ATKINS

FUTURE PROOFING INDIAN CITIES

Bangalore Action Plan for Water and Sanitation Infrastructure

December 2014

Atkins in partnership with

dpu Development Planning Unit

UCL

BWSSB

iihs INDIAN INSTITUTE FOR HUMAN SETTLEMENTS

Notice

Acknowledgements

We would like to thank Dr Ravindra I.A.S Additional Chief Engineer (New Initiatives and Design) and the rest of the team at BWSSB for their immense support to the project without which the Action Plan would not be possible. A wide range of other stakeholders and organisations took part in surveys, contributed ideas, and helped to shape the action plan proposals and we would like to thank their support and commitment.

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About the project partners

Atkins

Atkins is one of the world's leading infrastructure and design companies, with the depth and breadth of technical expertise to respond to the world's most complex infrastructure and environmental challenges. These include responding to the increasing rate of urbanisation and the urgent transition to a low carbon economy. Atkins works with municipal authorities, national and regional government, development agencies, private sector companies, and other stakeholders to develop and implement strategic plans and investment projects to shape and manage the future growth of cities. With over 17,000 employees worldwide, Atkins is able to bring together its technical knowledge across a wide range of disciplines such as transport, water, energy, design, architecture, climate science, ecology, planning, and economics to help cities and those investing in them to act upon the long term opportunities and challenges of resource use and a changing climate. Our international work spans Africa, Asia, Europe, the Middle East and North America. Through our 'Carbon Critical' initiative Atkins has developed a range of bespoke tools to reduce the carbon emissions associated with major urban infrastructure programmes including a low carbon Masterplanning tool to reduce city carbon footprints.

University College London: Development Planning Unit

UCL is one of only three UK universities in the top 20 in the 2011 Shanghai Jiao Tong world rankings, and in the latest research assessment exercise UCL was rated third overall in the UK after Oxford and Cambridge. The Bartlett Development Planning Unit (DPU) is internationally recognised for its academic and professional contributions in relation to city development in the developing world in active collaboration with partner institutions and researchers in the Global South. It is concerned with promoting sustainable forms of development, understanding rapid urbanisation and encouraging innovation in the policy, planning and management responses to the economic, social and environmental development of urban areas, giving emphasis to social justice, participatory local governance and poverty reduction. The key distinctive features of the DPU are its commitment to action research and its focus on rapidly urbanising areas in the developing world. The DPU maintains a wide network of partner organisations in Latin America and the Caribbean, Africa and South and Southeast Asia working on sustainable cities.

IIHS

The Indian Institute for Human Settlements (IIHS), based in Bangalore, is a national education institution committed to the equitable, sustainable and efficient transformation of Indian settlements. IIHS aims to establish an independently funded and managed National University for Research and Innovation focused on the challenges and opportunities of India's urban transition. IIHS has also been designated a National Resource Centre (NRC) by the Ministry of Housing and Urban Poverty Alleviation.

Foreword

Bangalore shares many of the issues and challenges of Tier 1 Indian cites, as the percentage of population living in urban areas rises from around 30% at present to more than half by 2030. The population of Bangalore is expected to reach 14.7m by 2030 and the pressures of becoming one of the world's mega cities has serious implications in terms of the water and energy security and the ecological systems sustaining the city's population.

The service providers in Bangalore need to address existing gaps to respond to the needs of existing communities and the future population who will also require the full range of urban services – water supply, sanitation, drainage services as well as power, housing and urban mobility.

It is recognised that Bangalore is likely to be impacted by the effects of climate variability. These are slower onset changes but could impact on the water resources and food security of the city. The city may also experience a greater frequency and intensity of storm events in the future which could impact on households, businesses and the infrastructure of the city.

The scale of these challenges and emerging needs means that Bangalore Water Supply and Sewerage Board (BWSSB) has to consider how it can best take action and evolve its existing approach to step up to the challenge. The BWSSB will use the results of this project to inform upcoming plans and programmes to enhance service provision in the city.

This cooperation has helped take stock of the existing issues around the city and look at them in a new light. I would like to thank all those who participated in this initiative.

This action plan defines a strategy and a number of constituent projects which will help to position the city to improve the quality of life for all residents as well as address long standing infrastructure gaps. In the process, we can build a more resilient city, better able to respond to future challenges.

We will also share the results of this project and the action being taken with other agencies operating in the Metropolitan area in order that a more integrated approach can be taken to responding to the challenges facing the city.

We are pleased with the involvement of BWSSB in this initiative and believe it represents a stepping stone on the path to a better future.

Dr P.N Ravindra
Additional Chief Engineer (New Initiatives and Design)

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Abbreviations

ADB Asian Development Bank

BAU Business As Usual

BBMP Bruhat Benguluru Mahanagara Palike

BEE Bureau of Energy Efficiency

BRT Bus Rapid Transport

BWSESMP Bangalore Water Supply and Environmental Services Master Plan

BWSSB Bangalore Water Supply and Sewerage Board

CAC Command and Control

CDM Clean Development Mechanism

CDKN Climate Development Knowledge Network **CER** Certified Emission Reduction

CF Carbon Footprint

CGWB Central Groundwater Board

CNG Compressed Natural Gas

CO_2e CO_2 Equivalent (Impact of greenhouse gases expressed interns of CO_2)

CMCs City Municipal Corporations

CGC City Coordination Group

CDP City Development Plan

CSR Corporate Social Responsibility

DPR Detailed Project Report

ECBC Energy Conservation Building Code

EE Energy Efficiency

ESCO Energy Service Company

FAR Floor Area Ratio

FSI Floorspace Index

GCM Global Climate Model

GIS Geographic Information Systems

GDP Gross Domestic Product

GEF Global Environment Facility

GHG Greenhouse Gases

GRIHA Green Rating for Integrated Habitat Assessment

Ha Hectares

HPEC High Powered Expert Committee

IGBC Indian Green Building Council

IHSDP Integrated Housing and Slum Development Programme

INCCA Indian Network for Climate Change Assessment

INR/Rs Indian Rupees

IPCC Intergovernmental Panel on Climate Change

ITS Intelligent Transport System

IT Information Technology

IDFC Infrastructure Development Finance Corporation

ICF International Climate Funds

IIHS The Indian Institute for Human Settlements

JNNSM Jawaharlal Nehru National Solar Mission

JNNURM Jawaharlal Nehru National Urban Renewable Mission

KUIDFC Karnataka Urban Infrastructure Development Finance Company

KWh KiloWatt hour

LEED Leadership in Energy and Environmental Design

LPA Local Planning Authority

LPG Liquefied Petroleum Gas

MoEF The Ministry of Environment and Forests

Mw Mega Watts

MNRE Ministry of New and Renewable Energy

MLD Million Litres per Day

NAPCC National Action Plan on Climate Change

NMT Non Motorised Transport

NTAG National Technical Advisory Group

NRW Non-Revenue Water

O&M Operations & Maintenance

PSPs Public Stand Posts

PV Photo Voltaics (Solar panels)

PWD Public Works Department

SPV Special Purpose Vehicle

SEZs Special Economic Zones

TERI The Energy and Resources Institute

TMC Thousand Million Cubic Feet

UCL University College London

UIDSST Urban Infrastructure Development Scheme in Satellite Towns

UIDSSMT Urban Infrastructure Development Scheme for Small and Medium Towns

UFW Unaccounted for Water

ULB Urban Local Body

01

INTRODUCTION

Introduction

Background

In March 2013, Atkins, supported by the Development Planning Unit of University College London (UCL) and the Indian Institute of Human Settlements (IIHS), were commissioned by the Climate Development Knowledge Network (CDKN) to undertake action planning with the city authorities of Bangalore and Madurai, focussed on developing future proofed urban strategies in the cities. In Bangalore, we have been working closely with Bangalore Water Supply and Sewerage Board (BWSSB) who is the client for the project.

The key objective of the project is to help both cities to develop an action plan which charts a clear way forward, via the development of policies and other interventions, to respond to climate risks and promote a transition to a low carbon economy while reducing poverty and catalysing economic development.

Overall approach to the project

The project has been undertaken over two key stages at the city level, which is consistent with the future proofing approach developed by Atkins and UCL, with the later stages consisting of disseminating the lessons learned (see Figure 1.1 on page 4).

This report is the final action plan for Bangalore which provides a basis to address the climate risks and development needs of the city.

At the conclusion of the urban diagnostic stage, stakeholders in the city converged on the view that the plan should focus on future proofing Bangalore's water supply and sanitation system which links with the responsibilities of BWSSB.

The action plan is essentially a plan for managing an interconnected set of challenges relating to BWSSB's water resources management (surface and ground water), water supply, water quality, sanitation and flooding in the context of the urban development trajectory of the city and its changing climate.

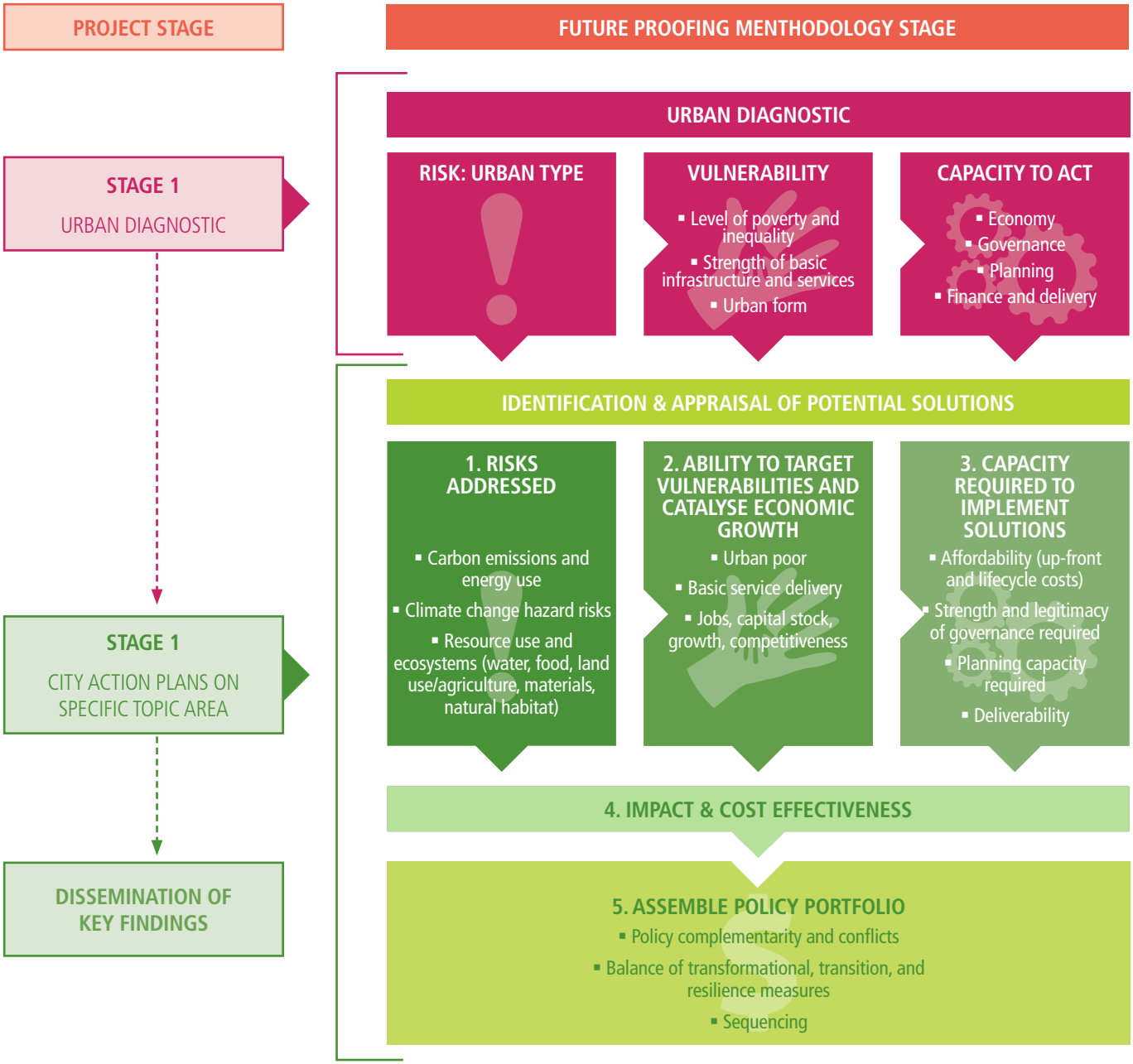

Figure 1.1 Overall approach to this project

The diagnosis of the present and future challenges for Bangalore now needs to be mobilised into action that can deliver change on the ground.

Purpose of the plan

The purpose of the action plan is to provide a mechanism for building the city's current and future resilience, as well as the capacity to act among communities, institutions, and government. The aim has been to foster collaboration between sectors and communities, in order to arrive at an integrated approach and to generate momentum for early action around the priority issue of water resources.

The aim of the action plan is to:

- mobilise action, target specific vulnerabilities and deliver change on the ground that will benefit a wide range of stakeholders, including those in multidimensional poverty
- address identified risks, including multiple risks to generate 'win-win' and 'triple win' environmental benefits
- catalyse economic development.

Action in Bangalore will be driven through the planning and implementation of projects. Some projects relate to spatial interventions in neighbourhoods, while others relate to systemic issues. The action plan will:

- make the case for the mobilisation of resources to address issues and infrastructure gaps in Bangalore
- contribute to the shaping of actions to address level of service gaps and upcoming capital programmes
- link with initiatives to revise the Bangalore development plan and other initiatives to address the city's infrastructure needs including the Bangalore City Cluster Development Programme supported by Asian Development Bank (ADB)
- be implementable, in the context of other existing plans, capacities and incentives
- to identify those organisations, departments and institutions who have the responsibility for implementing each element of the action plan
- to identify potential sources of investment, funding, and delivery vehicles for key interventions and projects.

The action plan for Bangalore charts a clear way forward. It helps the city respond to climate hazards and promote a transition to a low carbon economy while reducing poverty and catalysing economic development.

The frame of reference for the plan is to cover the period up to 2025. The plan considers ongoing actions required over the whole plan period together with actions required to build resilience and tackle vulnerability over the short term while preparing for measures to tackle slow on-set climate change risks.

The structure of this document

This document is structured in four sections following this first introduction section.

Section 2 provides a summary of the diagnostic for Bangalore and the underpinning rationale for its focus on addressing water resources and sanitation issues in the context of increasing climate variability.

Section 3 outlines the overall strategy for Bangalore focusing on how the components should be integrated and sequenced. This section also contains project plans for 13 projects across five themes relating to water resources; water supply distribution management; wastewater and sludge collection and management; improved service delivery to households and establishments; and water demand management.

Section 4 focuses on delivery and implementation of the plan including three projects addressing the arrangements for improved governance and regulatory changes to provide the framework for implementing the other proposals contained within the plan. This section also includes a preliminary of the cost of implementing the plan. A range of financing options are also explored.

Appendix A - provides the results of the further analysis of risk and vulnerability facing households, service providers and regulators.

Action planning in Bangalore

The approach

Action planning for future proofing Bangalore has taken place over a period of 20 months (refer to figure 1.2). The approach consisted of a number of components:

- **Urban diagnostic for Bangalore.** This study informed by secondary data analysis, examined the wide range of existing risks and challenges that the city faces, focusing on those that relate to climate change.
- **Stakeholder consultation.** Consultations with key stakeholders from government agencies, NGOs, academic and research institutions has been a core element of action planning in Bangalore in order to reflect their vision and views. The goal was to work with the stakeholders, especially those in government agencies, to produce a realistic plan that would help Bangalore grow sustainably. One of the biggest challenges is in developing an understanding of an integrated approach to dealing with environmental risks, particularly because most city-level agencies do not see this as part of their mandate. The second challenge is to bring officers from different city and state level agencies together to discuss challenges within the water and sanitation sector, since the governance of this sector in Bangalore is fragmented, with several agencies responsible for different aspects. The third is to bring government officers and other non-governmental stakeholders together in order to build a shared understanding of issues, and inform the development of the action plan.
- **Identification of potential solutions.** The projects that comprise the action plan.
- **Field-based case study.** This was a validation exercise conducted by IIHS in two locations in Bangalore. These site case studies provided a grounded illustration of water supply and sanitation opportunities to address the issues experienced by communities and establishments in the context of local realities of land use and planning. The case studies also help in the framing of what potential 'solutions' could be and what they might look like at the local level to enable BWSSB to take forward actions within its own planning, budgeting and regulatory framework. The aim of the field study was threefold: first, to validate the issues that were raised in the urban diagnostic study including issues related to disparities in access to water and sanitation services in Bangalore; the lack of good quality water, groundwater contamination, and the impact of this on vulnerable, especially poor populations in the city; second, to understand issues at household and neighbourhood level; and finally, to validate action plan components at the local scale. The first site is located close to the centre of Bangalore, in the older colonial Cantonment area (Site 1). The site has a range of land uses including residential, institutional and smaller commercial establishments. The second site is located on the south eastern periphery of Bangalore (Site 2), and is representative of newer forms of development in the city including large gated communities, information technology parks, and large commercial establishments such as malls.

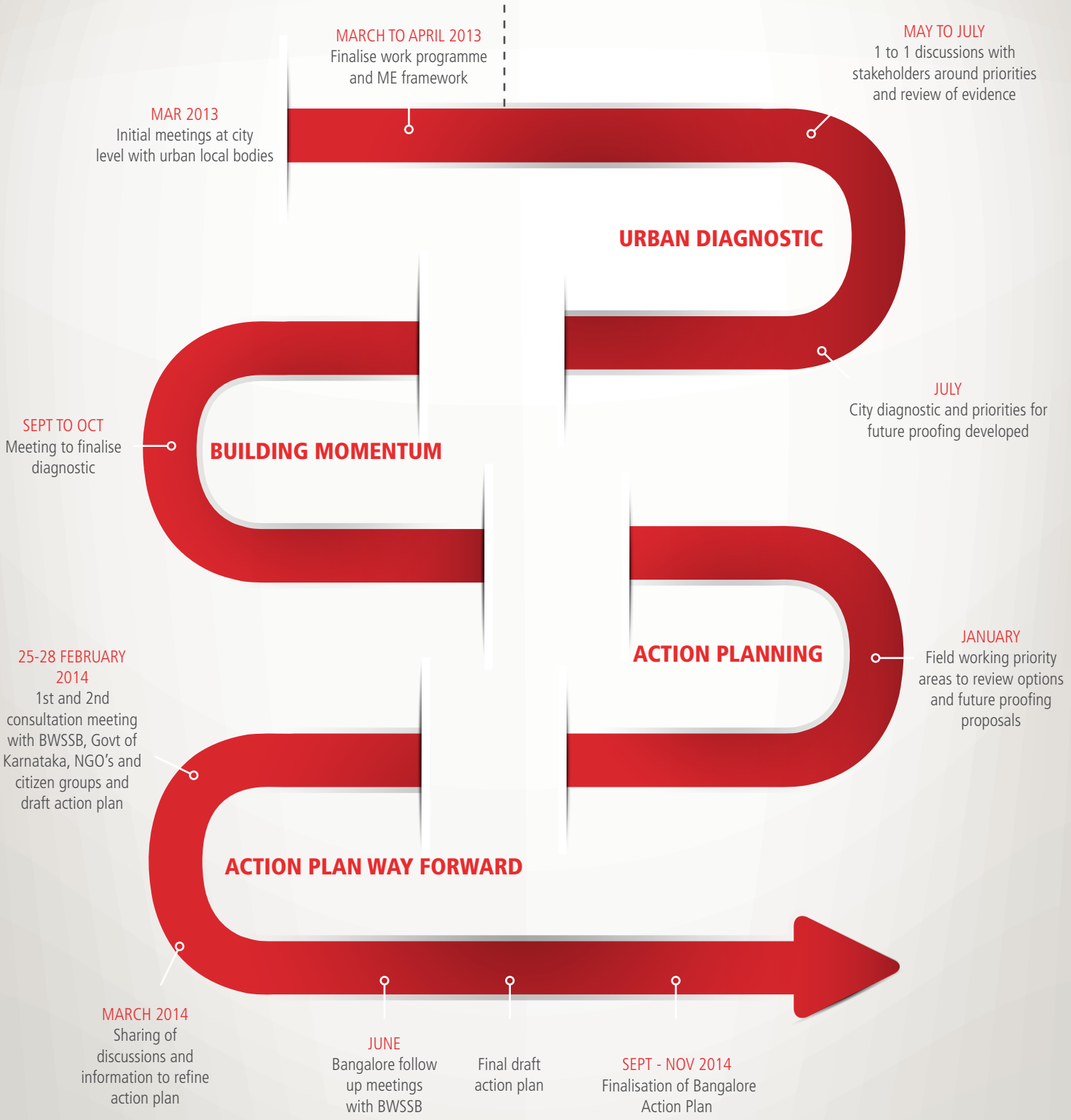

Figure 1.2 - Bangalore action plan timeline

From the urban diagnostic study and the early stages of consultation, the issue of water and sanitation emerged as a key area of vulnerability and one which is already having an impact on the liveability of the city. There is no institutional mandate for resilience planning and management in Bangalore. However, the BWSSB is the primary utility company in Bangalore and is charged with ensuring water supply, water quality and the provision of sanitation. BWSSB's ambitions include increasing the reuse of wastewater in Bangalore, reducing leakages and water loss, and improving revenue generation.

