

ATKINS

FUTURE PROOFING INDIAN CITIES

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Atkins in partnership with

UCL

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INDIAN INSTITUTE FOR
HUMAN SETTLEMENTS

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Summary

Bangalore is the capital of the state of Karnataka, contributing almost 34% to the state's GDP. While it has a long history of manufacturing (especially textile), the last few decades have seen it grow into a global centre for information technology and related services, with several domestic and international corporations such as Wipro, Infosys, Microsoft, and IBM locating there.

The city's physical footprint has increased by over 100% in the last decade but this has been at the cost of the city's vegetation and water resources. In particular, the growth on the city's peripheries is putting an increasing amount of pressure on Bangalore's natural and economic resources. In addition, the benefits of Bangalore's growth have not been equally distributed. Although Bangalore's distribution shows a lower proportion of extreme economic poverty, and a higher proportion of households that are in the middle and upper income classes than other urban areas in India, about 43% of the city's population is living in multi-dimensional poverty. Marginalized populations in Bangalore are particularly vulnerable to hazards such as urban heat island effect, urban floods, and water scarcity because of rapid and unplanned urbanisation, most of which will be exacerbated by climate change. Bangalore faces considerable socio-economic and environmental risks if it were to continue on its current development pathway. Governance in Bangalore is also fragmented, making coordination across different agencies challenging.

Bangalore has significant potential to play a major role in the future development of Karnataka and Southern India. However, to continue to leverage its knowledge-based economy, the city needs to address multiple challenges across a range of sectors. A significant proportion of the city's population lives in slum areas. The city is also growing rapidly, creating challenges in ensuring the provision of adequate infrastructure, housing, and basic services to meet the growing demands of its residents.

At the same time, Bangalore is facing a wide range of risks to its future growth and prosperity from issues such as water scarcity, climate change, damage to important natural habitats, and growing traffic congestion associated with private vehicle use. Unchecked, these issues could place a significant break on future economic growth and improvements on the quality of life of its residents. However, Bangalore has an opportunity to address these issues as part of its growth aspirations by looking at actions it can take now to future proof its development.

This Urban Diagnostic for Bangalore is a review of those existing and future risks and challenges that the city faces, particularly with respect to the growing threat of climate change. Informed by secondary data analysis, and input from key government stakeholders, the city diagnostic begins by laying out current risks, and vulnerabilities that Bangalore faces, as well as its potential capacity to address these issues. Drawing on individual engagements with government stakeholders, it identifies two key priority areas that present the greatest challenge for the city: water and energy systems. Focusing specifically on these two areas and targeting national and international funding sources, government stakeholders, policy makers, and non-profit organisations, it also identifies future scenarios and opportunities to help reduce vulnerability and increase adaptive capacity in Bangalore.

This document has been prepared for an audience of government, private sector and civil society stakeholders. The process of the preparation of this document proved useful in provoking discussion and debate among the wide range of stakeholders and in helping to determine the priority areas for action around which City Action Plans (CAPs) can be developed in partnership with and driven forward by key stakeholders. This document provides a synthesis of the key issues and priorities which have emerged from this dialogue, as well as information and issues highlighted within plans and strategies which have been developed for the city.

1. Introduction

1.1. The Future Proofing Indian Cities project

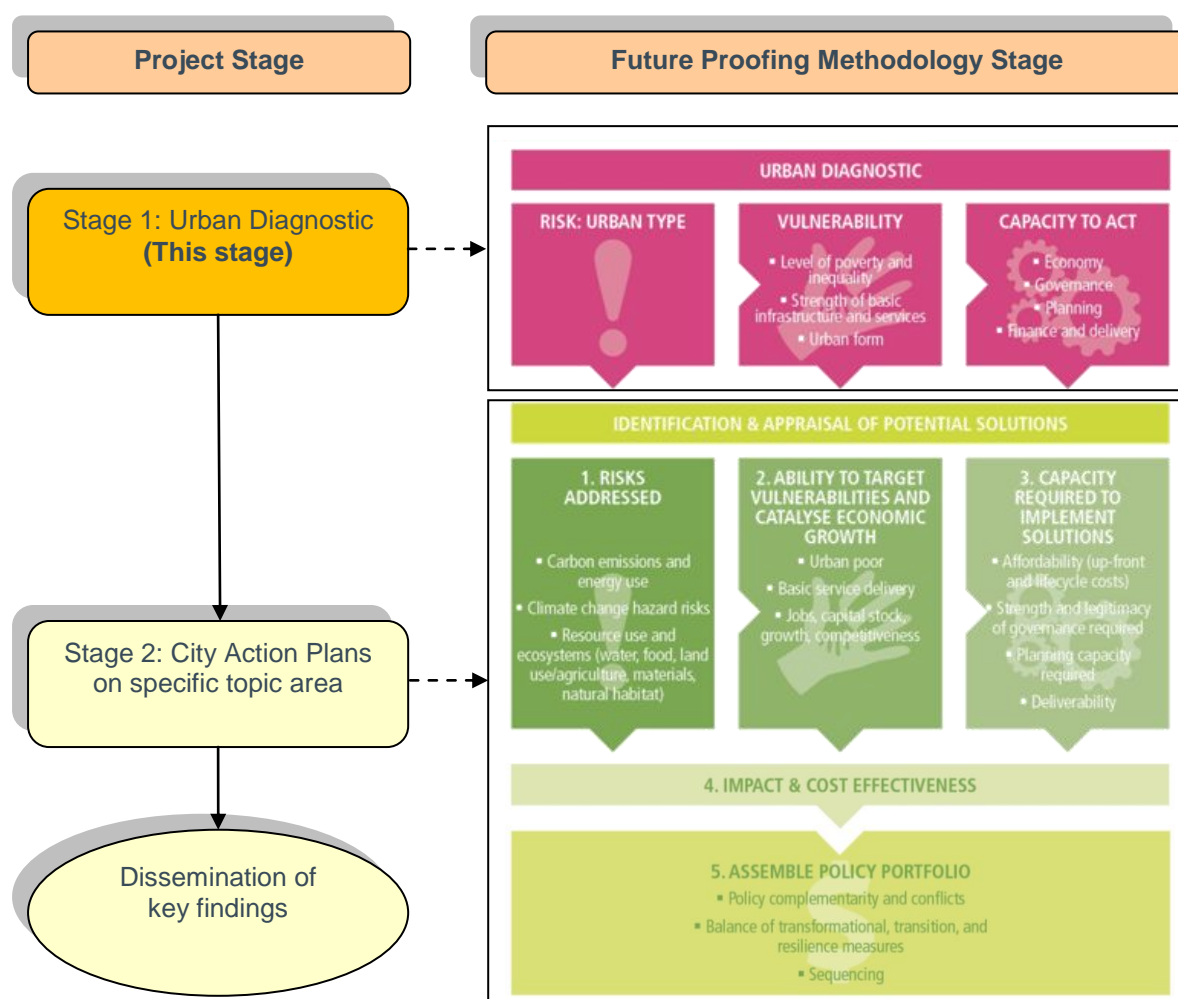
In March 2013, Atkins, supported by the Development Planning Unit of University College London and the Indian Institute of Human Settlements, were commissioned by the Climate Development Knowledge Network (CDKN) to undertake action planning with the city authorities of Bangalore and Madurai focussed on developing future proofed urban strategies in the cities.

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 help them respond to climate hazards and promote a transition to a low carbon economy while reducing poverty and catalysing economic development. A special emphasis is placed on supporting and enhancing locally owned policy processes.

1.1.1. Overall approach to the project

The project is being undertaken over two key stages at the city level, which is consistent with the Future Proofing Approach developed by Atkins and UCL, with later stages disseminating the lessons learned (see Figure 1). This report summarises the outcomes from the Urban Diagnostic stage, which identifies the key urban development challenges faced by the city and the capacity of the city's stakeholders to act to address these challenges. The outcomes of this stage form the evidence base to inform the creation of an Action Plan for Bangalore, which will be focused on specific topic area. The identification of this priority topic areas is also a key outcome of this stage of work.

Figure 1. Overall approach to this project



1.2. The choice about Bangalore's future

Bangalore is growing rapidly but there are concerns about how sustainable this growth is. In the last two decades, Bangalore, the capital of the state of Karnataka, has emerged as a global centre for 'new' service sector economies like information technology and biotechnology, with several domestic and international corporations such as Wipro, Infosys, Microsoft, and IBM locating offices here, attracted partly by the numerous academic institutions and the skilled workforce they produce (H. S. Sudhira et al., 2007). Bangalore has the highest district income in the state, contributing approximately 34% to Gross State Domestic Product (GSDP) at current prices (Directorate of Economics and Statistics, 2011) and is a magnet for investments and employment in Karnataka (see Table 1).

In addition to new service sector industries, Bangalore is also a stronghold of the domestic textile industry and other light manufacturing. The national economic reforms of the 1990s marked two distinct changes in Bangalore: while the 1950s to the 1980s had been characterized by public sector investment, the 1990s saw the growth of the private sector, particularly information technology (IT) and related industries. Companies like Texas Instruments, Infosys, and Microsoft are constructing large campuses on the edge of the city. To entice businesses, the state government of Karnataka is offering them several land and tax incentives in addition to building mega-infrastructure projects like elevated roads, a new metro, a new airport, and setting up special economic zones (SEZs). This rapid growth of new economic sectors in Bangalore has considerably boosted the prospects of the real estate industry, locally and regionally (Benjamin, 2006; Nair, 2005).

Table 1. Share of total State-wide investment in Bangalore

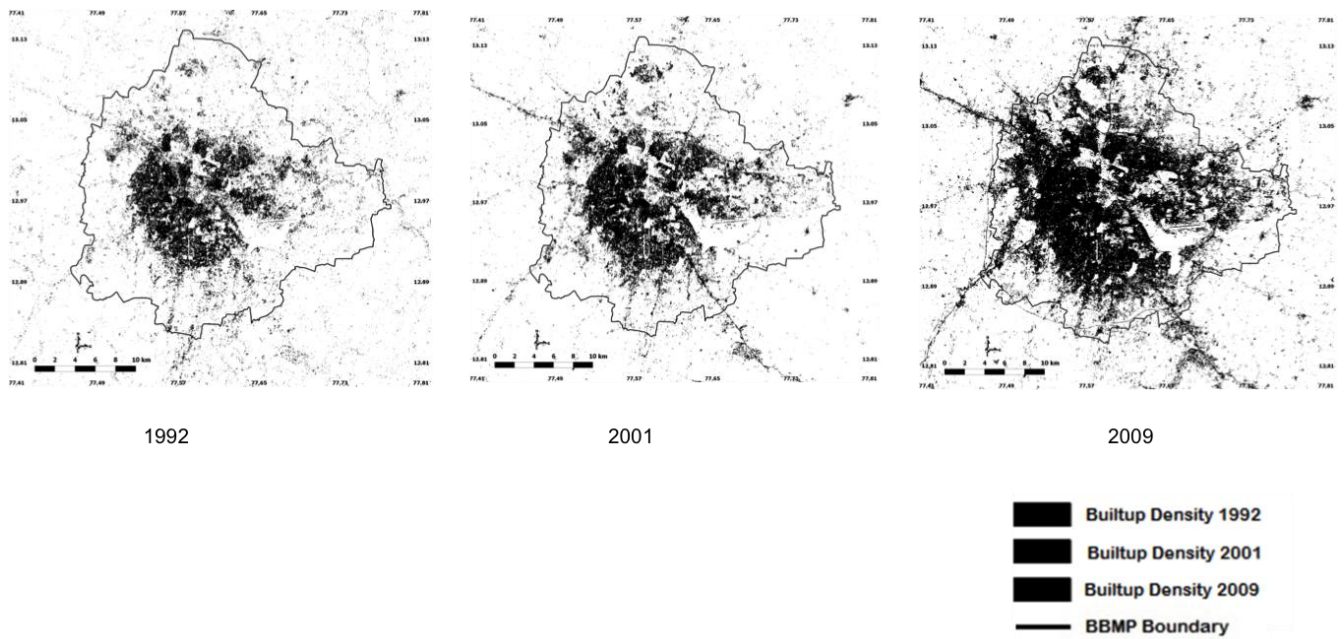
	Less than Rs. 50 Crores		More than Rs. 50 Crores	
	Karnataka	Bangalore	Karnataka	Bangalore
Total number of private projects	1,311	678 (52%)	195	85 (43%)
Total investment (Rs. Crores)	18,302	9,357 (51%)	62,255	19,650 (30%)
Employment	377,951	254,901 (67%)	565,451	451,495 (80%)

