Urbanisation - Poverty - Climate Change

A SYNTHESIS REPORT - INDIA

Case Studies

Volume II

Rockefeller Foundation
Innovation for the Next 100 Years

ACCCRN Asian Cities Climate Change Resilience Network

TARU

teri

November, 2013

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- Poverty -
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Prepared by

GEAG Gorakhpur Environmental Action Group

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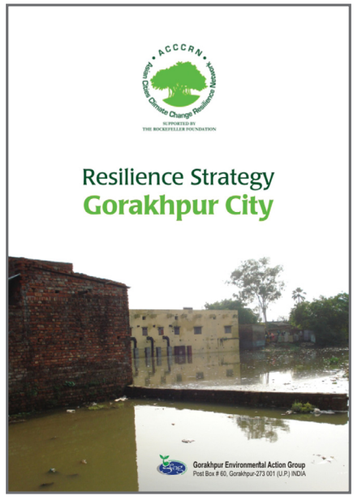


Prepared by:
Gorakhpur Environmental Action Group (GEAG)

Full Version of the Gorakhpur City Resilience Strategy can be downloaded from:
http://www.acccrn.org/sites/default/files/documents/IN_Gorakhpur_Aug10_resilience%20strategy_%20GEAG.pdf

1

1.1 INTRODUCTION

End of twentieth and beginning of twenty first centuries witnessed to two unprecedented changes happening across the globe. First was unrolling of economic reforms that continue to shape economic growth of large number of developing countries. Akin with pace of economic growth is rapid growth of urban centers all over but more particularly in South-East Asian countries[1]. Before it came to be realized such is the pace of economic change that almost 50% of world population has suddenly come to live in cities. India is no different and has observed 53.7% growth in number of towns in last decade[2]. According to recent World Bank report[3], India accounts for one-third of world poor[4]. It is implicit therefore that contrary to prevailing perceptions of poverty being endemic to villages in India, urban areas too are now home to millions of poor people. From where and why do poor people come to settle in urban areas, very often in most appalling subhuman living conditions is key question that needs serious thinking.

Parallel to global economic reforms but not necessarily consequence of it is growing concern of climate change. Climate being over arching phenomenon affecting every other function on earth, any significant change in climate has potential of affecting social, economic and political milieu of nations. Relation between economic growth and climate health is perhaps better understood in recent times than it was thought ever before. Government policies and development initiatives are more interested and inclined in favor of supporting sustainable models of economic growth and development. Climate impacts viz. floods, cyclone, draught and temperature whilst are increasingly becoming more devastating and frequent, beckons serious relooking and mainstreaming of into planning considerations of development projects.

Quest for sustainable development and to button down problems of urbanization, economic growth and climate change is extensively pursued at various levels. All said and done, what is visible more and more is shift in livelihoods of people from farm to non-farm based employment sectors. Development policies need to recognize and address current occupational shifts and make suitable corrections and adjustments, thereof.

City Resilience Strategy (CRS) is premised to address climate impact challenges faced by city systems and services offered to people. Strategy document has been conceived, designed and developed to test notion of resilience of a city made vulnerable to climate change impacts. Strategy document is enriched by first-hand experience of local people who have withstood many disasters by being at the center of it. Lessons drawn from other countries and important policy analyses go into making of present strategy document for its application by city managers. CR attempts to capture complexities of urban systems and suggests short to long-terms interventions to build city resilience. Strategy chooses to empower local people and their institutions who it believes hold keys to process of building resilience of city.

1.2 THE CITY

Gorakhpur is situated on banks of two major river systems, namely Rapti and Rohin. It is spread over 147 sq. km. area and located at height of 75-85 meters above mean sea level. Gorakhpur is unique to have large number of water bodies; biggest among all is Ramgarh Tal in south-east part of city. Proximity of city to Himalayan mountain range and location in tarai region, Gorakhpur has moderate climate with annual average temperature 25.68ºC. Summer and winter temperatures however peaks to 31.95ºC and 19.57ºC respectively. City receives 119.2 cm of annual rainfall with maximum precipitation recorded in months of July to September.

Gorakhpur is one of the fastest growing cities of mid-Gangetic region. City is administered by 70 municipal wards having a total population[5] of 692519 spread unevenly in city. Old wards of city have very high density of population. Population of Gorakhpur has increased rapidly with record growth of 64.1% during 1981-1991 due to expansion of city by incorporating 47 peripheral villages into municipal area[6]. Large number of slums constitute roughly 33% of total population of city resides in 110 different locations with or without tenure rights.

1 Asian Cities Climate Change Resilience Network – Aug 2012
2 Ministry of Urban Development, GoI, January 2012
3 World Bank Report 2013
4 Less than 1.25 US$ (about Rs 65) per day

5 Census 2011
6 Master Plan 2021 of Gorakhpur

1.3 THE CONTEXT

In last couple of decades, Gorakhpur has been experiencing unprecedented problems of water logging in large areas of city causing loss of employment and physical damages to property. Health issues are grave concerns for the city and have been increasing in exponential terms with large number of deaths reported every year due to water and vector-borne diseases. Population growth and vehicular pollution have reached to levels which were never experienced before. There is fast depletion of open areas in city due to large scale unplanned construction all over. Civic services are at the nadir, non-existent or at best exist in unhygienic and unusable state. City becomes virtual hell and unlivable during rains. Gorakhpur is fast turning to become a place where rains are NOT welcomed any more by large number of households.

In backdrop of humungous problem faced by city, crucial determinant for success for city resilience was to develop a method and approach that people and administration equally share and also willing to support. Method need to assess and establish climate risks to city and determine consequent vulnerability of communities. It meant designing participatory tools using which hydrogeology of city, climate variability and allied risks and vulnerability of people is put into perspective of development planning for overcoming challenges faced by people. In following sections, general outline of method and strategy formulation is explained.

1.4 ELEMENTS OF RESILIENCE STRATEGY FORMULATION

Strategy has looked into following essentials into making of resilient city:

1.4.1 Understand historic climate trends and futuristic projection

Over hundred years of precipitation and temperature data is analyzed to understand historic climate events and trends. Similarly, temperature and precipitation projections of Gorakhpur city for years 2046 to 2065 is analyzed by running CGCM3, CNRM, MIUB and CSIRO climate models. Such analysis show maximum and minimum temperatures of Gorakhpur will increase and decrease respectively for maximum and minimum temperatures compared to past hundred years of climate. Projection data shows increasing trend of maximum temperature for all four seasons. There is not enough model agreement over precipitation data. It might decrease in period from December to February and increase from March to May and later during September and October. Historic climate data however show that Gorakhpur is experiencing same amount of rainfall in less number of days, meaning thereby heavy to very heavy rainfall in shorter spells.

1.4.2 Understand fragility of systems and service

It is important to understand people's access to system and service, what are the systems most impacted by climate change, why do systems and services become fragile, are these designed to withstand climate impacts and able to render services even when stressed, have systems been designed after taking climate projections into consideration, what are roles and responsibilities of people who manage/use systems and how is one system linked and dependent on other systems and implications of failure of one over other systems.

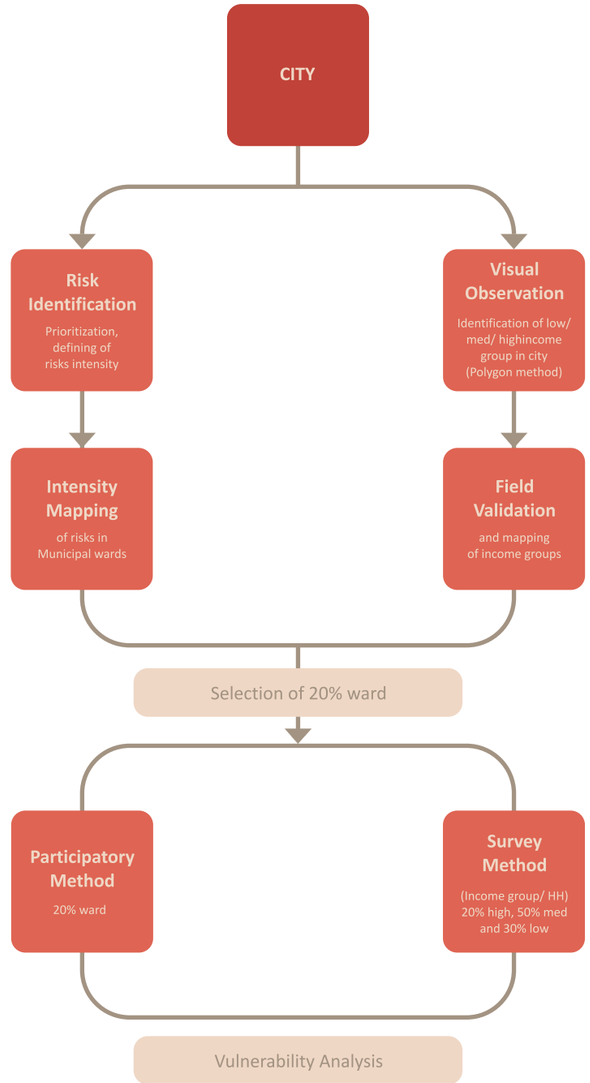
1.4.3 Understand vulnerability and resilience options

How do people cope and manage when denied access or deprived of accessing system and its services, who are most vulnerable and why are they so, what could be done to build resilience of people, systems and thus of city on whole

Inputs from above three steps have been extensively used in designing of city resilience strategy.

1.5 THE METHOD

Knowing well that climate impacts are harsh on vulnerable communities not properly protected or having safe access to infrastructures and services, it was challenge to design method[7] that well and truly represents entire city of Gorakhpur. Through rapid assessments and consultations with large population samples, preliminary survey inputs were collected. The city was divided into 7 police zones. Survey finding were shared and discussed with representatives of 7 zones. Representatives were facilitated to identify and also prioritize severity of climate risks, its impacts and vulnerabilities of communities in their respective areas. Perception mapping done with people were cross-validated with municipal data of services in respective wards. Using Google imagery and GIS techniques, 30% households were identified by stratified sample method for detailed household surveys were carried to ascertain climate impacts at micro-level on municipal services and systems. Sixteen problems related to systems and services were identified in Gorakhpur which was further prioritized into 5 core systems and services and recommendation for initial intervention with the Municipal Corporation of Gorakhpur.