BWSSB officers expressed interest in participating in the future proofing and the action planning process, and were keen to see examples and a case study of how water supply and sanitation is currently working, as well as ways in which their existing goals and plans could be informed by the action plan.

The identification of current risk and mitigation and this action plan has been developed and discussed with BWSSB and other agencies. In this way, the future proofing process has already started to build the need for improved institutional coordination and collaboration in respect of water and sanitation sector in Bangalore.

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DIAGNOSTIC AND PLAN FOCUS

Future proofing

What is the 'future proofing' approach?

One of the most pressing contemporary challenges is how to resolve the problem of economic growth and development without costly and irreversible environmental damage. As the world becomes increasingly urban, this is a challenge that will be played out largely in cities, especially in the developing world. Over 50% of the world's urban population growth is projected to take place in Asian and African cities.

Since economic liberalisation in the early 1990s, Indian cities have seen economic, physical, social, and political change at an unprecedented rate and scale. (Chatterjee, 2008; Shaw, 2007). The Indian economy has grown at about 6% annually from 1990 to 2010 with most of this growth taking place in cities (Allen et al., 2011; Just et al., 2006).

In order to tackle the risks to future growth as well as meet the demand for adequate infrastructure and basic services, Atkins in partnership with DFID and UCL have proposed a future proofing approach. Future proofing is about identifying and developing solutions which can respond to the risks associated with issues such as climate change, resource scarcities, and damage to vital ecosystems but in a way which catalyses broader economic development, improves access to basic services and tackles urban poverty.

Future proofing takes an integrated approach to tackling deep-rooted urban problems. The current approach in Indian cities like Bangalore is sometimes too sectorally focused to be fully effective in dealing with the complex, interlinked issues facing the city. Plans for the city rarely represent an integrated approach. For example, water supply issues are generally approached solely from the perspective of identifying water-engineering solutions, with the potential impacts on vulnerable groups, patterns of development, food security and flooding poorly understood. When urban problems are approached in this narrow way, solutions can sometimes be ineffective, opportunities for generating wider benefits are missed, or significant unintended negative consequences can occur.

The future proofing approach considers the growth dynamics of the city in parallel with the range of potential risks, which may impact future development. The approach involves looking at three groups of interrelated issues (refer to figure 2.1):

- climate risks e.g. flooding, extreme heat events
- resource and ecosystem risks within the city and its wider catchment e.g. water scarcity, food security, and damage to vital ecosystems due to urban growth
- energy use and carbon emissions e.g. from transport, domestic and commercial consumption, industry and waste.

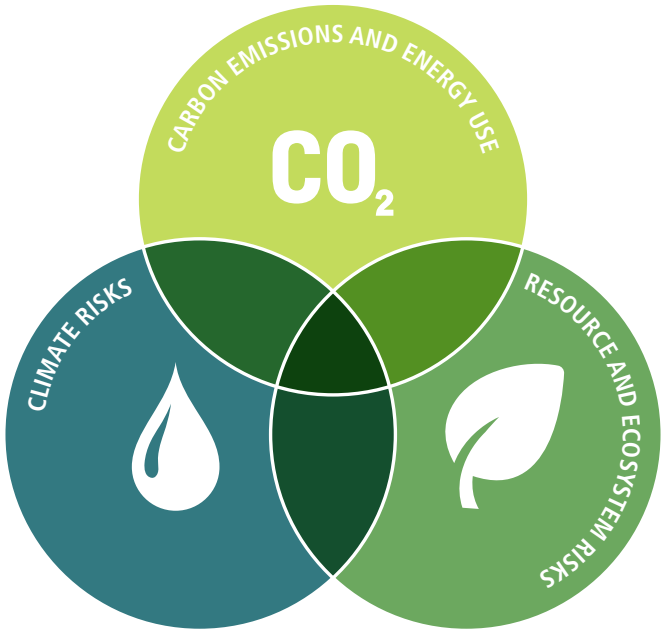


Figure 2.1 – Future proofing approach: Integrated assessment framework

Source: Atkins

1 Future Proofing Cities (2012), Atkins in partnership with DFID and UCL

Benefits of a future proofing approach

Building a profile – or urban diagnostic- of these key risks, in conjunction with assessing the vulnerability and capacity of local institutions and stakeholders to respond to them can help to identify implementable solutions which can deliver multiple economic, social, and environmental benefits. This differs from most current approaches to urban development which tend to focus on targeting one or a few narrowly defined objectives (e.g. city competitiveness, green cities) rather than looking at packages of complementary policies which can meet multiple objectives. The benefits for Bangalore of developing this approach include:

- an explicit focus on how the city can respond to four long run challenges – resource security (e.g. water), resilience to climate impacts, the move to a low carbon economy, and protection of ecosystems
- the identification of packages of complementary policies in these areas which can generate multiple environmental, social, and economic benefits, crucial in the context oflimited financial resources
- a focus on measures which respond to the needs of the urban poor
- the identification of measures which can be implemented and driven forward by stakeholders within the city given current capacities.

Why Bangalore?

Bangalore is the capital of Karnataka and has emerged as a global centre for 'new' service sector economies, such as information technology and biotechnology. Several domestic and international corporations such as Wipro, Infosys, Microsoft, and IBM are located here, some on city-edge campuses, attracted partly by Bangalore's academic institutions and the skilled workforce. (H. S. Sudhira et al., 2007). Bangalore has the highest district income in the state, contributing approximately 34% to Gross State Domestic Product (GSDP) (Directorate of Economics and Statistics, 2011). The Government of Karnataka has undertaken mega-infrastructure projects such as elevated roads, a new metro, a new airport, and establishing special economic zones.

This rapid prosperity, and the opportunities afforded by the new knowledge economy for which Bangalore is renowned, have led to a doubling of the city's physical footprint in the last decade (Census of India, 2011; Indian Institute for Human Settlements (IIHS), 2009; Ramachandra and Kumar, 2009). However, this rapid and unplanned urbanisation has been at the cost of the city's resources and liveability In particular, the growth on the city's peripheries is placing pressure on Bangalore's natural and economic resources and infrastructure. This poses environmental and health risks for the entire city, especially for low-income and other vulnerable populations such as women, children, and the elderly.

The benefits of Bangalore's growth have not been equally distributed. About 43% of the city's population is living in multi-dimensional poverty Marginalized populations in Bangalore are particularly vulnerable to hazards such as widespread water scarcity, localised urban floods, and urban heat island effect. Most of these issues will be exacerbated by climate variability and change. Governance in Bangalore is also fragmented, making coordination across different agencies challenging.

It is clear that Bangalore faces considerable socio-economic and environmental risks if it continues along the current development pathway. The city needs new approaches to help to deliver key sectors and infrastructure planning, to ensure that Bangalore, and all the communities in the city, can be resilient to climate change and other future challenges.

Purpose of the action plan

The purpose of the action plan is to provide the tools to plan Bangalore's resilience, as well as the capacity to act among city leaders, infrastructure and service providers and amongst the community. The urban diagnostic and the subsequent action planning has demonstrated that water and sanitation are fundamental to the present and future health and resilience of Bangalore. Therefore the action plan focuses on these issues, aiming to:

- provide an example of a key sector at risk and demonstrate the wide-ranging and interlinked impacts of current issues and future pressures
- help organisations and stakeholders to identify the key issues, challenges and the current and future impact on the communities and city's prosperity – and see how their role in the future management of water and sanitation can be framed in the light of these challenges
- demonstrate how their existing and future goals, plans and investments can be informed by this action plan
- make the case for mobilisation of resources to unlock and address the vulnerabilities
- identify groups and organisations who are stakeholders in the management of the water supply and sanitation and who can help to implement the action plan.

Summary of Urban Diagnostic

Risks to Bangalore's Future Growth and Prosperity

Bangalore faces significant risks[1] to its future growth and prosperity, including efforts to reduce urban poverty. These risks include those from climate hazards such as flooding, risks related to critical natural resources such as water, and risks associated with rising carbon emissions and increasing energy intensity of development. These risks cannot be looked at in isolation - they are multiple, interlinked, and they are growing.

1 We define risk broadly as the potential that the 'activities' of cities which drive carbon emissions and pressure on critical natural resources and 'events' in the form of climate hazards and external pressures on resources used by cities will have an undesirable impact. Given that cities both contribute to and are impacted by environmental risks it is difficult to disentangle cause and effect. Hence, no attempt is made to delineate between stresses or risk drivers (e.g. carbon emissions) and shocks (e.g. rises in the price of energy, climate hazards).

Climate hazards

Current risks

Bangalore faces a range of climate hazards – particularly flooding - which already impact its people and physical infrastructure. Bangalore is located in a warm-humid climatic zone and experiences a hot dry climate with intermittent and irregular rainfall. In recent years high volumes of rain during the monsoon has caused parts of the city to flood, including areas such as the City Market area and the Kormangala slum (see Figure 2.2).

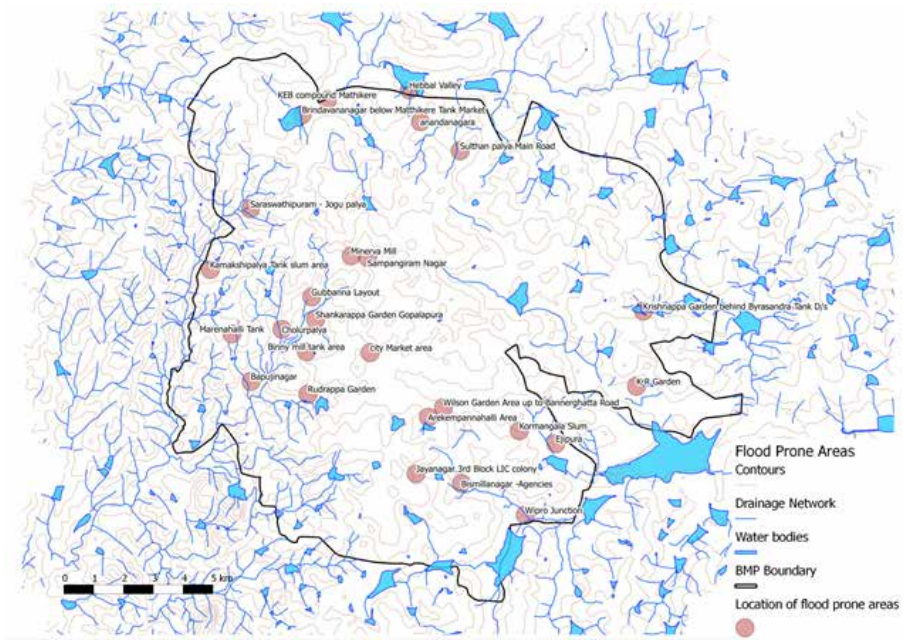
The areas which are particularly prone to flooding include parts of the city which lie within the natural floodplain of the river and drainage channels. Often slums have become established in these areas which are usually owned by public bodies and lack appropriate flood protection or flood resilient infrastructure. Moreover, much of the network of natural water bodies and tanks which play a key role in storm water drainage and runoff within the city have been encroached upon by development which leads to these areas flooding during heavy rainfall events.

Transportations systems (road networks, rail networks, and aviation) are often exposed to floods and their functioning is known to be severely hampered in case of an extreme rainfall event in Bangalore. Transportation systems and infrastructure are also major contributors to the heat island effect that will further exacerbate the impact of climate-induced temperature rise. Water supply, drainage, sewage and solid waste disposal systems are themselves at risk from flood.

TABLE 2.1: SUMMARY OF CLIMATE-RELATED HAZARD RISK PROFILE FOR BANGALORE

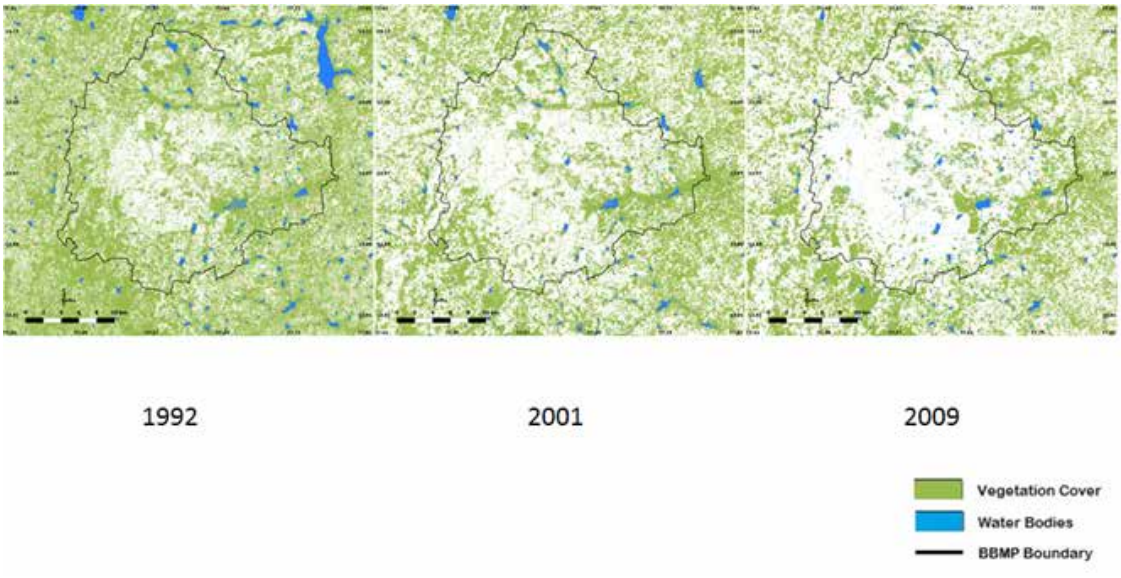
Bangalore: Key climate-related hazards and extreme events	
Heat	Bangalore has an annual average maximum temperature of 29C and average minimum temperature of 19C. A mean temperature increase of approximately 2 to 2.5C during the last decade has been reported, attributed both to urban heat island effect and potential early climate signals (Ramachandra and Kumar, 2010). Bangalore's built-up area has increased by 134%from 1992 to 2009. The coverage of water bodies in the city have reduced from 3.4% to 1.5% of the land area in the same time period (Ramachandra and Kumar, 2008).
Extreme Rainfall and Pluvial Floods	Bangalore receives rainfall both from the Northeast and Southeast monsoons. Its mean annual rainfall is 970 mm. Average monsoon season rainfall and average annual rainfall in the Bangalore region show an increasing trend for the period from 1901 to 2000. This trend is particularly pronounced for the period from 1951 to 2000 (De and Rao, 2004). There is a significant increasing trend in both the frequency of rainy days in a year and in one day extreme rainfall (maximum rainfall day for each year) for the period from 1901 to 2005 (Guhathakurta et.al., 2011).

Figure 2.2 - Areas prone to flooding



Source: IIHS Analysis, 2013

Figure 2.3 - Change in vegetation cover in Bangalore 1992 - 2009



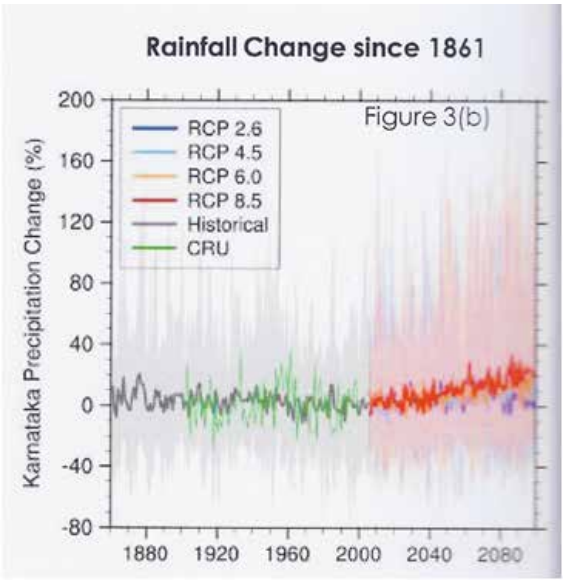
Air pollution and the outward growth of the city are contributing to an urban heat island effect, which has been noted to result in local temperature variations and irregular rain showers (Ramachandra and Kumar, 2010; Ramachandra and Kumar, 2009). This urban heat island effect is exacerbated by reducing tree cover (see Figure 2.3) and increasing built-up area, and has serious health implications for the local population.

Future risks

Climate change is likely to exacerbate these existing hazards: existing national and regional level climate studies indicate that climate change could result in: (i) an increase in average temperatures and increase in the number of extreme 'hot days' (with increased risk of drought); (ii) an increase in the unpredictability of the summer monsoon with potential for rainfall variability, and (iii) an increase in the frequency of heavy rainfall events (with increased risk of flooding) in Bangalore.

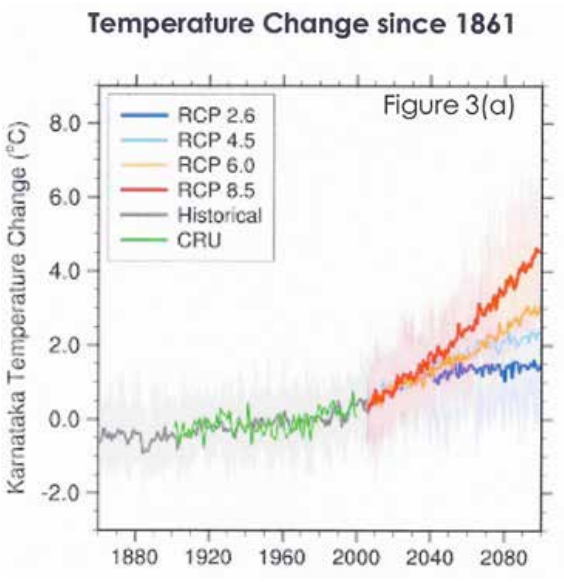
The Karnataka Climate Change Action Plan states that there has been a rise in the minimum temperature in six districts in north Karnataka by 0.6 degree Celsius in the last 100 years, while rainfall trends over the same period indicate an overall decline in annual rainfall for Karnataka state by 10% (Bangalore Climate Change Initiative – Karnataka (BCCI-K), 2011), with overall rainfall in the Bangalore Urban district expected to reduce by 10%-20% by 2050. However, for the Bangalore region, studies have shown a significantly increasing trend for both increased frequency of rainy days and annual one-day extreme rainfall events (maximum rainfall day within each year) over the last century (Guhathakurta et al., 2011; De and Rao, 2004) – see Figure 2.3.