Source: IIHS

However, there are concerns about how sustainable this growth is. With no natural features restricting its development, the spatial growth pattern of Bangalore city is characterised by urban sprawl. A scale comparison of Bangalore with other comparable mega cities in India reveals that it is the city with the largest spatial extent of urbanisation. As illustrated in Figure 2, 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).

In addition, Bangalore's population has grown by over 40% in the last decade to reach an estimated 8.5 million in 2011. As the densities of population are increasing, the risks to people, services and economy is also increasing. Developments in low lying areas, particularly informal settlements are most exposed to flood risks.

Figure 2. Change in Bangalore built-up area (1992-2009)



Source: IIHS

To continue to leverage its knowledge-based economy, the city needs to address multiple challenges across a range of sectors. Bangalore's growth dynamics point towards rapid urban growth, and growing energy use coupled with an inadequate public transport system, and increasing water scarcity.¹ Changing climatic conditions such as irregular rainfall patterns, a growing incidence of drought, and rising temperatures are likely to be magnified given current growth trajectories. Large sections of the city are also exposed to specific hazards such as urban heat island effect, urban floods, and water scarcity because of rapid and unplanned urbanisation. Most of these hazards will be exacerbated by projected climate change impacts for the region, such as extreme heat days, rise in mean temperature, heavy precipitation events or storms, and periods of low rainfall.

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). Most of those will likely be negatively impacted by environmental shocks and stresses.² People and households are also exposed to other risks due to increasing densities, location of habitation and their varying degrees of access to basic infrastructure facilities and resources. Increasing densities and growing land prices leave people with limited choice and many of them are forced to live in more exposed areas or low lying areas, with minimal access to basic services and resources, thereby increasing their own vulnerabilities. Children (especially those below the age of 6), elderly, women and the disabled, are often the most vulnerable. Their access to financial institutions, public programmes and social protection is often limited, resulting in low resilience to shocks. Increasingly, vulnerable populations live in areas where the risks are higher (low lying areas, flood plains, etc.). The low awareness of the risks increases the exposure to them.

However, the good news is that **Bangalore has an opportunity to address these issues as part of its growth aspirations by looking at actions it can take now to future proof its development.**

¹ These are discussed in more detail in the sections on risks and vulnerabilities.

² Populations living in slums and informal settlements typically pay between Rs. 40 to 120 per kiloliter (KL) Grönwall, J. T. 2008. *Access to water: Rights, obligations, and the Bangalore situation*. Ph.D., Linköping University. For more on the tariffs charged by the BWSSB, please see <http://bwssb.org/water-tariff-prorate/>

1.3. Purpose of this document

1.3.1. Rationale and purpose of the document

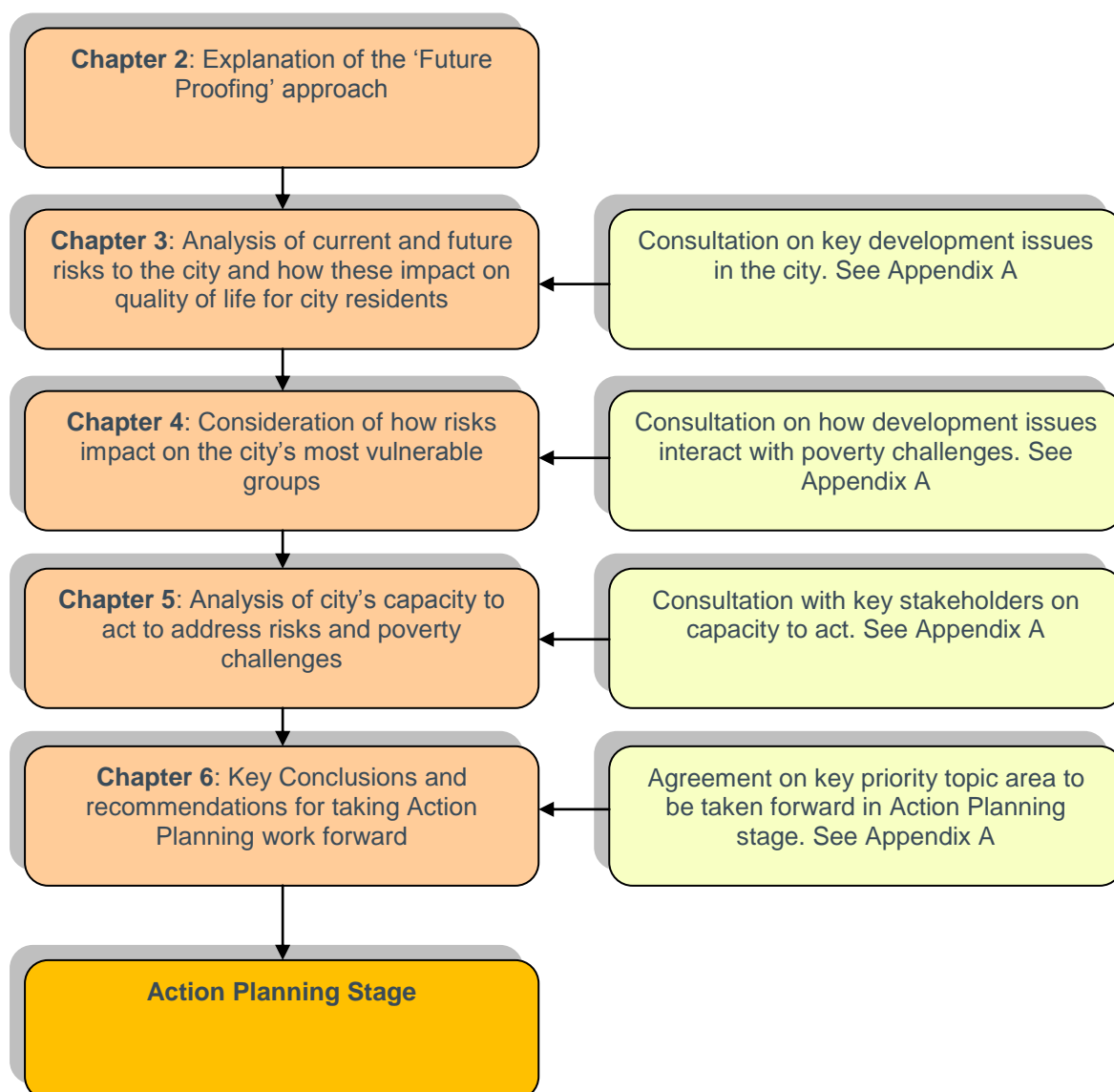
A key purpose of this document has been to stimulate a discussion among local stakeholders concerning the future development issues facing Bangalore and the role climate change could play in exacerbating existing risks and pressures.

This diagnostic has been used as an advocacy document which can be used to engage with City stakeholders as evidence of the multiple intersecting issues facing the city.

1.4. Structure of this document

Figure 3 illustrates the approach adopted for this stage of work. It also demonstrates the interrelationship between consultation with stakeholders and the development of the diagnostic.

Figure 3. Study Approach and Consultation



2. The Future Proofing Approach

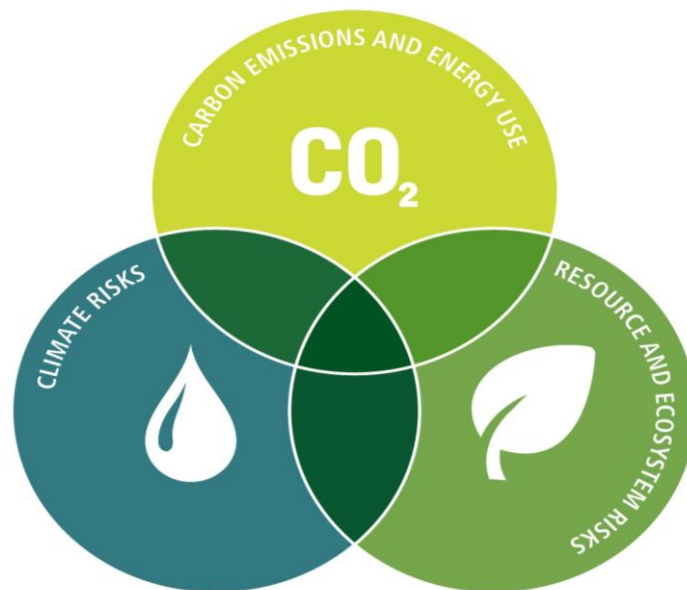
In order to tackle the risks to its future growth as well as to meet the demand for adequate infrastructure and basic services, Bangalore could benefit from a new approach to urban development: a 'future proofing' approach.³ Future proofing is about identifying and developing integrated solutions which 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 is about taking an integrated approach to tackling some of the city's deep rooted urban problems. Currently in Bangalore development, environmental, and human health issues are dealt separately and solutions are engineered according to separate sectors. For example if transport and landuse policy and urban growth were integrated, the vulnerability to flooding could be reduced through integrated engineering. Similarly an integrated approach would illuminate the poorly understood relationship between unchecked development, reduction in tree and vegetation cover leading to increases in pollution and impacts on human health. When urban problems are approached in a 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 its future development. The approach involves looking at three groups of interrelated issues:

- 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 4. Future Proofing Approach: Integrated Assessment Framework



Source: Atkins

³ Future Proofing Cities (2012), Atkins in partnership with DFID and UCL

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. The approach differs from most current approaches to urban development which tends 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 of limited financial resources;
- A focus on measures which respond to the needs of the urban poor; and
- The identification of measures which can be implemented and driven forward by stakeholders within the city given current capacities

3. Risks to Bangalore's Future Growth and Prosperity

Bangalore faces significant risks⁴ 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.

3.1. Climate hazards

3.1.1. 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 5).

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.