Community perception of problem in Gorakhpur

Water logging
Unregulated traffic
Water quality
Sanitation
Solid waste
Road design
Drainage
Civic amenities
Population increase
Slaughtering of animal
Education
Stray animal
Poor infrastructure
Open space
Green cover
Unplanned construction

Priority problem

Water logging
Sanitation
Drinking water
Drainage
Solid waste

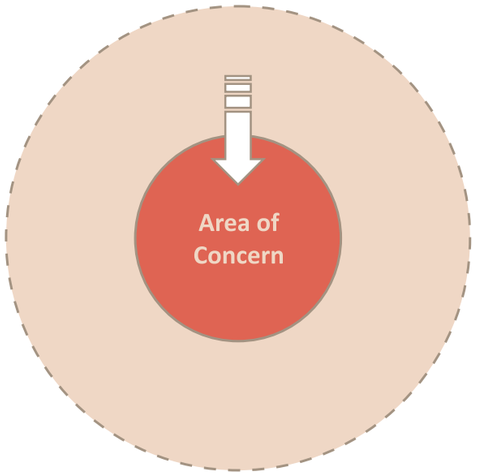
7 City Resilience Strategy Gorakhpur

1.6 RESILIENCE STRATEGY

Having identified and prioritized climate risks to systems and services and related vulnerability of communities, it was important to diagnose causes behind systemic failures and/or malfunctions when put under climate stressed conditions. It was more important to ascertain and establish systemic behavior under projected climate conditions for Gorakhpur city in order for strategy to recommend and influence short and long term investments decisions of Municipal Corporation for infrastructure development.

Climate change impacts in Gorakhpur have been broadly classified and put under three major causes. These are:

1. Natural causes
2. Behavioral causes of people who manage and use systems
3. Policy and political causes



1.7 THE APPROACH

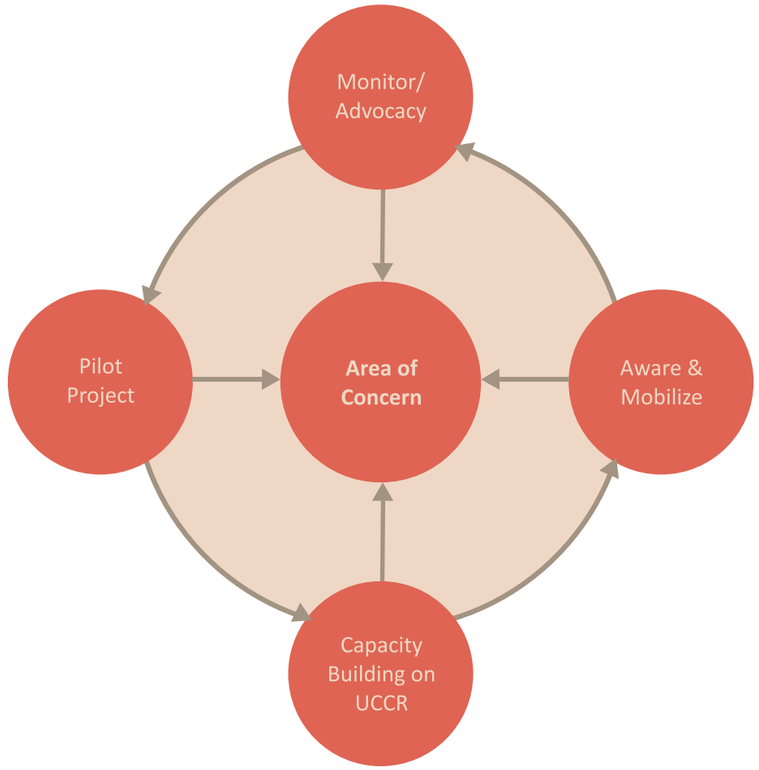
Approach towards city resilience is based on prudence of improving system efficiency through behavior change and performance improvement of people who manage systems and those who use. It works on principle of minimum demand for energy and investments together with high returns through public education and accountability measures. Resilience strategy of city is aligned with approach and to inherent principles therein. It addresses sphere of influence that works more at behavior to influence areas of concerns e.g. natural and infrastructure systems. In regions of high rural-urban ratio, it makes sense to work more at level of sphere of influence than sphere of concern.

In Gorakhpur water logging, drainage, solid waste, drinking water and sanitation services are hampered badly by climate change impacts. It is visualized that resilience could be build by addressing fragility of systems to climate change impacts by rendering improved access of communities to services and by quality implementation of rules and policies.

Major problems faced by residents of Gorakhpur due to climate change impacts have been put under seven groups each representing a sector.

Sector	Climate change, impacts and vulnerability
Basic services	Sanitation, hygiene, drainage and safe drinking water
Housing	Inundation, low cost house design for water logged situation
Industry	Industrial waste and pollution, safety at work place, housing for workers
Health	Seasonal outbreak of epidemic, preventive health, health surveillance
Energy/Electricity	Power failure and breakdowns, production/livelihoods, alternate energy
Transport	Efficient transport mechanism, vehicular emission,
Ecosystem	Conservation of public and open areas, water bodies

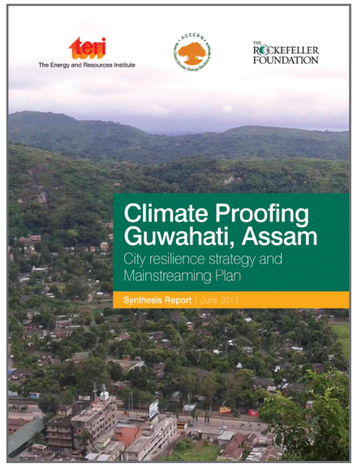
City resilience building is an evolving and continuous process. Therefore, CRS would need periodic reviews by stakeholders for needed adjustments. Proposed resilience strategy is unique in sense that it attempts to build synergy at three different levels i.e. system, users and providers and governing rules and policies. In Gorakhpur, out of seven interlinked sectors, four sectors have been identified for pilot interventions. Sectors like water, sanitation, drainage, housing, health and natural ecosystems are badly hampered under climate stressed conditions also are the most basic ones providing health, shelter and life to local populace. CRS has identified key actionable areas to build resilience of each sector in short and long terms



Climate Proofing Guwahati, Assam

City Resilience Strategy and Mainstreaming Plan

SUMMARY



Prepared by:
The Energy and Resources Institute (TERI)

Full Version of the "Climate Proofing Guwahati, Assam. City resilience strategy and Mainstreaming Plan" can be downloaded from:
https://acccrn.org/sites/default/files/documents/TERI_Guwahati%20Synthesis%20Report.pdf (English)

2

2.1 INTRODUCTION

As part of the Asian Cities Climate Change Resilience Network (ACCCRN), TERI has made an assessment of the risk and vulnerability of the city of Guwahati and has prepared a detailed resilience strategy. The focus of TERI's assessment is to facilitate adaptation initiatives and mainstream them into the city development paradigm to make Guwahati city more resilient and prepared towards the risks. This risk assessment largely extracted local information in the form of secondary data along with consultations with the government departments and relevant stakeholders. Besides this a climate scenario assessment was also carried out by TERI to understand the future implications of climate change on the city. Review of existing policies and governance framework of the city was an integral part of the assessment to identify channels for integrating adaptation and disaster risk reduction measures in planning and development.

2.2 ABOUT GUWAHATI AND ASSAM

The population of Assam according to the 2011 census stands at about 31 million, making it the 14th most populated state in India. The state is spread over an area of about 78000 sq. km. making it the 16th largest state in the country in terms of area. The density of population per sq. km. is about 397 against the national average of 382. It comprises of 27 districts, 219 development blocks and 26,395 villages[1].

Guwahati is the capital city of Assam and the largest city in the North East Region. The total population of Guwahati UA/Metropolitan Region is 968,549. Guwahati is located towards the south-eastern side of Kamrup district, surrounded by Nalbari district in the North, Darrang and Marigaon districts in the East, Meghalaya State in the south and Goalpara and Barpeta districts in the West. Located on the banks of the Brahmaputra River, it is the largest commercial, industrial and educational centre of the N-E Region. The city also surrounds one of the Ramsar Notified wetlands, the Deepor Beel which is under threat due to the encroachment and unplanned urban development of the city. The city is prone to floods and landslides and is located on the earthquake prone belt. The preparedness to deal with disasters and combat its impacts is low which has made the city and its residents quite vulnerable.

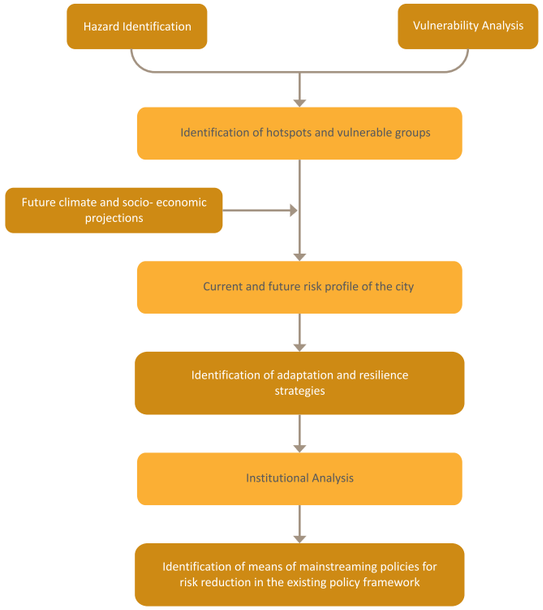
1 http://www.agriassam.in/agriHorti_profile/Profile_ofAgri-HortiSector_ofAssam-June2012.pdf

2.3 METHODOLOGY AND APPROACH

A detailed step by step description of the methodology adopted for risk and vulnerability assessment in Guwahati is given below:

1. **Hazard identification:** The initial step in risk assessment was the identification of natural, human-made and human induced hazards and stressors (climatic and non-climatic) which have been affecting the city of Guwahati. This was done on the basis of literature review, city level stakeholder consultation, and an analysis of the relevant secondary data.
2. **Vulnerability analysis:** An analysis of the characteristics of the city was conducted to determine the level of exposure to the identified hazards and stressors. Variables such as topography, population dynamics, socio-economic condition and land use pattern were studied to understand the sensitivity of the city to the hazards. The quantitative assessment was supported by an analysis of the spatial information retrieved from satellite imageries and inputs from the stakeholder consultations.