Figure 2.4 - Karnataka rainfall change and projections under RCP scenarios (1861-2080).



Source: (Bangalore Climate Change Initiative – Karnataka (BCCI-K), 2012)

Figure 2.5 - Karnataka temperature change and projections under RCP scenarios (1861-2080).



Source: (Bangalore Climate Change Initiative – Karnataka (BCCI-K), 2012)

These projected climate hazards are likely to have wide ranging impacts on a range of sectors in Bangalore – including food and water systems, health, buildings, transport, and natural ecosystems and biodiversity. Table 2.2 summarises the potential impacts indicated by a range of recent regional level studies out to 2030 and 2050, including a study by the Ministry of Environment and Forests, as well as the Karnataka State Level Climate Change Action Plan. These impacts could include significant declines in agricultural yields in Bangalore's wider catchment (potentially impacting Bangalore's food security and livelihoods for those working in agriculture), increased morbidity and mortality from flooding, an increase in water borne diseases and cholera, an increase in power demand in buildings, and damage to road infrastructure.

TABLE 2.2. SUMMARY OF POTENTIAL CLIMATE CHANGE IMPACTS FOR BANGALORE OUT TO 2030/2050

Sector	Implications for Bangalore
Agriculture[2]	Production of potatoes and soybeans could reduce by up to 45% by 2050. Amount of water retained in the Cauvery basin expected to decline rapidly leading to reduced yields across a range of other crops
Natural ecosystems and biodiversity[3]	The ecosystem and natural capital of Bangalore consists of a system of inland lakes and wetlands of a scale which is of national significance. The climate change impact on the functioning of these systems, flora and fauna is classified within the national assessment document[4] as moderately vulnerable based upon the percentage of areas identified as experiencing change.
Water resources[5]	Actual water availability within Bangalore is a function of rainfall within the Cauvery basin catchment (fed predominantly by monsoon rains)pipeline systems linked with water storage and replenishable groundwater resources within the city boundary. Total precipitation within the Cauvery basin is expected to reduce by 10%-20% which could impact on the ability to provide water resources for the city's growing population. Further work is needed to understand the needs of the city and implications of climate change on water resources.
Human health[6]	The following risks have been identified: ▪ Increased morbidity and mortality from flooding. ▪ Temperature increases lead to increased morbidity from water borne diseases and cholera. ▪ Risk of increased malaria transmission. ▪ Loss of livelihoods due to the effect on agriculture, tourism impacting health and life expectancy
Buildings	Increased temperatures lead to increased usage of air conditioning. Increase power demand. Forced migration and loss of housing in coastal Karnataka following storm events may lead to increased pressure on inland cities such as Bangalore.
Roads and intensity	Increased temperatures of rainfall events have implications for road maintenance and repair.
Flooding	Potential increased risk of fluvial flooding and storm water run-off during the monsoon and precipitation events

The latest longer time horizon central estimates compiled by the World Bank using downscaled GCM projections[8] provide more recent projections over a longer timescale but at a broader geographic scale. The World Bank study - looking out to 2080 - suggests the following climate change impacts could occur in Bangalore and its hinterland:

- An increase in average temperatures of around two degrees by 2080. Other scenarios anticipate an increase in temperatures of up to four degrees. This will be associated with an increase in the frequency of unusual and unprecedented spells of extreme hot weather events and drought conditions, potentially impacting agriculture in the wider catchment, access to water, and risk of mortality.
- An increase in the unpredictability of the summer monsoon, reducing rainfall during the wettest months by 2080. This could have a significant impact on agriculture, as well as creating additional stress on water systems.
- An increase in the frequency of heavy rainfall events, with increased risk of flooding, particularly in areas close to the river basin.

Resource use and security

Issues related to water and food supply will impact the future growth and prosperity of Bangalore, and particularly its ability to reduce urban poverty given the dependency of the vulnerable on access to clean water and robust food systems.

Water security

One of the most serious challenges that Bangalore faces is the reducing availability and access to reliable good quality water supply, and an increasing incidence of urban floods. The public health, environmental health and economic implications of these are already becoming evident and will become increasingly severe as the Indian subcontinent moves into more unpredictable rainfall regimes associated with climate change.

Current risks – water availability

Bangalore is situated in a region of watersheds on top of four natural river valleys, contributing to a large number of lakes and water tanks, which are now, however, diminishing[9]. Water consumption in Bangalore is growing and while precipitation in the city catchment means that Bangalore is not at risk of drought[10], water scarcity problems are localised in different areas of the city. The city is situated on a ridge and does not have access to its own year-round source of water. It relies instead on drawing water from the Cauvery River at a 100 km distance; transferring about 14000 million litres per day to the city centre, which covers only about half of the city's need[11].

The total estimated water supplied to the city is approximately 1,800 million litres per day (MLD) from a range of sources (see Table 4). The total estimated water used is approximately 1311 MLD, if we deduct the amount of unaccounted for water (UFW), which is approximately 45% of total water supplied. The city relies extensively on groundwater through municipal supply, private self-supply and a thriving informal water tanker market. Estimates place the extent of this dependence at 43 to 58% of the total water use (Narain and Pandey, 2012; Anand et al., 2005).

A recent tribunal decision has ruled that Bangalore's current withdrawal of the Cauvery water is in excess of its fare share and will be reduced dramatically to a to-be-determined percentage of the revised figure of 678 MLD for the entire state of Karnataka, further increasing dependence on groundwater sources (Cauvery Water Disputes Tribunal (CWDT), 2007).

2 Karnataka State Level Climate Change Action Plan
3 Ministry of Environment & Forests: Climate Change and India: a 4 x 4 assessment
4 Ibid
5 Karnataka State Level Climate Change Action Plan
6 Ministry of Environment & Forests (2010) Climate Change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s.
7 Karnataka State Level Climate Change Action Plan
8 World Bank Climate Portal and Turn Down the Heat, World Bank
9 Sudhira, 2007. The city is a flat apart from a ridge that runs from north to south (TERI, 2008).
10 Drought risk, measured as % of city catchment at significant risk of water scarcity is 0% (Atkins, 2012). Mean annual rainfall about 880 mm and around 60 rainy days per year (Sudhira, 2007).
11 UN Water 2012

TABLE 2.3 ESTIMATES OF WATER USE IN BANGALORE (IN MILLION LITRES/DAY) ACROSS MODES OF SUPPLY AND SOURCE

Mode of Supply	Municipal Utility	Private tankers	Self-supply by households	Self-supply by others	Total by source
Ground	200	162	261	167	790
Surface	994	65	N/A	N/A	1,059
Total	1,194	227	261	167	1,849

Groundwater levels in the newly developed peripheries of the city which do not receive municipal supply have fallen steadily as a result of withdrawal for private self-supply and supply through private water tankers. This has been further exacerbated by the location of new infrastructure (e.g. the new Devanhalli international airport) and developments in areas that are deficient in groundwater. In parts of the city where groundwater levels are high, it is contaminated by the wastewater from surface water bodies and leaking sewer lines (Central Groundwater Board (CGWB), 2012). Out of a sample of 2,209 tested by the Department of Mines and Geology in 2011, more than 31% were found to be unfit for drinking on at least two or more parameters (Department of Mines and Geology, 2011). Bangalore also had to withdraw from contention for India's first chip manufacturing facilitation (an investment of between 2 and 6 billion US Dollars) citing a lack of adequate water supply and quality, in spite of having the best business context to support technology companies.

Given that ground water levels are falling quickly, carbon emissions related to water extraction are also growing. Acute water shortages arise across parts of the city when groundwater levels become so low that water can no longer be extracted. The extraction of groundwater is also energy intensive, which is expensive and generates additional carbon emissions.

Current risks - water distribution

Estimates of leakage also suggest high losses in the transmission and distribution of water - about 40% of the overall municipal supply is lost to leakages (Narain and Pandey, 2012),

Current risks - surface water management

Many of Bangalore's lakes and surface water bodies have been seriously degraded or even built upon reducing the capability of the city to deal with heavy rainfall events. Climate change represents an additional stress factor which will exacerbate the situation. A network of natural and manmade water bodies and tanks within the city collect runoff with the tanks providing a stormwater detention role. Many of the tanks are used for irrigation with some of the tanks also playing a role in water storage for the city.

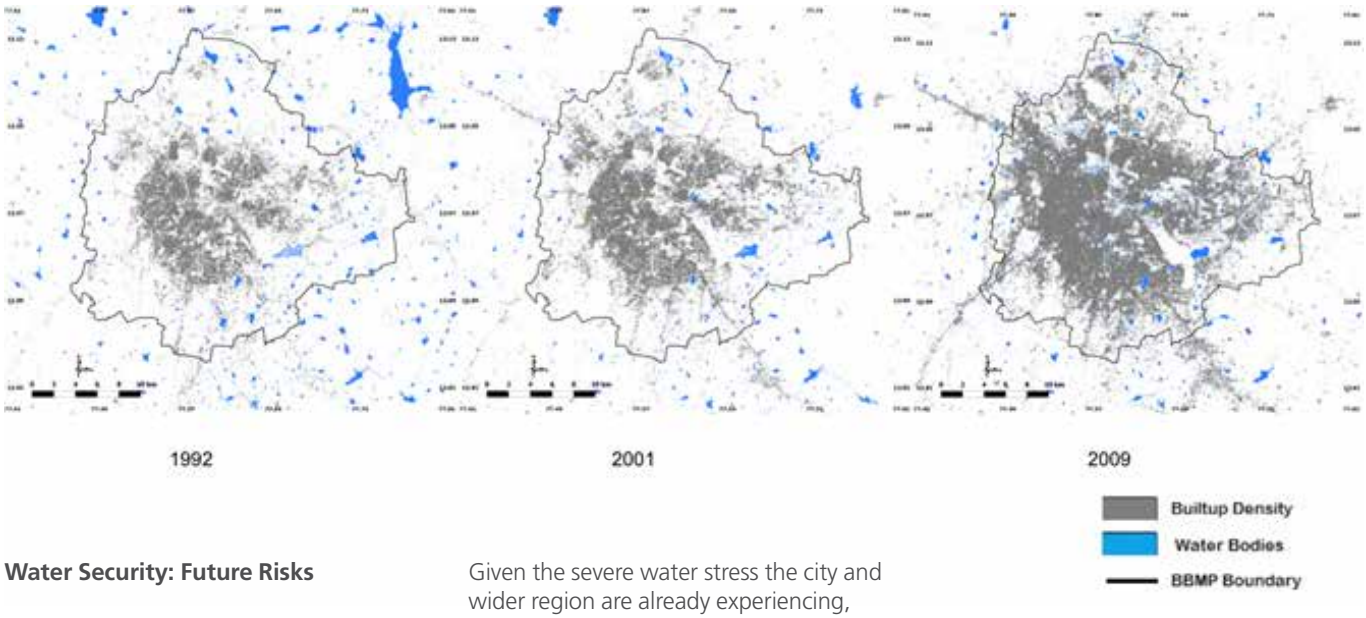
Although Bangalore historically had a network of hundreds of manmade lakes and wetlands that captured and conveyed rainwater for irrigation, this network has been disrupted over the past three to four decades through reclaiming of lake beds for development and drying up of water bodies (Ramachandra and Kumar, 2008; H. S. Sudhira et al., 2007). This in turn has led to regular floods in some parts of Bangalore (see Figure 5) (Ramachandra et al., 2012).The Bruhat Bengaluru Mahanagara Palike (BBMP) has recently identified 1,077 areas in Bangalore as 'flood-prone' and 85% of them have been categorised as 'critical'.

The system of lakes and water bodies are a significant feature of the city, as well as providing potential significant future amenity and tourism value. However, Bangalore's ability to store rainwater for irrigation and water supply has fallen over time for a variety of interconnected reasons:

- Development pressures in the city and the shortage of land has led to loss of some of the tanks to development. These areas are prone to flooding during rainfall events due to lack of provision of alternative storm water storage or drainage infrastructure.
- Some of water bodies and connected channels have been abandoned or have silted up as a result of changes in agriculture including the emergence and development of energised well irrigation, reducing the incentive of farmers to participate in common work for tank maintenance as well as migration of labour from rural areas into the city[12].

12 Bangalore CDP

Figure 2.6 - Change in water bodies in Bangalore 1992 - 2009



Water Security: Future Risks

Actual water availability within the city of Bangalore is a function of rainfall within the Cauvery River catchment (fed predominantly by monsoon rains); pipeline systems linked with water storage and replenishable groundwater resources within the city boundary. The Karnataka State Level Climate Change Plan estimates that total rainfall could reduce by as much as 10%-20% by 2050.

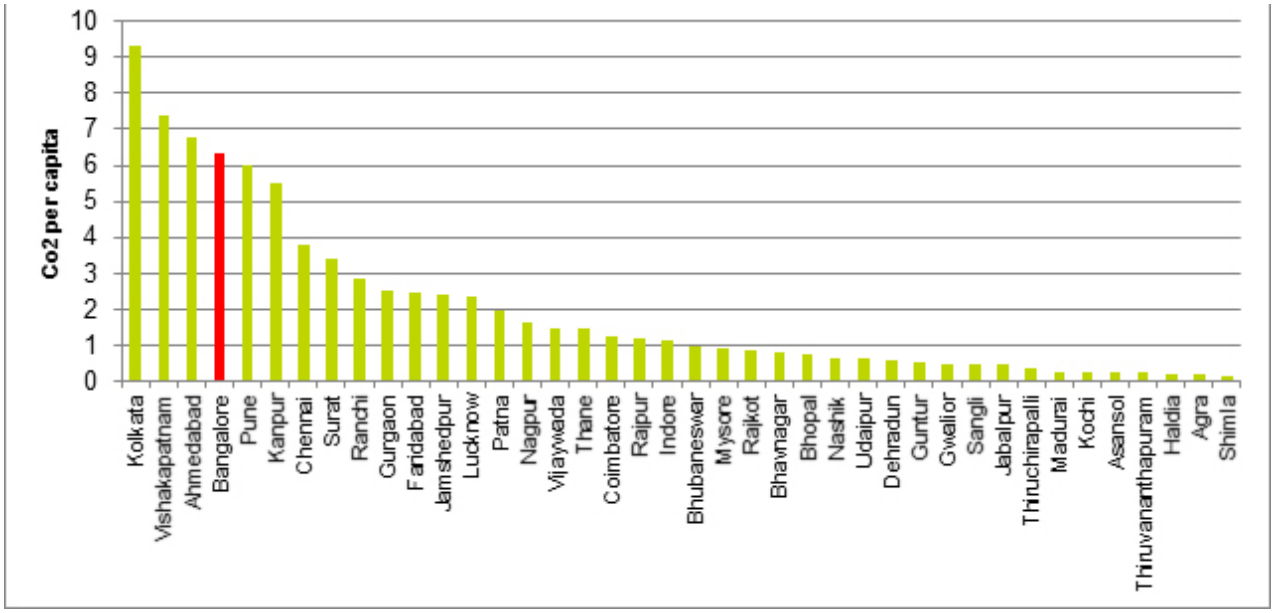
The combination of increasing demand for water resources, poor water distribution infrastructure, and contamination of existing supplies could constrain the ability of Bangalore to grow and prosper in the future as demand in the city and wider region continues to grow. Development is already constrained in areas of the city without a piped network where there is only limited access to ground water. Urbanisation, population growth, economic development and increasing demand for water from agriculture and industry are all likely to aggravate the situation further.

Given the severe water stress the city and wider region are already experiencing, the interconnectedness of Bangalore's 'blue infrastructure' to other challenges such as managing the impacts of climate change and spread of communicable diseases, along with concerns about the environmental quality of water, addressing water security represents an urgent system wide priority for Bangalore.

There is an important opportunity for Bangalore to consider an integrated urban water management approach to address its water security challenges. The current strategies employed by the city have not been able to keep pace with demand for drinking water, sanitation, wastewater treatment, and other water-related services. Bangalore has an opportunity to consider an integrated urban water management approach which offers a set of principles that underpin better coordinated, responsive, and sustainable resource management practices. It is an approach that integrates water sources, water use, water services, and water management[13].

13 Integrated Urban Water management Report

Figure 2.7 Benchmarking Bangalore's CO2 Emissions with other Indian cities



Source: Energy and Carbon Emission Profile of 45 South Asian Cities, ICLEI

Agriculture and food security

Future risks

The Karnataka State Level Climate Change Action Plan states the estimated 2.1 °C rise in mean temperature and a 4.5% increase in mean precipitation would reduce net agricultural production in the state by 2.5% for the State as a whole. Agriculture in the coastal regions Karnataka is estimated to be the most negatively affected. Small losses are also indicated for the major food-grain producing regions of few districts. On the other hand, interior North and South Karanataka districts are estimated to benefit to a small extent from warming. Bangalore is likely to see significant negative impacts on certain crops such as potatoes and soy beans.

These increases in temperature and humidity may also lead to livestock rearing becoming a more cost intensive with livelihood implications for more marginal farmers.

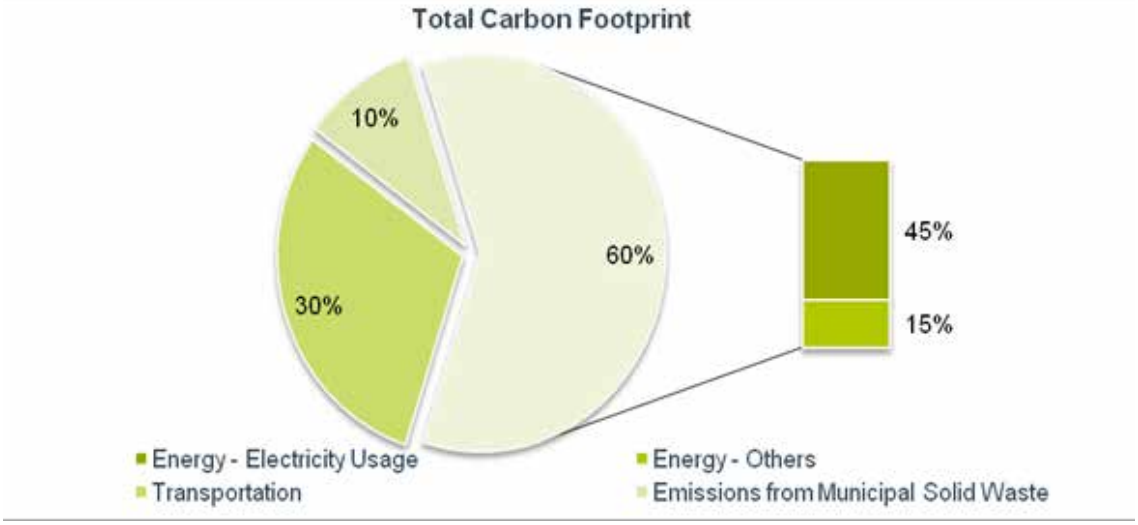
Energy use and carbon emissions

Current risks

Bangalore's estimated current carbon emissions are relatively high when benchmarked against a range of other Indian cities. Figure 2.7 indicates Bangalore's carbon emissions per capita vis-a-vis the average of 40 other Indian cities. At 6.36 tonnes of CO2 per capita this is currently high by national standards.