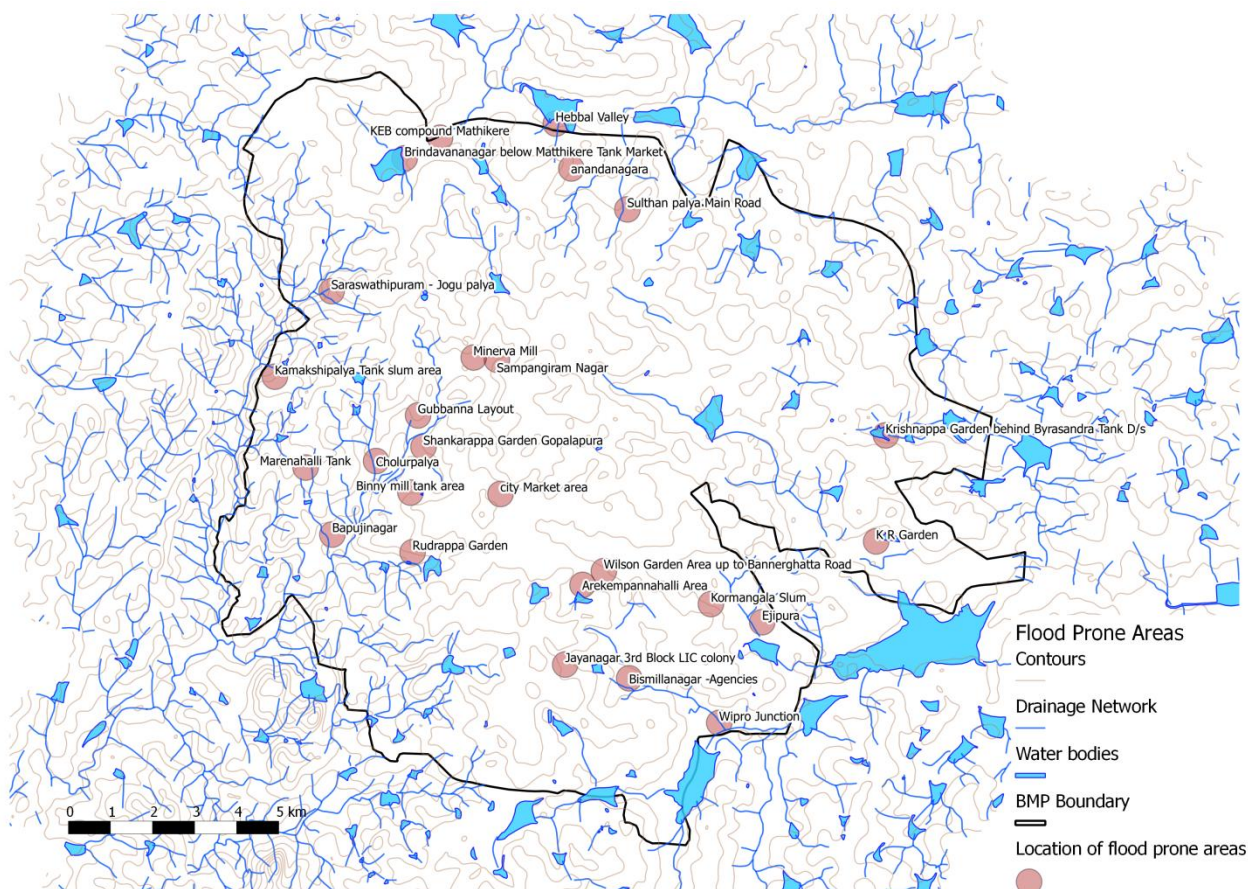
Air pollution and the outward growth of the city are contributing to an urban heat island effect, which has been noted to result in local temperature variations and irregular rain showers (Ramachandra and Kumar, 2010; Ramachandra and Kumar, 2009). This urban heat island effect is exacerbated by reducing tree cover (see Figure 6) and increasing built-up area, and has serious health implications for the local population.

⁴ 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).

Table 2. Summary of climate-related hazard risk profile for Bangalore

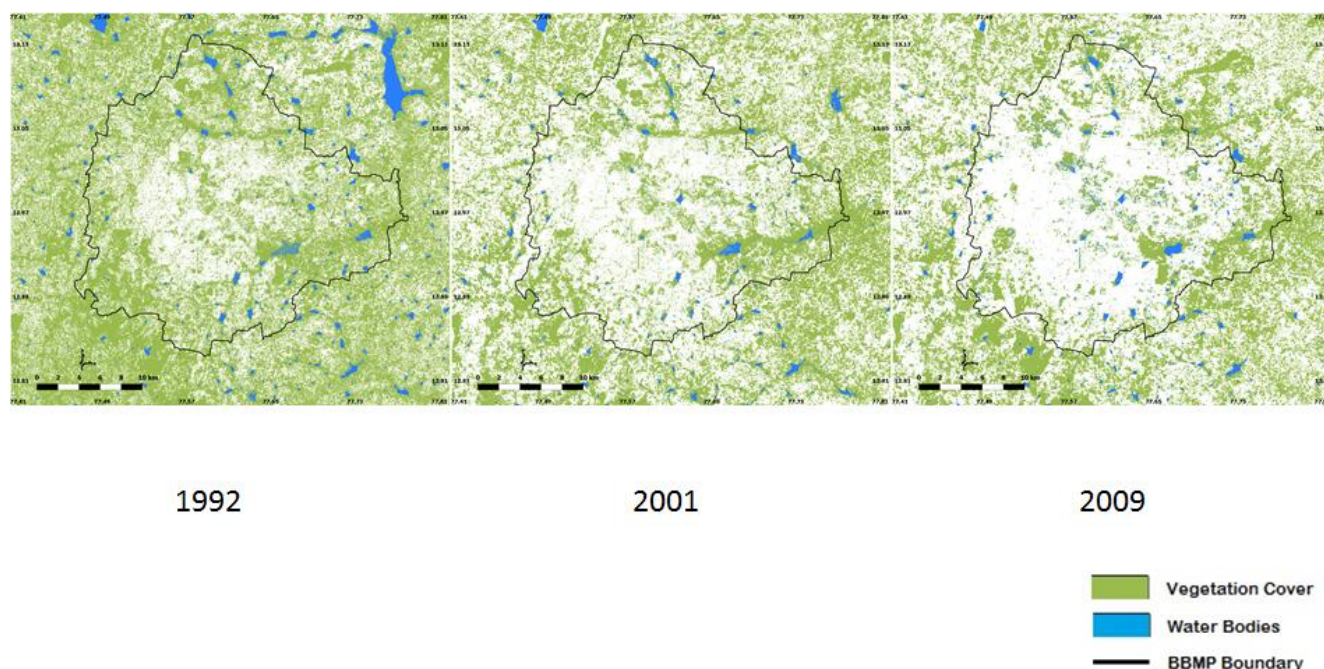
Bangalore: Key climate-related hazards and extreme events	
Heat	<p>Bangalore has an annual average maximum temperature of 29C and average minimum temperature of 19C. A mean temperature increase of approximately 2 to 2.5C during the last decade has been reported, attributed both to urban heat island effect and potential early climate signals (Ramachandra and Kumar, 2010).</p> <p>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).</p>
Extreme Rainfall and Pluvial Floods	<p>Bangalore receives rainfall both from the Northeast and Southeast monsoons. Its mean annual rainfall is 970 mm.</p> <p>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).</p>

Figure 5. Areas prone to flooding 2011



Source: IIHS Analysis, 2013

Figure 6. Change in vegetation cover in Bangalore 1992 - 2009

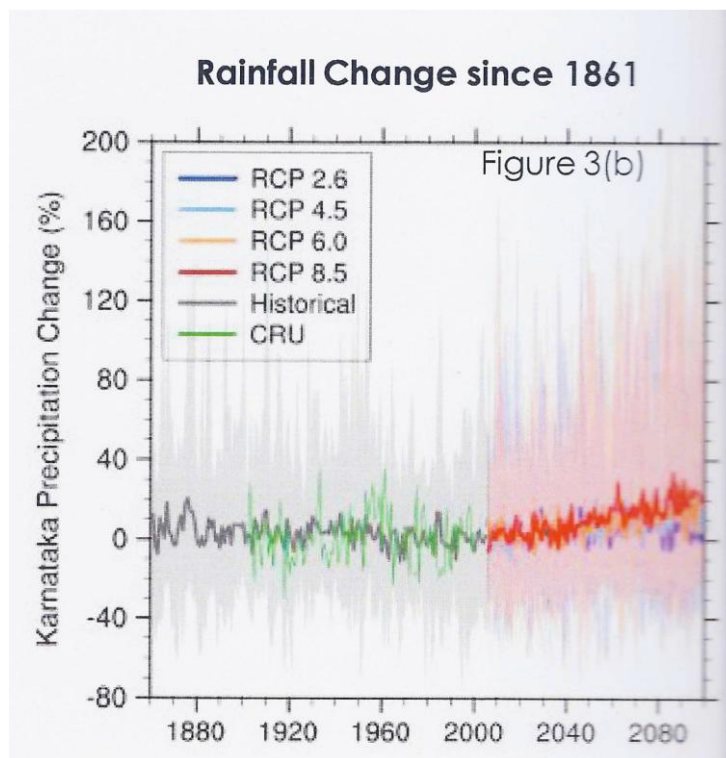


3.1.2. Future risks

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.

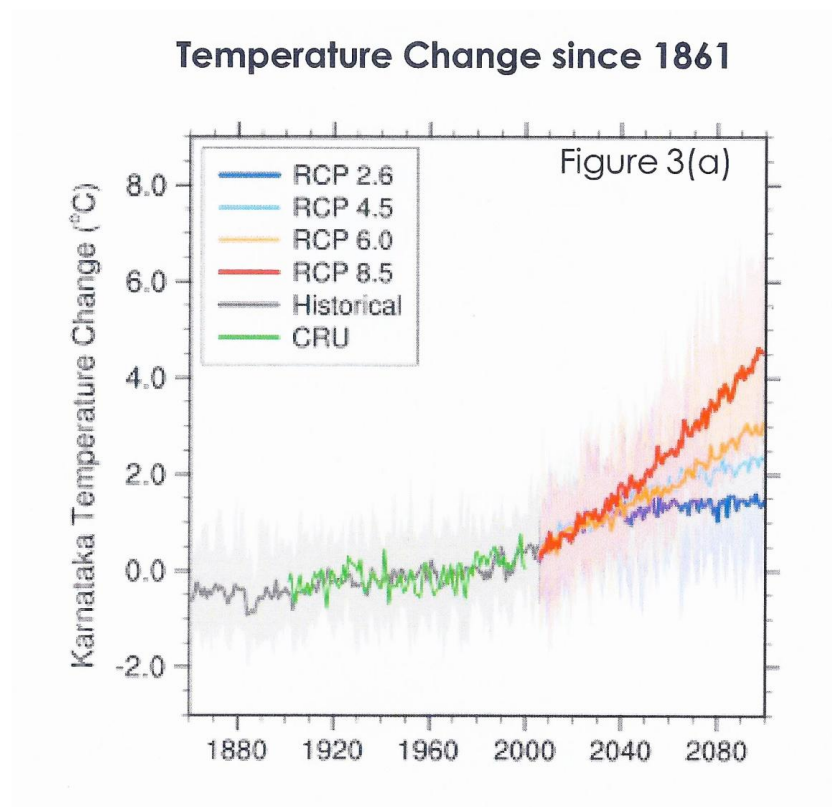
The Karnataka Climate Change Action Plan states that there has been a rise in the minimum temperature in six districts in north Karnataka by 0.6 degree Celsius in the last 100 years, while rainfall trends over the same period indicate an overall decline in annual rainfall for Karnataka state by 10% (Bangalore 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 6.

