



The Energy and Resources Institute



THE
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Climate Proofing Guwahati, Assam

City resilience strategy and
Mainstreaming Plan

Synthesis Report | June 2013

For more information

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This publication was prepared with support from the Rockefeller Foundation as part of the Asian Cities Climate Change Resilience Network (ACCCRN). ACCCRN aims to catalyze attention, funding, and action on building climate change resilience for poor and vulnerable people in cities by creating robust models and methodologies for assessing and addressing risk through active engagement and analysis of 10 cities in Asia. The ACCCRN program engages local level and national organizations in India, Indonesia, Thailand and Vietnam, and was conceived and launched by The Rockefeller Foundation in 2008.

TERI was appointed as the National Policy Adviser to ACCCRN in India in the year 2009. In 2012, TERI started working on preparing a resilience strategy for Guwahati city. This synthesis report is an abridged version of the final report submitted to the Rockefeller Foundation, Guwahati Municipal Corporation and Guwahati Development Department, Government of Assam. The report draws from TERI's detailed assessment of the risk and vulnerability of the city of Guwahati and presents an overview of the city resilience strategy. The report also presents recommendations on mainstreaming the proposed Resilience strategy and outlines the regulatory and institutional mechanisms for the same. Various city stakeholder consultations have brought in a lot of city specific understanding into this study and have helped shape the recommendations. Any comments and questions on this publication can be directed to divyas@teri.res.in

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List of Abbreviations

ACCCRN	:	Asian Cities Climate Change Resilience Network
APHED	:	Assam Public Health Engineering Department
AREDA	:	Assam Renewable Energy Development Agency
ASHB	:	Assam State Housing Board
ASPCB	:	Assam State Pollution Control Board
AUWSSB	:	Assam Urban Water Supply and Sewerage Board
BSUP	:	Basic Services to Urban Poor
CAA	:	Constitutional Amendment Act
CPHEEO	:	Central Public Health and Environmental Engineering Organization
DEWATS	:	Decentralised wastewater treatment system
DMAs	:	District Metered Areas
DoEF	:	Department of Environment and Forests
EWS	:	Early Warning System
GDD	:	Guwahati Development Department
GMC	:	Guwahati Municipal Corporation
GMA	:	Guwahati Metropolitan Area
GMDA	:	Guwahati Metropolitan Development Authority
GMDWSB	:	Guwahati Metropolitan Drinking Water and Sewerage Board
GoI	:	Government of India
ICT	:	Information communication technology
IPCC	:	Intergovernmental Panel on Climate Change
ISWM	:	Integrated solid waste management
JnNURM	:	Jawaharlal Nehru National Urban Renewal Mission
KMDEOC	:	Kamrup Metropolitan District Emergency Operation Centre
LIG	:	Lower Income Group
MAD	:	Directorate of Municipal Administration
MLD	:	Million Liters per Day
MIG	:	Middle Income Group

MoEF	:	Ministry of Environment and Forests
MoHUPA	:	Ministry of Housing and Urban Poverty Alleviation
MoUD	:	Ministry of Urban Development
MSW	:	Municipal Solid Waste
NDMA	:	National Disaster Management Authority
NDVI	:	Normalized Difference Vegetation Index
NMSH	:	National Mission on Sustainable Habitat
PHED	:	Public Health Engineering Department
PPP	:	Public Private Partnership
PWD	:	Public Works Department
RAY	:	Rajiv Awas Yojana
SWM	:	Solid Waste Management
SDMA	:	State Disaster Management Authority
SOP	:	Standard Operating Procedure
SPCB	:	State Pollution Control Board
SPV	:	Solar Photovoltaic
SSLB	:	Standardized Service Level Benchmarks
SUDA	:	State Urban Development Authority
SUDS	:	Sustainable urban drainage system
TCPO	:	Town and Country Planning Organization
TCPD	:	Town and Country Planning Department
UDD	:	Urban Development Department
UDPFI	:	Urban Development and Plan Formulation and Implementation Guidelines
UIDSSMT	:	Urban Infrastructure Development Scheme for Small and Medium Towns
ULB	:	Urban Local Body

Executive Summary

Rapid and unplanned urbanization being observed in several urban centres of the world and especially in developing countries is contributing to increase in vulnerability of the cities to the threat of climate change.

Guwahati city is located at the Banks of River Brahmaputra and several of its tributaries pass through the city and nurture great biodiversity. Urban growth in the city of Guwahati has been rapid, unplanned and organic. Change in land use pattern of the city due to uncontrolled development activities is said to have done a lot of harm to the ecology and environment of the city. 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 not up to the mark which has made the city and its residents quite vulnerable.

In order to prepare the city in response to the various climatic and non-climatic stressors, 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.

Following sectors were identified as the key sectors that were studied to understand the present and future vulnerability of the city in the context of climate change impacts. These sectors also form the key pillars of Guwahati city's resilience strategy:

- **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**
- **Poverty and livelihood**
- **Ecosystems and land-use**
- **Emergency response capacity**

Analysis of land use imageries for Guwahati city indicates increase in the built-up area and decrease in the dense forest area. The reduction in green cover increases the vulnerability of the city towards hazards like flooding and landslides, and also

impacts the ambient micro-climate of an area. The individual consultations revealed that water supply is greatly hampered in the city during the flood event. 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. Preliminary analysis of rainfall data obtained from regional meteorological centre showed an increase in extreme rainfall events in the last ten years. This implies that events with more rainfall in a short span are increasing and the drainage system of the city is not adequate to handle this amount of rain.