Figure 1: Study Framework



3. **Identification of hotspots**: Outcomes of the vulnerability analysis were used to identify and map the climate sensitive hotspots using GIS. The analysis also highlighted vulnerable communities and sectors as well as urban functions which are more vulnerable to risks and hazards.

4. **Climate projections:** Climate projections for 2030s at a resolution of 25 km X 25 km were conducted for the region to understand the change in temperature (mean, min and max) and precipitation from the baseline. For this purpose, daily outputs from PRECIS model were used at 25 km x 25 km resolution. Projections for A1B scenario for the time slice 1961-1990 referred to as 'baseline', and 2021-2050 referred to as '2030s' were utilized.

5. **Current and future risk profile of the city:** The information generated on vulnerable hotspots, communities and urban functions was used to generate the current risk profile of the city.

6. **Identification of adaptation and resilience options to address the risks:** In the next step, adaptation and resilience options to address these risks were identified. The strategy aimed at having a holistic set of sector specific adaptation options to address their vulnerability and building climate resilience in the city.

7. **Review of existing policies and legislations to identify gaps in addressing to risks:** A review of existing policies, legislations and by-laws was conducted to prepare a mainstreaming action plan.

2.4 KEY FINDINGS

Change in land use pattern of Guwahati city due to uncontrolled development activities is said to have done a lot of harm to the ecology and environment of the city. A trend analysis of the change in land use land cover shows an increase in the built up area. It is also evident that there has been more sprawl and infill development in certain pockets in the past 5 years. The city consultations and literature review about the city revealed three major components to hazards in the city:

1. Unplanned, unregulated urbanization and its consequences
2. Past climate variability and associated impacts
3. Disasters including floods, earthquakes and land slides

The individual consultations revealed that water supply is greatly hampered in the city during the flood events. Besides this, the overall lack of drainage, absence of solid waste management system and pollution of surface water bodies and ground water sources has created a vicious cycle that leads to flooding and water logging in the city every year. Cutting of hills for encroachment, constructing buildings and large scale deforestation in the city has led to blockage of drainage channels, destruction of top soil and high rate of soils erosion on the exposed hill slopes.

2.5 CLIMATE PROJECTIONS

2.5.1 Temperature trends

Data for both maximum and minimum temperature shows an increasing trend over the city of Guwahati. For minimum temperatures barring 1997 and 2011, all the years show a clear increasing trend in the values. Similarly, except for 2003-2005, values for the maximum temperature also show an increasing trend.

2.5.2 Rainfall trends

The daily rainfall data from Indian Meteorological Department Regional Meteorological Office (RMC), Guwahati from 1982-2011 was averaged to get monthly values. A decreasing trend of seasonal as well as annual rainfall over the city was observed. It was also observed that there has been an increase in extreme rainfall events resulting in more rainfall in short duration. This can be one of the attributing factors for urban flooding.

2.6 OUTPUTS OF TERI'S STUDY

2.6.1 City Resilience Strategy

As an output of this study, a city resilience strategy document was prepared which captured the key findings of the various assessment stages (climate projections, vulnerability, hazard and risk assessment exercise) and comprised of a set of sector specific adaptation options to address the vulnerability of the city. The following sectors were identified as the key sectors to address the present and future vulnerability of the city in the context of climate change impacts:

- Housing and urban planning
- Urban infrastructure and services (water supply; sewerage; natural and storm water drainage; solid waste management; electricity; health)
- Informal settlements and slums
- Ecosystems and land-use
- Emergency response capacity

2.6.2 Mainstreaming strategy

In order to ensure implementation of the recommended resilience measures, a mainstreaming strategy was also prepared with the aim of understanding the current institutional mechanisms to address the risks and disasters faced by the city. An integral step for this stage was review of existing policies, legislations and by-laws which helped in identifying the gaps in the existing policy regime to address the current and future risks. The strategy aims to communicate the means of integrating and mainstreaming policies for risk reduction in the existing policy and institutional framework of the city.

2.7 SUMMARY OF RECOMMENDATIONS

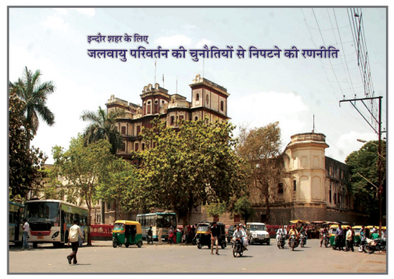
As a result of this assessment exercise, TERI has proposed several recommendations, some of which are highlighted in the table below. For instance, it was found that the ground water is inflicted by high fluoride and arsenic content and that the lack of sewage system is impacting the ground water quality. TERI therefore recommends that the city should take up the sewerage and storm water plan of the city with immediate priority. In addition, TERI also recommends the enactment and adoption of the 74th Constitution Amendment Act which devolves many functions to local bodies. This will empower the ULBs to make decisions and plan for their development and will also enable ULBs to initiate climate action.

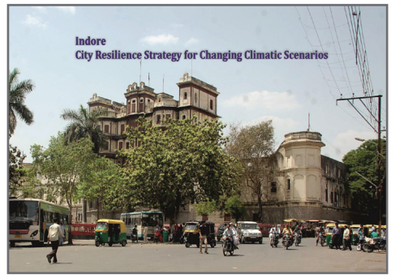
Table 1: Sector Wise Recommendations

Sector	Recommendation/Strategy	Vehicle
Housing	Guidelines for construction of buildings on slope Structural stability of buildings in hills and for the entire GMA Soil erosion and sedimentation control for construction in non-hill GMA areas Precautions and technical details for use of Septic tanks and Soak-pits Rain water harvesting for storage	Section 61 on 'Special regulations for construction in hilly areas' in the Building Bye laws for Guwahati Metropolitan Area need to integrate these points. Intensive micro-zonation studies to be conducted to identify vulnerable areas as per the sub soil conditions of GMA. Norms to be introduced in the Building Bye Laws of GMA 2006 Enforcement of Section 56 of 'Building Bye-laws for GMA 1998' and 'Revised Building Bye-laws-2006 for GMC' which states the necessary provisions and precautions to be followed for septic tank/seepage pits/dispersion trenches Section 65 (i)(b) in the New Revised Building Byelaws for GMC- 2006 provides for terrace water collection and connected to a recharge point in all group housing schemes/apartment and commercial complexes/institutional buildings. This provision should be mandated for such buildings
Urban planning	Demarcate eco-sensitive areas in the city as low/no built up areas Planning of 3 new satellite towns to be on the principles of sustainability	Change in land use zoning and development regulations Use of Urban Development and Plan formulation Guidelines (UDP FI) for norms for optimum densities, land use zoning in hilly areas while Master Plan formulation Use of National Habitat Standards as proposed under the National Mission on Sustainable habitat-One of the 8 Missions of The Prime Minister's National Mission On Climate Change.
Urban ecosystem management and conservation	Conservation of green areas/wetlands/beels-Inside the jurisdiction of GMDA	Preparation of Conservation and management plan for wetlands Preparation of inventory and demarcation of natural water bodies and green areas
Water	Augmenting the water supply system in the city Regulating withdrawal of ground water and rain water harvesting Water quality monitoring and control	Geo-hydrological studies for new projects Conduct exploratory studies for establishing new withdrawal points Centralized monitoring system through a quality monitor team
Drainage	Protecting and managing natural drainage systems of the city Restricting waste disposal in Bharalu and Bashishtha rivulets	Improvement of drainage in the Brahmaputra Valley and Barak Valley, including project planning and construction of dams, flood control and bank erosion measures. Identify points of drainage blockage/ encroachment in the rivulets
Electricity/ Power	Promoting energy efficiency urban land uses Promoting use of renewable energy sources	Employ fiscal measures like a progressive and use based tariff structure to promote energy efficiency Enforcement of energy efficient building code (ECBC) or GRIHA guidelines for energy efficiency in HVAC systems in buildings, particularly under institutional and commercial uses Implementation of Solar City Plan under the Jawaharlal Nehru National Solar Mission (as part of NAPCC).

Indore City Resilience Strategy for Changing Climatic Scenarios

SUMMARY





Prepared by:
TARU Leading Edge

Full Version of the "Indore City Resilience Strategy for Changing Climatic Scenarios" can be downloaded from:
http://indiaurbanportal.in/BestPracticesResult.aspx?type=3&SearchID=182
http://indiaurbanportal.in/Publications/Publications182/Publications182760.PDF (Hindi)
http://indiaurbanportal.in/Publications/Publications182/Publications182756.PDF (English)

3

3.1 HISTORY AND BACKGROUND

Indore is the most prominent city and commercial capital of Madhya Pradesh. It is also the headquarters' of Indore district. Indore agglomeration's population increased from 1.51 million persons in 2001 to 2.17 million persons in 2011(decadal growth rate of 42%). It was 17th largest city in India during 2001 and is now to 15th largest city.

Situated on the western part of the Malwa (Deccan Plateau) at an altitude of 550 m above mean sea level (MSL), it links Central India with the coast. The city lies in black cotton soil region in a relatively flat plateau having a gentle slope towards the north. The Khan River and its tributaries traverse through the densely populated areas of the city. The city of Indore had its first municipality in 1870. In the year 1956, it was declared as a Municipal Corporation and is currently governed by the Madhya Pradesh Municipal Corporation Act, 1956. The Indore Municipal Corporation is divided into 14 Zones administered by two functional bodies namely Political Wing (deliberative) and Executive Wing. The city has a municipal area of 134 sq.km and the total planning area (including IMC and Indore Development Authority area) is 524 sq.km.