Figure 7. Karnataka rainfall change and projections under RCP scenarios (1861-2080).



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

Figure 8. 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 3 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 3. Summary of potential climate change impacts for Bangalore out to 2030/2050

Sector	Implications for Bangalore
Agriculture ⁵	<p>Production of potatoes and soybeans could reduce by up to 45% by 2050</p> <p>Amount of water retained in the Cauvery basin expected to decline rapidly leading to reduced yields across a range of other crops</p>
Natural ecosystems and biodiversity ⁶	<p>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 document⁷ as moderately vulnerable based upon the percentage of areas identified as experiencing change.</p>
Water resources ⁸	<p>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.</p> <p>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.</p> <p>Further work is needed to understand the needs of the city and implications of climate change on water resources.</p>
Human health ⁹	<p>The following risks have been identified:</p> <ul style="list-style-type: none"> 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	<p>Increased temperatures lead to increased usage of air conditioning. Increase power demand.</p> <p>Forced migration and loss of housing in coastal Karnataka following storm events may lead to increased pressure on inland cities such as Bangalore.</p>

⁵ Karnataka State Level Climate Change Action Plan

⁶ Ministry of Environment & Forests: Climate Change and India: a 4 x 4 assessment

⁷ Ibid

⁸ Karnataka State Level Climate Change Action Plan

⁹ Ministry of Environment & Forests (2010) Climate Change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s.

Sector	Implications for Bangalore
Roads	Increased temperatures and intensity 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 ¹⁰

The latest longer time horizon central estimates compiled by the World Bank using downscaled GCM projections¹¹ 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.

3.2. 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.

3.2.1. 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.

3.2.1.1. 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, diminishing¹². Water consumption in Bangalore is growing and while precipitation in the city catchment means that Bangalore is not at risk of drought¹³, 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 need¹⁴.

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

¹⁰ Karnataka State Level Climate Change Action Plan

¹¹ World Bank Climate Portal and Turn Down the Heat, World Bank

¹² Sudhira, 2007. The city is a flat apart from a ridge that runs from north to south (TERI, 2008).

¹³ 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).

¹⁴ UN Water 2012

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 fair 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).

Table 4. 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

Source: (Centre for Sustainable Development, 2012; Anand et al., 2005)

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 Devanahalli 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.

3.2.1.2. 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),

3.2.1.3. Current risks - surface water management

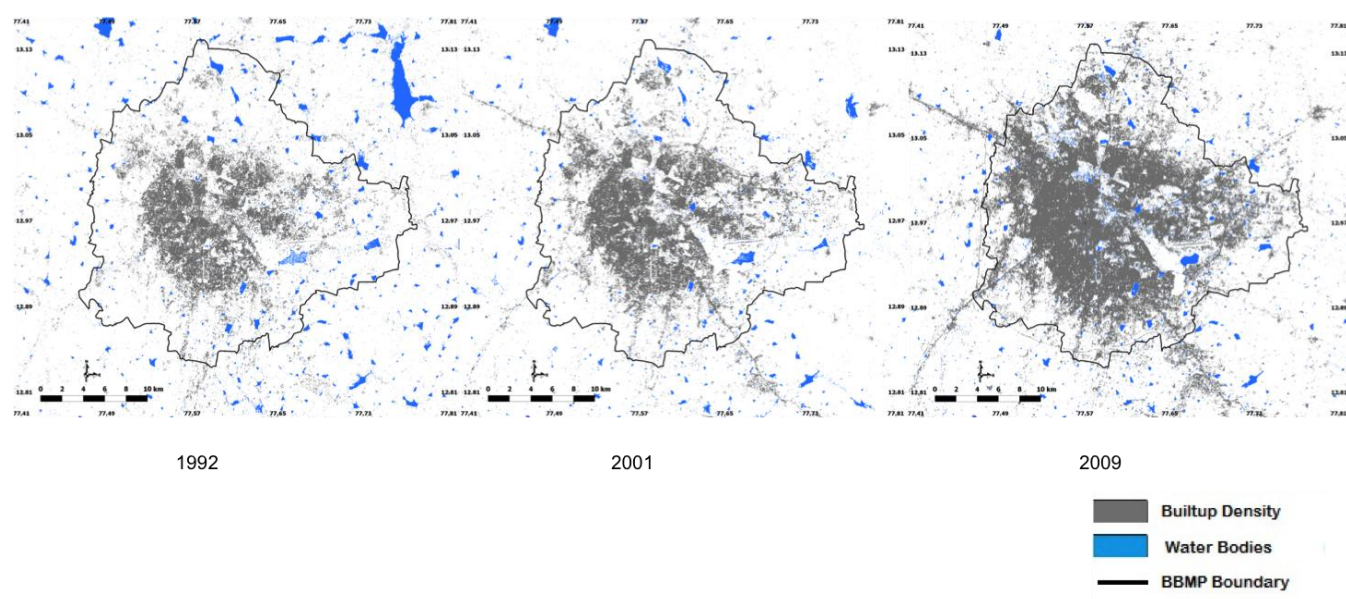
Many of Bangalore's lakes and surface water bodies have been seriously degraded or even built upon reducing the capability of the city to deal with heavy rainfall events. Climate change represents an additional stress factor which will exacerbate the situation. A network of natural and manmade water 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 city¹⁵.

Figure 9. Change in water bodies in Bangalore 1992-2009



3.2.2. 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-

¹⁵ Bangalore CDP

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.¹⁶

3.3. Agriculture and food security

3.3.1. 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 Karnataka 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.

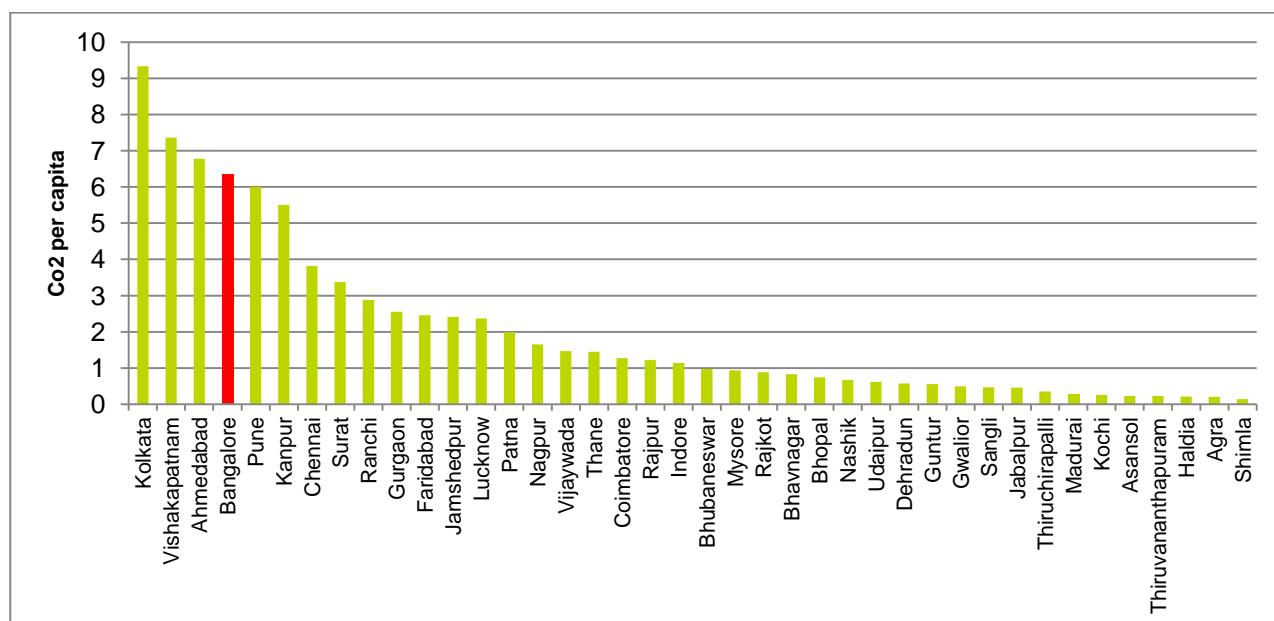
These increases in temperature and humidity may also lead to livestock rearing becoming a more cost intensive with livelihood implications for more marginal farmers.

3.4. Energy use and carbon emissions

3.4.1. Current risks

Bangalore's estimated current carbon emissions are relatively high when benchmarked against a range of other Indian cities. Figure 10 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.

Figure 10. Benchmarking Bangalore's CO₂ Emissions with other Indian cities



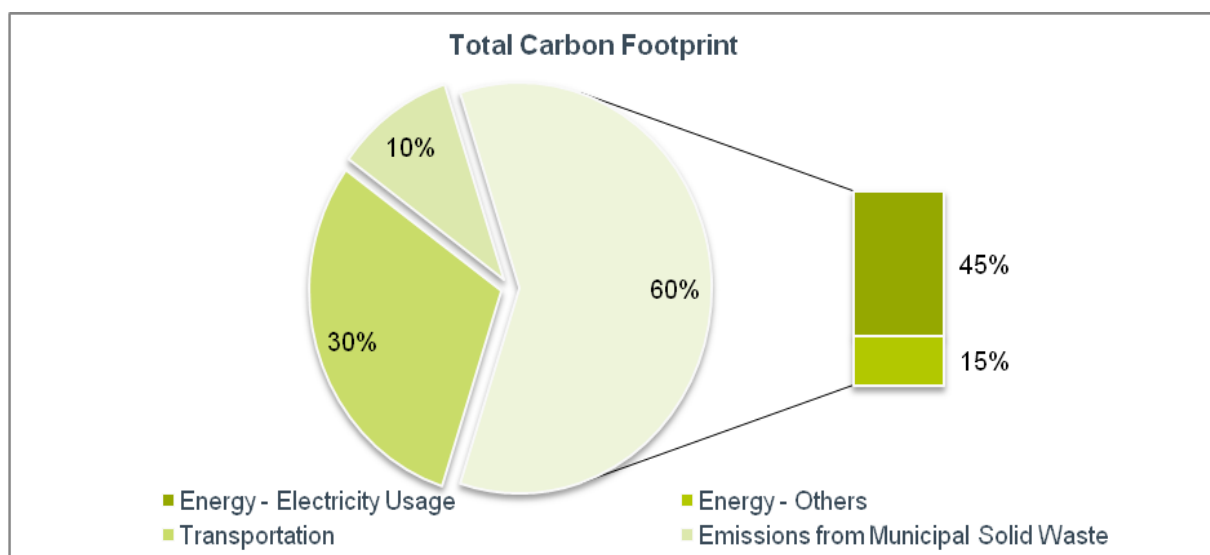
Source: Energy and Carbon Emission Profile of 45 South Asian Cities, ICLEI

¹⁶ Integrated Urban Water Management Report

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):

As Figure 11 shows, the energy component is 60% of the total carbon footprint (CF), 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.¹⁷ 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).