As a result of this assessment exercise, TERI proposes several recommendations, some of which are highlighted in the table below. For instance, it was found that the ground water is afflicted 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.

These recommendations are explained in further detail in ‘Section 6: City Resilience Strategy’ of this synthesis report.

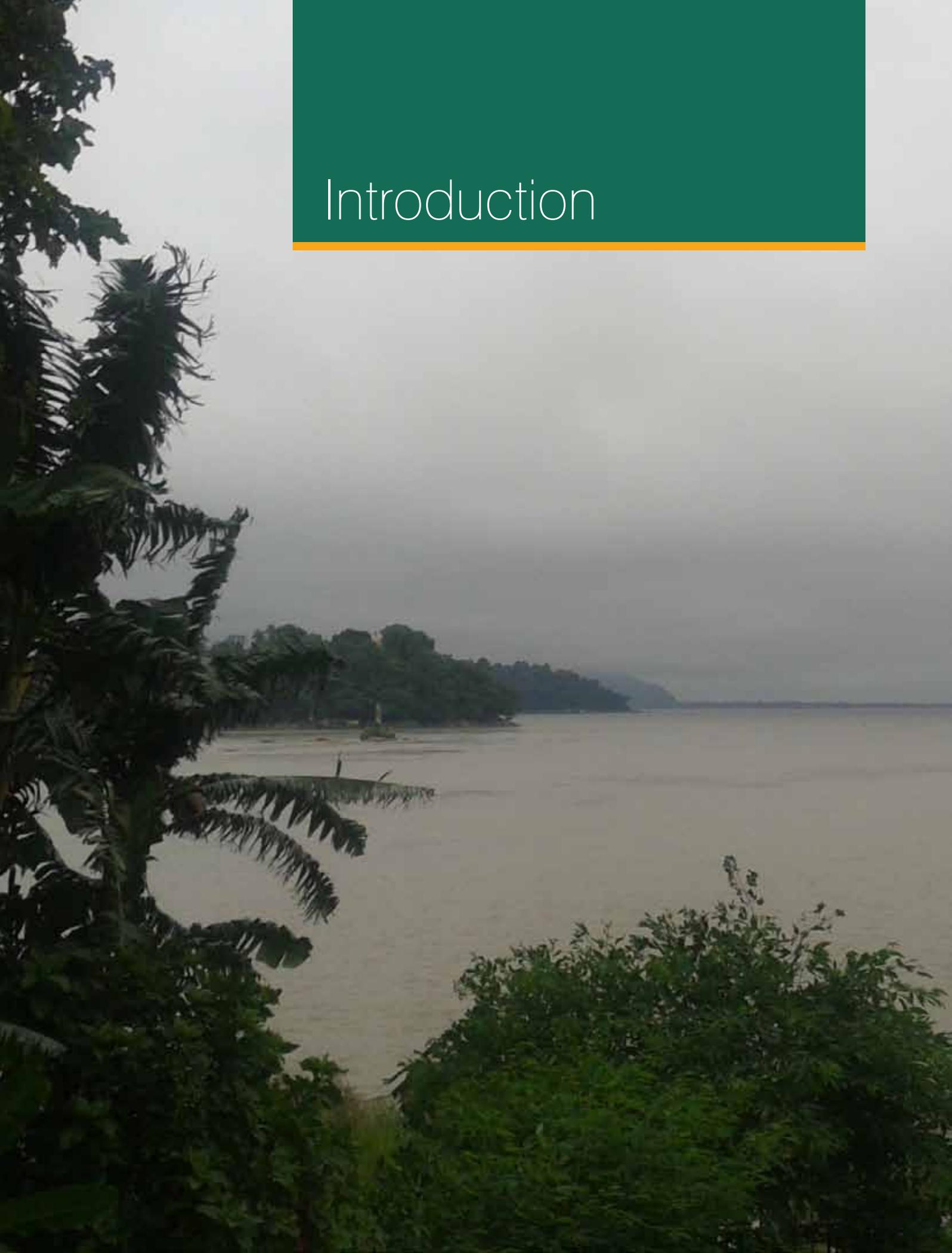
Sector	Recommendation/Strategy	Vehicle
Housing	Guidelines for construction of buildings on slope	Section 61 on ‘Special regulations for construction in hilly areas’ in the Building Bye laws for Guwahati Metropolitan Area need to integrate these points.
	Structural stability of buildings in hills and for the entire GMA	Intensive micro-zonation studies to be conducted to identify vulnerable areas as per the sub soil conditions of GMA.
	Soil erosion and sedimentation control for construction in non-hill GMA areas	Norms to be introduced in the Building Bye Laws of GMA 2006
	Precautions and technical details for use of Septic tanks and Soak-pits	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

	Rain water harvesting for storage	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	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
	Planning of 3 new satellite towns to be on the principles of sustainability	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	Geo-hydrological studies for new projects
	Regulating withdrawal of ground water and rain water harvesting	Conduct exploratory studies for establishing new withdrawal points
	Water quality monitoring and control	Centralized monitoring system through a quality monitor team
Drainage	Protecting and managing natural drainage systems of the city	Improvement of drainage in the Brahmaputra Valley and Barak Valley, including project planning and construction of dams, flood control and bank erosion measures.
	Restricting waste disposal in Bharalu and Bashishtha rivulets	Identify points of drainage blockage/ encroachment in the rivulets
Electricity/ Power	Promoting energy efficiency urban land uses	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
	Promoting use of renewable energy sources	Implementation of Solar City Plan under the Jawaharlal Nehru National Solar Mission (as part of NAPCC).
Health	Public health management and surveillance system	The JD-H is the district level administration officer for public health and the nodal public officer overseeing implementation of government schemes, missions and public health care set-up including PHCs, UHCs, Medical units
	Emergency medical response	The office of the JD-H is also the nodal agency for preparing and enforcing the SOP of ESF-4 under the KMD District Disaster Management Plan prepared under the provisions of the Disaster Management Act, 2005