3.2 URBANISATION ISSUES

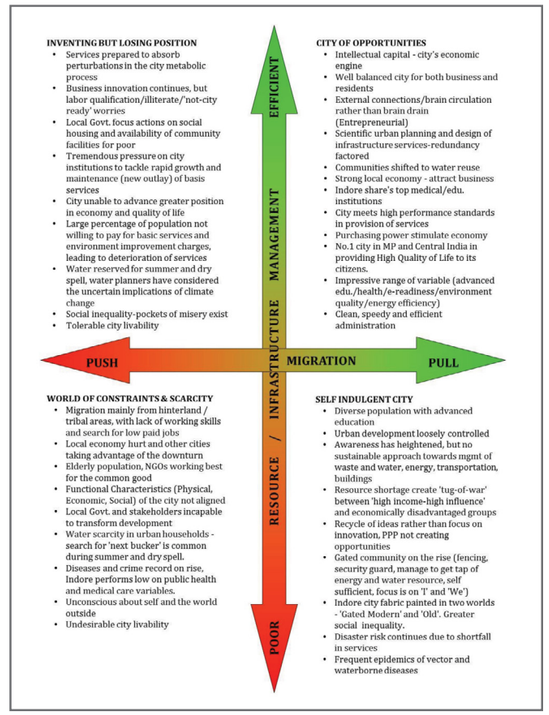
Indore is one of the fastest growing cities and is called Mumbai of Madhya Pradesh. It is also the largest industrial hub of Madhya Pradesh. The decadal population growth of 42% during the last decade indicates that it is growing faster than many other cities across India.

Since the city is located in plateau environment, there are no land constraints. Indore is the largest city in the neighborhood and is likely to be the destination of push migrants from rural hinterlands. The city scenario exercise conducted with the city stakeholders indicated that migration as well as infrastructure and service quality would be most important critical uncertainties that would determine the future growth.

3.2.1 Migration Pattern

The city is located in the semi-arid zone, by complex, diverse risk-prone agricultural region lying in rain-shadow zone of Western Ghats. In the hilly parts neighboring the city, land quality is poor and per capita cultivable land is low and agricultural yields are low and uncertain due to rain-fed agriculture. It is inhabited by a mix of tribal and caste population who are predominantly poor. Any climate change can further increase the risk to subsistence agriculture and rural population is forced to migrate to the nearby cities, with economically stronger Indore becoming the preferred destination for the migrants. These rural migrants are skill poor and the city economy may be affected by the push migration. In such a case, the proportion of low skilled workers will increase and they need to be supported by subsidized lifeline services. If Indore continues to attract secondary and tertiary sectors of economy, Indore may become preferred destination for skilled workers. Its current potential to attract educational and medical institutions will be an added advantage. Such pull migration is likely to result in demand for better services and ability to pay for better services. Therefore, the migration pattern will be most important critical uncertainty for the future

Figure 3.2: Indore Urban Future Scenarios (Risk to Resilience Workshop, Indore 2010, ACCCRN)



3.2.2 City Level Resource/Infrastructure Management

Since the Indore city depends on distant water resource of Narmada River to meet its growing water demands, the cost recovery will be critical for managing water infrastructure of the city. Also, with the increasing energy costs can add additional burden on the IMC. The maintenance as well as capital investments required will depend on the city's ability to recover the costs. Considering the huge gap in municipal finances, the ability to charge the consumers and to maintain the infrastructure will be another major critical uncertainty.

The quality of services would improve only if there is expressed demand for services. So far, the citizens have not been proactively demanding for better services even though water supply is provided only once in two days. Only in case of non-supply, the people protest, but even they are unorganized.

The city stakeholders built four scenarios based on the two critical uncertainties. These scenarios are presented in the previous figure. While "City of Opportunities" scenario is most desired, it would require several enabling conditions to be met and the living environment needs to be kept above the minimum threshold much above the current status. Political will, continued investments and willingness of community to demand and pay for the services would be essential preconditions for this scenario to emerge. For each one of the scenarios, early signs were identified, so that realignment of the goals of the ULB to provide basic services.

3.3 CLIMATE AND HYDRO-METEOROLOGICAL RISKS

In the past, Indore was known for pleasant evenings even during peak summers, known as Shabe' Malwa. Indore is already facing increased temperatures in summers. Combined effect of regional climate change as well as urban heat island effects have reportedly led to continued temperature lag well in to the nights during the summers. The peak temperatures reach upper 40's and also dust storms from western desert region often reach the city. Indore was also known for gentle rains throughout the season, while now it faces dry days with few very heavy showers. This has led to increased water logging as well as occasional floods. Water logging has reportedly increased the incidence of vector-borne diseases. Impervious soils, increasing proportion of paved areas, blockage of drainage by construction of roads as well as blockage of drainage by solid wastes are believed to be increasing the incidences and duration of waterlogging.

The indirect impacts of climate change include increased incidence of water and vector-borne diseases, exacerbated by the water scarcity routinely experienced by the citizens. The major growth in peak demand for electricity can be expected to occur due to higher summer temperatures as well as affordability of air conditioners among majority of the households as well as offices/ commercial/industrial work spaces. With the continued high temperatures lasting through evening and early part of the night, the energy demand for space cooling is likely to stress the electricity network. Occasional droughts can reduce the hydel power generation as is being experienced by the state this year. Grid failures can increase the vulnerability of the energy was well as water supply sector significantly.

For analysis on Rainfall, temperatre, future rainfall and temperature analysis (2021-2100), extreme event analysis, refer to the city resilience strategy document.

3.4 EXPECTED IMPACTS FROM CLIMATE CHANGE

The water will remain the critical resource that can cause large scale impacts on Indore. Models indicate that in this century there is a possibility of only a marginal increase (+200 mm) in annual rainfall. The climate projections indicate dominance of extreme events that would mean either long dry spells or few very heavy rainfall events dominating the monsoon. In case of droughts, the city's reliance on Narmada would increase, which may be accompanied by unreliable power supplies. With heavy rainfall events dominating the monsoon, rainwater storages of higher capacity would be needed at various levels starting from individual buildings to city level. The city should have sufficient sewerage as well as solid waste management system, which would prevent mixing of rainwater with the contaminants from sewage. The Indore water security study has indicated about 5% increase in evapo-transpiration, which will offset much of the increase in precipitation, if the water is stored in surface reservoirs.

Ground water recharging offers an option, but it would require decentralized efforts at household and colony levels. Strengthening of ward committees as well as Rehwasi Sangh (Residents welfare associations) would be critical in ensuring these along with active cooperation from sewerage and solid-waste management utilities.

With high costs of water imported distant source and increased water scarcity, it is important to conserve and recycle water. Current paradigm of centralized sewage treatment outside the city may not be suitable for recycling water. Decentralized options can create opportunities to reuse water from irrigation of gardens and ground water recharge. Such paradigm shift can reduce costs of sewerage network as well as integrate water supply systems with recycling and reuse at colony levels. It would necessitate policy and legal interventions like rainwater harvesting bill enacted few years back.

3.4.1 Storm water drainage and floods

Increase in intensity of precipitation can result in increased frequency as well as intensity of floods. Since the city has black cotton soils, in the events of floods very low coverage of storm water drainage and limited sewerage will prolong the duration of water logging/ flooding. Without integrated storm water drainage and flood control plan, the city may be subjected to more frequent and intense floods under climate change scenarios. Haphazard growth and blockage of natural drainage may further worsen these issues.

3.4.2 Energy

The energy dependency for water pumping will increase with population growth and the impacts of climate change. The PRECIS model indicates reduction of rainfall in the upper catchment of Narmada, while increase in the middle and lower reaches.

The increase of 2ºC of maximum temperature across the year is likely to increase the energy demand for space cooling significantly-especially during the summers,-adding to increase due to life style changes. The human thermal comfort levels are likely to shrink further by combined effect of climate change and urban heat island effects. The urban heat island effects may further increase the temperature in the inner city area by about 3-4ºC.

The current per capita consumption of 250 kwh/year is very low, and is expected to increase by about 10% over next decade while the consumption may increase by about 61% under BAU calculations of the Utility(with 50% decadal population growth). The additional increase due to climate change would depend on the affordability of the households. The practice of using individual owned space cooling systems is likely to concentrate heat in semi-closed spaces in multi-storied buildings.

The extreme heat days can create peak loads and black outs similar to ones faced during last summer. Cascading effects of power supply breakdowns can impact distant source based water supply system and impacts of water supply can only be prevented with continued conservation of local surface and ground water resources, managed by the communities. Recycling of water, recharge and conservation of ground water and conservation of local sources like lakes are important to deal with such cascading impacts.

3.4.3 Land

Land is not a major constraint in Indore, except for the core area of the city. Two main growth axes are seen in the development pattern of the city. They include South-west (towards Mhow) north (towards Ujjain). The population growth across wards indicates that the core area is getting depopulated and converted in to commercial areas, while there is high growth in outer core and periphery. Except for the core and lower income group colonies, Indore has significant open areas. The population growth is likely to put pressure on these open areas.

While there is growing trend of building multi-story buildings as well as increasing use of glass cladding in the city, the urban heat island effect and increased energy use density(for space cooling) can worsen with haphazard taller buildings blocking free flow of winds. A significant number of low height buildings (up to 3 story) currently seen in the outer core may change to high rise buildings, especially along the main roads.

3.4.4 Health

Vector borne disease outbreaks have become more common over last decade due to combined effects of urban development without sufficient drainage and poldering effects of road construction resulting in prolonged water logging of some of the areas. Integrated drainage development has not been done so far. Only about 20% of roads have drainage. Poor solid waste management has further blocked the natural drainage. Along with water logging, increase in humidity, increase in minimum temperatures are likely to extend the disease vector viability periods and may worsen the disease incidences.

3.4.5 Infrastructure Impacts

With Sufficient storage along the upstream stretch of the river basin, water resource at Narmada River is not a major issue in the coming decades, but this source needs significant energy for pumping. The combined effect of increasing electricity demand without concurrent increase in generation capacity and competing uses can impact the Narmada water supply system, which is dependent totally on electricity. The city water supply can be impacted severely if the electrical system is over loaded, especially during summers when the local sources dry up.

To overcome the road maintenance problems in black cotton soil terrain, the IMC has been laying concrete roads in important stretches as well as in slum areas prone to water logging. Unless large funds are available, these measures are unlikely to cover most of the road network. The existing roads may be affected by rains and increased temperatures, causing increased expenditures. Increasing intensity of rains without sufficient storm water drainage and sewerage network is likely to contribute to the deterioration of road infrastructure in expanding black cotton soils as well as increase waterlogging.

3.4.6 Differential impacts on poor

Significant proportions of slums in Indore are located along the streams and are prone to flash floods. Slums are also most vulnerable to waterlogging and vector-borne diseases due to their location. Under various donor funded programmes, improvement of drainage and road network are being attempted. But the outcomes of such measures often do not last beyond the project periods. The recent donor funded programme, MPUSP, has overcome many of these issues, but the issue of solid waste management still needs attention to provide sustainable solutions. Sustainability of community based organizations created by the project would necessitate continued engagement by the ULB.