Figure 11. Structure of Bangalore's carbon footprint



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 is relatively low in residential areas and industrial areas as compared to commercial buildings.¹⁸ 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 use of air-conditioning, increases the costs of operating a building, and deepens the dependence of residents and businesses on unsustainable forms of energy.**¹⁹ There is a 15% energy deficit in the State (Government of Karnataka, 2013) and electricity black-outs are not uncommon in the city.

¹⁷ 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.

¹⁸ 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.

¹⁹ 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.

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).

3.4.2. 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.²⁰

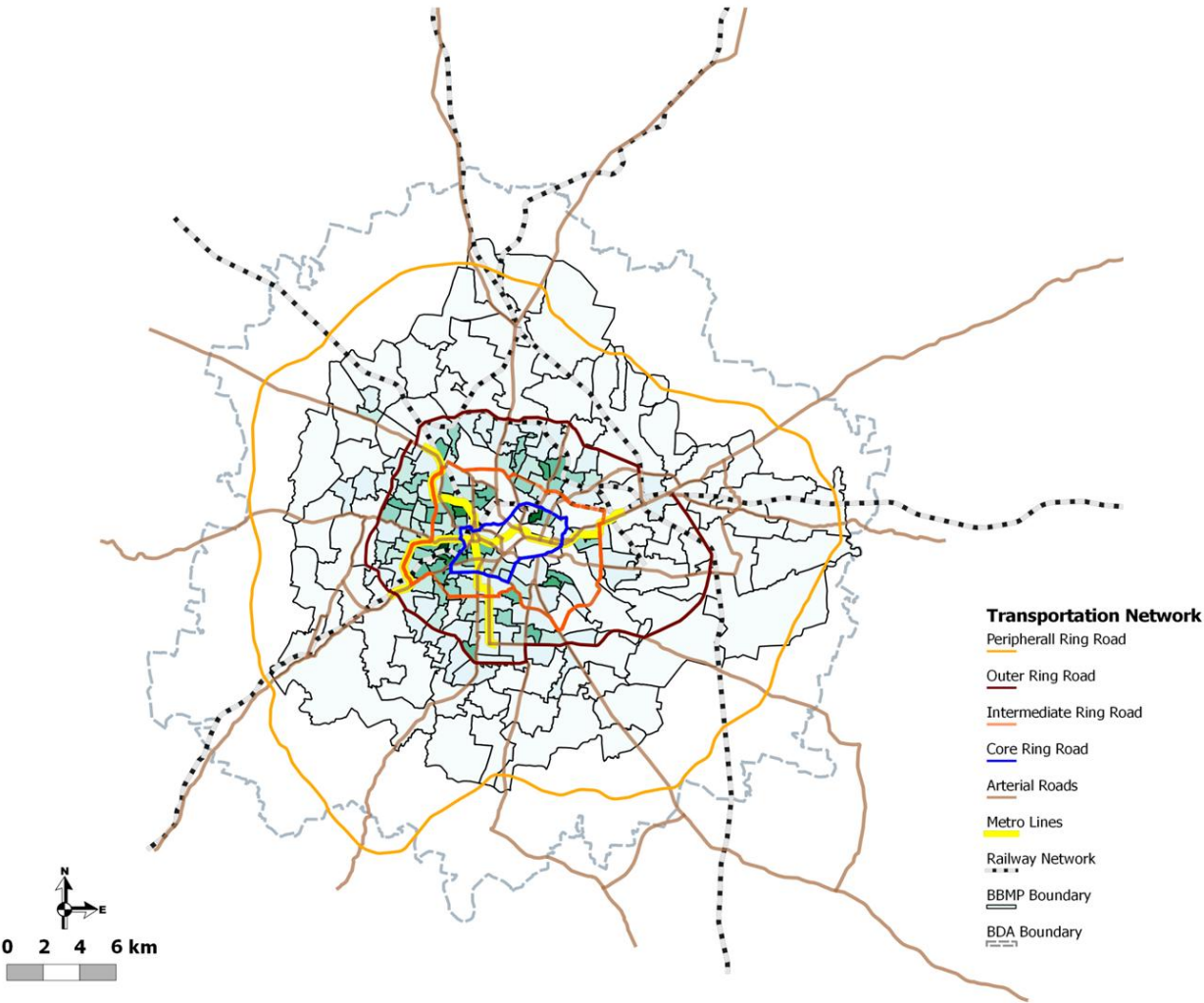
With no natural features restricting its development, spatial growth patterns of Bangalore city are characterised by urban sprawl, increasing the distances the city residents have to travel to work. Bangalore's physical footprint has increased by over 100% from 1992 to 2009 with a 134% increase in built 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%.

²⁰ 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.

Figure 12. Transportation networks in Bangalore



Source: IIHS

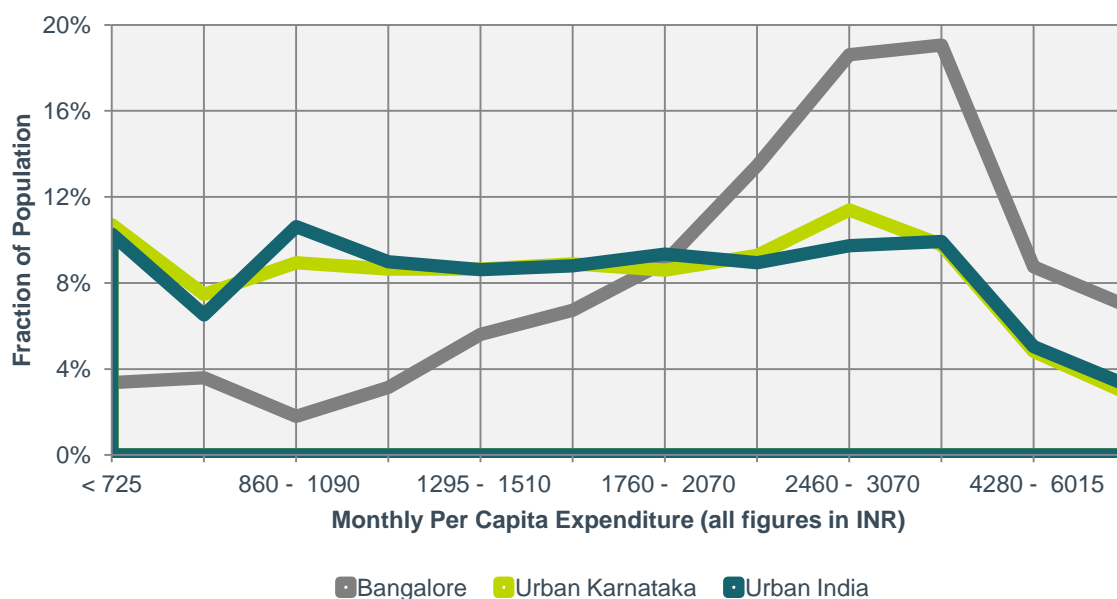
4. Vulnerability to Risks

4.1. 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 vulnerable²¹ 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 13)²²

Figure 13. 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 study conducted by the Development Planning Unit at University College London, and Atkins indicates, **approximately 43 per cent of Bangalore's population lives in multi-dimensional poverty**²³. In addition, data points to an increasing marginalization of work, with marginal workers increasing at a faster

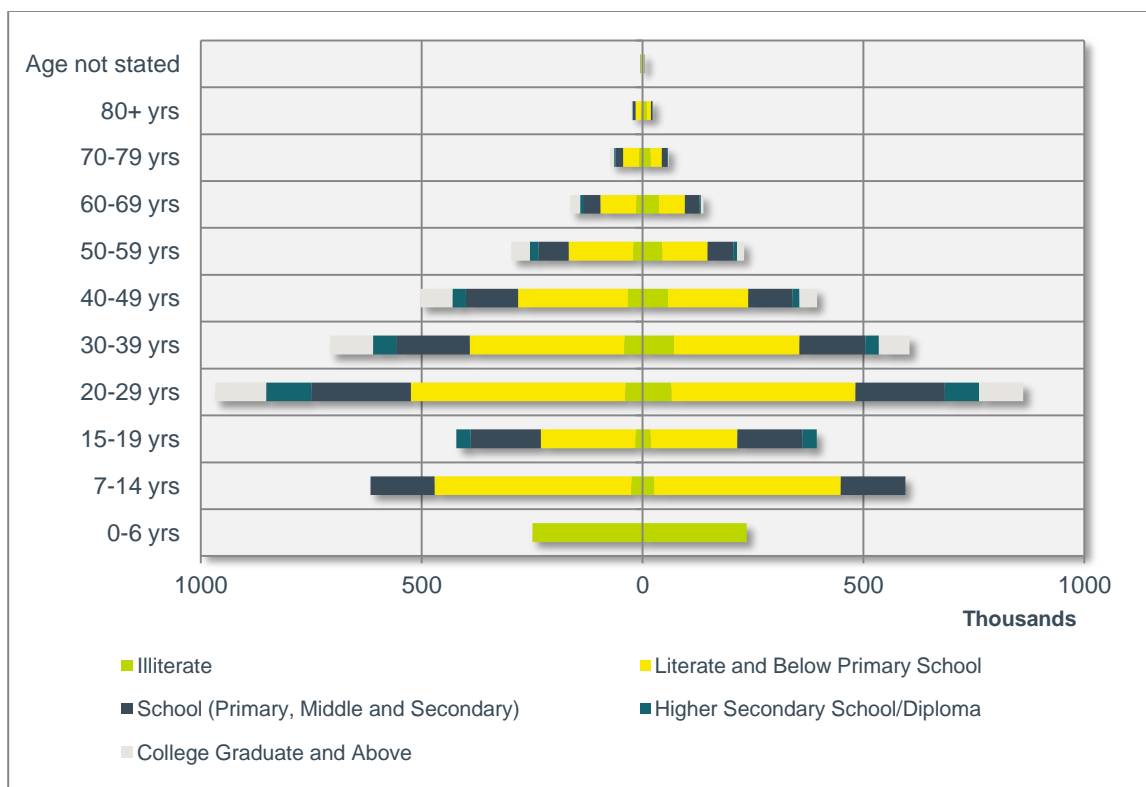
²¹ We define vulnerability as the degree to which a city and its inhabitants are susceptible to and are likely to be detrimentally impacted by the stresses and shocks associated with climate change, resource scarcities, and damage to vital ecosystems. At the heart of all definitions of vulnerability is the notion of 'lack of means to cope' with the adverse impacts associated with shocks and stresses.

²² 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.

²³ Future Proofing Cities (2012), Atkins in partnership with DFID and UCL

rate than main workers, leading to a growing proportion of marginal workers in the total workforce despite the overall proportion of marginal work being relatively low (see **Error! Reference source not found.**). Bangalore also has a high proportion of people that are illiterate, or are literate and have not completed primary school. The big challenge emerging from this picture is the large cohort of 20-29 year olds that are entering the workforce with very low levels of education and literacy (see Figure 14).