We hope that this detailed city assessment finds relevance at all levels of Guwahati city's policy and regulatory framework and goes a long way in mainstreaming climate change adaptation in the urban planning process at both the city and state level. Further to this, the endeavour is to work towards responses that are mainstreamed at national and sub national levels but are rooted in local conditions as well as built into local laws and regulations.

Introduction



Introduction

1. Introduction to Guwahati City

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. Guwahati is the capital city of Assam and the largest city in the North East region.

Guwahati is situated at 26°10' north latitude and 92° 49' east longitude. Located on the banks of the Brahmaputra River, it is the largest commercial, industrial and educational centre of the N-E region. The city 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.

The city is situated on an undulating plain with varying altitudes of 49.5 m to 55.5 m above Mean Sea Level (MSL). The Southern and Eastern sides of the city are surrounded by hillocks. Apart from the hilly tracts, swamps, marshes, water bodies like DeeporBeel, Silpukhuri, DighaliPukhuri, BorsolaBeel and SilsakooBeel etc. also cover the city (City Development Plan, JNNURM)¹.

The total population of Guwahati UA/Metropolitan region is 968, 549. As per the data released by Govt. of India for Census 2011, Guwahati is an Urban Agglomeration coming under the category of Class I UAs/Towns. The city is governed by Municipal Corporation and is situated in Guwahati Urban Region.²



Figure 1: Guwahati location map

2. Study Methodology

This exercise aims to understand the existing and future risk profile of the city based on the hazards and stressors which the city faces and its' vulnerability determined by the local factors of the city and prepare a resilience strategy for the same. The focus of the 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 extracted local information in the form of secondary data along with consultations with the Government Departments and relevant stakeholders. Review of existing policies and governance framework of the city was an

1 http://jnnurm.nic.in/wp-content/uploads/2010/12/CDP_Guwahati.pdf

2 <http://www.census2011.co.in/census/metropolitan/177-guwahati.html>

integral part of the assessment to identify channels for integrating adaptation and disaster risk reduction measures in planning and development. A number of case studies were referred to, which carried out risk assessments using different methodologies and framework to capture the hazard and vulnerability components of urban risk. Figure 2 shows the broad framework for risk assessment adopted for Guwahati.

▪ **Identification of hazards and challenges:**

The initial step in risk assessment was identification of main hazards and stressors (climatic and non-climatic) which have been affecting the city of Guwahati. Using secondary data, along with literature review and results from consultation with government departments and experts, past trends of the hazards and stressors in terms of duration, frequency and damages were analysed (*Section 3 presents the main findings from the hazards and risk assessment exercise*).

▪ **Vulnerability Analysis:**

Vulnerability to hazards and stressors is dependent on a number of intrinsic factors of the region. These factors govern the differential level of exposure and sensitivity of different communities and regions. Variables such as topography, population dynamics, socio-economic condition and land-use pattern were studied on the basis of data availability.

The vulnerability analysis is

essentially deduced from the base line situation of the city in terms of the above mentioned parameters and is defined with the degree of change in the base line situation due to climate impacts.

▪ **Identification of hotspots:** Drivers of hazards and stressors combined with vulnerability levels of the city helped in identification of eco-sensitive hotspots. The analysis also helped in highlighting vulnerable communities and sectors as well as urban functions which are more vulnerable to risks and hazards. GIS platform was used to integrate the data obtained on hazard trends and distribution with the exposure factors of the city.

▪ **Future climate and socio-economic projections:** Along with the socio-economic projections (drawn in from secondary sources like Master plan documents, other reports and literature), the current climate trends and future climate projections carried out through climate models were overlaid with the current stressors and risks to get