The two main contributors to Bangalore's emissions are energy use (primarily from electricity) and fossil fuel based transportation (Carbon Dioxide Information Analysis Center, 2013):

Figure 2.8 Structure of Bangalore's carbon footprint



As Figure 2.8 shows, the energy component is 60% of the total carbon footprint (CF)[14], with electricity usage in residential, commercial and industrial sectors contributing just over 75% of the energy component; while the transportation component is approximately 30% of the total CF. Emissions from municipal solid waste (generated at the rate of 3,600 tons per day) constitute the remaining 10% (Kulkarni et al., 2012; IIHS analysis, 2013).

Rapid urban development is also contributing to growing emissions in Bangalore. Bangalore has witnessed a 466% increase in built up area from 1973 to 2007 (Ramachandra and Kumar, 2009), and this trend continues to grow. New construction is associated with two sets of emissions: first, from the consumption of large quantities of extracted or mined raw materials and associated carbon emissions (also known as embodied energy); and second, from maintenance and energy use during the lifecycle of the building.

Based on electricity data from the Bangalore Electricity Supply Company for 2007-08, residential buildings consume about 33% of electricity supplied to the Bangalore Metropolitan Area. Commercial and industrial buildings, on the other hand, consume 30% and 29.6% respectively (The Energy Research Institute (TERI), 2009). However, the intensity of energy usage per square km of built up area in relatively low in residential areas and industrial areas as compared to commercial buildings[15]. Therefore, attaining energy efficiency in commercial buildings is critical for reducing electricity consumption as well as energy-based emissions in Bangalore (The Energy Research Institute (TERI), 2009).

While residential buildings can be climate responsive and naturally ventilated, utilising the pleasant climatic conditions of Bangalore, a majority of commercial and IT offices are completely glazed structures (Majumdar, 2010). The risk of continuing with this built form is manifold as it exacerbates UHI through growing

14 Data for comparisons with other Indian cities are currently not available. Pune claims to be the only city in India that has conducted a carbon footprint (CF) analysis, although their study is not publicly available. There are a few other cities such as Nashik that are conducting a CF analysis. This analysis is based on data collated from a range of sources for Bangalore including the 2008 State of the Environment report, the Bangalore Electricity Supply Company, and the database for the Indian Power Sector. This statement indicates that targeting electricity and transportation is the key to reducing emissions from energy.

15 Intensity of energy usage in residential areas is 16 kWh/m2, and that in industrial areas is 42kWh/m2 whereas in commercial buildings, this figure was at 159kWh/m2.

use of air-conditioning, increases the costs of operating a building, and deepens the dependence of residents and businesses on unsustainable forms of energy[16]. There is a 15% energy deficit in the State (Government of Karnataka, 2013) and electricity black-outs are not uncommon in the city.

Embodied and operational sources of emissions pose different challenges for mitigating emissions in the city and offer opportunities for innovation and reduced dependence. To address emissions from embodied energy in buildings, researchers at the Indian Institute of Science have been involved in developing and disseminating large number of low carbon building materials and technologies over the last three decades. Some of the buildings constructed with these new materials were found to be energy efficient and result in at least a 50% reduction in carbon emissions (Indian Institute of Science, 2013).

Future risks

A key area of concern in the city is that carbon emissions are likely to increase under current growth trajectories. The way that Bangalore is expanding spatially and a lack of integration between land use and transport policy presents challenges for introducing public transit options which could temper emissions growth from private vehicle use[17].

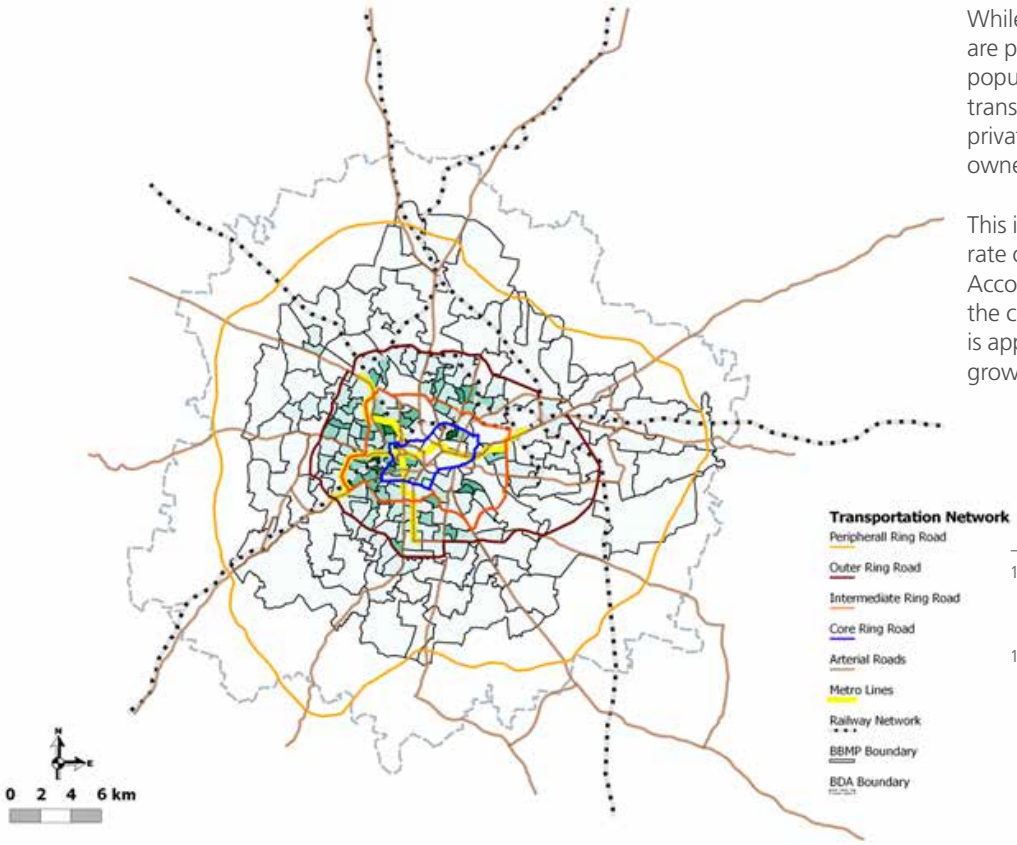
With no natural features restricting its development, spatial growth patterns of Bangalore city are characterised by urban sprawl, increasing the distances the city residents have to travel to work. Bangalore's physical footprint has increased by over 100%from 1992 to 2009 with a 134% increase in built up area, accompanied by a sharp decline in water bodies and natural vegetation (Census of India, 2011; Indian Institute for Human Settlements (IIHS), 2009; Ramachandra and Kumar, 2009).

Structured by a radial road network that is connected by ring roads, Bangalore has expanded along Tumkur Road in the northwest, Doddaballapur and Bellary Roads in the north, Old Madras Road towards the northeast, Sarjapur and Hosur roads towards the southeast, Mysore Road towards the southwest and Magadi Road towards the west. In the north, the KIADB Apparel Industrial Park and the Bangalore International Airport serve as major catalysts for urban development. This is further intensified by the presence of Peenya Industrial area along Tumkur Road, which is transforming from being one of the largest manufacturing hubs in India to services sector driven industrial activity. The Electronic City serves as a major pole of growth in the southeast.

The recent pattern of dispersed low density development which has been planned without integration of public transport means that it is difficult to reach a critical mass of population necessary to support a viable high frequency public transport network. While the bus system in Bangalore is better than in most Indian cities, overall mass transit is inadequate. While 90%of the vehicles on the road are privately owned, the majority of the population walks, cycles, or takes public transit. A range of modes, public and private providers, and growing automobile ownership pose serious mobility challenges

This is compounded by the fast growing rate of private vehicle ownership. According to the Bangalore Traffic Police, the current vehicle population in Bangalore is approximately 1.5 million with an annual growth rate of 7% to 10%.

Figure 2.9 Transportation networks in Bangalore



Source: IIHS

16 These are initial findings from our conversations with researchers and government officials. These will be investigated during the field component of the action planning process.

17 Urban form has a significant impact on carbon emissions. Compact cities with mixed land-use and higher population density can provide more energy efficient mass transit infrastructure, reducing carbon and energy costs. For example, many newer U.S. cities are defined by the Interstate Highway system and their reliance on the automobile for most public travel whereas European cities tend to be more compact, with a greater reliance on public transportation with this variation in density and design being a major reason for the striking differences in per capita greenhouse gas emissions between newer cities in the United States and older cities in Europe.

Vulnerability to Risks

Vulnerability of local population

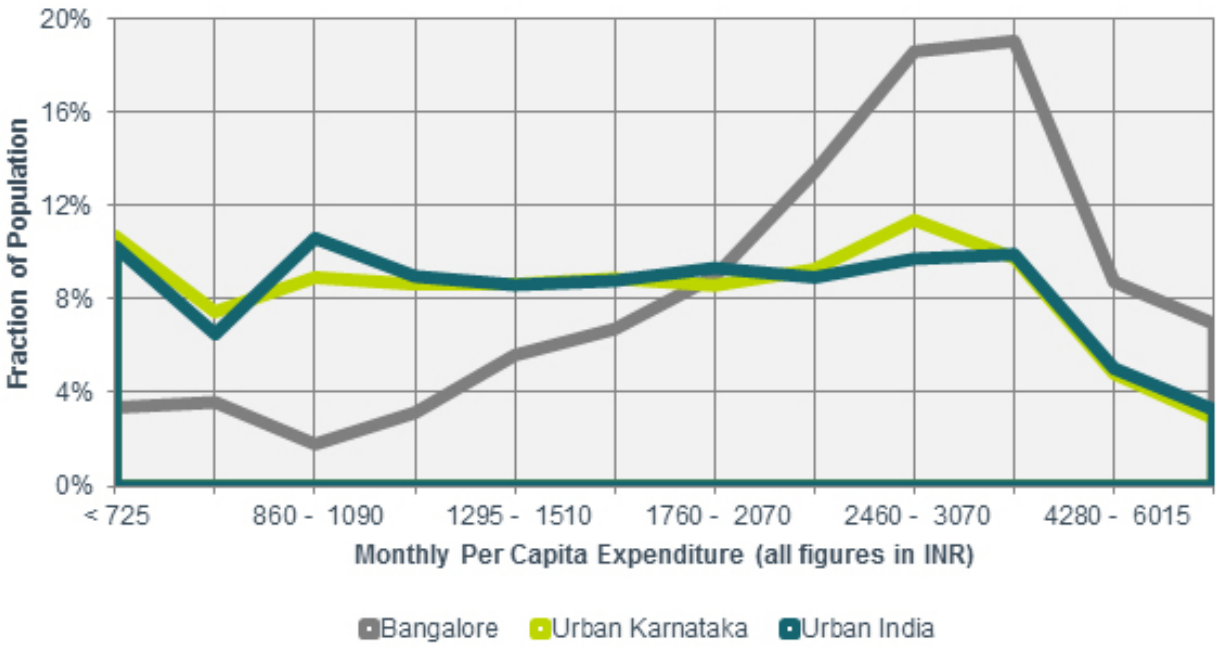
Not only does Bangalore face a wide range of environmental risks, but segments of Bangalore's population - especially the urban poor - are particularly vulnerable[18] to those risks. For example, the urban poor can be expected to be hit first and hardest by climate hazards such as flooding – they do not have the assets to protect themselves against stresses and shocks. Poor residents tend to be located in the most vulnerable areas and in poor quality housing, as well as in low paid jobs that can be impacted by flooding. Equally, rising resource prices affect the urban poor disproportionately because they spend a larger share of their income on energy, water, and food. When parts of the city experience intermittent power outages, many businesses and households rely on fossil fuel powered backup generators but which are unaffordable for the poorest households.

While Bangalore has grown rapidly in the last two decades, the benefits of this growth have not been spread equally across all socio-economic classes. The number of informal settlements in the city have grown from approximately 540 in 2007 to about 640 in 2011 (Karnataka Slum Clearance Board (KSCB), 2011; H. S. Sudhira et al., 2007). However, relative to urban India and urban Karnataka, Bangalore's distribution shows a lower proportion of extreme poverty, and a higher proportion of households that are in the middle and upper income classes (see Figure 2.10)[19]

18 We define vulnerability as the degree to which a city and its inhabitants are susceptible to and are likely to be detrimentally impacted by the stresses and shocks associated with climate change, resource scarcities, and damage to vital ecosystems. At the heart of all definitions of vulnerability is the notion of 'lack of means to cope' with the adverse impacts associated with shocks and stresses.

19 The classification is carried out based on Monthly Per Capita Expenditure (MPCE) data collected as by the National Sample Survey Organization which carries out quinquennial surveys that measure consumption expenditure, which is a cleaner measure than income.

Figure 2.10 Distribution of Monthly per Capita Expenditure (2010-11)



Income, however, is only one measure of poverty and does not present a comprehensive picture. As an earlier studies indicate, **approximately 43 per cent of Bangalore's population lives in multi-dimensional poverty**[20].

Bangalore's slum dwellers are particularly vulnerable to changes in the availability of critical resources, particularly water supplies. As development is largely unauthorised, the slum areas are not connected to city water supply and sanitation networks unless they have been regularised, leading to dependency on ground water or tankered water which may be of poor quality. The needs of some slum areas are met through hand pumps and public stand posts (PSPs) as a stop gap measure.

Water access problems are compounded with sanitation deficiencies. The lack of latrine facilities, with many households lacking access and high fees being paid for public facilities, have forced citizens to resort to open areas, contributing to the spread of diseases (e.g. worms, diarrhoea, cholera and typhoid)[21]. Similar issues exist for waste collection, which encompasses 80% of the city's waste, but in slums is often not removed at all, unless inhabitants pay municipal representatives directly[22]. Formal measurements tend to overlook the role of "human infrastructure"; in Bangalore an estimated 10'000 street sweepers ("pourakarmikas") with minimum wages and rough working conditions are in charge of cleaning streets and garbage dumps[23].

High levels of informality and inequality creates vulnerability to the city's future proofing risks in terms of energy use, as consumption of the high-income classes has contributed to escalating resource use, whereas the urban poor in many cases suffer from lack of access (energy supply in Bangalore is already both expensive and scarce, and hydropower-generated electricity tends to be affected by episodic growth and weather events, such as irregular rainfalls and monsoon cycles, leading the city to periodically suffer from shortages and power cuts[24]).

Vulnerability of urban infrastructure and services

Bangalore's transportation systems, environmental services, energy and water resources, food, communication systems and critical infrastructure are all at risk of the impacts of climate-induced hazards. Transportations systems (road networks, rail networks, and aviation) are exposed to floods and their functioning is known to be severely hampered in case of an extreme rainfall event in Bangalore. Water supply, drainage, sewage and solid waste disposal systems are themselves at risk from flood.

Energy derived from renewable sources such as hydropower, will be at increased risk with any shortfall in water availability. The distribution of power lines and location of towers make delivery systems vulnerable in some locations. Ground water and surface water are at high risk, due to resource over-exploitation and increasing water pollution, posing increasing public health risks. Although most of Bangalore's food is produced and transported from outside the city limits, the conditions of many markets and their access to customers are vulnerable to flood risk. Lifeline infrastructures will also need to be protected in case of extreme events especially communication systems and other critical social infrastructure (fire stations, schools, hospitals, police stations).

4.3. Strategic vulnerabilities to climate risk

Table 5 illustrates the varying vulnerabilities of the different elements to the different hazards. Physical elements such as buildings and infrastructure are more vulnerable to extreme hydro-met hazards, but not as much to pollution or temperature variations. People, on the contrary, are affected by almost all major hazards to which Bangalore is exposed, including direct impacts on health, education, and financial resources. Financial assets and resources of individuals, corporations and the city are observed to be hugely impacted during events such as rainfall and flooding. Energy consumption also increases due to heat island effects, affecting the costs of running large infrastructure.

20 Future Proofing Cities (2012), Atkins in partnership with DFID and UCL
21 Solomon, 2000
22 CIVIC, 2008
23 CIVIC, 2008
24 Khandekar, 2008

Table 5. Bangalore: strategic vulnerabilities to climate-related risk[25]

Hazard	Physical		Social	Financial	
	Buildings	Systems	People	Asset	Revenue
Temperature Increase	Medium	High	High	Low	High
Heat Island Effect	High	High	High	Low	High
Drought	Low	Very High	Low	Low	Very High
Pluvial flooding	Medium	Very High	Very High	High	Very High
Fluvial flooding	Low	Low	Low	Low	Low
Storm / Pressure Winds	Medium	Medium	Low	Medium	Medium
Solid waste release	Low	Very High	High	High	Very High
Water pollution	Low	Very High	Very High	Medium	High

Figure 15. Lack of habitation choices are evident sources of vulnerability

20 A qualitative assessment of the strategic hazard risks that the city maybe exposed to over the short (1-10 years), medium (10-50 years) and long (50-100 years) term. Hazard risk intensity typically increases with the event return period. A qualitative 5-point scale has been used to rate the risks based on secondary data, interviews, site visits and the team's assessment. This is indicative to assist in scoping and decision-making, and a more detailed data and assessment is required for a rigorous analysis.

Conclusion

Why water and sanitation?

Bangalore historically had a network of hundreds of artificial lakes and wetlands that captured and conveyed rainwater that served the city's water needs. As Bangalore has prospered, this network has been disrupted due to the reclaiming of lake beds for development and drying up of water bodies (Ramachandra and Kumar, 2008; H. S. Sudhira et al., 2007). This, coupled with the destruction of natural drainage courses, has in turn led to regular floods in some parts of Bangalore (Ramachandra et al., 2012).

Groundwater levels in Bangalore, particularly in those newly developing urban peripheries that lack municipal supply, have also fallen steadily as a result of withdrawal for private self-supply and supply through private water tankers. This has been further exacerbated by the location of new infrastructure (e.g. the new Devanahalli international airport) and developments in areas that are deficient in groundwater. In the parts of the city, often towards the centre, where groundwater levels are high, it is contaminated by the wastewater from surface water bodies and leaking sewer lines (Central Groundwater Board (CGWB), 2012).

Bangalore's water infrastructure is therefore severely threatened by environmental degradation, and indiscriminate land use planning, as the city continues to grow out in areas where there are serious groundwater deficits. In addition to the obvious impacts that this will have on Bangalore's population, it also has wider implications for livelihoods, and food security. As the densities of population are increasing, the exposure of hazard risks to people, services and economy is also increasing. Developments in low lying areas, particularly informal settlements are most exposed to flood risks. Most of Bangalore is exposed to drought induced drinking water shortage, and with more people are increasingly dependent on limited and increasingly polluted groundwater resources, the exposure to water supply linked drought risk is also increasing. An additional risk is that Bangalore is essentially dependent on a single source of water - the river Cauvery. This water shortage is likely to worsen following the recent Inter-State Water Tribunal decision (Feb., 2013) which limits the amount of water Bangalore can draw from the Cauvery, thereby taking away a critical source of water for the city.