Figure 14. Age and Education Pyramid: Bangalore U.A (2001)



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)²⁴. 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 directly²⁵. 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 dumps²⁶.

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

²⁴ Solomon, 2000

²⁵ CIVIC, 2008

²⁶ CIVIC, 2008.

growth and weather events, such as irregular rainfalls and monsoon cycles, leading the city to periodically suffer from shortages and power cuts²⁷).

4.2. 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.

Table 5. Bangalore: strategic vulnerabilities to climate-related risk²⁸

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

Source: IIHS

²⁷Khandekar, 2008

²⁸A 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.

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



Source: IIHS

5. Capacity to Respond to Risks

The capacity of Bangalore to respond to the environmental risks to its growth and prosperity will be shaped by the strength of its governance and planning structures, and its ability to access, mobilise, and structure financing to respond to identified risks. This section provides a short overview of the main challenges shaping the capacity of the city to respond to the identified risks. Targeted work is needed to unpack how these issues are likely to impact the ability of the city to respond to priority issues. This will be taken forward in the next phase of the project.

5.1. Governance

The mandate for planning and governance at the local level in India is typically a fractured one – the responsibility for these functions distributed across a range of city, parastatal, and state-level agencies. Municipal corporations in Indian cities are often financially strapped, understaffed, and lack the technical capacity to undertake planning and development functions. Responsibility for planning and development often lies largely with state government-appointed parastatal bodies like the development authorities, as is the case in Bangalore. In addition, there are several non-state actors that are involved: academic and research institutions, a very active civil society, and a range of private sector players.

In the case of Bangalore, and Karnataka, as in several other Indian cities, there is no single agency at the city level that controls future urban planning and development. In fact, this power is dispersed widely among several municipal and state-run agencies, often leading to contentious decision-making as jurisdictions and functions of the various agencies tend to overlap. Moreover, in the case of parastatal agencies like the developmental authorities, the officials involved in planning and governance are more often state-nominated bureaucrats rather than democratically elected local officials (Sami, 2012).

The distribution of authority in Bangalore is being shaped by a process of decentralization that originated with the introduction of the 74th Constitutional Amendment in 1992. The document delegated planning, regulation and development authority to Urban Level Governments (ULBs). With over 1 million inhabitants, Bangalore falls into the Urban Local Government (ULB) type known as a Municipal Corporation, an urban governance body made up of elected councillors and a Mayor elected for one-year turns. In Bangalore, the Greater Bangalore City Corporation, known as the Bruhat Bengaluru Mahanagara Palike²⁹, is in charge of provision of elementary education, basic health care, infrastructure and development strategies, safety, sports, recreation and entertainment³⁰.

In spite of the endorsement of the 74th amendment, much of the power over development in the municipal region still resides with the state government, whereas the City Corporation is comparatively underfunded and services are provided by an array of parastatal bodies (Table 1)³¹. The Bangalore Development Authority (BDA), which is the parastatal body responsible for urban development, planning of land use and infrastructure, has remained comparatively understaffed, with limited political support and financial resources³².

The ability of the municipal government to tackle local challenges in a comprehensive fashion and to direct development in a sustainable direction has thus been limited. Fragmented authority is an impediment to dealing with risks such as urban sprawl, which need to be mitigated by integrated planning. So far, the government's ability to shift development trajectories away from escalating energy use and rising emissions also seems to have been restricted. This may, however, have more to do with development priorities than government capacity.

²⁹ BBMP, 2012. In an effort to empower the local government in 2006, the Bangalore City Corporation merged with nearby municipal, town and village authorities to form The Greater Bangalore City Corporation.

³⁰ Sudhira, 2007

³¹ Parastatal agencies are organisations that depend of the state government but operate in different administrative areas. This system has been criticised for lack of democratic legitimacy, as parastatal agencies handle service provision at a municipal level, but may not be held responsibility to the urban population for shortcomings. For example, the Bangalore Water Supply and Sewerage Board (BWSSB) is in charge of water supply and wastewater treatment and the Bangalore Electricity Supply Company is in charge of power distribution (Sudhira, 2007; TERI, 2009).

³² Ghosh, 2006

According to the Future Proofing Cities (FPC) framework, the capacity of cities to act and respond to risks and vulnerability depends on the economy of the city, governance structures, the ability and capacity to plan, and access to finance³³. All of these are areas for concern in Bangalore. The key to all of these however lies in the governance of the region. To be able to convene stakeholders across different political and administrative mandates is a critical area of focus for the FPIC project. This has been evident in our engagements with various government stakeholders. **While the major planning agencies in Bangalore have been willing to participate in initial engagements, they are hesitant to commit to more, particularly because they do not consider issues relating to planning for climate change as part of their mandate.**

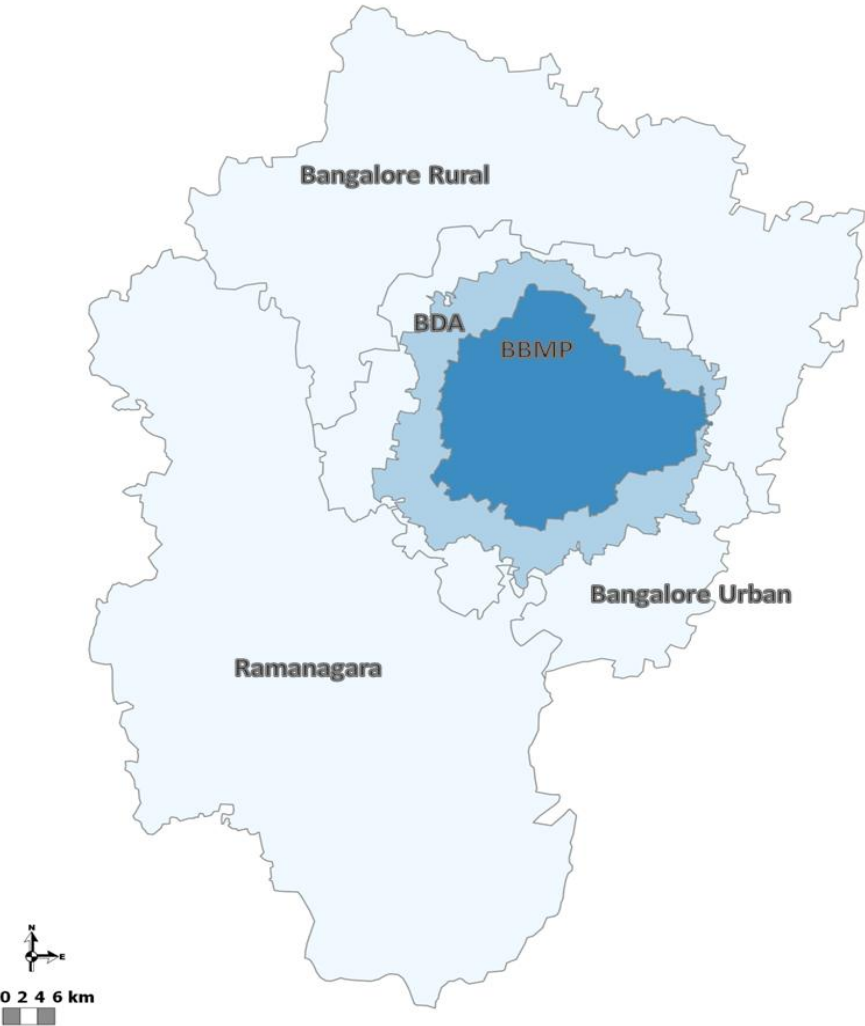
There is also a fundamental conflict in the perception and understanding of the gravity of the issues that climate change will bring to Bangalore. **While there is agreement and buy-in at the higher levels of government, there is little understanding of these issues at the local institutional (operational) level.** A more essential concern here in Bangalore is to build an understanding and a capacity to deal with these issues at the city level. For example, planners from the Bangalore Development Authority, the key planning agency for the city, indicated that this was not part of their mandate, but rather that of the environmental department. They also did not identify these as critical issues for Bangalore.

However, the new master plan does incorporate an integrated planning approach, and mentions the need to plan for the impacts of climate change in Bangalore. Therefore, there is an understanding of the issues and a buy-in at the higher level, but this does not translate into capacity or understanding at the operational level, and have a limited capacity to respond. All government stakeholders that we talked to also indicated a preference for engaging around a concrete project. While the state of Karnataka has a Disaster Management Authority with a policy for disaster management and a State Climate Action plan in place as well as district level disaster management authorities for the Bangalore metro region, they have not begun to operate effectively.

Figures 16, 17 and 18 below show the administrative boundaries for different agencies in Bangalore: the BDA (planning), the BBMP (municipal corporation), the BWSSB (water supply and sewerage), and BESCOM (electricity). **As is evident, there are multiple administrative boundaries leading to conflict between the various agencies.** There is also considerable fragmentation in the planning and governing process in the city. Moreover, as the BESCOM and BWSSB boundary maps below show, the utility networks and service areas have completely different boundaries which do not map very well on the administrative jurisdictions of the planning and governing agencies. Figure 19 shows the distribution of functional responsibilities between various government agencies in Bangalore, indicating the complexity of the governance systems in the region.

³³ Future Proofing Cities (2012), Atkins in partnership with DFID and UCL

Figure 16. Administrative boundaries in Bangalore



Source: IIHS

Figure 17. BESCOM Service areas in relation to the planning and municipal jurisdictions for Bangalore