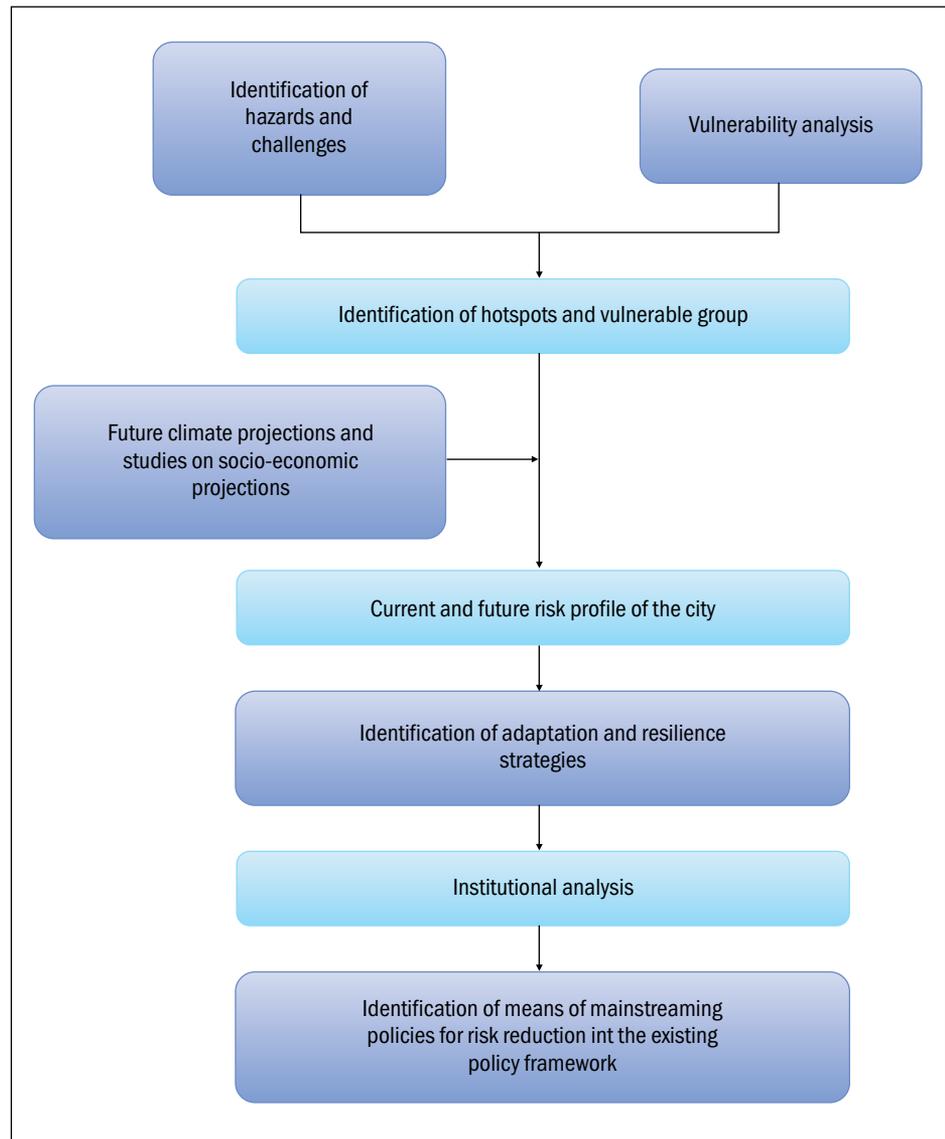


Figure 2: Risk Assessment Framework for Guwahati

an understanding of future risk profile of the city. For generating future climate projections, 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 to understand the likely changes in the key climate parameters including temperature (minimum, maximum and mean) and percentage change in precipitation from the baseline. The analysis was carried out at The Energy and Resources Institute (TERI), New Delhi. The spatial extent covered for the modelling exercise is shown in Figure 3.

- **Current and future risk profile of the city:** The information generated on vulnerable hotspots, communities and urban functions helped in generating the current risk profile of the city. This combined with the future climate projections provided a snapshot of the likely future risk profile of Guwahati. The results of the risk assessment were also shared and consulted with the relevant stakeholders to address any gaps. (Section 4 presents the main findings from the vulnerability assessment exercise).
- **Identification of adaptation and resilience options to address the risks:** The current and future risk profile of the city assisted in recognizing adaptation and resilience options to address these risks. The objective was to have a set of adaptation options which address the vulnerabilities of different sectors and communities and can help in making the city more resilient (Captured in Section 6 which gives an overview of the city resilience strategy).
- **Review of existing policies and legislations to identify gaps in addressing to risks:** Understanding the current institutional mechanisms to address the risks and disasters faced by the city is an important component of risk assessment. An integral step of the risk assessment was a review of existing policies, legislations and by-laws to address disaster risk reduction. This review helped in identifying the gaps in the existing policy regime to address the current and future risks (Section 5 focuses on the Institutional Analysis).
- **Identification of means of integrating and mainstreaming policies for risk reduction in the existing policy framework:** The overall analysis helped in identifying means to address the gaps in policy framework and legislations. The results are expected to make the city more resilient towards current and future potential risks.

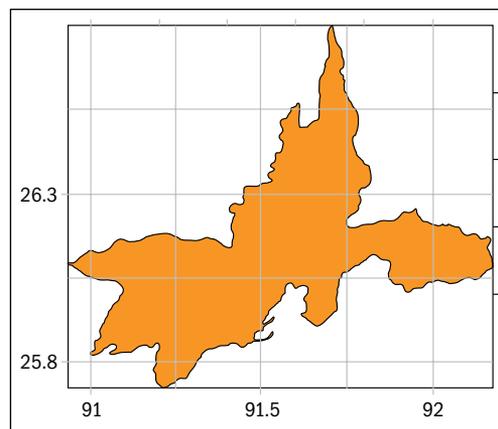


Figure 3: Spatial Extent of Kamrup District

Risk and Vulnerability Assessment



Risk and Vulnerability Assessment

3. Key observations

The city consultations and literature review about the city reveal three major components to hazards in the city:

- Unplanned, unregulated urbanization and its consequences
- Past climate variability and associated impacts
- Disasters including floods, earthquakes and land slides

3.1 Unplanned /unregulated urbanization

Urban growth in the city of Guwahati has been rapid, unplanned and organic. Rapid population growth, high migration rates and change in land use pattern of the city due to uncontrolled development activities is said to have done a lot of harm to the ecology and environment of the city. Illegal construction on hills has been one of the major causes for landslides. Uncontrolled urban development, particularly construction activities in and around the city is a major threat to this city on high seismic activity zone.