The temperature increase is also likely to cause differentially higher impacts on poor due to overcrowded settlements, low ventilation and poor vegetation cover. Since most poor cannot afford space cooling devices beyond fans, nor the increasing costs of electricity, they are likely to be impacted differentially. During the monsoons, high humidity conditions, combined with increased monsoon temperatures can increase discomfort in under-ventilated houses.

3.5 ISSUES AND IMPACTS SUMMARY

Indore already faces major issues of water scarcity, sewerage and solid waste management. While resource scarcity exists in case of water, low expressed demand from users and poor management is largely responsible for the current status. The city population is expected to double if the current trends continue. That would mean building to fill the gap in infrastructure and services and additional investment equivalent to cumulative investments done so far in housing, water supply, sewerage, solid waste management. Considering current challenges, Transport and urban health management would be other two major areas of concern. The main issues and impacts that Indore city has to address over coming decades is presented in the following table.

Table 1: Issues Matrix

Scenario Sectors	Current Status	Future Trends (BAU) Without CC	CC Issues
POPULATION	Medium demographic growth (43%)	Growth rates increases unless economic growth slows down/push migration stops	Increased Push migration periods from impacts on hinterlands, dominance of low skilled population
DISASTERS	Droughts common, occasional short term flooding and water logging	Trend likely to continue, Impacts due to city expansion and other anthropogenic changes likely to worsen the flood intensity, vector borne diseases may increase due to water logging	More intense and frequent floods amplified by urban development. Poor residing along drainage lines, even in the upper parts of minor catchments impacted by flash floods. Droughts trigger increased push migration. High temperatures and dist storms in summer
HEALTH	Malaria and dengue common, strong seasonality, Heat strokes unknown	Trend likely to continue	Seasonality of the vector-borne diseases likely to change, expansion of disease transmission period likely to increase due to increased temperature and changes in humid seasons. Morbidity from heat strokes expected
RESOURCES (WATER, LAND, ENERGY)	Water scarcity despite about 85% dependence on distant sources, high UFW. Growing clout of informal water markets. Focus on capital works, without exploring soft paths	Short-lived water sufficiency followed by water scarcity driven by increase in energy prices and unreliable power, Major challenges to recover cost of water. Competing demands. IMC continues to stress on capital investment route without opting for soft paths	Re-emergence of water scarcity due to increasing unreliability of local sources due to uncertain rainfall, Competition over Narmada water from other sectors and thefts/water conflicts along the route with local user Increasing peak energy demand from increased temperature
ENVIRONMENT	Very dense core, vehicular pollution high in core area	Traffic issues, pollution may increase, rapid transport can reduce some load Downstream impacts of disposal of sewage in to streams	Higher impacts of pollution due to higher temperatures, especially during summer Increased algal growth in water reservoirs due to pollution and temperature increase leading to eutrophication and fish kills
ECONOMY	High growth	Medium to high growth expected with increase in efficiencies. Quality of life may not improve if current trends continue.	Minor change in energy consumption for processes, but significant impact on energy demands for space cooling, vector borne diseases may impact the labour productivity.

Scenario Sectors	Current Status	Future Trends (BAU) Without CC	CC Issues
TECHNOLOGY	Fast up gradation to overcome labour scarcity	Shift to more efficient water and energy technologies, especially by those who can afford.	Water reuse technologies can alleviate scarcity. Efficient lighting, mass rapid transport can reduce energy use and pollution impacts
SOCIAL/ EQUITY	Iniquitous growth being addressed by improving Service access to poor, sustainability issues exist	Gated communities and slums coexist. Poverty may increase due to push migration from large underdeveloped drought prone hinterlands with skill poor population	Push migration can lead to conflicts and distress

With near doubling of population, impacts of urbanisation would be much higher than climate change impacts in case of Indore. Extreme precipitation patterns are likely to catalyse large scale push migration from complex diverse risk prone environments with large pool of skill poor labour in to Indore and neighboring cities, which have high costs of water and other basic needs. Poverty is likely to grow, unless conscious efforts are done in skill building of the push migrants and providing opportunities to for them to be absorbed in to the formal economy.

3.6 CITY RESILIENCE STRATEGY HIGHLIGHTS

Being located in the underdeveloped state, Indore faces resource and policy constraints from the state level. The city also faces challenges in terms of lack of demands for better services, capacity of the city administration to address rapid urbanisation, amidst of finance and natural resource base constraints.

On the positive side, Indore has been the focus of donor attention over last two decades and has implemented several donor funded projects aimed at improving the access to urban services to poor. Valuable lessons have been learnt from these projects which has informed this resilience strategy. Indore is expected to continue to attract donor funds for pro-poor inclusive urban development and also expected to guide the inclusive development programmes and debate at state and national levels.

Indore city ULB faces challenges of administrative, municipal financial autonomy and health, political will and lack of consensus. The following approach has been used to build leadership about resilience building by the local and state stakeholders:

- Building on addressing current risks and vulnerabilities with CC context
- Create awareness about climate risks and generate demand: Bottom up approach
- Demonstrate resilience projects to generate interest among the ULBs and other decision makers
- Generate Multi-Sectoral Information & Shelf of Project Proposals
- Building synergy with state and national institutions

It has to be noted that the local stakeholders linked the climate change with water scarcity, changing precipitation pattern as well as increasing temperatures during summer evenings. Series of "Risk to Resilience" and scenario building workshops helped in their raising awareness about a variety of issues like migration, possible resource scarcities and urban health. These workshops built consensus over the linkages between urban growth, poverty and climate change. These exercises traced the recent history of Indore and changes being felt by the citizens and possible impacts of such changes continuing along with rapid urbanisation and migration.

These workshops led to identification of interventions to address the issues raised from analysis of secondary data ranging from climatic, demographic and economic model outputs, local knowledge of stakeholders and facilitation by us. The main sets of interventions across the sectors are presented in the following tables.

Significant changes are expected in economic, urban governance and social situations over this period and more information would be available from emerging higher resolution climate models, economy and demographic trends. It is suggested that a reassessment of these proposed interventions is done by 2015 and suitable modifications may be done in the strategies and interventions.

Table 2: Suggested Short Term Interventions

Sectors	Needs	Interventions	Potential Partners/ Stakeholders
RESOURCES (WATER, ENERGY)	**Water Availability:** Build redundancy for meeting CC impacts Augment alternate supplies/ source, reuse options **Energy:** Improve efficiency, reduce space cooling costs Build redundancies Meet demands and control price, meet shift in energy demands	**Water** A. Comprehensive water management of local and Narmada resources • Assessment of resources • Developing options for different spatial scales/ SECs • Rainwater harvesting/Water reuse options at various scales B. Demand side management • Leak detection and retrofitting • Water literacy modules • Citizen engagement & reporting system **Energy** A. Energy efficiency • Promotion of energy efficiency products • Codes for passive cooling and energy efficiency residential, commercial and industrial buildings, and incorporation of these codes in weaker section housing projects • Develop guidelines and regulations for environmental sustainable building design, construction and operation (Water/Energy/SWM) B. Study on renewable energy options at various scales and end uses	IMC, Water Dept., Narmada and water resources Dept., MPEB, Centre of Energy Studies and Research - D.A.V.V, National Institute Industry Forum for Energy, Industry Associations

Sectors	Needs	Interventions	Potential Partners/ Stakeholders
NATURAL DISASTERS/ HEALTH ISSUES	Reduce risk exposure, especially for poor Warning and forecasting products for severe weather events strengthen city disaster management plan Vector borne disease surveillance and health monitoring system	A. Flood plain zoning and advance warning system B. City level storm water drainage master plan including rainwater harvesting options C. Improving disaster response plans including evacuation of citizens from high flood risk zones D. Disease monitoring system with epidemiological research support & health GIS	IMC, Public Health Deptt. Emergency officials, Hospitals, Irrigation Deptt. NGOs
URBAN SERVICES	Meet global standards, high rating in service level benchmarks Access to affordable, appropriate and health services and information	A. Benchmarking vulnerability of critical lifelines and infrastructure to CVCC risks B. Develop framework for online/continuous monitoring of gaps/ deficiencies in urban services	IMC, Service Deptts, IDA, NGOs, Community Volunteers
POPULATION	Income Vulnerability reduction through Informal education, skill upgradation	A. Increasing livelihood options through informal skill building courses on technologies, improved services and management with close linkages with industry B. Industry approved certification process C. Climate leadership training programmes introduced	Educational institutions, Vocational Training Institutes, NGOs, Chamber of Commerce and Industry

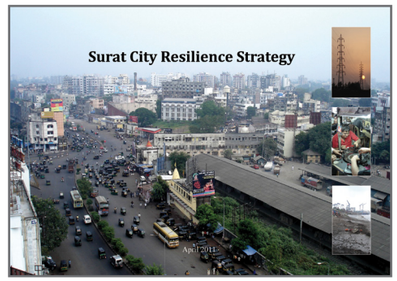
Sectors	Needs	Interventions	Potential Partners/ Stakeholders
ENVIRONMENT	Reducing vehicle pollution, traffic issues, park cool island (PCI) effect, better environmental services	A. Plan for increasing share of public transport, IT enabled Transport system B. Increase in green cover, especially along road network C. City's environment management plan (monitoring of key parameters, maintain within specified standards) D. City level group for monitoring and advisory to the ULB	IMC, IDA, Educational & Research Institutions, Industry/Automobile Associations, MP Pollution Control Board, Civil society
ECONOMY	Reducing economic losses	A. Establishment level disaster management plans, B. Water/energy efficiency improvement conservation plans	Industry associations, Industry Leaders
TECHNOLOGY	Use of state of art water and energy saving technologies. City level water, energy, transport management system Energy audits, awareness about energy saving	A. Technology plan for water and energy sector B. Support agency for energy efficiency improvement C. Demonstrate effectives of technology in select units (residential/ commercial/ industrial)	IMC, IDA, MPEB, Industry Associations, Educational and Research Institutions
SOCIAL EQUITY	Build, strengthen and empower citizen's local groups in managing their local areas Empowering and devolving resource /service management to ward levels	A. Ward level planning program focusing it's on the ground level issues B. Form and facilitate issue based groups for community action and managing of local assets C. Empowering poor communities	IMC, NGOs, CBO, TCP Office