In common with many large Indian cities, one of the most serious challenges for Bangalore is the reducing availability and access to reliable good quality water supply, and an increasing incidence of local urban flooding. The public health, environmental health and economic implications of these are already becoming evident and will become increasingly severe as the Indian subcontinent moves into more unpredictable rainfall regimes.

Finding workable solutions to the multiple challenges facing the water supply and sanitation is central to the future resilience and prosperity of the city. This is the focus of the action plan for Bangalore.

Risk and climate change

It is worthwhile noting that Bangalore does not directly face some of other high hazards such as storms and cyclones that could be aggravated by climate risks.

The climate change hazards that are most likely to put at risk water and sanitation sector in Bangalore consist of possible changes in precipitation: in total annual rainfall, distribution of twin peaks, and increase in intensity and frequency of extreme events (Revi, 2008,). There is limited information available at Bangalore on these changes as robust down-scaled regional models are not yet available.

Changes in both total annual rainfall and distribution of peak rainfall would exacerbate the risk posed by the current dependence on single source. The current water treaties and laws, specifically water allocation are based on the assumption that water distribution would remain fairly stable (Glieck, 1993). In India and elsewhere, there have been very few attempts to address the implications of climate change for water availability. There may be a need for the courts to reallocate water supply, taking cognisance of the changes in precipitation and an increase in Bangalore's resilience by diversifying risks.

Similarly, at the infrastructure level, current water resources engineering and infrastructure are based on the principle of stationarity (i.e.'natural systems fluctuate within an unchanging envelope of variability'), and hence are unsuited to cope within the uncertainty brought by climate change (Milly et. al, 2008). Likewise, current urban water infrastructure systems are typically centralised systems with low flexibility.

In the medium to long term, the infrastructure systems need to become more flexible. Both technical design and institutional arrangements need to ensure this.

The other potential climate change risk is increase in mean temperature. This will lead to more evaporation from surface bodies such as lakes, and increased evapotranspiration from green cover. The combined impact of increased temperature and changes in precipitation is likely to have impacts on evapotranspiration and on lake ecology. The precise impacts are unclear but there may also be second order impacts of increased temperature, increasing the need for energy hungry cooling. Since these changes are not clear, Bangalore must find a way of increasing its adaptive capacity.


A.N.STREET

03

THE FUTURE PROOFING STRATEGY FOR BANGALORE

Introducing the strategy themes

The actions and projects reflect the range of issues which stakeholders in the community identified as priorities.

Figure 3.1 sets out the five themes which form the framework for 13 proposed future proofing projects to address the combination of water related issues of the city including water resources management (surface and ground water), water supply, water quality, sanitation and flooding in the context of the urban development trajectory of the city and its changing climate. The section on page 43 provides details on the methods used to selected and develop projects. Figure 3.1 also shows how the five themes will be integrated across three dimensions.

Enabling infrastructure improvements

There are a series of enabling infrastructure improvements which are needed to address water security issues of the city. The range of improvements extend beyond water resources projects which focus on supply in isolation. Improvements to wastewater collection and treatment and distribution management are aimed at making more effective use of the water resources available to the city which at the same time will reduce the vulnerability of households to climate risks and build resilience. There are also a range of initiatives focussed on demand management are needed to build resilience and reduce vulnerability to climate change and to tackle pollution of the groundwater resources.

Policy and regulatory improvements

Spanning the five themes are improvements to policy, legal and regulatory mechanisms and systems which are needed to help sustain change and align incentives between different interests within the city. Measures extend from enforcement of water abstraction permits through to fines and penalties relating to dumping of waste are examples.

Strengthening social capital

While capital improvements will take time to be fully delivered in the city, social capital can be used to initiate action, deliver improvements and change behaviour norms (for example of on demand management) on an ongoing basis across the strategy themes. The action plan proposals identify how action from BWSSB in association with community-based organisations and initiatives is necessary not only for coping with and managing the issues and gaps, but to complement BWSSB which are capital intensive in terms of finance.

The projects in the action plan have been developed through an iterative process of discussions and dialogues on the interventions needed to address the needs and risks facing Bangalore.

This approach to developing the action plan was helpful in both capturing and clarifying the possibilities of what future proofing interventions could be, blending a variety of perspectives based on lived experience within vulnerable communities in Bangalore as well as workshops with city level government, academic and research organisations and civil society representatives

Figure 3.1 - Tackling risk and vulnerability together in Bangalore
Tacking risk and vulnerability together in Bangalore requires integration action across sectors (see project key on page)

Themes	Enabling infrastructure improvements	Policy regulatory improvements	Strengthening social capital and governance
Water resources	1 A, B, C	1 D, 3	2
Water supply distribution management		4, 5	
Waste water and sludge collection and treatment	6, 7 C	7 A, B	
Improved service delivery to households and establishments	8		9
Water demand management (Ensuring water sufficiency)	10, 11, 12	10	13

SHORT TERM VULNERABILITY

LONGER TERM RISKS

Phasing and prioritisation

While all the identified projects are important, it is clear that certain prioritisation is needed. This section lays out the criteria by which the projects need to be prioritised, and presents the phasing of the projects.

- **Impact on vulnerability** (of households, systems or resources): The first criterion for phasing is the potential of the projects to reduce vulnerability. All the projects in the long run would aid in reducing vulnerability, and increasing resilience. However, some projects hold the potential to have immediate impacts. These kind of projects include ensuring universal water supply, ensuring sanitation (for households), and collection of waste-water and septage management (for households and natural resources).
- **Criticality of timing and sequence:** Some projects can only commence if certain other projects are finished. For example, recycling of waste water requires waste water collection and treatment facilities to be in place first. Also, generating awareness is also essential for sustenance of many projects. Similarly, ensuring an O&M plan is in place is required to ensure sustainability of many of the infrastructure creation projects.
- **Complexity of implementation:** Certain projects are likely to be extremely complex, owing to design or the existing policy and institutional environment. It would be best to take up such projects later, after the successful completion of some of the earlier projects. Both the regulatory projects - regulation of tanker supply, and regulation of ground water - require clarity on goals, powers and procedures, apart from the risk of opposition if introduced without recourse to alternatives. Also, both seek to regulate ground water which fulfils household needs due to inability of the public utility to provide requisite quantity of water across the city. Hence while monitoring and analysing the extent of the stated problem could be a start, controls would become tolerable when the alternatives are also available. Also, there are only a few precedents for such regulation at city scale, in India. The other projects that are likely to be complex are demand management because it requires sustained behaviour change, and also possibly intervention in a fragmented market (for fixtures etc.) demand management for commercial and industrial establishments could possibly begin earlier. Likewise, a project on awareness generation is complex since it is likely to involve a range of stakeholders.

Trade-offs need to be made between implementation, complexity, vulnerability and impact. Hence certain complex projects could have significant impact and could be commenced earlier, if appropriate institutional capacity, resources and political appetite for change were in place.

Out of all the projects, awareness generation is critical, as improvements made through other projects can only be sustained through awareness generation and behaviour change. In addition,

advocacy amongst decision makers (political leadership and bureaucracy) to rationalise sector policies and rules have a long gestation but are central to sustainable changes. Hence, this project needs to be start at the earliest, despite the complexity.

While both the regulatory projects are necessary, there are other projects/ways that would both be required and effective before regulations come into place. A possible approach would be to increase BWSSB's ability to supply water through non revenue water reduction, storm water harvesting, and recycling waste water.

Table 3.1 presents prioritisation of the projects, according to the criteria described above, which have been evaluated and selected according to these criteria

Table 3.1 - Prioritisation of future proofing projects

THEMES AND PROJECTS	Vulnerability	Criticality	Complexity
WATER RESOURCES			
1 Storm water harvesting in lakes	Medium	Low	Medium
2 Regulate groundwater access and use	Low	Low	High
3 Regulation of tanker supply	Low	Low	High
WATER SUPPLY DISTRIBUTION MANAGEMENT			
4 Reduction of non-revenue water in BWSSB distribution	Medium	Medium	Medium
5 Improved and sustained O&M at BWSSB	Medium	High	Medium
WASTE WATER AND SLUDGE COLLECTION AND TREATMENT			
6 Augment setting up full cycle collection and treatment of waste water	High	High	Low
7 Septage management in city	High	High	Medium
IMPROVED SERVICE DELIVERY TO HOUSEHOLDS AND ESTABLISHMENTS			
8 Ensure universal access to safe drinking water	High	Medium	Low
9 Ensure universal access to household sanitation	High	Medium	Low
WATER DEMAND MANAGEMENT (ENSURING WATER SUFFICIENCY)			
10 Increase recycle and reuse of treated wastewater	Low	Low	Medium
11 Utilising large reservoirs for decent4ralised supply of drinking water	Low	Low	High
12 Demand management through devices efficiency	Low	Medium	High
13 Creating awareness within various stakeholder and collating platforms for stakeholder engagement	Medium	High	High

Source: IIHS Analysis, 2014

- Phase 1 or Short term- up to three years
- Phase 2 or Medium Term- three to five years
- Phase 3 or Long term- five to 10 years.

This is broadly co-terminus with the balance of the current (Twelfth) Five Year Plan (2012/2017) – about three years; and the following two Five Year Plans of the Union and State Governments. The proposed phasing also assumes continuation of JNNURM or other similar programme for infrastructure financing at the national level.

Short term projects are those that will take up to three years to complete, medium term about three to five years, and long term projects would take up to 10 years.

Phase 1 includes mostly projects which have high impact on vulnerability or are critical like storm water harvesting, NRW reduction, O&M management, waste water collection and septage management and ensuring access to both water supply and sanitation. Some of these projects continue into second phase. In addition to projects continuing from Phase1, the project for reuse of water commences in Phase 2.

Phase 3 projects include regulation of ground water and tanker, augmenting water supply through select lakes and demand management.

Table 3.2 - Phasing of projects

THEMES AND PROJECTS	Phase I	Phase II	Phase III
WATER RESOURCES			
1 Storm water harvesting in lakes			
2 Regulate groundwater access and use			
3 Regulation of tanker supply			
WATER SUPPLY DISTRIBUTION MANAGEMENT			
4 Reduction of non-revenue water in BWSSB distribution			
5 Improved and sustained O&M at BWSSB			
WASTE WATER AND SLUDGE COLLECTION AND TREATMENT			
6 Augment setting up full cycle collection and treatment of waste water			
7 Septage management in city			
IMPROVED SERVICE DELIVERY TO HOUSEHOLDS AND ESTABLISHMENTS			
8 Ensure universal access to safe drinking water			
9 Ensure universal access to household sanitation			
WATER DEMAND MANAGEMENT (ENSURING WATER SUFFICIENCY)			
10 Increase recycle and reuse of treated wastewater			
11 Utilising large reservoirs for decent4ralised supply of drinking water			
12 Demand management through devices efficiency			
13 Creating awareness within various stakeholder and collating platforms for stakeholder engagement			

Future proofing projects

The remainder of this chapter describes the projects that collectively address the risks and priorities that were identified identified during action planning for future proofing Bangalore. They address five themes with thirteen projects.

Most of the projects are further divided into sub-components. Each of the sub-components have been detailed out separately. For each subcomponent, a description, estimate of costs, potential impacts and possible delivery mechanisms, are presented. In addition, there is a brief description of anticipated challenges, current gaps, and estimated time frame for implementation. The costs presented below are capital requirements for the projects. The costs presented in these tables are costs to complete the project unless mentioned otherwise. Most of the projects have a subcomponent related to research studies and awareness and each project requires certain changes in the policy and/or regulatory framework.

Theme 1
Water resources

1 Project 01: **Storm water harvesting in lakes**

OUTCOME

Increased storage of surface water in lake reservoirs within city maintaining suitable quality. The restoration of the storm water drains and lakes would enable the city to enhance water storage capacity within the city enhancing water security. Rehabilitating and extending the system of storm water drainage and increasing the capacity of lakes would enable the city to cope with flooding events. The segregation of sewage will manage the pollution of potential water resources and the incidence of vector borne diseases.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
1A Preparation of action plan for rehabilitation of storm water drains – Ground-level mapping of drainage channels, obstructions (encroachments), contamination sources (sewage entry points, garbage dumps), flow volume potentials and vent volumes in demarcated watershed within identified lake series (e.g. Varthur lake series) and preparation of action plan.	(cf. note below)	Diagnostic for revival of natural drainage; creation of action plan for segregation of sewage and storm water, modelling appropriate drainage. Existing communities would benefit from the improvements especially vulnerable low income groups who are often located on land located close to channels and lake areas.	▪ BBMP is the nodal institution for storm water drains. The work is carried out through contracted agency with technical capacities. ▪ The task has been carried out and a Master Plan has been developed. ▪ Requires coordination with multiple agencies - BBMP, BWSSB, Lake Development Authority (LDA), Karnataka Forest Department (KFD) and private institutions - to align ownership and jurisdiction (especially of lakes that fall under different agencies and parties) and drainage practices in local area.

CHALLENGES

Delineation of sewage pipelines located in storm water drains, dynamic nature of garbage dumping.

DATA GAPS

Ground truth of land use integrated in GIS.

TIMEFRAME

Short-term (up to three years).

The Master Plan Project Report for Remodelling of Storm Water Drains in Entire BBMP Area, Bengaluru prepared by STUP Consultants Pvt. Ltd. For Bruhath Bengaluru Mahanagara Palike, 2012.

OUTCOME

Increased storage of surface water in lake reservoirs within city maintaining suitable quality. The restoration of the storm water drains and lakes would enable the city to enhance water storage capacity within the city enhancing water security. Rehabilitating and extending the system of storm water drainage and increasing the capacity of lakes would enable the city to cope with flooding events. The segregation of sewage will manage the pollution of potential water resources and the incidence of vector borne diseases.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
1B Remodelling of drainage channels for separation of sewage and storm waste.	Rs. 15,000 million*	Segregation of storm water and sewage; improved drainage to water bodies. Existing communities would benefit from the improvements especially vulnerable low income groups who are often located on land located close to channels and lake areas.	▪ BBMP is nodal agency to carry out work through contracted agency(s). ▪ Piece-meal works have been taken up for restoration of selected lakes. Approval of Master Plan awaited. ▪ Will need to control dumping of garbage and debris to pre-assigned locations. ▪ Will need to coordinate with BWSSB, LDA, KFD for dove-tailing activities (e.g. laying sewer pipelines) and enlist cooperation of residents while carrying out work, and for later maintenance management.

CHALLENGES

Litigation, local resistance, improvements will not be sustained if garbage dumping continues.

DATA GAPS

Micro-level data on sewerage connections, encroachments (could be covered in 1A.

TIMEFRAME

Medium term (three to five years).

*Derived from the estimate by the Master Plan Project Report for Remodelling of Storm Water Drains in Entire BBMP Area, Bengaluru prepared by STUP Consultants Pvt. Ltd. For Bruhath Bengaluru Mahanagara Palike, 2012 (2010-11 prices.)

OUTCOME

Increased storage of surgace water in lake reservoirs within city maintaining suitable quality. The restoration of the storm water drains and lakes would enable the city to enhance water storage capacity within the city enhancing water security. Rehabilitating and extending the system of storm water drainage and increasing the capacity of lakes would enable the city to cope with flooding events. The segregation of sewage will manage the pollution of potential water resources and the incidence of vector borne diseases.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
1C Developing lakes/reservoirs as holding ponds.	Rs. 30,000 million*	Allow increased storage of storm water run-off in lakes. Increased protection from flooding impacts.	▪ BBMP is nodal agency to carry out work in coordination with owner/managing agency (of lake) through contracted agency(s). ▪ Permission/Approvals from LDA and coordination with BDA/KFD required. Work has been carried out on a few lakes by BDA/ LDA. Will require treatment plants at inlet. ▪ Will need to coordinate with BWSSB, LDA, KFD for dove-tailing activities (e.g. laying sewer pipelines) and enlist cooperation of residents while carrying out work.

CHALLENGES

Sustaining rejuvenated lakes and ensuring non-contamination.

DATA GAPS

Lake bed profile data, adequate hydrologic modelling required.

TIMEFRAME

Medium term (three to five years).

*Derived from the estimate by the Master Plan Project Report for Remodelling of Storm Water Drains in Entire BBMP Area, Bengaluru prepared by STUP Consultants Pvt. Ltd. For Bruhath Bengaluru Mahanagara Palike, 2012 (2010-11 prices)

OUTCOME

Increased storage of surgace water in lake reservoirs within city maintaining suitable quality. The restoration of the storm water drains and lakes would enable the city to enhance water storage capacity within the city enhancing water security. Rehabilitating and extending the system of storm water drainage and increasing the capacity of lakes would enable the city to cope with flooding events. The segregation of sewage will manage the pollution of potential water resources and the incidence of vector borne diseases.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
1D Land-use planning around lake buffer zone and management of reservoirs/ lakes.	Rs. 5,000 million*	Protection of rejuvenated lake and in a limited manner, groundwater. Avoiding risks associated with flooding.	▪ Nodal agency will be the owner/managing agency of the lake - LDA/BDA/BBMP/KFD. ▪ Few lakes managed currently but more for recreation than aquatic quality. ▪ Fencing and enforcement of buffer zone. Data monitoring of water quality, flows, groundwater quantity and quality and dissemination. Coordination with civil coalitions around lake.

CHALLENGES

Sustaining demarcated land use and developing ecologically benign recreation use.

DATA GAPS

Rain gauge stations, flow meter data capture, SCADA for sustained maintenance.

TIMEFRAME

Short to Medium term (one up to five years).

*Estimate based on IIHS analysis, 2014

2 Project 02: **Regulate groundwater access and use**

OUTCOME

Safeguarding and management of ground water resources within the BBMP (Metropolitan area) to boundary to reduce the level of unsustainable depletion.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
2A Enforcement of groundwater drilling and access controls through permits and monitoring.	Rs. 30 million (annually)*	Reduction of indiscriminate drilling and use of groundwater.	▪ Karnataka Groundwater Authority (KGA) is nodal agency. BWSSB is the notified agency by KGA for registration of bore-wells and for grant of permits to drill. ▪ Registration done partially, but database is not linked to BDA or BWSSB databases. ▪ Need a one-time campaign to populate database of existing bore-well owners, followed up with licensing of DTH service providers and enforcement of permit system. Annual campaigns and redress mechanisms will need to be evolved.

CHALLENGES

Availability of staff/personnel to carry out this task; modalities to be worked out by KGA on action where high usage (e.g. 10 bore wells in 200 household apartment complex reportedly impacting local wells and bore wells) is reported; conformity to act is limited.

DATA GAPS

Sparse database on bore wells and us.

TIMEFRAME

Short term and ongoing.

*Estimate based on IIHS analysis, 2014

3 Project 03: **Regulation of tanker supply**

OUTCOME

Effective control over use/abuse of water resources. Safeguarding ground water resources through effective control of unauthorised water abstraction within the BBMP (Metropolitan area) to boundary to reduce the level of ground water depletion.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
3A Judicious control of tanker supply market to cater to low-supply areas and prevention of indiscriminate exploitation of groundwater.	Rs. 10 million (annually)*	Reduced risk of contaminated water for households and reduction in indiscriminate use of groundwater.	▪ BBMP is responsible for licensing services within city jurisdiction and to effect any controls on movement needed. Will require support from BWSSB for identification of low supply areas or high ground water risk zones. ▪ At present, no licensing and controls in place. ▪ Licensing of tankers and regulation of movement within city as well as access to groundwater sources. Create monitoring systems to understand extent of water drawal in different areas. BBMP implements with support from BWSSB in ensuring that tanker supply is restricted to low-BWSSB-supply zones.

CHALLENGES

Strong tanker lobby with political support.