Population growth

Guwahati city has experienced considerable population growth in the past few decades although the decadal growth rate seems to have a declining trend over the years. The population of Guwahati city including the urban agglomeration has seen a decadal growth of 18.29% from 8, 18,809 in 2001 to 9, 68, 549 in 2011. 10% of the population in 2011 falls in the age group of 0 to 6 as compared to the national average of 13.12% and the state average of 14.47%.

Also, there is large floating population ranging to about 1.5-2 lacs in a week which also leads to load on infrastructure (Consultation with JICA). Besides the main population residing in the city, 10% is floating population which comes for daytime activities (Master Plan).

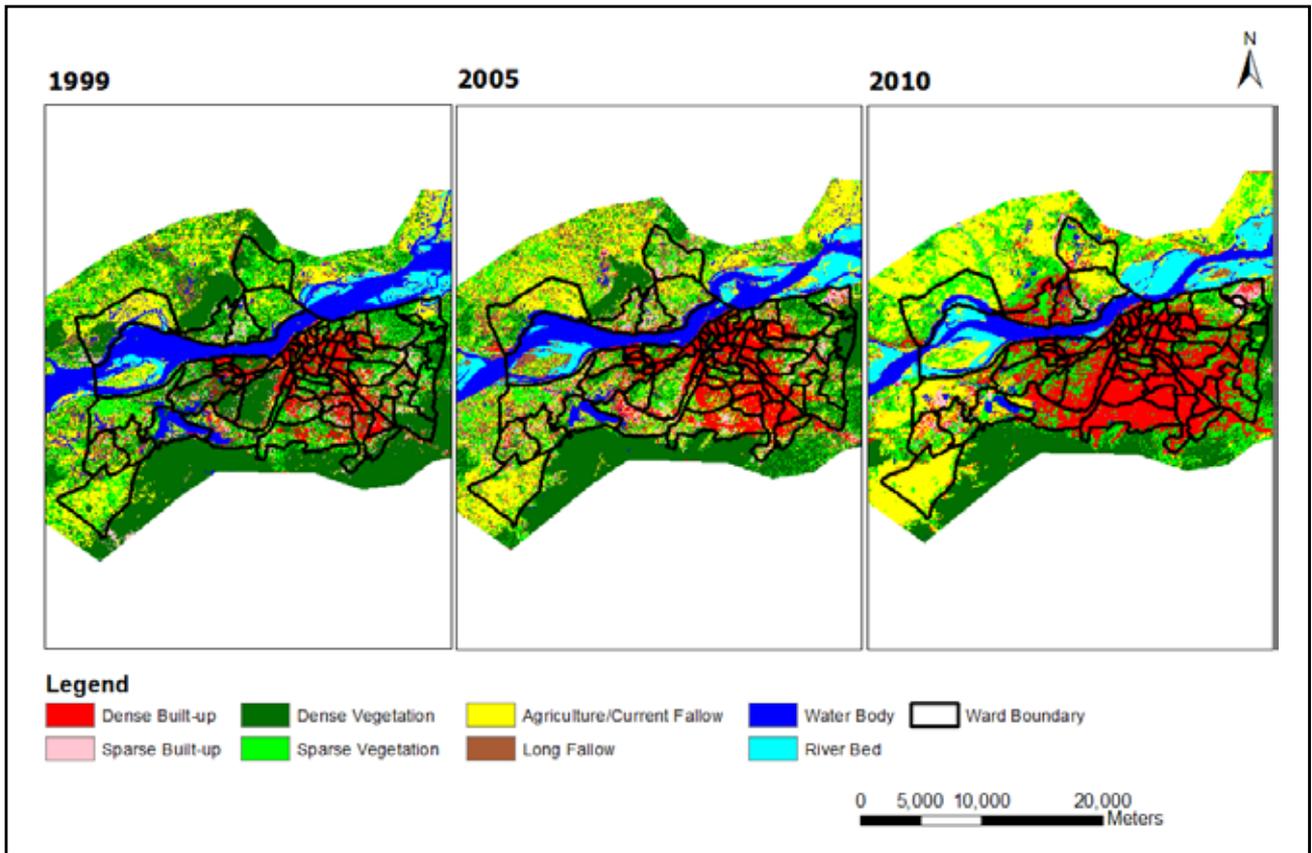
Migration

Migration has been a continuous phenomenon for Guwahati city in the past few decades. Economic opportunities along with many social and political reasons govern migration of people to the city. Better urban services as compared to other rural areas such as education and medical facilities also are factors affecting immigration. In the past few years, with a rapid increase in employment opportunities due to growth of industries and other secondary & tertiary sectors, migration has taken place from different cities and villages. As in most cases these people are poor or from economically backward background and thus they tend to settle in illegal settlements and encroachments on hills or fragile lands. The recent increase in slum areas is an indication of increased migration in Guwahati (CDP, Guwahati).

3.2 Climate trends

3.2.1 Temperature trends

Data for the past 14 years (1997-2011) obtained from the Regional Meteorological Centre, Guwahati was analyzed to understand the trend in temperature and precipitation for Guwahati region. Data for both maximum and minimum temperature shows an increasing trend over the city of Guwahati. For minimum temperatures barring



Map 1: Urban Sprawl and change in land use

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 region north to the river Brahmaputra has emerged as a new built-up area in layout for the year 2010. There has also been an expansion in built-up areas along NH 37 especially near the Maligaon NE Railway headquarters, and the area between Fatasil Hills and the highway. The area towards the east near Noonmati and Narengi has also expanded considerably.