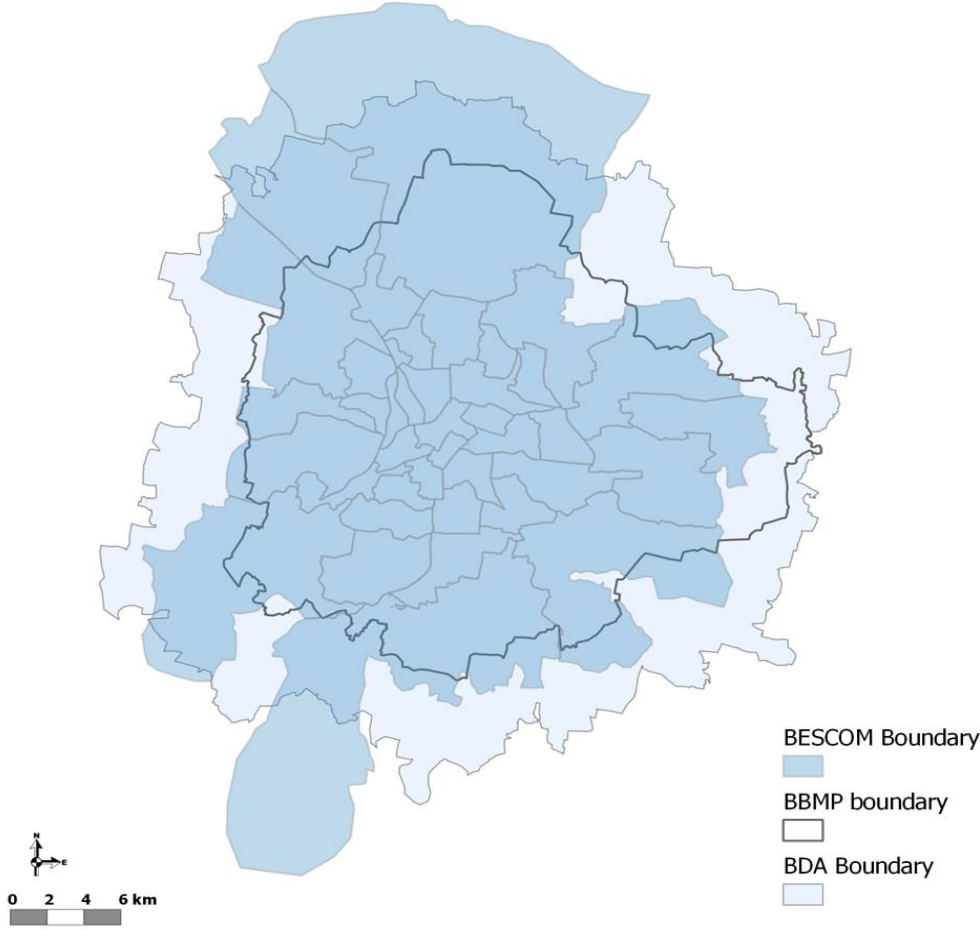


Figure 18. BWSSB divisions in relation to planning and administrative boundaries

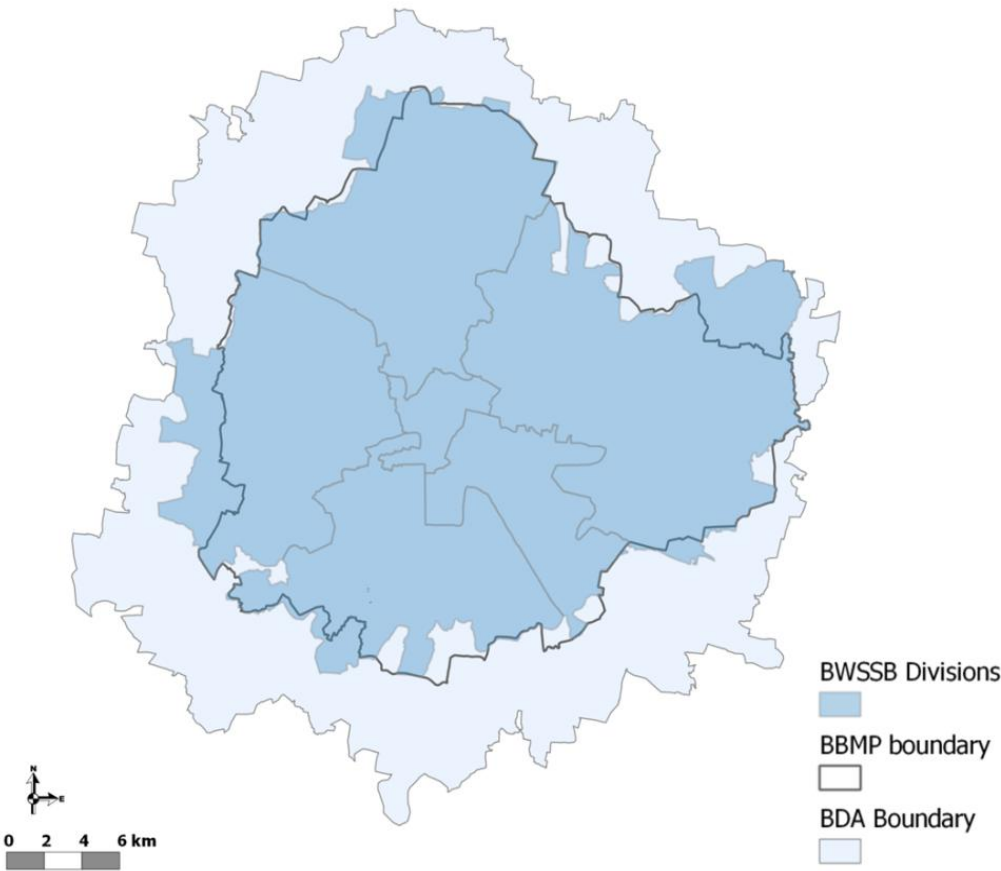


Figure 19. Functional analysis of government agencies

Agency	BBMP	BDA	BMRDA	BWSSB	BESCOM	BMRL	BMTCL	KSRTC	KUIDFC	KSCB
Jurisdiction	Municipal limits	Urban dvpt. area	Metro area	Metro area	Metro area	Metro area	Metro area	State-wide	State-wide	State-wide
Water, sewerage, & drainage										
Electricity										
Transport: road										
Transport: rail										
Road infrastructure										
Development control										
Slum clearance & rehabilitation										
Urban finance										
Tax collection										

Key

Original function		Overlapping function		Coordinating function	
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Source: IIHS analysis, 2013

5.2. Finance

The Corporation has historically been dependent on external resources for implementation of its capital programmes. Rates of collection for local taxes and levies are low and no revenues are forthcoming from areas of informal or unauthorised development to support infrastructure enhancement. The city does not measure favourably against national benchmarks and some infrastructure improvements remain partially implemented as insufficient match funding has been mobilised.

Most Indian cities have a significant proportion of residents living and working in the non-formal sector and many cities have a poor fiscal base. Bangalore is no exception. The management of resources at a city level therefore needs to embrace a variety of levels and diverse practices, ranging from the formal private and state sectors to community-managed local systems.

There is a need to find new solutions to mobilise funding to address the challenges facing the city. There is a growing realisation among urban managers on the need to innovate, especially in the context of declining state and central government's financial support to ULBs, to sustain investments and to carry on their functions. Bangalore has the opportunity to enhance its resource base through a series of reforms at local levels and by making the case for funding from a range of other sources including international agencies and the private sector.

There may be potential for funds in the form of direct borrowing from capital markets (through municipal bonds), or through appropriate financial intermediaries or institutions and various other arrangements for attracting direct private investment (indirect access).

In order to access such funds or supplement resources by way of external borrowing, the city will need to strengthen its finance and budgeting capabilities and to make progress in revenue collection and local contributions towards service provision and enabling public-private partnerships.

5.3. Planning

Land use in the Bangalore municipal region is planned by the BDA, mainly through Comprehensive Development Plans (CDP) that are drafted every ten years³⁴. The current CDP determines the amount of land allocated for different purposes in the city (such as residential and industrial land use), prohibits development in Green Belt Areas and aims to extend infrastructure provision into peri-urban areas³⁵. One major plan for urban development and infrastructure upgrading is the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), out of which investments have been directed towards large infrastructure projects and to some extent towards redevelopment and service provision of informal settlements.

Implementation of the CDP plans has often been ineffective and the planning process tends to remain inaccessible for most of the population³⁶. As a result, planning strategies in the city have to a large extent been directed towards the needs of the IT and outsourcing industries with the BDA favouring the creation of a business friendly environment and construction of iconic projects, in order to promote Bangalore as a Singaporean-style hi-tech city³⁷. In fact, much of the low-carbon or poverty reducing economic transformations that have taken place in the city have not appeared as the result of master-plans, but rather through the activity and strategies of the private sector, civil society or poor inhabitants themselves³⁸.

The co-ordination between the formulation of plans to support urban development and sector plans for infrastructure is weak, leading to gaps. Whilst there are formal mechanisms in place to develop land use strategies for the long term growth of the city, the plans focus on identifying future opportunities for land development and the zoning of land and are not formulated to fully respond to the full range of development needs of the city in terms of socio-economic development, infrastructure needs, environmental protection and safeguards. For example, there are no policies in place to safeguard areas at risk from flooding or water bodies from development. Guidelines and

³⁴ Sudhira, 2007. The most recent one, the Bangalore Revised Master Plan 2015 was drawn up for 2005-2015 and latest revised in 2007, and envisages a "compact, balanced and equitable, urban growth" (GOK, p.9, 2007).

³⁵ GOK, 2007; Sudhira, 2007. Industrial areas, which tend to be located at the outskirts of Bangalore, are planned by the Karnataka Industrial Area Development Board (KIADB).

³⁶ Ghosh, 2006. Due to limited time and resources available for the preparation of this report, this discussion does not extend to an analysis of who plans, implements and is held accountable (however, an illustration is provided in Table 1). Another problem is that planning has not considered land use patterns, which has led to stereotyped responses, such as road widening, which in many cases have proven unsuitable (Sudhira, 2007).

³⁷ Nair, 2000. The central areas have been populated by up-market stores, international banks and international food chains, and the authorities have invested in mega-projects such as exclusive mass housing rather than upgrading of informal settlements, which has involved resettlement of poor inhabitants to peripheral areas (Solomon, 2000). Until 2015, the BDA has reserved 2'500 hectares for development of the IT sector (1'500 hectares for all other industries) and employed preferential policies of land-acquisition for the IT-industry (Ghosh, 2006; Harriss, 2010).

³⁸ Solomon, 2004

mechanisms to promote sustainable models of city development were has been identified by stakeholders in the city as a gap.

The speed of growth and lack of staff to enforce planning regulations often means that the independent decisions of landowners drive city development rather than the long term interests of the city and its citizens. Major decisions with respect to the approval of masterplans and city development plans rest with the state level nodal agencies. The number of qualified staff which the city has is relatively small compared with other cities of its size. The resources the city has to follow up on development opportunities are limited and the penalties for non compliance are an insufficient deterrent.

The lack of an effective mechanism to acquire, assemble land, and provide infrastructure and distribute serviced land to both citizens and the development industry, reduces the effectiveness of the city in meeting its development needs and is an impediment to growth. Development authorities in other cities play a role in this process and have had some success in addressing this issue. However, there is a need for the needs of those sections of the population who do not own land or property to be addressed.

Weaknesses and gaps in planning lead s to a situation where the urban poor are unable to afford and are generally deprived of access to basic urban services.. In such cases, even where these services are provided by the urban local bodies, the real beneficiaries are generally everyone else other than the urban poor.

6. Conclusion: Priority Areas for Future Proofing

The development of the urban diagnostic for Bangalore involved a range of with key state and city level stakeholders to better understand the most important environmental risks to growth, prosperity and Bangalore's development. This dialogue was used to review the relevant issues facing the city and validate and agree with relevant stakeholders the key priority areas which will form the basis for the development of a City Action Plan (CAP). This process is documented in further detail in the Appendix A.

Discussions with stakeholders revealed that Bangalore can capitalize on to move to a more sustainable path, particularly in view of a changing climate and growing vulnerabilities from the shocks and stresses that this will bring.

The specific climate and development risks the city stakeholders see as urgent areas for action were confirmed, and this highlighted the priority topic areas for Bangalore

First, Bangalore must address the challenge posed by the lack of access to water. The city is fortunate to have a single agency that manages water supply, sewerage, and sanitation. Our engagement with the Bangalore Water Supply and Sewerage Board (BWSSB) has helped us identify clear challenges that the agency is facing: (i) wastewater management, (ii) leakage reduction, and (iii) proper accounting for non-domestic uses.