DATA GAPS

Sparse data on groundwater access and quantities used.

TIMEFRAME

Short term and ongoing.

*Estimate based on IIHS analysis, 2014

Theme 2
Water supply distribution management

4 Project 04: **Reduction of non revenue water in BWSSB distribution**

OUTCOME

Increased availability of drinking water within BWSSB distribution system. Reduction of non - revenue water will enable BWSSB to accelerate the programme of improvements to water resources, distribution and sanitation in the city and build the resilience of Bangalore to respond to climate risks. Recognising the value of water will incentivise consumers to avoid waste.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
4A Phased reduction of NRW water in identified high-NRW zones (4 packages).	Rs. 5,000 million*	Increased availability of water within BWSSB distribution system; Improved revenue earned for unit water supplied.	▪ BWSSB is responsible for water supply distribution management and will work through contracted agency with technical capacities. Pilot NRW reduction in small areas carried out. ▪ BWSSB maintenance team will need work on for consumer level corrections (change of meters, replacement of pipelines). Will require BWSSB to act on billing/collection problems identified and take up any trunk infrastructure corrections.

CHALLENGES

Sustaining improvements after project (currently maintained at 3+5= 8 years); ownership within BWSSB for maintaining improved system at operating efficiencies.

DATA GAPS

Incomplete GIS of pipeline infrastructure, database of connections, etc.

TIMEFRAME

Short-medium term
(up to three years to five years.)

*Estimate derived from Expert Committee report, 2013 and discussions with BWSSB, 2014.

OUTCOME

Increased availability of drinking water within BWSSB distribution system. Reduction of non - revenue water will enable BWSSB to accelerate the programme of improvements to water resources, distribution and sanitation in the city and build the resilience of Bangalore to respond to climate risks. Recognising the value of water will incentivise consumers to avoid waste.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
4B City-wide reduction of NRW across BWSSB distribution system {with District Metering Areas (DMA) constitution and monitoring in newly connected areas}.	Rs. 8,000 million*	Increased availability of water within BWSSB distribution system; Improved revenue earned for unit water supplied.	▪ BWSSB is responsible for water supply distribution management and will work through contracted agency with technical capacities. Zone-wise operating data available for phased expansion. ▪ Experiences with four NRW packages will be helpful in main-streaming. BWSSB Maintenance team will need to institutionalise NRW monitoring as part of normal operations.

CHALLENGES

Assimilation of technology and capacities in-house; sustaining improvement post-project.

DATA GAPS

N.A.

TIMEFRAME

Medium term (three to five years).

*Estimate derived from Expert Committee report, 2013 and discussions with BWSSB, 2014.

5 Project 05: **Improved and sustained O&M at BWSSB**

OUTCOME

Sustain increased availability of drinking water within BWSSB distribution system. Investment in operations and maintenance will enable BWSSB to increase efficiency and avoid wastage of potable water. Operational improvements may also reduce the need for pumping which is energy intensive and dependent on fossil fuels leading to carbon emissions.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
5A O&M Plan for water supply network on a time-bound basis.	(Within the Annual maintenance budgets of BWSSB - additional requirements to be incorporated as needed).	Sustain improvements in water availability within BWSSB distribution system; Improved revenue earned for unit water supplied.	▪ BWSSB is responsible for O&M of water supply network. Use of ICT and best practices like SCADA are part of BWSSB's efforts inhouse to improve operations; this needs to be given higher priority-options to create cost-profit centres maybe considered within its O&M team.

CHALLENGES

Assimilation of technology and capacities in-house; sustaining improvement post-project.

DATA GAPS

N.A.

TIMEFRAME

Medium term (three to five years).

Theme 3
Waste water and sludge collection and treatment

6 Project 06: **Augment collection and treatment of waste water from households – Sub-component a.**

OUTCOME

Reduce/eliminate contamination of surface water and groundwater sources. Avoiding contamination of surface water and groundwater resources will enable resources to be managed as a source of clean water. The segregation of sewage will manage the pollution of potential water resources and the incidence of vector borne diseases.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
6A Expand sewerage network coverage and treatment and connectivity aiming for universal sanitation coverage.	Rs. 55,000 million *	Reduced contamination of surface and groundwater sources.	▪ BWSSB is responsible for provision of sewerage infrastructure and implements through contracted agency with requisite capacities; 40% of the BBMP area is covered and 7 CMC and one Town Municipal Corporation will be covered by end of 2014. Other newly added areas need to be covered.

CHALLENGES

Dense and informal settlements (might need shallow sewer and similar adaptations).

DATA GAPS

Database of households with sanitation connection.

TIMEFRAME

Short term and ongoing.

*Estimate from BBMP City Development Plan (Revised), 2009

OUTCOME

Reduce/eliminate contamination of surface water and groundwater sources. Avoiding contamination of surface water and groundwater resources by connecting households to the sewerage network will avoid contamination the ground water and enable resources to be managed as a source of clean water.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
6B Ensure household connectivity and monitor and maintain network to assure full conveyance.	Rs.20,000 million*	Reduced contamination of surface and groundwater sources.	▪ BWSSB is responsible for provision of sewerage services and implements throughcontracted agency with requisite capacities. Connectivity is reported low in new areas and requires to be addressed through citizen engagement and financial incentives.

CHALLENGES

Enforcing connection

DATA GAPS

Database linked to property database of BDA and BBMP

TIMEFRAME

Short term and ongoing

*Estimate from BBMP City Development Plan (Revised), 2009

OUTCOME

Reduce/eliminate contamination of surface water and groundwater sources. Avoiding contamination of surface water and groundwater resources will enable resources to be managed as a source of clean water. The segregation of sewage will manage the pollution of potential water resources and the incidence of vector borne diseases.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
6C Create interim solutions (till storm water - sewage segregation is effective) for guiding sewage flows to sewage treatment plants (STPs) - interceptors, pumping to manholes, etc.	Rs. 15,000 million*	Reduced contamination of surface and groundwater sources. Positive health impact.	▪ BBMP is responsible for the upkeep of stormwater drains.. Storm water master plan will be implemented by BBMP and interim measures to guide sewage flows away from storm water flows and to STPs will need coordination with BWSSB.

CHALLENGES

Coordination at the local level will need institutional support.

DATA GAPS

Identification of area-based interim solutions

TIMEFRAME

Short term (up to three years)

*Estimate based on IIHS analysis, 2014

7 Project 07: **Setting up full cycle septage management in city**

OUTCOME

Reduce/eliminate contamination of surface water and groundwater sources.Regular clearing and maintenance of sewerage networks will reduce contamination of surface water and groundwater resources. The level of service would also be improved reducing blockages and associated health risks. This measure safeguards water resources in the city.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
7A Market intervention in septage clearance services to demonstrate safe procedures, work safety and safe disposal and review service charges.	Rs. 10 million (annually)*	Reduced contamination of surface and groundwater sources.	▪ BWSSB is responsible for sewerage services and will need to lead on on-site sanitation support services. They will work through licensed service providers. ▪ Currently private operators provide services. ▪ Coordination with BBMP required. Licensing system and clear demarcation of sewage treatment plants and septage dump sites with adequate protection.

CHALLENGES

Managing partnership with vendors to ensure quality of service

DATA GAPS

Database of service providers and households enlisting service

TIMEFRAME

Short term (up to three years)

*Estimate based on IIHS analysis, 2014

OUTCOME

Reduce/eliminate contamination of surface water and groundwater sources. Enabling access to sewage treatment plants to private providers of septage services will help reduce unauthorised dumping by septic tank collection vehicles. The result will reduce contamination of surface water and groundwater resources. This measure safeguards water resources in the city.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
7B Utilise sewage treatment plants for co-treatment of septage	Rs. 10 million (annually)*	Reduced contamination of surface and groundwater sources.	▪ BWSSB is responsible for the management of STPs in the area (STPs are BWSSB managed or contracted by BWSSB to third party for O&M) and will work itself or through STP management agency. ▪ Currently, procedures are not uniform across STPs and access is limited. ▪ Clear and easy procedures for accessing STPs. Monitoring septage clearance, disposal volumes and households enlisting service

CHALLENGES

Customer orientation of STP management

DATA GAPS

Database of service providers and households enlisting service

TIMEFRAME

Short term (up to three years)

*Estimate based on IIHS analysis, 2014

OUTCOME

Reduce/eliminate contamination of surface water and groundwater sources. Providing additional septage treatment facilities will help reduce unauthorised dumping by septic tank collection vehicles. The result will reduce contamination of surface water and groundwater resources. This measure safeguards water resources in the city.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
7C Set up additional septage treatment facilities if needed (where distance to STP is uneconomical).	Rs. 650 million*	Reduced contamination of surface and groundwater sources.	▪ BWSSB is made responsible for septage management services and will work through contracted agency with requisite capacities. ▪ No septage treatment facility in the city. ▪ Monitoring septage clearance, disposal volumes and households enlisting service.

CHALLENGES

Additional land availability.

DATA GAPS

Estimates of households needing services within catchment of proposed Septage treatment facility.

TIMEFRAME

Short term (up to three years).

*Estimate based on IIHS analysis, 2014

Theme 4
Improved service delivery to households and establishments

8 Project 08: **Ensure universal access to safe drinking water**

OUTCOME

Reduce/eliminate risk of households consuming water from contaminated sources. This measure will build the resilience to climate risks by enabling access to infrastructure. The action would be targeted to benefit vulnerable groups.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
8A Increase access to piped water supply (more household connections, esp. in new BBMP areas through expansion of the distribution network with additional storage reservoirs and metering).	Rs. 150,000 million*	Improved health of households, especially vulnerable groups.	▪ BWSSB is responsible for provision of safe drinking water. ▪ Expansion of programmes to peripheral areas. ▪ Additional technical feasibility required to target actions ▪ Low income areas or slums could possibly require partnerships with civil society organnisations. Options for access need to be generated such as the projects carried out by BWSSB in (2000-2008).

CHALLENGES

Provision of legal connections and payments.

DATA GAPS

Identification of area/zone where individual household options are limited and need for partnerships.

TIMEFRAME

Short term and ongoing.

*Estimate BBMP City Development Plan (Revised), 2009

OUTCOME

Reduce/eliminate risk of households consuming water from contaminated sources. This action provides an interim solution to meeting the needs of households in advance of solutions which take a longer term perspective.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
8B Supply of potable water in containers or through kiosks in interim phase.	Rs. 5,000 million *	Improved health of households, esp. poor; reduction of theft.	▪ BWSSB is the nodal agency in partnership with distribution agents. ▪ Current market is serviced by private players. ▪ Poor areas or slums could possibly require partnerships with NGOs/CSOs.

CHALLENGES

Disposal of waste-reject in the case of kiosks; appropriate pricing.

DATA GAPS

Target population estimates.

TIME-FRAME

Short term and ongoing.

*Estimate based on IIHS analysis, 2014: this is a preliminary estimate only and needs review.

9 Project 09: **Ensure universal access to household sanitation**

OUTCOME

Reduce/eliminate risk of contaminated water sources. This action builds resilience to climate risks by enabling access to infrastructure to deliver health benefits.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
9A Provision of individual or community household sanitation facilities for households without access to sanitation.	Scaping exercise required to determine the scale of requirements. Individual latrines to be funded by households, behaviour change communication and community toilet capital costs from public investments.	Improved health of households, esp. poor.	▪ BBMP is the nodal agency with support from BWSSB. Poor areas or slums could possibly require partnerships with civil society organisations; Options for access need to be generated like in the projects carried out by the BWSSB Social Development Unit in the past two decades.

CHALLENGES

Technical challenges in dense neighbourhoods and floating/ squatter settlements.

DATA GAPS

Spatial database of households with no access to sanitation.

TIMEFRAME

Short term and ongoing.

Theme 5
Water demand management (ensuring water sufficiency)

10 Project 10: **Increase recycle and reuse of treated wastewater**

OUTCOME

Increased availability of water for supply within BWSSB distribution system. Analysing the requirements of bulk users can help to identify possible options for improved processes and solutions to improve water efficiency. This action contributes towards improved water security.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
10A Collection of micro-data on end use for prospective bulk users.	Rs. 5 million*	Information database for consumer marketing and groundwater enforcement.	▪ BWSSB is responsible utilising contracted agency having requisite capacities. ▪ Data should be GIS enabled to assist BWSSB next steps.

CHALLENGES

None foreseen.

DATA GAPS

End use data on bulk users.

TIMEFRAME

Short term (up to three years).

*Estimate based on IIHS analysis, 2014

OUTCOME

Increased availability of water for supply within BWSSB distribution system. Conserving potable water and replacing its use with treated non potable water can enhance the efficiency of the system and enhance water security.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
10B Locate and identify bulk users situated near sewage treatment plants and identify potential fordual-piping trunk lines (20m roads).	Included in project10A.	Enables targeted marketing and sale of wastewater to increase revenues.	▪ BWSSB is responsible through managed contracts. ▪ To be done in-house by BWSSB.

CHALLENGES

Assimilation of analytical and strategic capacities in-house.

DATA GAPS

Data connections included within project 10A.

TIMEFRAME

Short term (up to three years).

OUTCOME

Increased availability of water for supply within BWSSB distribution system. Conserving potable water and replacing its use with treated non potable water can enhance the efficiency of the system and enhance water security.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
10C Enable dual-piping supply of treated water to bulk users.	To be determined as part of 10A.	Satisfy high revenue user water needs; improve BWSSB revenues.	▪ BWSSB is responsible for water supply distribution. ▪ To be carried out through strategic discussions with bulk user groups in each location (tech parks, SEZ, large campuses); ▪ Advocate use of treated water for non-potable uses; Explore need for high quality water and ensure supply; ▪ Carry out pipeline investments and recover over first year of supply. Make rainwater harvesting mandatory and enforce.

CHALLENGES

Dual role of market development and enforcement.

DATA GAPS

Covered in project 10A and B.

TIMEFRAME

Short term (up to three years).

11 Project 11: Utilising large reservoirs for decentralised supply of drinking water

OUTCOME

Augmenting drinking water supply through conjoint use. The tanks and reservoirs around the city have potential to be used as a source of water for domestic and commercial use in addition to their primary use for agriculture/irrigation. Assessing the feasibility of utilising this potential source of water is a first step to defining their role in strengthening the water security of Bangalore.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
11A Identification of large storage reservoirs for drinking water supply and assess capability to be used as supply source.	Covered in project 8A	Decreasing dependence on Cauvery river which is insufficient to meet the needs of all users within the catchment over the long term.	▪ BWSSB as nodal agency in coordination with owner agency of the lake. ▪ Data collection around the year to estimate flows and optimal withdrawal simulation; estimation of treatment requirements.

CHALLENGES

Seasonal flows and balancing reservoir storage.

DATA GAPS

Rain gauge stations, flow meter data capture, Supervisory Control and Data Acquisition (SCADA).

TIMEFRAME

Short-Medium term (up to three to five years).

OUTCOME

Augmenting drinking water supply through conjoint use. The tanks and reservoirs around the city have potential to be used as a source of water for domestic and commercial use in addition to their primary use for agriculture/irrigation. Assessing the feasibility of utilising this potential source of water is a first step to defining their role in strengthening the water security of Bangalore.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
11B Pilot use of large storage reservoirs for drinking water supply after treatment and up-scale after time.	Covered in project 8A	Decreasing dependence on Cauvery river which is insufficient to meet the needs of all users within the catchment over the long term.	▪ BWSSB as nodal agency. Lease rights for BWSSB from owner agency of the lake. ▪ Set up treatment plant; Pilot uptake and distribution in phases; Possible use as buffer/emergency source.

CHALLENGES

Seasonal flows and balancing reservoir storage

DATA GAPS

Capture real-time precipitation data; Rain gauge stations, flow meter data capture, Supervisory Control and Data Acquisition (SCADA).

TIMEFRAME

Short-Medium term
(up to three to five years)

12 Project 12: **Demand management through efficiency devices**

OUTCOME

Reduced use of water. The use of water efficient devices and metering will enable more efficient use of water. The water saved can be used to meet rising demands and play a contributing role in strengthening water security.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
12A Adoption of less water-using devices and technologies	Rs. 25 million (Annually)*	Reduced use of water at household level.	▪ BWSSB as nodal agency in partnership with appropriate agency to develop and implement communication plan. ▪ Research and manufacturer/ vendor development, promotion/ advertisements with prizes/ incentives. Tariff/price signals and light-handed regulation will be needed.

CHALLENGES

Unfamiliar role of market development

DATA GAPS

Market size of components, fixtures, etc. to be estimated

TIMEFRAME

Short to medium term (up to three to five years)

*Preliminary estimate based on IIHS analysis, 2014

13 Project 13: **Creating awareness within various stakeholders and creating platforms for stakeholder engagement**

OUTCOME

Active citizen participation in water governance. Improved citizen awareness can promote more efficient use of water. The water saved can be used to meet rising demands and help strengthen water security.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
13A Awareness campaigns for water conservation, rainwater harvesting, and water-use efficiency.	Rs. 20 million annually for five years*	Active citizen participation and buffer to vested interests.	▪ BWSSB as nodal agency. Coordinate with BBMP to conceive this and create suitable platforms at appropriate levels for engagement. ▪ Use ward committees and other neighbourhood coalitions. ▪ Campaigns can be started through schools and broad-based through multiple media.

CHALLENGES

Sustaining and moving towards clear outcomes.

DATA GAPS

Need to identify audience and how to target and incentivise action.

TIMEFRAME

Short term and ongoing; possibly regular annual events timed appropriately.

*Preliminary estimate based on IIHS analysis, 2014

OUTCOME

Active citizen participation in water governance. Improved citizen awareness can help avoid littering and pollution of water channels prmote the use of solid waste management facilities. This action can play a contributing role in conserving the quality of water resources and help to build water security.

Description of sub component	Estimated cost	Impacts	Delivery mechanisms
13B Awareness campaign on solid waste management, upkeep of storm-water drains, natural drainage channels and lakes, water-use efficiency.	Rs 20 Million (Annually)	Active citizen participation and buffer to vested interests.	▪ BBMP as nodal agency in coordination with BWSSB to conceive this and create suitable platforms at appropriate levels for engagement. Use ward committees and other neighbourhood coalitions. ▪ Campaigns can be started through schools and broad-based through multiple media.

CHALLENGES

Sustaining and moving towards clear outcomes.

DATA GAPS

Stakeholders, risks, channels of communication, influencers – data for communication campaign.

TIMEFRAME

Short term and ongoing; regular annual campaigns timed appropriately.

*Preliminary estimate based on IIHS analysis, 2014

04

DELIVERY AND IMPLEMENTATION

Delivery mechanisms and implementation issues

While the previous chapters described the projects required to 'future proof' Bangalore, they are not sufficient by themselves to ensure resilience of the water and sanitation system of the city. The projects must also be executed in an efficient manner, supported by an enabling policy and regulatory framework, adequate and sustainable sources of funding.

The first part of the chapter mechanisms required for city wide application of the projects and sustenance of benefits from these. The concluding section presents the funding required
for the projects, and lists out sources of funding.

Current institutional arrangements

Currently, Bangalore Water Supply and Sewage Board (BWSSB) is the primary agency responsible for water and sewerage in Bangalore. BWSSB functions fairly autonomously and is responsible for design, implementation, and maintenance of water and sewerage projects. However, the capital investments for the projects are underwritten either by the Government of India or the Government of Karnataka.