1997 and 2011, all the years show a clear increasing trend in the values (Figure 4). Similarly, except for a couple of years between 2003 and 2005, values for the maximum temperature also show an increasing trend (Figure 5). The extreme temperature values as seen from the 14 year data has been recorded as high as 40°C (Tmax) in 1999 and as low as 6.4°C (Tmin) in 2007.

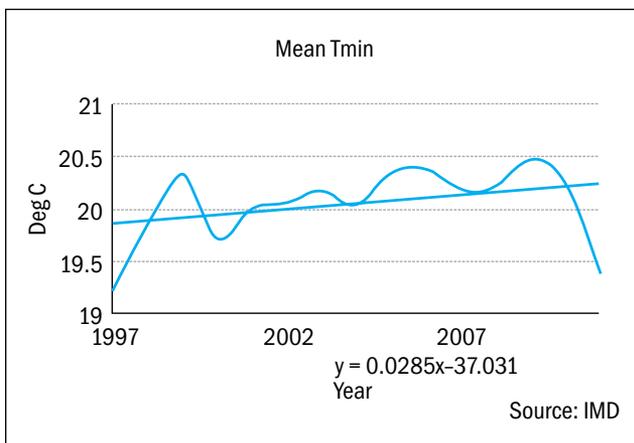


Figure 4 Time series for mean minimum temperature over

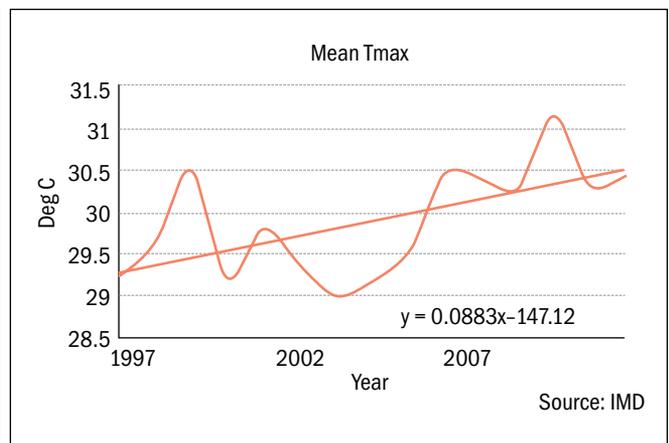


Figure 5 Time series for mean maximum temperature over Guwahati

3.2.2 Rainfall trends

The daily rainfall data from Indian Meteorological Department Regional Meteorological Office (RMC), Guwahati from 1982-2011 was averaged to get monthly values. The data was analyzed for the monsoon months of June, July, August, and September as well as for the entire year. The rainfall over Guwahati occurs throughout the year with majority occurring during monsoon months. A decreasing trend of seasonal as well as annual rainfall over the city is seen (Figure 6). The number of rainy days for July, August and September show a very slight decreasing trend barring June, however, the overall trend for rainy days is not significant for the period of 1982-2011 (Figure. 7). The data for the highest rainfall experienced in one day in the entire season for the 29 year period over Guwahati was analyzed. Similar to Goswami et al. (2006)³ and Rajeevan et al. (2008)⁴, we have considered the rainfall events between 5 and 100 mm/day as moderate events and rainfall events between 100 and 150 mm/day as heavy rain (HR) events. Rainfall events equal or greater than 150 mm/day are termed as very heavy rain (VHR) events. The data for the extreme rainfall events for the 29 year period shows that 12 out of 29 years have experienced heavy rainfall (HR) events of which 3 years viz. 1985, 1991, and 2011 have witnessed very heavy rainfall (VHR) events. The data also shows that 6 of these 12 years have occurred in the recent decade (2003, 2004, 2005, 2009, 2010 and 2011) (Figure 6). It was also observed that although there has been a decreasing trend in the overall seasonal rainfall as compared to the long term average but there has also been an increase in extreme rainfall events (Figure 8) resulting in more rainfall in short duration. This can be one of the attributing factors for urban flooding.

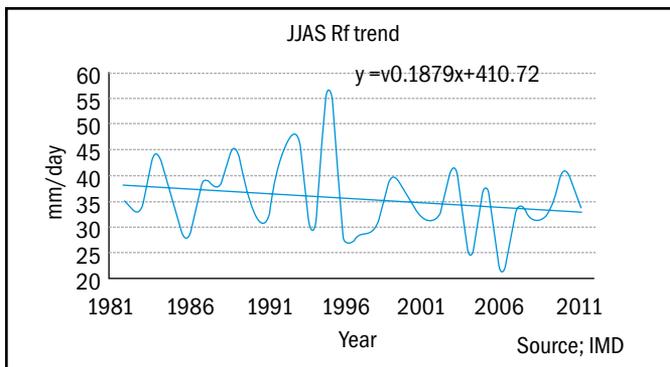


Figure 6 Seasonal mean rainfall for monsoon months over Guwahati from 1981 to 2011

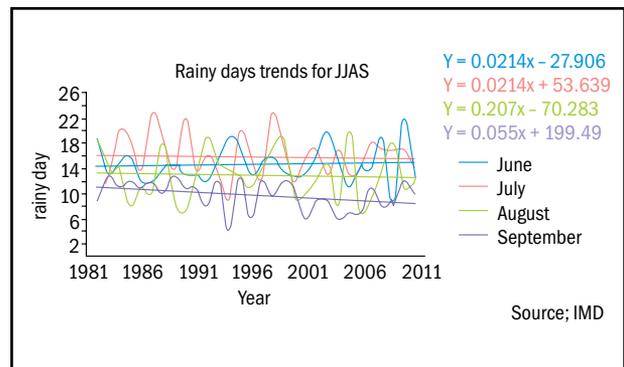


Figure 7 Seasonal mean rainfall for monsoon months over Guwahati from 1981 to 2011