Second, Bangalore's domestic and commercial energy use is growing with severe impacts on emissions: the city must begin to move towards a more efficient fuel mix, which includes a growing proportion of renewable sources as well as low energy alternatives.

Our consultations with government stakeholders indicate that while there is interest in engaging with the FPIC action planning process, the various planning agencies in Bangalore: the Bangalore Development Authority (BDA), the Bangalore Metropolitan Regional Development Agency (BMRDA), and the Bruhat Bengaluru Mahanagara Palike (BBMP) or the Municipal Corporation, continue to have a very specific lens on planning that is largely spatially driven. Therefore structuring further engagement around a particular sector(s) is likely to be most effective.

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Appendix A. Outcomes from Stakeholder Engagement Process

The process of stakeholder engagement in Bangalore involved several one-on-one meetings with officers of the State Government and city agencies. Through the stakeholder interactions during the diagnostic process, two key sectors have emerged as focal areas for Bangalore for purposes of the current exercise. Therefore, we are working closely with two agencies in particular: the BWSSB (the key water utility agency in Bangalore), and BESCOM (the key electricity provider to the city). A summary of the key meetings is included in this Appendix.

IIHS also has an on-going engagement with several of these institutions on a range of issues. The meeting dates indicated here are in addition to other interactions that we have with government officials on a regular basis.

Name of agency:

Government of Karnataka

Name and position of the Interviewee and Institution:

Dr. Amita Prasad, Principal Secretary, Department of Energy, Govt. of Karnataka

Mr. Govindraju, Executive Engineer, Electrical, (EMC Cell), Department of Energy, Government of Karnataka

Date and Location of Meeting(s)

October 28, 2013 (Telephone interview)

November 6, 2013, Vikas Soudha

Interviewer(s)

Sathish Selvakumar

Devi Kalyani

Neha Sami

Sumetee Pahwa-Gajjar

Summary of the discussion

Dr. Prasad was provided a brief summary of the FPIC project. She suggested that we meet with officers at the state and city level who work on electricity and non-conventional energy. She also put us in touch with an officer: Mr. Govindraju, from her department who would facilitate these meetings. She requested IIHS to send her a draft of the report when it was available to circulate.

Mr. Govindraju provided the team an overview of the state's energy priorities, and future trends. He also shared some state-level data for the past year, as well as specific policy documents and government orders that indicated a shift towards renewable energy at the state level. He agreed to put the team in touch with officers at the Bangalore Electricity Supply Company (BESCOM), the electricity distribution company.

Name of agency:

Bangalore Electricity Supply Company (BESCOM)

Name and position of the Interviewee and Institution:

B.C Shivanna, General Manager, Demand Side Management

Mr. Chikkaninjappa, Chief General Manager Electricity (Operations)

Mr. Malleshappa, Deputy General Manager, Operations, BESCOM

Date and Location of Meeting(s)

September 27, 2013 (Telephone interview)

September 30, 2013 (Telephone interview)

November 19, 2013, BESCOM office

Interviewer(s)

Amogh Arakali

Neha Sami

Summary of the discussion

Following discussions with the State's Energy Department, the team met with several officers from the Bangalore Electricity Supply Company (BESCOM). Chief Gen Mgr Operations explained that different sub-divisions and departments within BESCOM dealt with the different dimensions of electricity distribution and consumption, and advised meetings with these divisions.

The Deputy General Manager Operations, provided the IIHS team with information on current energy consumption in Bangalore city, including official data for the last year. More work would be required to obtain the data on sectoral breakup of energy, and the cost of power purchase and transmission. He advised the team to meet the relevant departments for these.

The meetings with BESCOM indicated that while there is interest in engaging with the project process, there is a need for specific areas in which proposals and strategies need to be outlined to obtain their formal interest. At the current juncture, BESCOM appear to be willing to share data and information.

Name of agency:

Bruhat Bengaluru Mahangara Palike (BBMP), Municipal Corporation

Name and position of the Interviewee and Institution:

Mr Lakshminarayan, Municipal Commissioner, BBMP

Mr C S Umashankar, Executive Engineer, (Technical Advisor to the Municipal Commissioner), BBMP

Mr V. Yashwanth, Special Commissioner (Projects), BBMP

Mr Santhosh Kumar, Environmental Engineer (Solid Waste Management and Health), BBMP

Date and Location of Meeting(s)

September 20, 2013, BBMP office

September 26, 2013, BBMP office

October 3, 2013, BBMP office

October 5, 2013, BBMP office

October 7, 2013, BBMP office

Interviewer(s)

Garima Jain

Devi Kalyani

Summary of the discussion

The BBMP Municipal Commissioner's office has started sharing information on specific sectors and the current portfolios on resilience building and risk reduction. They have also expressed interest in discussing sites in the city as potential pilot test locations for particular planning and infrastructure interventions. The meetings revealed their interest in the idea of resilience planning for Bangalore. While they recognise there is limited understanding of integrated risk assessment, they are willing to explore the possibilities of integrating a resilience and climate-planning framework. At the current juncture, it will be prudent to keep the engagement of officers and divisions of BBMP albeit a concerted agency-level commitment may not be forthcoming given the agency's myriad pre-occupations.

Name of agency:

Bangalore Development Authority (BDA)

Name and position of the Interviewee and Institution:

Mr Rangesh, Town Planning Member, BDA

Mr Thippeswamy, Joint Director, Planning Department, BDA

Mr. Shyamanna, Deputy Director, Planning Department, BDA

Date and Location of Meeting(s)

September 23, 2013, BDA office

September 27, 2013, BDA office

Interviewer(s)

Neha Sami

Geetika Anand

Summary of the discussion

The Bangalore Development Authority (BDA) is the primary planning agency for the city. During the course of the meetings with the IIHS Team, the planning officials at the BDA indicated that they would prefer a more focused engagement around a particular sector or area, where the benefit to the BDA were clearer and tangible, and where there would hence be a closer alignment with their mandate. Infrastructure financing was not being explored at this stage, but the agency was open to ideas in this regard.

The Planners' Team at the BDA perceived climate change and related impacts more as mandates of the State/city environment and forestry departments. These were not identified at present as critical issues for Bangalore. However, the new Master Planning process does incorporate an integrated planning approach, and mentions the need to plan for the impacts of climate change in Bangalore. Therefore, there is an understanding of the issues and a buy-in at the higher level, but this does not translate into capacity or understanding at the operational level at the current juncture. There is hence perhaps a limited capacity to respond to the current exercise on part of BDA.

Name of the agency:

The Bangalore Water Supply and Sewerage Board (BWSSB)

Name and position of the Interviewee and Institution:

Mr M.S. Ravishankar, Chairman, BWSSB

Mr Lokesh, Financial advisor, BWSSB

Date and Location of Meeting(s)

September 25, 2013, BWSSB office

October 1, 2013, IIHS office

Interviewer(s)

Krishna Balakrishnan

Neha Sami

Summary of the discussion

The Chairman of BWSSB expressed interest in engaging with the current exercise and he appeared keen to exploring specific avenues or projects. He proposed deputing a member of the New Initiatives cell at the BWSSB to attend a water-specific consultation.

Mr. Lokesh, Financial Advisor at the BWSSB visited IIHS and held discussions with the team. According to him, the three priority requiring intervention were:

Wastewater management:

BWSSB has been making efforts to encourage reuse of treated wastewater by industrial units in Bangalore. Wastewater after secondary treatment is supplied at Rs.9/KL and after tertiary treatment at Rs.15/KL. But only 5 to 10 % of treated wastewater gets sold every month since industrial units seem to prefer buying water from private water tankers rather than arrange to pick up water from BWSSB wastewater treatment plants. Therefore rest of the treated wastewater gets discharged into surface water bodies. So, interventions to encourage wastewater reuse (eg: dual piping in the newly developing areas) would be a big priority.

Leakage reduction

BWSSB pays about Rs. 25 to 30 Crore (INR) every month to BESCOM out of a total monthly revenue of about Rs. 45 to 50 Crore (USD XYZ). This revenue forms about 48% of the water supplied and the rest 52% is Non Revenue Water. Therefore reducing unaccounted for water (UFW) is a major priority area.

Proper accounting for non-domestic water use

BBMP has registered about 12 lakh properties in Bangalore out of total of about 15 lakh properties. BWSSB provides about 6.5 lakh connections. Out of these only 10 to 15,000 are non-domestic connections. This is a very low number considering there are at least 1 to 1.5 lakh (100 to 150,000) industrial units alone within the BBMP jurisdiction. Hence, either many of these non-domestic consumers are using domestic connections or relying on groundwater or purchasing tanker water. By properly identifying and accounting for the non-domestic consumers who are using BWSSB water, revenues could increase substantially.

Name of agency:

Bangalore Metropolitan Regional Development Authority

Name and position of the Interviewee and Institution:

Mr Lingamurthy, Additional Commissioner, BMRDA

Date and Location of Meeting(s)

September 30, 2013, BMRDA office

Interviewer(s)

Neha Sami

Amogh Arakali

Summary of the discussion

Bangalore Metropolitan Region Development Authority (BMRDA) is an autonomous body created by the Government of Karnataka under the BMRDA Act 1985 for the purpose of planning, coordinating and supervising the development of the areas within the Bangalore Metropolitan Region (BMR) which comprises Bangalore urban district, Bangalore rural district and Ramanagara district.

The Addl Commissioner, recommended the IIHS Team to meet with the town-planning department within the BMRDA instead. He also recommended that we engage more closely with the BDA rather than the BMRDA, as the former appeared more suited to the current exercise. While the IIHS team is pursuing engagements with the town planning department of the BMRDA, it seems unlikely that the agency will exhibit any major interest in the current exercise.

Name of agency:

The Bangalore Metro Rail Corporation Limited (BMRCL)

Name and position of the Interviewee and Institution:

Mr Pradeep Singh Kharola, IAS, Managing Director

Date and Location of Meeting(s)

September 13, 2013, BMRCL office

Interviewer(s)

Neha Sami

Summary of the discussion

The BMRCL Managing Director advised the IIHS team that the Metro Rail Corporation was also a party helping mitigate environmental issues. The agency was not seized of the current exercise while they may be interested in commenting on the final action plan proposed. The scale of financing available under the current exercise was minuscule compared to the resource requirements and financing available to the BMRCL.

Inferences from the stakeholder engagement process

The foregoing account of meetings and interactions with Stakeholders in the Govt of Karnataka and Bangalore agencies shows a mixed picture of interest in the current exercise.

- There are fundamental differences in the perception and understanding of the gravity of the issues that climate change will bring to Bangalore. While there is appreciation of these issues at the higher levels of government, there is perhaps only a limited awareness of these issues at the operational levels.
- The institutions (State and city level agencies) that operate in Bangalore have considerable gaps and overlaps in institutional arrangements and operational functioning. This necessitates an exercise like this to work across these institutions but poses considerable difficulties too.
- There is also a reluctance to sharing programmatic resources between agencies. If the quantum of funding is not significant, this also detracts from according institutional priority to subjects and issues perceived as new.
- A fundamental concern in Bangalore is the need to building awareness and understanding of issues that the current exercise is seeking to highlight, and these also involve building capacities to deal with these issues operationally.