Table 3: Medium Term Interventions Incorporating CC Risks

Sectors	Issues	Projects	Potential Partners/ Stakeholders
RESOURCES (WATER, ENERGY)	Water scarcity issues can become more acute with increase in variability, increased energy demand due to temperature increase and humidity level	A. Improving redundancy of the water supply system B. Near real time water system monitoring C. Interlinking water supply projects D. Urban user groups for conjunctive water management E. Hotline maintenance in monitoring of lines and transformers F. Setting up of cogeneration plant G. Technology upgradation for electricity distribution at city level	IMC, Water department, Water resources department, MPEB, Education and research institutions, Industry & Trade Associations, CEPRD
NATURAL DISASTERS/ HEALTH	Disaster preparedness and adaptation	A. Community based flood preparedness programme in high risk prone areas B. GIS based Disease Surveillance System	IMC, Public Health Dept, Emergency officials, Hospitals, Irrigation Dept, NGOs
POPULATION	Push migration periods from impacts on rural areas, dominance of low skilled population	A. Monitoring programme on push migration and launch of suitable programmes and safety nets B. Initiate programmes that focus on skill development	IMC, NGOs, Educational Institutions, Industry Associations
URBAN SERVICEs	Deterioration of urban services	Harden the city infrastructure to withstand climate risks (Water/Energy/Transport/ Drainage/Sewerage)	IMC, Service departments, IDA, Technical/Educational/ Engineering Institutions
SOCIAL/EQUITY	Push migration, higher inequity due to skill constraints of new immigrants, pressures on infrastructure & services	A. Community planning program focusing on providing services through a revenue model B. Training and Learning Centres to impart skill development	IMC, NGOs, CBO, TCP Office
ENVIRONMENT	Higher impacts of pollution due to higher temperatures, severe loss of green cover, poor quality of urban environment	A. Comprehensive Transport Master Plan based on forecasting latest technologies B. Revive old water tanks across the city and increase green cover C. Development of integrated municipal waste processing facility D. Implementation of environmental building guidelines/energy code in the construction of new buildings and retrofit of existing buildings	IMC, Horticulture Department, Transport Department, Educational and Research Institutions, Industry/ Automobile Associations, NGOs, Environmental consultancy firms
ECONOMY	City loses opportunity due to CC impacts and risks	A. Reassess economic growth and global demand pattern to bring in greater efficiency in services and business B. Develop and implement forward looking policies action plans that proves best for business and residents (infrastructure landscape, health, safety and security, liveability) C. Create environment (branding, marketing) for encouraging pull migration of high quality human resources	IMC, IDA, Planning Institutions, Industry & trade Associations, Resident Associations, Transport Department, Police and Emergency Services
TECHNOLOGY	Indore becoming a centre for CC technologies, resilience approaches	A. Expansion focused on clean and sunrise industry/ service sector B. Establishment of Theme Park to create public awareness and provide solutions	IMC, Educational and Research Institutions,

Surat City Resilience Strategy

SUMMARY



Prepared by:
TARU Leading Edge

Full Version of the "Surat City Resilience Strategy" can be downloaded from:
http://indiaurbanportal.in/frmDocAlbum.aspx?Srno=181&Type=3
http://indiaurbanportal.in/Publications/Publications181/Publications181755.PDF (English)

4

4.1 BACKGROUND OF THE CITY

The city of Surat, located on the western part of India in the state of Gujarat on the River Tapti, is an important historical trade centre and trade link between India and Gulf countries. Surat was a gateway to the Deccan plateau and was an important port and trading centre during the Mughal period. The city has one of the highest proposed investments and almost zero percent unemployment. It is one of the fastest growing cities in India.

Surat has a Tropical Monsoon Climate. Summer temperatures in Surat range from 37 to 44ºC with winter temperatures dropping to 22ºC. Monsoon begins in June and last till end of September, with the average temperature being around 28ºC during those months. Average annual rainfall is approximately 1,143 mm. The city faces the risks of both sea level rise and flooding. The Ukai multipurpose dam built upstream, 94 km from Surat, was meant for flood control management and for irrigation, power generation. During the last two decades the city of Surat and the surrounding metropolitan region has witnessed major floods.

Surat city has seen an unprecedented growth in last four decades recording one of the highest city population growth rates in the country. The City now ranks as the 9th largest city in the country. Coupled with this, the spillover of population into periphery has also been observed. From time to time jurisdictional limits of SMC have also been extended to include the outgrowth.

4.2 URBANISATION ISSUES

Surat is 70th largest City in the world and is expected to become 41st largest city in the World by 2020 (City Mayors.com Website 2010). It is also ranked as the fourth fastest growing city in the world with population of more than 1 million. It is ranked as the 131st richest cities of the world with a GDP of 22 billion USD in 2006, which is expected to rise to 119th rank by 2020 with a GDP of about 57 Billion USD and a growth rate of 6.5 percent annually.

The city population is expected to grow to nearly 7.53 million by 2025, without considering the city area expansion (UN population data 2010) with average decadal population growth rate of about 50% percent over the 2011-25 period as against all India decadal urban growth rates of 27% only. This would mean that the city has to provide housing and lifeline services for another 3 million people or nearly 67% additional capacity in lifeline services. The expansion of basic urban services for the additional population would need investments of at least Rs.1,436 Crore for water supply, sewerage, storm water drainage, solid waste disposal, roads and streetlights as per Planning commissions' per capita investment estimates at 2004-2005 prices. This is over and above the costs towards hardening the existing infrastructure.

The Surat city, being located on the flood plain of Tapi River, is already facing high tide inundation issues during rainy seasons. It is likely to face challenges of increasing vulnerability to floods and sea level rise. Also, further expansion of Hazira industrial area in the lower flood plain, is expected to worsen the flood risks.

One of the major characters of the Surat city is the strong social fabric. The future scenarios developed by the city stakeholders have raised the issue of community cohesion arising out of the growing immigrant population.

Considering the current industrial, infrastructure and investment growth (both in Surat and Hazira) as well as the demand for the labour for Surat's textile and diamond industries combined with push migration from rural/agricultural hinterlands can give rise to 50% + population growth during the next decade. The UN population projections estimate 48% decadal growth in population during 2010-2020 period. (UN 2010)

4.3 POVERTY

Similar to other rapidly growing cities in India, Surat has its own share of slums. The slums have mostly migrant population who are unable to afford formal housing. As per 2001 Census, about 20% of the Surat's population (0.49 million) lived in 307 slums. With the recent expansion of the city in 2006, this number has increased to 420 slums. Many of these slums are located along the tidal creeks, between the river embankments and other drainage lines. These slums face higher risk of flooding (pluvial, fluvial and tidal). In addition to slums, the low income settlements exist throughout the city. Some of them are upgraded slums. The slum and low income population of the city is

estimated to be about 34% of the total population (TARU 2010).

The Urban community development department (SMC) is active and monitors delivery of essential services in slums. In comparison other Indian cities, slums in Surat have better access to water supply, drainage and sewerage facilities. But, very high in-migration of semi-skilled workers from across the country is challenging the efforts of SMC. Having recognized the flood risks, efforts to relocate the slums were initiated by the government under various schemes (mainly during the last decade under various national projects including JNNURM) and more than 30,000 permanent houses at safer location were provided to the slum dweller.

4.4 CLIMATE AND HYDRO-METEOROLOGICAL RISKS

Surat is lies in the flood plain of Tapti river near it's confluence with Arabian Sea. Tapti basin is about 587 km long from east to West and about 201 km wide (N to S) and is elongated in shape passing through Madhya Pradesh and Maharashtra. Tapi is one of the large perennial rivers in Western India. It is 724 km long originating from Multai in Betul district of Madhya Pradesh and cutting across the Western Ghats and joining Arabian Sea near Surat. Total catchment area of the Tapti river basin is 65,145 km2 including about 79%, 15%, and 6% in Maharashtra, MP, and Gujarat respectively. Its upper catchment lies in semi-arid region with high coefficient of variability in rainfall.

In the catchment area of Tapti River, the monsoon generally starts during the third week of June and there are occasional heavy rainstorms from the beginning of August to the end of September. The mean annual rainfall in the basin is estimated to be about 758 mm. and the average monsoon rainfall from 1988 to 1998 was 897 mm. The maximum annual rainfall (1,168 mm) and the minimum of (257 mm) were recorded in 1944 and 1899. Most of the floods in Tapti occurred during August.

4.4.1 Flood History

Throughout the history of more than seven centuries, the city of Surat has experienced floods, fires and plague epidemics. The city earlier had a flood protection ring wall built with bricks and several gates, which were closed during floods. Westerly moving depressions arising out of Bay of Bengal moving from upper Tapi catchment to the Arabian Sea cause heavy rainy spells lasting 3-5 days. The runoff often gets concentrated due to this process, causing heavy river discharges by the time the flood water reaches Surat. During the period 1876 to 2009, the Tapti crossed the danger level at Hope Bridge in Surat 27 times, i.e., on an average every five years.

For current and past climate data analysis, Rainfall, Future Precipitation Analysis: 2021 – 2100. Extreme Event Analysis, Temperature, Future Temperature Analysis: 2011-2100, refer to the Surat City Resilience Strategy document.

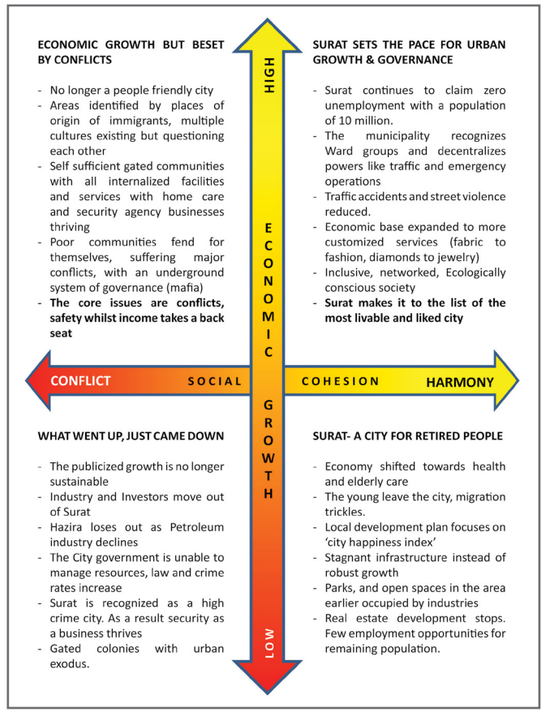
4.5 CITY FUTURE SCENARIOS

Based on two critical uncertainties identified by the City Advisory Committee, four future socio-economic scenarios were developed. These provide a combination of improvement or decay of Social cohesion (X axis) and economy (Y axis). These scenarios reflect 2030-2040 periods and are based on the set of certainties and uncertainties identified by CAC. The diagram highlighting the four scenarios is presented in the Figure 4.5: Surat Urban future Scenarios.