Apart from BWSSB, Bruhat Bangalore Mahanagara Pallike (BBMP) is the other major agency responsible for environmental services. Storm water drainage and solid waste management fall under the purview of BBMP. Both BWSSB and BBMP have representation of the Urban Department of Govt. of Karnataka, as well as Chairpersons of each agency on the other. However, the operational level challenge of coordination between the agencies is daunting.

Lakes in Bangalore come under the jurisdiction of multiple organisations at the state at the city level. While ownership of different lakes is vested with different custodians - the State Revenue Department, Minor Irrigation Department, the BBMP, the BDA (the city planning authority) and the Lake Development Authority (LDA). The oversight powers (as per the High Court ruling) rest with the LDA, and these agencies have tried out some coordinated efforts to manage the lakes in Bangalore. The Chairman of BWSSB, and the Commissioners of BBMP and BDA are also members of the LDA (LDA, 2013).

Groundwater resources in the city by right vest with the owner of the land above. The newly constituted Karnataka Groundwater Authority has been given the responsibility of monitoring and regulating groundwater use all across the state (Government of Karnataka, 2011). The Karnataka State Pollution Control Board (KSPCB) is also in charge of monitoring pollution of surface and groundwater resources. The Central Groundwater Board (CGWB) and the State Department of Mines and Geology (DMG) are involved in the monitoring and assessment of groundwater resources; the BWSSB extracts groundwater (in a limited manner) for municipal water supply and is the notified agency (by the KGA) for registering and granting permits for new borewells in the city.

Implementation Issues

Some implementation issues are common across projects.

- **Coordination:** When a particular project requires more than one lead agency to implement the project, coordination between the agencies is of paramount importance. However, currently there are no mechanisms/procedures and no incentives in place to ensure this coordination at the operational level. The structure and procedure followed by the Supreme Court to tackle New Delhi's air pollution might be useful here as a model.

- **Capacity issues:** Though not clear from the above table, there are serious capacity constraints within the institutions. There is lack of availability of trained and competent personnel. There is lack of procedures and systems for projects to be implemented to high standards. Lastly, there is major capacity deficit with regard to ability to interface with customers and citizens.

Delivery mechanisms for projects

Given the diverse range of projects, the delivery mechanisms and institutional arrangements will differ widely. Broadly, three kinds of delivery mechanisms are possible.

1. **Implementation by single agency:** These are projects will fall clearly within the mandate of a single institution- mostly BWSSB and BBMP. A large majority of projects fall under BWSSB: NRW reduction, O&M management, waste water collection and reuse, septage management, service delivery improvements etc.
2. **Implementation by two agencies:** These are projects that might be implemented by a single agency, but might need require coordination with another agency. For example, while BBMP is responsible for storm water harvesting, and already has a Drainage Master Plan in place, however it needs to coordinate with BWSSB which is responsible for sewerage network.
3. **Multiple agencies:** These are projects which would potentially involve multiple agencies. While exact arrangements would depend on the specific projects, it is however desirable for either one or two agencies to clearly lead the initiative.

Table 4.1 below outlines the delivery mechanisms for each of the projects.

Table 4.1 - Institutional and delivery mechanisms for action plan projects

PROJECT	SUBCOMPONENT	LEAD INSTITUTION	CURRENT STATUS	INSTITUTIONAL COORDINATION AND SUPPLEMENTARY ACTIVITIES
1A	Preparation of action plan for rehabilitation of storm water drains	BBMP	Master plan prepared and awaiting approval.	Required consultation with multiple agencies - BBMP, BWSSB, LDA, KFD and private institutions - to ascertain ownership and drainage practices in local area.
1B	Remodelling of drainage channels enforcing separation of sewage and storm water	BBMP	Master plan prepared and awaiting approval.	Will need to control dumping of garbage and debris to pre-assigned locations. Will need to coordinate with BWSSB, LDA, and KFD for dove-tailing activities (e.g. laying sewer pipelines) and enlist cooperation of residents while carrying out work.
1C	Developing lakes/ reservoirs as holding ponds	BBMP in coordination with LDA/ BDA/KFD	Work on few lakes taken up by owner agencies. Needs coordination.	Will require treatment plants at inlet. Will need to coordinate with BWSSB, LDA, and KFD for dove-tailing activities (e.g. laying sewer pipelines) and enlist cooperation of residents while carrying out work.
1D	Land-use planning around lake buffer zone and management of reservoirs/lakes	Owner agency of the lake - LDA/BDA/ BBMP/KFD.	Few lakes managed currently but more for recreation than aquatic quality.	Fencing and enforcement of buffer zone. Data monitoring of water quality, flows, groundwater quantity and quality and dissemination. Civil coalitions around lake rejuvenation exist and they need to be engaged with constructively.
2A	Enforcement of groundwater drilling and access controls through permits and monitoring	KGA	BWSSB is notified agency by KGA for registration of bore well and for grant of permits to drill. Partially enforced, but database is not linked to property database of BDA or connection database of BWSSB.	Need a one-time campaign to populate database of existing bore well owners, followed up with licensing of DTH service providers and enforcement of permit system. Annual campaigns and redress mechanisms will need to be evolved.

PROJECT	SUBCOMPONENT	LEAD INSTITUTION	CURRENT STATUS	INSTITUTIONAL COORDINATION AND SUPPLEMENTARY ACTIVITIES
3A	Judicious control of tanker supply market to cater to low-supply areas and prevent indiscriminate exploitation of groundwater	BBMP	No licensing and controls in place currently.	Licensing of tankers and regulation of movement within city as well as access to groundwater sources. Create monitoring systems to understand extent of water drawal in different areas. BBMP implements with support from BWSSB in ensuring that tanker supply is restricted to low-BWSSB-supply zones.
4A	Phased reduction of NRW water in identified high-NRW zones (4 packages)	BWSSB	Three packages contracted, one in process.	BWSSB O&M team will need work on for consumer level corrections (change of meters, replacement of pipelines). Will require BWSSB to act on billing/ collection problems identified and take up any trunk infrastructure corrections.
4B	City-wide reduction of NRW across BWSSB distribution system (with DMA constitution and monitoring in newly connected areas)	BWSSB	Small area packages contracted in 4A.	BWSSB O&M team will need to institutionalise non revenue water monitoring as part of normal operations.
5A	O&M Plan for water supply network on a time-bound basis	BWSSB	Work taken up as needed only.	Use of ICT and best practices like SCADA; BWSSB will need to create cost-profit centres within its O&M team to institutionalise this.
6A	Expand sewerage network coverage and connectivity aiming for universal sanitation coverage	BWSSB	Work in progress to cover the urban areas brought into BBMP.	Other newly added areas need to be covered.
6B	Ensure household connectivity and monitor and maintain network to assure full conveyance	BWSSB	Low connectivity.	Connectivity is reported low in new areas and requires to be addressed through citizen engagement and financial incentives.

PROJECT	SUBCOMPONENT	LEAD INSTITUTION	CURRENT STATUS	INSTITUTIONAL COORDINATION AND SUPPLEMENTARY ACTIVITIES
6C	Create interim solutions (till storm water - sewage segregation is effective) for guiding sewage flows to STPs - interceptors, pumping to manholes, etc.	BWSSB	Storm water master plan awaiting approval. STPs not working to full capacity.	BBMP will need coordination with BWSSB.
7A	Market intervention in septage clearance services to demonstrate safe procedures, work safety and safe disposal and regulate service charges	BWSSB	Services provided by private sector.	Coordination with BBMP required. Licensing system and clear demarcation of STPs and septage dump sites with adequate protection.
7B	Make available access to STPs for co-treatment of septage	BWSSB	Procedures are not uniform across STPs and access is limited.	Monitoring septage clearance, disposal volumes and households enlisting service.
7C	Set up septage treatment facilities additionally if needed (where distance to STP is uneconomical)	BWSSB	No septage treatment facility in the city.	Monitoring septage clearance, disposal volumes and households enlisting service.
8A	Increase access to piped water supply (more household connections, esp. in new BBMP areas through expansion of network)	BWSSB	Expansion of ongoing work.	Poor areas or slums could possibly require partnerships with NGOs/ CSOs; Options for access need to be generated like in the projects carried out by BWSSB SDU.
8B	Supply of potable water in containers or through kiosks	BWSSB	Private sector market.	Poor areas or slums could possibly require partnerships with NGOs/CSOs.
9A	Provision of individual or community household sanitation facilities for households without access to sanitation	BWSSB	Expansion of ongoing work.	Poor areas or slums could possibly require partnerships with NGOs/ CSOs; Options for access need to be generated like in the projects carried out by BWSSB SDU.

PROJECT	SUBCOMPONENT	LEAD INSTITUTION	CURRENT STATUS	INSTITUTIONAL COORDINATION AND SUPPLEMENTARY ACTIVITIES
10A	Collection of micro-data on end use for prospective bulk users	BWSSB	New project.	Data should be GIS enabled to assist BWSSB next steps.
10B	Locate and identify bulk users situated near STPs and potential dual-piping trunk lines (60 feet roads).	BWSSB	New project.	Engagement with water users.
10C	Enable dual-piping supply of treated water to bulk users	BWSSB	New project.	To be carried out through strategic discussions with bulk user groups in each location (tech parks, SEZ, large campuses). Advocate use of treated water for non-potable uses; Explore need for high quality water and ensure supply. Carry out pipeline investments and recover over first year of supply. Make RWH mandatory and enforce.
11A	Identification of large storage reservoirs for drinking water supply and ascertaining capability to be used as supply source	BWSSB in coordination with lake owner agency	New project.	Data collection around the year to estimate flows and optimal withdrawal simulation; estimation of treatment requirements.
11B	Pilot use of large storage reservoirs for drinking water supply after treatment and upscale after time	BWSSB in coordination with lake owner agency	New project.	Set up treatment plant; pilot uptake and distribution in phases; possible use as buffer/emergency source.
12A	Adoption of less water-using devices and technologies	BWSSB	New project.	Market development involving vendors and coordinated campaign with prizes/ incentives. Tariff/price signals will be needed.
13A	Awareness campaigns for water conservation, rainwater harvesting, and water-use efficiency	BWSSB	New project.	Use Ward committees and other decentralised institutions
13B	Awareness campaign on solid waste management, upkeep of storm-water drains, natural drainage channels and lakes, water-use efficiency	BBMP	New project	Use Ward committees and other decentralised institutions.

Policies and regulations

There are some projects that require new policy framework, or changes in the legal frameworks to empower institutions to take on additional responsibilities.

This section highlights some of the key changes that are required. These changes are required not only to implement projects, but also to sustain changes.

The schedule of proposals summarised in Table 4.2 shows where policy changes and additional guidance and regulation have been identified as part of the Projects and as a necessary component of ensuring the long term effectiveness and sustainability of the actions identified.

Table 4.2 -Key regulatory and policy changes required for enabling action plan projects

THEME	ACTIONS NEEDED FOR CREATING ENABLING ENVIRONMENT
Water resources	Regional planning at BMRDA level for comprehensive water resource management.
	Clear ownership/custodianship of lakes within BBMP and facilitation of coordinated activities within each watershed.
	Detail and implement the procedures for enforcing the Karnataka Ground Water Act and Rules, 2011 to create a database of bore wells, monitor abstraction and control abstraction.
	BBMP bye-law for facilitating regulation of tanker supply.
	Licensing and right-of-way controls on tanker supply of water.
	Statutory master plan Bangalore Development Authority (BDA)-Linking considerations of water and sanitation in Plan guidelines.
	Enforce RWH for new buildings and campaign increased adoption in existing buildings.
Water supply distribution management	Regulatory framework for guiding water utility performance parameters and ensuring adequate investments in O&M.
Waste water and sludge - collection and treatment	Develop city sanitation plan for BBMP as guided by National Urban Sanatation Policy (NUSP) with planning at ward and neighbourhood level.
	Encourage ward-level adherence and performance on cleanliness through competitions.
Improved service delivery to households and establishments	Rational Tariff policy with lifeline supply and telescopic pricing towards enabling water conservation.
	Create incentive for BWSSB to adhere/achieve service level benchmarks.
Water demand management	City water policy to be developed with a visionary plan of utilising multiple sources and reducing dependence on water imports.
	Provide incentives for adopting water-use efficiency fixtures to catalyse market.
	Mandate use of recycled water for non-potable uses in larger complexes, establishments, campuses and private layouts.

Financing for future proofing

At present, the BBMP has received approval from JNNURM for funding worth about Rs. 9,250 Million for stormwater drains (http://bbmp.gov.in/jnnurm, accessed 27th March, 2014). Similarly, the BWSSB has also accessed funds under JNNURM for various projects that include:

1. 1. Extension of sewerage network, **Rs.2,883 Million**
2. 2. Augmentation of water from Cauvery, **Rs.160 Million**
3. 3. Installation of bulk meters, **Rs. 63 Million**
4. 4. Replacement of sewage mains, **Rs. 1, 767 Million.**

(Source: http://www.deccanherald.com/content/357152/bwssb-projects-jnnurm.html, Accessed 27th March, 2014)

The Mega City Revolving Fund of the KUIDFC is provided on a 50:50 basis and about Rs. 470 million has been granted to BBMP for the ongoing lake rejuvenation initiative.

The National River Conservation Plan (NRCP, Min of Env and Forests, Govt. of India) provides 100% Central Government assistance for projects that comprehensively work on limiting pollution to rivers. Under the revised guidelines (2010), the City Sanitation Plan (CSP) shall be the basis for planning and formulating projects. A holistic approach is called for and provision of integrated sewer network up to house-property line in place of drain interception and diversion is advised. The project proposals will have to ensure dovetailing with projects under JNNURM/UIDSSMT/ State Plan. The estimate of O&M cost for the first 5 years is to be in-built in the project cost. The O&M cost for subsequent 10 years is to be also worked out with revenue generation plan. The O&M responsibility beyond 5th year will rest with the State Government/ ULB (MoEF, 2010). Currently, the BWSSB is carrying out a component on rehabilitation of existing sewers (about Rs. 470 Million) through funds from the NRCP. (http://bwssb.org/current-projects-3/, accessed 27 March, 2014)

Loans on concessional terms are available (and being accessed by BWSSB at present) from agencies like JICA for the creation of infrastructure. Part of the planned works on replacement and rehabilitation of existing sewers is being carried out through loans from JICA and some grants under JNNURM, apart from the funds made available under NRCP.

BWSSB has entered into an MoU with PUB (Public Uitilities Board, the national Water Agency for Singapore) for the indirect potable reuse project in the Arkavathi catchment, where treated wastewater from the STPs is being put back into the up-stream of the Arkavathi river for access at the reservoir and reuse. PUB brings in part of the investment and provides the technical know how. The BWSSB plans to supplement this with funds under JNNURM for expanding this up to 250MLD over time.

HUDCO also provides loans for the water sector agencies in Bangalore. A more detailed examination of financing potential will require a review of the past financial performance and status of the agencies involved like BBMP and BWSSB. Access to different sources of finance would also mean that these agencies need to contribute a share of the project costs, and later bear O&M expenditure. A more detailed analysis of this aspect is required for building a financing plan that can seek to address this comprehensively in the future.

Asian Development Bank has an upcoming Bangalore Cluster Development Investment Programme which will seek to support the economic competitiveness of Bangalore as an economic cluster by

addressing gaps to enable the growth of the city. The lack of access to water and available infrastructure has been identified as a potential brake on growth and one of the reasons hampering the productivity of the city. The program will provide physical and non-physical investment in selected clusters within the BBMP area to: (i) improve regional and metropolitan planning, (ii) upgrade key economic and social infrastructure, and (iii) enhance urban governance (including service delivery) to create a better business and investment climate. The Program proposes to achieve the above objectives by: (i) ensuring that multi-stakeholder demand-based (cluster) infrastructure development is preceded by metropolitan economic and sector planning, (ii) promoting sectoral coordination and convergence, and (iii) establishing a strong partnership between public and private sectors.

The Program will seek to use a number of innovative financing, capacity development, and reform instruments. The Bangalore Metropolitan Region has been selected for support under the program based on (i) its potential to achieve enhanced growth, productivity and employment; (ii) prevalent enabling environment for accelerated industrialization; (iii) the State's reform willingness and exemplary initiatives; and (iv) opportunity for development and testing of new urban development models and potential for replicability in Karnataka and India.

There is potential for BWSSB to link with BBMP to align action and explore how the projects identified by BWSSB with stakeholders in the Action Plan can be taken forward.

The programme is able to support the financing of projects through a multi-tranche financing facility (MFF). The MFF is well suited for delivering the range of capital investment identified in the Action Plan as well as supporting actions to determine the feasibility and targeting of projects. The project also allows the capacity development to be supported in conjunction with infrastructure provision. The MFF will also enable Bangalore Metropolitan Region to implement a structured roadmap on a programmatic basis which takes into consideration the economic, social, and environmental needs together. The facility allows for private and public interventions and finance to be linked. ADB have been engaged around the Action Plan and exploratory discussions are proposed between BWSSB and ADB as the next step.

In order to implement the Future Proofing Action Plan for Bangalore Bangalore Water Supply and Sewerage Board with other government agencies will need to update and refine funding and finance business plans to address the new project and Action Plan project which have only partially committed funds at present.

Table 6 shows the broad level of funding needed to develop and deliver the 13 Projects. A range of preliminary cost estimates are identified for each project where it is possible to do so to provide an indication of the funding needed.

More detailed cost estimates for particular projects and actions would need to be defined for capital programmes after the technical feasibility and options are further developed.

Table 4.3 - Phasing and financing of action plan projects

Project	Subcomponent	Cost estimate (INR Million)	Phase 1	Phase 2	Phase 3
1A	Preparation of action plan for rehabilitation of storm water drains	N.A	Already sanctioned under NURM		
1B	Remodelling of drainage channels enforcing separation of sewage and storm water	15,000	3,000	12,000	
1C	Developing lakes/reservoirs as holding ponds	30,000	3,000	21,000	6,000
1D	Land use planning around lake buffer zone and management of reservoirs/lakes	5,000	500	4,000	500
2A	Enforcement of groundwater drilling and access controls through permits and monitoring	30	6	2	22
3A	Judicious control of tanker supply market to cater to low supply areas and prevent indiscriminate exploitation of groundwater	10		5	5
4A	Phased reduction of NRW water in identified high NRW zones (4 packages)	5,000	3,000	2,000	
4B	City wide reduction of NRW across BWSSB distribution system (with DMA constitution and monitoring in newly connected areas)	8,000		2,000	6,000
5A	O&M plan for water supply network on a time-bound basis	To be provided for within BWSSB annual budgets			
6A	Expand sewerage network coverage and connectivity aiming for universal sanitation coverage	55,000	22,000	8,800	24,200
6B	Ensure household connectivity and monitor and maintain network to assure full conveyance	20,000	8,000	3,200	8,800

Project	Subcomponent	Cost estimate (INR Million)	Phase 1	Phase 2	Phase 3
6C	Create interim solutions (till storm water - sewage segregation is effective) for guiding sewage flows to STPs - interceptors, pumping to manholes, etc.	15,000	6,000	2,400	6,600
7A	Market intervention in septage clearance services to demonstrate safe procedures, work safety and safe disposal and regulate service charges	10	4	6	
7B	Make available access to STPs for co-treatment of septage	10	10		
7C	Set up septage treatment facilities additionally if needed (where distance to STP is uneconomical)	650	650		
8A	Increase access to piped water supply (more household connections, esp. in new BBMP areas through expansion of network)	150,000	30,000	90,000	30,000
8B	Supply of potable water in containers or through kiosks	5,000	3,000	2,000	
9A	Provision of individual or community household sanitation facilities for households without access to sanitation	Not estimated	Not estimated		
10A	Collection of micro-data on end use for prospective bulk users	5	5		
10B	Locate and identify bulk users situated near STPs and potential dual-piping trunk lines (60 feet roads).	Included in 10A			
10C	Enable dual-piping supply of treated water to bulk users	Not estimated	Not estimated		
11A	Identification of large storage reservoirs for drinking water supply and ascertaining capability to be used as supply source	in 8A			
11B	Pilot use of large storage reservoirs for drinking water supply after treatment and upscale after time	in 8A			

Project	Subcomponent	Cost estimate (INR Million)	Phase 1	Phase 2	Phase 3
12A	Adoption of less water-using devices and technologies.	25 (annual)	25		
13A	Awareness campaigns for water conservation, rainwater harvesting, and water use efficiency.	20 (annual)			
13B	Awareness campaign on solid waste management, upkeep of stormwater drains, natural drainage channels and lakes, water-use efficiency.	20 (annual)	20 (annual)	20 (annual)	20 (annual)

It will be necessary to blend and combine a range of different sources of financial and non-financial support. Funders have specific eligibility criteria for commitment and investment which means that only projects which meet their criteria will be fundable.

