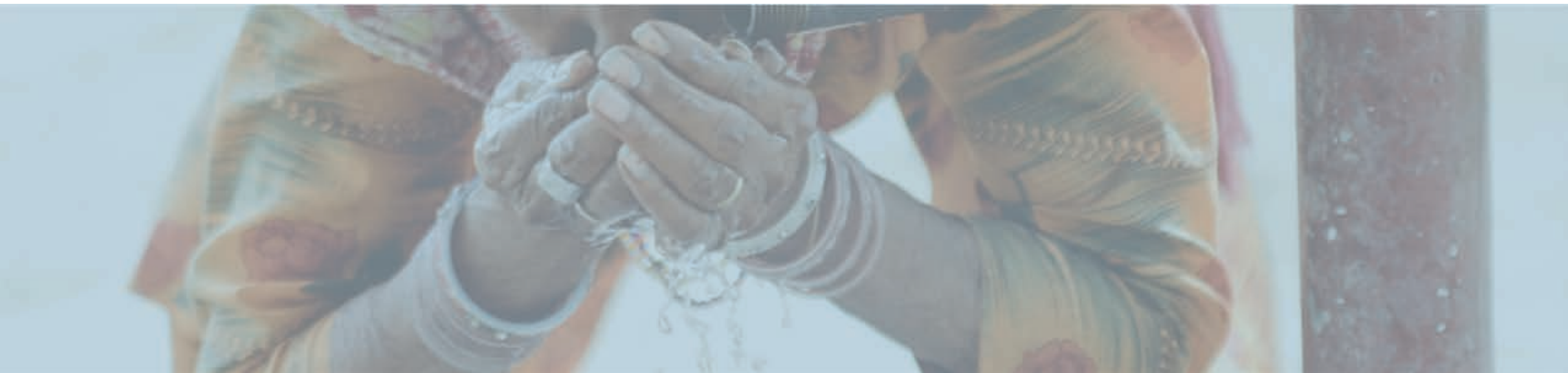
Urbanisation and climate change pose many challenges for urban ecosystem and resource management especially in urban and peri-urban locations. Our research shows that local communities are struggling to find ways to prepare for the potential future impacts of climate change while dealing with immediate pressures through changing agricultural practices, livelihoods and coping with water stress. Decisions on how to respond to future risks are complicated by the long time-horizons and the uncertainty associated with the distribution of impacts and gap in knowledge to understand climate variability and change. Our engagement in this project shows that

summary

existing management approaches do not adequately incorporate changing stakeholder preferences. Affected communities are mostly aware of the trade-offs but that is not reflected in the planning process.

This project innovated a way in which direct stakeholders and responsible government departments could come together to discuss the local issues. The objective was to induce climate-smart planning by sensitizing the local authorities and immediate stakeholders. This process was divided into three steps. Step one included research to understand the local specific issue critical to the peri-urban communities. Step two was to bring the local line department face to face with the affected communities in a dialogue format. Step three was to have joint deliberations and joint exposure visits to villages that have solved similar issues through collective efforts under the format of shared learning dialogue.

This strategy worked in bringing the local departments closer to the communities and sensitizing the local authorities to bring significant changes and fix local problems that people had been facing for a long time. At larger urban and peri-urban scales, this approach may need to be extrapolated as it has elements that can influence the planning process crucial for developing city-wide resilience policies. Stakeholders' engagement therefore is not only critical but also paramount for better urban planning aimed at sustainability of resources.



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Project Partners

SaciWATERs

Project Support

IDRC | CRDI

Canada

ISBN: 978-81-929178-0-1 | © SaciWATERs, 2014