Considering the major global and national level economic changes, Surat may face any one of the above scenarios. The population projections may not represent the reality if the economic growth slows down or the social cohesion breaks down, thereby reducing the resilience of the society.

The climate change is likely to roll out impacting various sectors and sections of population differentially over coming decades. Issues of extreme temperatures, floods and water scarcity may impact the city, even though currently the city only faces the flood risk. With the increasing competition over water resources from Ukai dam, the conflicts over water across sectors can be expected in the coming decades, especially from growing industry and energy sector.

Figure 4.5: Surat Urban Future Scenarios (Risk to Resilience Workshop, Surat 2010, ACCCRN)



4.6 CLIMATE CHANGE IMPACTS

4.6.1 Severe rainfall events

The rainfall increase in the Tapi catchment and Surat city is a matter of concern. This situation may be further aggravated with the possibility of high variation in the distribution of rainfall (longer dry spells and increased intensity of and frequency of severe events). Even though the flood event lasts for two to three days, the city and its economy takes several months to recover. The floods are also expected to impact the Hazira industrial area, despite land filling and other protective measures taken by the Hazira industrial area.

The Maharashtra state (neighboring state) is planning to build dams upstream, which may buffer peak discharges to certain extent. However, the maximum storage that can be added is small given the forest and hilly areas upstream. Conversely, with the increase of siltation in Ukai dam, the carrying capacity and the flood control capacity is likely to be reduced. The situation of flooding due to peak discharges in to Ukai dam is highly likely. This calls for an Flood early warning system for Surat.

The flood damages also should be explored from the perspective of the changing economy and social cohesion. While the city may be able to recover within months in case the city's economy is strong, conversely during economic downturns, the city may take much longer time to recover. Surat's economy is still largely labour dependent and any disasters would lead to mass exodus, which would take many months to reverse as evidenced during the 1994 plague and 2006 floods. In such cases, the city may not be able to recover for long periods. Considering mobility of labour and growing alternate centres of opportunities for workers, the city has no option except reducing the flood risks with improved flood forecasting systems and more effective management of Ukai reservoir.

4.6.2 Sea level rise

Surat has been experiencing some of the highest tides on record during past few years and SMC had to evacuate huts located at the edge of the creeks in 2008 and 2009. Since the high tide level is increasing, some of the already built up areas near the tidal creeks may also face the impacts of submergence as well as weakening foundations of multi-storied buildings due to ingress of corrosive sea water. Sea level rise is also likely to cause further erosion of the coastal area near Dumas included in the city area in 2006.

The coast is potentially high value property due to beach access, which may be developed as the city grows. There are already demands by various interest groups to build coastal erosion control structures, which if implemented can catalyse further real estate development in these high sea level rise risk areas.

4.6.3 Temperature increase

Surat lies in high humidity coastal environment and summer maximum temperatures crosses 40ºC and night temperatures cross 25ºC. The traditional buildings were designed with sufficient ventilation to reduce thermal discomfort. Along with high humidity, these ranges cause discomfort for people. The increase in thermal discomfort due to urban heat island effect

and higher affordability has led to people preferring air conditioning system instead of natural ventilation.

Such change in lifestyle combined with changes in temperature would eventually lead to increased energy consumption. Further, any increase in summer maximum temperature (April May period) is also a matter of concern with respect to health. Since, the humidity levels are quite high in this coastal city, an additional increase in temperature may lead to health problems. The increase in minimum temperature, especially during the winter months, will also lead to increased survivability of disease causing insect vectors and pathogens.

4.6.4 Water demand and resources

Surat city depends on Tapi for meeting most of its water demand. Surat Municipal Corporation prepared a long-term Master Plan in the year 1995 for Water Supply Scheme of Surat city for an area of 112 sq.km before expansion.

The new master plan including the expanded area under the SMC is being prepared. The SMC has only 700 MLD of allocation from Ukai reservoir. Droughts and late onset of monsoon are already creating stress on Surat's water supply system during peak summers. Under both the high economic growth scenario, the population growth is expected to grow significantly. For meeting the demand of future population of 7.5 million plus in 2025 as well as meeting industrial and energy generation needs, the current allocation from Ukai dam is insufficient. This situation may increase the competition over limited resources currently allocated for irrigation and power generation. Water scarcity will become an issue, unless major changes in cross sector allocation Ukai dam water resources takes place.

The climate models have indicated minor increase in annual precipitation along with reduction of rainy days as well as increase in extreme events including droughts and heavy rainfall in the catchment. Considering already increasing conflicting and competing demands for Ukai water storage, the water scarcity can become a reality in this city. With the sea level rise, the aquifers are likely to face increase in salinity, especially in the western parts of the city. Blessed with more than 1000 mm of annual rainfall, rain water recharge systems and storage of emergency release water, reuse of treated sewage water and desalination options need to be explored to meet growing stress on water resources.

4.6.5 Health

Urban health is a major issue in the tropical coastal city of Surat. Located in a nearly flat coastal terrain, Surat was infamous for Filaria and Malaria. Even now, Surat doctors are well known for their knowledge about managing Malaria cases. The health sector study highlighted near-extinction of Filaria due to extension of underground sewage across the city. Similarly, the Malaria is under control due to a strong citywide monitoring system including over 300 doctors and municipal health centres. Mosquito vector control measures including door to door monitoring of breeding and monetary fine system as well as fogging reduces the incidences.

The health sector study also raised concerns regarding changing climate that can cause changes in vector propagation and recommended conducting continued action research on climate and vector-borne diseases. This is especially important since this region is a Malaria endemic area and also faces recurrent outbreaks of Leptospirosis.

4.6.6 Land & buildings

The 2006 floods inundated 75% of the city area. With Arabian Sea on the west, only three directions of growth are possible. The coastal erosion and sea level rise is expected to reduce the area available for city expansion towards west, thereby reducing the area of the current municipal limits over coming years, as evidenced by coastal erosion along the Dumas beach and increasing level of tides entering the creek areas within the city. At least five percent of the total municipal area of 326 sq.km would be prone to sea level rise related risks.

Building of bridges, weirs and embankments have reduced the safe carrying capacity of the river channel. Earlier, more than 1 million cusec of flood waters could be safely discharged without causing any major damage, which now the channel is unable to handle even 0.4 million cusec, mainly due to growing number of bridges, weirs, embankments covering both river banks. The ground floor of any building in the most parts of the city is prone to direct flood risk, with some areas facing risks to first floor also. Any climate change induced precipitation increase can only increase risk to the areas close to the river, especially on the immediate leeward side of the embankments.

In both high economic growth scenarios, the real-estate demand is expected to increase. With some of the coastal and tidal creek areas affected by sea level rise, remaining areas will be subjected to real estate development pressures. Expansion of the city towards south (twin city of Navsari and Surat) as well as towards east (National highway) and towards north can reduce the population density significantly. Given the flood risks, vertical and compact growth may be a good option that needs to be explored in the old city area, but issues of narrow roads and traffic congestion needs to be resolved before increasing the FSI limits in the core area. Major shift to public transportation as well as maintaining/improving energy security would be necessary before any changes in density can be attempted in the core areas.

4.7 ISSUES/IMPACT MATRIX

Urbanisation, poverty and climate change are expected to raise several challenges to the citizens, communities and ULBs. It has to be noted here that the scale of changes catalysed by rapid urbanisation would be of much larger scale demanding major investments in infrastructure and lifeline infrastructure, as highlighted by various analyses (MGI, 2010; MoUD, 2011). With near doubling of the population (with 60+% decadal growth), and existing gap in lifeline infrastructure and services, Surat may have to invest more than cumulative investments done so far for housing, water supply, sewerage and solid waste management. Large investments on infrastructure and efforts in management of services done over last two decades would benefit on short term, but high growth would demand continued large investments and innovative management practices. The main issues that the city has to address are presented in the following table.

Table 1: Surat: Issues/Impact Matrix

Scenario / Sectors	Current Status	Future Trends (BAU) Without CC	Climate Change Issues
POPULATION	High demographic growth	Trend potentially continues, unless economy slows down significantly due to externalities	Push migration periods from impacts on rural areas, dominance of low skilled population
NATURAL DISASTERS	Floods, high tides frequent, the increase in flood levels for similar discharges due to embankments and land filling. Cyclones rare	Trend likely to continue, Impacts due to city expansion and other anthropogenic changes likely to worsen the flood intensity, Disease profiles may change	More intense floods, water scarcity periods, local floods, Tides, Cyclones frequency may change, and the storm surge may impact more areas due to sea level rise
HEALTH	Malaria and Dengue common, strong seasonality, Heat strokes unknown	Trend likely to continue	Seasonality of the vector-borne diseases likely to change, expansion of disease transmission period likely to increase due to increased temperature and changes in humid seasons
Scenario / Sectors	**Current Status**	**Future Trends (BAU) Without CC**	**Climate Change Issues**
RESOURCES (WATER, LAND, ENERGY)	Sufficient, for meeting current demands	Water scarcity issues likely to crop up with high population growth, reuse options can reduce impacts	Water scarcity issues can become more acute with increase in variability

ENVIRONMENT	Very dense core, vehicular pollution, lack of open spaces	Traffic issues, pollution may increase, but with stringent norms expected	Higher impacts of pollution due to higher temperatures
ECONOMY	High growth	Medium to high growth expected with increase in efficiencies, can be affected by external shocks	Minor change in energy consumption for processes, but significant impact on energy demands for space cooling, vector borne diseases may impact the labour productivity
TECHNOLOGY	Fast up gradation to overcome labour scarcity	Shift to better technologies, focus on energy conservation	Surat becoming a centre for CC technologies, resilience approaches possible
SOCIAL/EQUITY	Iniquitous growth being addressed by housing, Rare conflicts	Migration can change world views, social cohesion, would need interventions	Push migration can lead to more diversity in worldviews, Higher inequity due to skill constraints of new in-migrants, pressures on resources

4.8 CITY RESILIENCE STRATEGY

HIGHLIGHTS

The city resilience strategy has been developed based on a set of principles starting from anticipating and forecasting of risks across various time scales giving priority to avoidance, risk reduction and management of residual risks in the same order. This approach is undertaken mainly due to large uncertainties in population growth and economy as well in climate change. Considering these limitation, resilience strategy is based on adaptive management, considering current risks from models and observations and provide scope for improvement over time.