The possible sources of funding identified are National Urban Renewal Mission (NURM), Grant/Loans via Karnataka Urban infrastructure Development Finance Company (KUIDFC) (like the Mega City Revolving Fund), funds under the NRCP, loans from bilateral agencies (JICA) and multilaterals (World Bank, Asian Development Bank), partnerships with agencies like Singapore Public Utility Board and loans from HUDCO.

The National Urban Renewal Mission (NURM) grant funding is provided to cities in the funding pattern presented in
Table 4.4.

Table 4.4 Funding pattern under NURM

Category	Population (2001 Census)	No. of cities	Funding Pattern (%)		
			Grant		ULB/ Parastatal Share/ Loans from Banks
			GoI	GoK	
A	More than 4 million	7	35%	15%	50%
B	1 up to 4 million	28	50%	20%	30%
C	Selection cities/ UAs with less than 1 million	28	90%	10%	-

Next steps

This plan will be shared and used to engage with potential project funders to explore how individual projects could be further developed and supported.

Those actions relating to strengthening and extending existing projects could be the focus of developing early win initiatives to build momentum. A more detailed phasing and budgeting plan can then be developed for the short term actions identified within the plan.

This should link with the planning and budgeting process of BWSSB and other State Level bodies whose support would be required to develop and approve individual projects.

End note

A further final report which provides a comparison of the future proofing action plan process in Madurai and Bangalore has been produced. This provides lessons learned from applying the approach and key issues which are relevant to cities who may also wish to explore applying a similar approach in their city.

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APPENDIX A

Appendix A: Expanded Risk Analysis and entry points for BWSSB

Expanding the analysis of water supply and sanitation systems to identify entry points where a water supply and sanitation service provider can take future proofing action.

Bangalore Water Supply and Sewerage Board (BWSSB) were keen to explore the implications of the diagnostic on their end users and consumers, the implications for their operations and networks and wider pressures and challenges which could impact on how they develop and shape their planned capital improvement programmes.

To help relate the diagnostic issues at a practical level to the operations of BWSSB an expanded bottom up analysis of the risks and vulnerabilities was undertaken. The analysis helps to identify how institutions and communities are responding to the risks at present in order to help identify gaps which the Action plan strategy and projects identified in Section 3 should address. An overview of the analysis follows in this section and the conclusions are included in Appendix A.

- The household level analysis of risks considers the perspective of end users/ consumers. The findings were drawn from the site case study analysis from parts of Bangalore with contracting levels of service to consider the different position of end users in terms of their vulnerability and challenges faced. This analysis was used to help to identify appropriate actions to tackle the issues.
- The system scale of risk considers the issues facing BWSSB as a network operator and service provider including gaps in regulation and the implications for BWSSB of the competitive environment for water supply.
- The Environmental level of analysis considers the implications of climate risks on water resources which the urban diagnostic identified would be exacerbated by the scale and pace of urbanisation and climate change.

The widely accepted IPCC definition of risk has informed the future proofing action planning in Bangalore:

Hazard: The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision and environmental resources.

Exposure: The presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social or cultural assets in places that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected.

For Bangalore the risks associated with water supply and sanitation are identified in the three levels below.

Household risks

The findings from the site case study in Bangalore at the household level are slightly counterintuitive. Some commonly identified concerns like water scarcity or intermittent supply do not seem to pose a risk to a large proportion of the households. Further detailed work needs to be done

to establish this as currently, there is no reliable measure of household consumption, and variations depending on supply. While the current coping mechanisms may seem to work at present, these strategies are unlikely to sustainable in the future. This underlines the need for actions to address household level risk in the medium and long term.

Risks at the household level are disproportionately borne by poor households. Households that do not have access to BWSSB supply are particularly vulnerable.

While only a small percentage of households do not have access to improved sanitation—inadequate waste collection and septage management implies that all households are exposed to health hazards due to likely contamination of potable water. Here again, rich and middle income households are able to protect themselves from these risks by the use of purification devices, but poor households are unable to do so.

Risks at the household level also demonstrate that many of the risks that one would assume to appear at the city level because of the public services nature of water and sanitation, are to some extent, internalised and controlled as richer households have adequate coping mechanisms.

RISK LEVEL	KEY RISKS
01 Household 'End user perspective'	Contamination of potable water Availability of water (quantity, timing, reliability) Affordability and poor valuation of water Inadequate access to sanitation
02 System 'Service provider and regulator'	High dependence on single source Inadequate supply/limited stock Mismatch of supply/demand Non-revenue water Unregulated supply chains Continually increasing demand
03 Environmental 'External factors'	Depletion of ground water Contamination of ground water Depletion of lakes and other water bodies Disruption of natural drainage channels

Souce: IIHS Analysis, 2014

The case of a vulnerable household in Lingarajapuram

M, a middle aged woman, lives with her one son and four daughters in a single room house in Lingarajapuram, close to the Banaswadi railway line. They have been living in this house for the last 12 years. M lost her husband eight years ago and does not work, her son being the primary earning member of the family – he works as an unskilled construction worker for approximately 8 months in a year, and in other work for rest of the year. As a construction worker, his earns about Rs. 10,000 monthly. His eldest sister also brings home about Rs.3,500 monthly working as a domestic worker. Both have been educated only up to high school. The other two sisters are still enrolled in school. The family has minimal assets – only a TV, and is heavily dependent on the PDS system both for food and cooking fuel.

They have access to BWSSB water through a tap located immediately outside their house. This water is used for both potable and non-potable users, and is stored in pots at home. The water is not treated in any way before being used for drinking.

At the time of interview, they claimed that they had not received water from the tap for the last 10 days. Such disruptions are fairly common. In such instances, the family procures water from the nearby Sulabh public toilet complex by paying Re. 1 per pot. The family does not have a toilet, and relies on the public toilet complex, which charges Re. 2 per use. The house is built over a drain, and is susceptible to flooding.

The case of M and her family highlight two concerns to be addressed adequately in the action plan:

A. There is a need for greater focus on the poor and vulnerable households because of lower level of service delivery to them, and

B. There is a need for additional of data collection and monitoring of multiple water sources to be able to assess some risks more accurately, and hence inform decision making.

Source: IIHS Primary Study, 2014

Systemic risk

The biggest systemic water-related risk to Bangalore is high dependence on single source of water. The city is additionally vulnerable because of its location far away from other major water bodies. In turn, this risk of high dependence on a single source increases the vulnerability of the city to all other hazards: high loss of water, inequitable supply and climate variability. This risk of dependence on a single source is likely to worsen because of climate change, in the wake of an increasing population.

Cauvery Water Dispute Tribunal reduces water allocation for Bengaluru

BWSSB supplies drinking water sourced from the Arkavathy and the water pumped into the city from the river Cauvery which lies 98km away. However the Cauvery Water Dispute Tribunal in February 2013 significantly reduced the Bangalore allocation of water sourced from the river Cauvery because Bangalore only partially lies within the Cauvery basin. Bangalore's current drawal is at 18.1TMC. The tribunal has reduced the allocation for all of the urban areas of Karnataka to 8.75TMC.

"Since two thirds of the Bangalore city lies outside the basin, we are considering the drinking water requirement of Bangalore city for its portion of that area only which lies within the Cauvery basin….In respect of Bangalore city, area falling within the basin, water at 150lpcd has been provided....urban water requirements for all towns in the Cauvery basin is estimated at 8.47TMC…assuming that 50% of the drinking water requirement will be met from ground water and 50% from surface water..." [Extract from Cauvery Water Dispute Tribunal Report, 2013]

Resource/Environmental risks

The risks to the environment can broadly be categorised into two types: quantity (depletion) and quality. While often concerns of depletion are generally highlighted, potentially contamination poses a greater hazard, both due to difficulty in cleansing water bodies and aquifers, and also as it emerges as the major hazard at the household level.

Summary of risks and current mitigation measures

The table below is a summary of the key risks and current mitigation measures adopted by the communities of Bangalore. The projects contained in the action plan aim to address the key risks.

TABLE A.1: KEY RISKS AND EXISTING RISK MITIGATION MEASURES

	Key issue	Where/who is exposed	Level of Risk	Vulnerability	Current risk mitigation measures ("coping mechanisms")
I	HOUSEHOLD LEVEL				
1	**Contamination of potable water** Due to uncontrolled faecal contamination and multiplicity of household water supply sources, all households are potentially exposed to this hazard, especially the poor who may not have access to BWSSB supply or effective water treatment at home. Perception amongst households about this hazard appears low.	Households and institutions	The exposure is less for rich and middle class households due to their ability to procure treated bottled water and/or electrical filters at households level	High vulnerability for poor households who either have no BWSSB water, a purification device at household level, or only have mechanical filters	▪ Purchase of bottled water ▪ Installation of water purification devices
2a	**Dependence on intermittent public supply** BWSSB supplies water for 4-5 hours every alternate day or once in three days depending on the location.	Households	All households, with BWSSB connections, are exposed to this hazard as no area has 24 X 7 reticulated supply. However, this hazard is not perceived by rich and middle class households because of various storage and pumping mechanisms.	Limited storage and/or pumping capacities makes poor households more vulnerable.	▪ Access to multiple water supply sources. ▪ Investments in various storage/ pumping mechanisms, either at household or community level

	Key issue	Where/who is exposed	Level of Risk	Vulnerability	Current risk mitigation measures ("coping mechanisms")
2b	**Unreliable supply** In some locations, public supply also tends to unreliable at times. Other supply viz. ground or tanker also may not be in the household's control.	Households	Households who have access to some ground water are less exposed to this hazard. Others are variably exposed to this hazard depending on reliability of other supply sources.	Same as above. Vulnerability is higher since tanker prices may increase in event of temporary disruption in public supply.	▪ Dependence on multiple sources.
2c	**Inadequate quantity** Inadequate supply does not appear to be a major hazard for households, except for poor and vulnerable households. There is a significant percentage of households (30%) which does not have access to BWSSB water supply, however, most of these households have access to other forms of water supply	Households	Rich and middle class are not exposed to this hazard, though they are exposed to other hazards like unreliability etc. Poor households have high exposure due to lack of public supply, reliance on shared sources, and high cost of procuring water from private sources	Poor households are vulnerable because of lack of buffers in form of storage capacities, or limited capacity to pay high rates for water from alternate sources.	▪ Rich and middle class households: extraction of water through bore wells, either arrangement at individual household level, or at building level
3	**Affordability and poor valuation of water** Absence of tariff revisions has perhaps conveyed to households that water is cheap, even though BWSSB tariffs are among the highest in India. Rich and middle income households are hence not valuing and sustainably using water whereas poor households are paying higher prices for water.	Households and others	Only poor households apparently but because of feedback into wasteful use of water, the entire city system is potentially exposed to depleting water stock.	Seasonal variations in water prices do not impact the middle and rich income households as price for water is marginal proportion of their income. Poor households are vulnerable due to limited incomes-a large proportion of which needs to be used to buy water.	▪ Poor households have to resort to consuming less water or from non-potable sources that may pose health hazards.
4	**Inadequate access to sanitation leading to diseases** Some households especially in the periphery are dependent on unimproved options like pit latrines. A small proportion of households depends on open defecation. This poses health hazards.	Households	Very small percentage of population, poor and vulnerable households especially in the periphery. However entire neighbourhoods could be exposed.	Poor households especially women and children are vulnerable to diarrhoeal and other diseases.	▪ None

	Key issue	Where/who is exposed	Level of Risk	Vulnerability	Current risk mitigation measures ("coping mechanisms")
II	INFRASTRUCTURE/ CITY LEVEL/ SYSTEMIC				
1	**High dependence on single source** The biggest hazard that the water supply system the city faces is near-total dependence on Cauvery. Any disruption in this source, temporary or permanent, poses a risk for the entire city in two ways: a. long term depletion and unavailability; and b. temporary disruptions arising out of climate, environmental, socio-economic, and other reasons.	City water and sanitation system	The entire city is exposed to these hazards especially since there is no captive charge on water resources.	The city is additionally vulnerable because the alternative sources of water viz. lakes and ground water have been continually depleted and contaminated. Vulnerability due lack of exclusive holding tanks for BWSSB. While g/w currently serves as a possible alternative, there are no other backup infrastructure eg. RWH tanks, lakes	▪ Waste water recycling ▪ NRW reduction initiated
2	**Inadequate supply/ limited stock** While inadequacy of supply is not felt at the household, the stock within the city is same, and is limited to g/w and the entitlement from Cauvery actually realised.	Entire city	Entire city, especially the periphery areas and areas in the city that suffer from inequitable distribution.	Improper rainwater harvesting, lack of holding tanks and under drawal of actual entitlements make the city more vulnerable.	▪ WW Recycling ▪ NRW Reduction initiated
3	**Inequitable supply/ mismatch of supply/-demand in water supply districts** Due to improper management of allocation, withdrawal and distribution to GLRs	Water Supply Districts and Sub-Divisions	Part of the city	Limited water and lack of proper management and monitoring systems.	▪ None
4	**Unsustainable financial situation of BWSSB** High losses and less than commensurate recovery from customers, and revenues foregone from waste water etc. may render costs of debt servicing and O&M management unsustainable	BWSSB	BWSSB, and related city and state stakeholders	Constraints of personnel, lack of alternate revenue sources and dependence on government for capital financing	▪ GoK funding
5	**Non-revenue water (NRW) and unaccounted for water (UFW)** Reductions in the above may not be sustained at city wide scale	City water and sanitation system	City distribution systems are more exposed than transmission system.	Old stock of infrastructure and inadequate O&M	▪ NRW Initiative, Improved O&M systems?

	Key issue	Where/who is exposed	Level of Risk	Vulnerability	Current risk mitigation measures ("coping mechanisms")
6	**Unregulated supply chains** Since BWSSB does not cater to entire water needs of the city, the households and industry are dependent on a range of other options. There is no information, and monitoring of these multiple chains resulting in the hazards of a. poor quality of water and b. unregulated drawal from ground sources	Areas not supplied by BWSSB	Periphery areas are more exposed to this hazard as core is mostly catered to by BWSSB.	Lack of information, and difficulty of monitoring ground water.	▪ None
7	**Continually increasing demand** This implies reduced per capita availability in the medium term	Entire city/ region	Parts of the city that are away from water sources are more exposed.	Unbalanced, unplanned development of the city.	▪ Structure plan attempted to address some of these issues.
III	RESOURCES/ ENVIRONMENTAL				
1	**Depletion of ground water** Ground water may deplete to an unreplenishable level.	Aquifers	Higher in the periphery, as there is limited BWSSB supply.	Local hydro-geology is responsible for isolated aquifers, making them more vulnerable.	▪ None
2	**Contamination of ground water** There is a high risk of water contamination due to improper collection/ conveyance of waste water/ faecal sludge. Industrial contamination also reported.	Aquifers	Higher in areas which has higher prevalence of on-site systems and industries	Highly vulnerable since it is impossible to flush out aquifer contamination.	▪ WW Collection + Treatment being extended
3	**Depletion of lakes and other water bodies** Lakes are steadily depleting due to blockages in natural drainage channels, and also dumping of sewage, solid waste, and industrial wastes.	Lakes and aquifers	Some lakes are more exposed as higher quantities of wastes are being dumped on a regular basis.	More vulnerable because of unplanned growth	▪ Lake conservation initiatives
4	**Disruption of natural drainage channels and their contamination** Natural drainage channels are getting blocked due to unplanned development; and untreated sewage and industrial wastes are released into them.	Drains, lakes	Drains in fast growing areas are more exposed.	Poor coverage and collection efficiency of the sewerage system makes it more vulnerable.	▪ WW collection + treatment being extended

Linkages between different levels

While the risks have been presented in three levels, there are clear connections between them. While a risk might appear at the particular level, the corresponding mitigation measure might lie at a different level. For example, to address the household risk of water contamination, the primary risk mitigation measure (i.e of treatment) could lie at the systemic level. It is important to traces some of the important connections.

One of the most significant risks at the system level is that of of limited stock/ fixed supply. This is largely due to dependence on one source: the River Cauvery. This is somewhat supplemented by ground water but there are no other sources , and rain water is not harvested. This is exacerbated by the lack of perceived water scarcity at the household levels. The rich and middle income households have the wherewithal to deal with this scarcity. Thus water demand remains the same despite the overall scarcity in Bangalore. Lack of water conservation measures at household level potentially puts the entire city system at risk.

Contamination is another issue that is felt at a number of levels. The lack of capacity at the city level to manage waste water, and to supply potable water to the entire population has led to both risk of potable water contamination, and scarcity of water resources in the city.

The inability at the city level to supply water in adequate quantity to the entire population has meant that risks which would be equally distributed across different segments of the population, has fallen disproportionately on certain households.

BN Thyagaraja Expert Committee on sustainable water supply for Greater Bangalore

The B. N. Thyagaraja expert committee (Set up in November 2010, after the CWDT award of 2007) for identification of sources for sustainable water supply to Greater Bangalore presented its recommendations in August 2013 and signalled the need for diverse strategies to ensure sustainability of water. The committee working out of the offices of the BWSSB sought the views of experts, NGOs, academic institutions and citizen groups during the course of deliberations and data analysis. The committee in its recommendations proposed the following for optimal utilisation of existing water resources:eduction of Unaccounted for Water (UfW) and other losses in the distribution system to an acceptable standard of 16%:

- rejuvenation of Arkavathi river and augmentation of water into Arkavathi catchment by diversion of treated effluent
- integrated water supply through utilisation of rainwater, rejuvenation of lakes and recharge of phreatic zones to sustain groundwater
- dual-pipeline supply (first in new developments and later city-wide) for potable and non-potable use
- conservation of water at household.

Considering existing and proposed (projects already in pipeline) distribution infrastructure and volumes of water in the system, the committee estimated additional availability of nearly 1,200 MLD to be readied over a period of 38 years, with a third available in the short term (within five years) and the rest developing over the remaining period. The Committee estimated investment requirements of about INR 288,000 million for this and suggested pilot studies in four sites of 5-10skm area in order to equip BWSSB with better information for planning and development.

The committee also examined proposals for new sources of water, ranging from 390MLD to 1,500MLD, that could be taken up and developed over the next 20 years. More than half of these are achievable within five-seven years. The investment requirement ranged from INR 47million/MLD to INR 193million/ MLD. The committee prioritised these proposals in terms of ease of execution and timeframes and recommended the way forward.


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