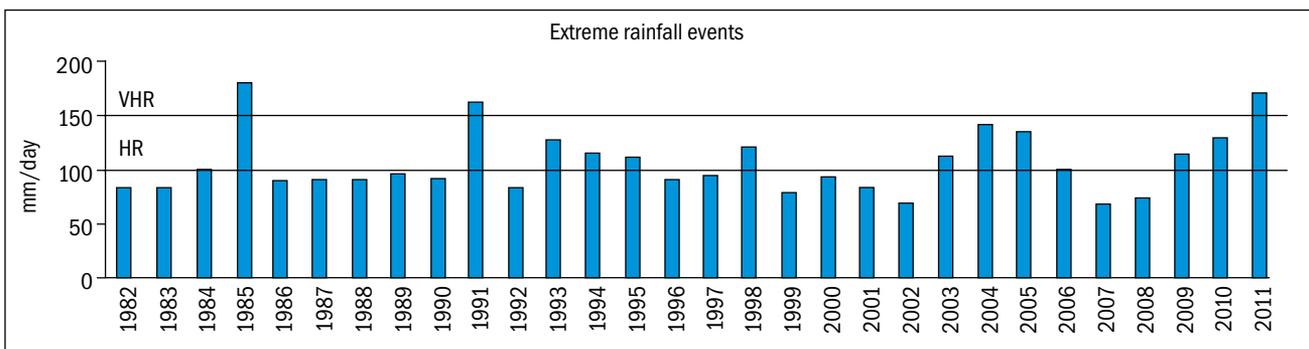


Figure 8 Extreme rainfall events

Note: Rainfall events between 5-100 mm/day termed as moderate events, those between 100-150 mm/day as High Rainfall events (HR) and those equal or greater than 150 mm/day as Very High Rainfall events (VHR).

3 Goswami, B. N., V. Venugopal, D. Sengupta, M. S. Madhusoodanan, and P.K. Xavier (2006), Increasing trend of extreme rain events over India in a warming environment, *Science*, 314, 1442– 1444.
 4 Rajeevan, M., Bhat, J. and Jaswal, A.K. (2008), Analysis of variability and trends of extreme rainfall events over India using 104 years of gridded daily rainfall data, *Geophysical Research Letters*, 35, L18707, doi:10.1029/2008GL035143

3.3 Extreme events/ Disasters

According to the Assam State Disaster Management Policy (2010), landslides and urban floods are the two most prevalent hazards that undermine the urban development of Guwahati. A number of landslides have occurred in Guwahati in recent past causing extensive damage to life and property and have adversely impacted economic development. Continuous rainfall during monsoon aggravates the situation by causing more soil erosion associated with siltation. The poor and socio-economically weaker sections living in marginal and fragile areas are the most affected and vulnerable communities. Apart from these location in high seismic zone also makes Guwahati quite vulnerable.