Surat city stakeholders are already aware of current risks, and have taken several measures to reduce risks and improve resilience. Also the city has been implementing several infrastructure development programmes like JNNURM as well as basic services for urban poor. The current strategy will build upon the on-going efforts, existing infrastructure and established institutions. The resilience building process will be spearheaded by SMC and other city stakeholders by providing key knowledge inputs and pilot projects to leverage processes and increase resilience of the system at community/household level.

Surat has the advantage of efficient city administration, strong political consensus and fairly healthy municipal finances. Surat is one of the few cities with AA credit rating, which enables it to raise funds for infrastructure development. The city has also demonstrated its capacity to build resilience by improving the quality of the lifeline services like water supply, sewerage, solid waste disposal and health. The future target is to harden the existing infrastructure to withstand flood risk, to build redundancies and improve resilience.

The ULB has proved its capacity to deal emergencies and take up proactive initiatives in urban development, community health and disaster management working closely with industry and citizens. Surat is considered as a model for good governance as well as for verity effective service delivery in comparison with many Indian cities. Therefore, any progress in this city will be keenly observed and can set models for urban resilience across other Indian cities. A multi-stakeholder Surat Climate change Trust led by the SMC would address issues not only at city level but would also attempt to influence policy at state/central levels.

The city Resilience strategy is designed on following objectives:

- Build on existing and proposed interventions by the SMC
- Demonstrate resilience building projects to leverage further action
- Multi-sectoral information generation and shelf of projects
- Build synergy with state and national level institutions to incorporate the lessons into national urban development policies

The sector studies conducted during Phase I and II indicate that hydro-meteorological risks, coastal inundation risks, health risks and their interlinkages are the most critical issues facing Surat. High population growth and physical expansion of the city would modify these risks significantly. Anthropogenic impacts on river hydrology and climate would be added risks as the city is already experiencing reduced carrying capacity of the river. Climate variability and change will further modify these existing risks. These factors are likely to influence the safety as well as quality of life of the citizens.

The poor would be differentially impacted due to higher exposure and inherent vulnerability. Based on the findings of sector studies and engagement with multiple stakeholders, the resilience strategy outlines short and medium term interventions.

Short term interventions are projects that may span for 3-5 years and medium term interventions are project that may span for 5-20 years. Over next five years, technology innovations may be able to provide better climate forecasts thereby reducing uncertainty about cause-effect relationships. New set of climate information may reduce uncertainty leading to select choice among a set of alternatives. Till this more accurate climate model results are made available and understood by the stakeholders of the social system, it is suggested to intervene with the followings set of activities (short/medium).

Table 2: Short Term Interventions-Surat

Sectors	Needs	Projects	Potential Partners/ Stakeholders
NATURAL DISASTERS	Early warning system, Strengthen response plans, use of ICT in emergency management	Formation of a Climate Watch group to collect and manage data on various fast and slow changing parameters, provide support to decision makers Modeling and sharing of real time weather information to increase respite time (Flood MIS). Developing multi-scalar and multi-sectoral disaster response plans including support to citizens even during emergencies. Flood, surge and tidal area zonation and appropriate building zonation rules	GSDMA, Irrigation department, SMC

Sectors	Needs	Projects	Potential Partners/ Stakeholders
URBAN HEALTH	Vector borne and water borne diseases	Improving disease surveillance and epidemiological research support to track diseases Health GIS	SMC, Health department, SGCCI, Private doctors, Hospitals
RESOURCES (WATER LAND, ENERGY)	Plan for alternate supplies, reuse options, plans for redundancies for meeting future needs	Water resources and supply management plan, Future demand growth under various urban scenarios, CC informed Resource assessment, Technology options including Reuse and desalination, Demand side management, Water conservation options Hardening infrastructure to withstand sea level rise, floods; Emergency supply management	SMC water department, Narmada and Water Resources, Water Supply and Kalpasar Department
POPULATION	Reducing livelihood vulnerability by skill up gradation, informal education	Informal skill building courses on technologies, improved services, management. Certification accepted by industry	Educational institutions, SGCCI
ENVIRONMENT	Reducing vehicle pollution impacts through CC, improve quality of life	Plan for increasing share of public transport, create no-vehicle areas and time zones in over-crowded core	SMC, Police department
NATURAL DISASTERS	Increasing respite time, decreasing response time	Basin level real time flood warning systems to provide 5 day warning, Continued improvement in response time to less than 1 day Improvements in disaster response plans, training and involvement of citizen groups in response action	GSDMA, Irrigation department, SMC

Sectors	Needs	Projects	Potential Partners/ Stakeholders
ECONOMY	Reducing economic losses	Minimize losses by preventive measures (asset banks, vehicle parks outside flood zones, Emergency and Business continuity management plans for natural disasters)	SGCCI, Industry leaders
SOCIAL/EQUITY	Housing for poor. Build, strengthen and empower citizens local level groups in managing their areas and services, Federation of these local level agencies	Affordable, thermally comfortable, flood resistant houses for poor Awareness generation, forming issue based groups for community action on managing local assets, address issues	Community Development (CD), NGOs, SMC, CSS
TECHNOLOGY	Energy audits, awareness about energy saving, demonstration	Support agency for energy efficiency improvement	SGCCI, Torrent Power, DGVCL

Table 3: Medium Term Interventions-Surat

Sectors	Needs	Projects	Potential Partners/ Stakeholders
URBAN HEALTH	Vector and water borne diseases, Heat strokes, flood related health risks to vulnerable	Networking and access with state of art disease surveillance and epidemiological research Improved vector control system Health GIS with data on vulnerable and their needs IEC on heat related diseases	SMC, Health and Family Welfare, SGCCI, Private doctors, Hospitals
RESOURCES (WATER LAND, ENERGY)	Water scarcity issues, temperature, humidity induced increased energy demand	Improving redundancy of the water supply system based on climate change informed water management plan Water monitoring system with zero tolerance	SMC water department, Narmada and Water Resources, Water Supply and Kalpasar Department

Sectors	Needs	Projects	Potential Partners/ Stakeholders
POPULATION	Push migration from impacts on rural areas, dominance of low skilled population	Monitoring programme on migration and demand focused skill building Skill building programmes	SMC, State government
ENVIRONMENT	Higher impacts of pollution due to increasing temperatures	Decongestion of road system, public transport, parking fee rationalization (disincentives) to reduce congestion and avoidable short journey, pedestrian friendly roads without encroachment	Police department, SMC with Civil society support
ECONOMY	Labour days lost due to due to higher temperatures, diseases Risks due to location	Health support systems for Industrial workers Managed retreat of industries to low risk zones	Industry, SGCCI, Industry department
SOCIAL/EQUITY	Social cohesion issues	Managing the Surti social image through local groups and positive action. Preventive action on conflicts.	Citizens groups and SMC
TECHNOLOGY	Surat becoming a centre for CC technologies, resilience approaches	Expansion focused on clean and sunrise industry/service sector	Industry, SGCCI, Industry department

These activities are being advocated through the Surat Municipal Corporation, Industry and academic institutions. City advisory committee was formed in 2009, which now has registered Surat Climate Change trust, with SMC, Irrigation department, GSDMA, SGCCI and academic institutions as members.

4.9 LESSONS LEARNT

The ULBs across the country are facing major issues of functional and financial autonomy, which constrains their capacity to invest on infrastructure and services. Surat, despite being financially more independent compared to many other cites, still has to depend on the state and central finances for infrastructure development. It is able to meet most of the O&M costs of services, but changes in tax regime has impacted it like other cities across the state.

The city had floated municipal bonds to overcome the financial constraints in the past, but innovative financial instruments and attracting private sector would be necessary to expand the infrastructure and services in this fast growing city requiring major expansion of infrastructure.

The city has been unable to expand the staff strength to meet the rapid urbanisation and nearly three times growth in municipal area. SMC has partially addressed this issue by private partnerships in solid waste management and introduction of technologies to improve efficiency of the staff. In the coming decades, strategic partnerships along with private sector participation with increased focus on governance and regulation would be necessary.

The rapid strides in technologies have opened many possibilities for effective management of infrastructure and services. While ICT can support smart management of transport, electricity, water supply etc., the new water and sewage treatment technologies have made household/colony level treatment of water and wastes possible. Unless the city is able to take advantage of these developments, the city's competitiveness and efficiency may go down while creating issues of traffic, waste management and health.

The current master planning process is essentially restricted to landuse planning. Increased focus will be necessary to integrate the transport, communication, water supply and sewerage system in the ambit of master planning. A paradigm shift from landuse based planning to network based planning would significantly improve traffic and essential services delivery.

Hydro-meteorological risks are very high in this city as evidenced by repeated floods and increasing scale of losses. The ULB has so far tried to address flood risks by increasing focus on embankments and crisis management. The embankments have given the false sense of security, as evidenced by 2006 floods. Unfortunately, the ULB has no control over the decisions on emergency releases from the Ukai dam. With growing competition over limited water resources, and increasing frequency of extreme events predicted, the dilemma over flood buffers and summer water storage needs are bound to grow. Integrated water resource management methods with multi-stakeholder engagement would be necessary to manage water resources and floods under changing precipitation patterns and growing population living in the flood plain city.

Stakeholder engagement can be initiated with current issues facing the city. The past emergencies have built and strengthened the resilience of the city and there is increasing willingness of city stakeholders to engage with these issues. Awareness generation and advocacy is to be initiated and followed up by generating options, technical support and demonstration of pilot projects. The Surat climate Change Trust can spearhead such process, as exemplified by the City advisory committee formed earlier in the city.

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