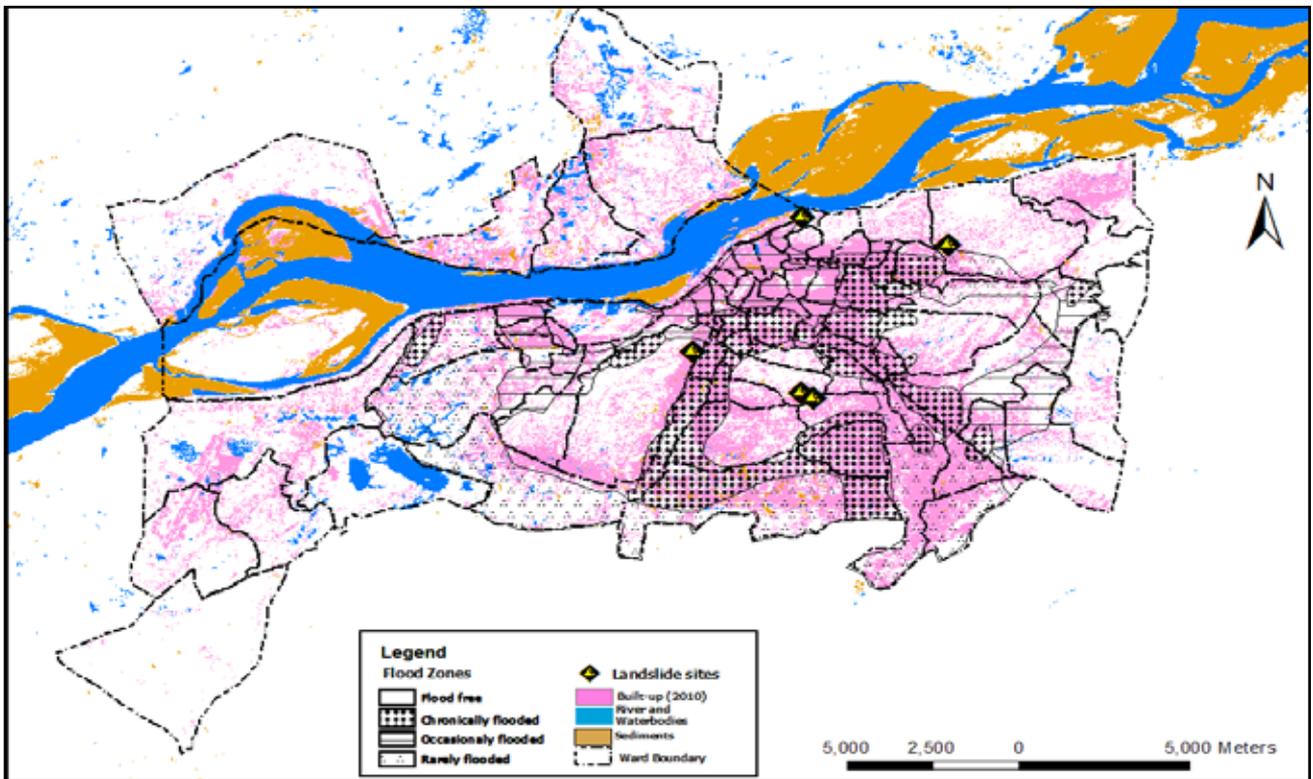
3.3.1 Flooding

Flooding events have become quite common in Guwahati in past few years. Although there is no data available on such events but during the consultation it was told that Guwahati city has a typical situation of manmade hazard as the city does not experience normal flooding events but is characterized by urban flooding owing to a number of issues like lack of drainage, unmanaged solid waste, reclamation of low lying lands and unchecked/unplanned urban growth, hill cutting, etc. Another reason is the increased intensity of rainfall occurring in a very short duration. Although there are no recorded statistics on this but it has been observed that frequency of such extreme events has increased.

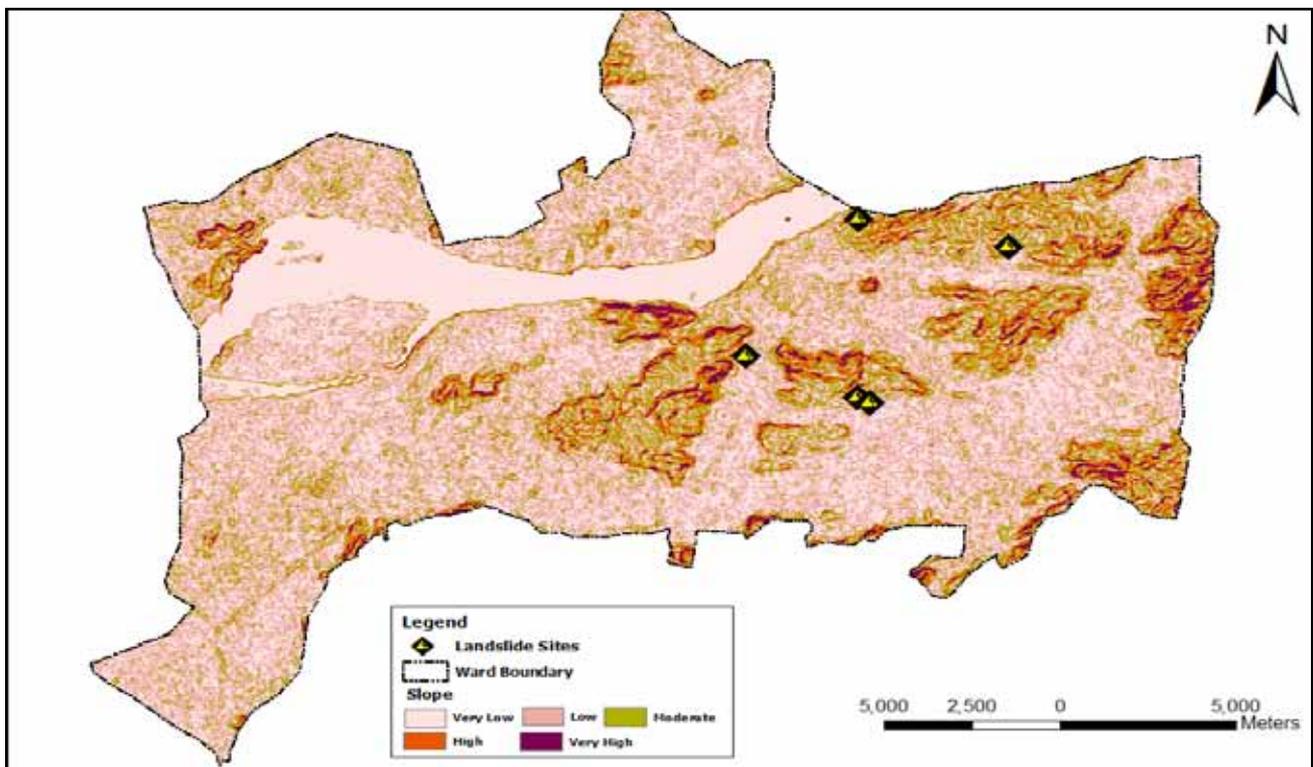
According to the city assessment report⁵, backflow of the water from the River Brahmaputra, due to blockage in the drainage system through Bharalu, Khanajan and Bondajan, causes floods frequently every monsoon. Bharalu basin is the most flood prone area in the region. This is probably because most of the drains fall on the upstream side of River Bharalu. The river is at a higher level than the level of the drains leading to the retarded outlet of the water (Master Plan) Also, there is heavy siltation and dumping of garbage in the Bharalu River. Map No 2 shows the built-up area overlaid with flooded areas in Guwahati. The map shows that the stretches along the Basistha River and the Bharalu River basin are chronically flooded areas while some patches near the Brahmaputra River lie in the occasionally flooded areas. These are also the densely populated areas of the city. Rarely flooded areas are mainly on the outskirts of the city and the stretch along NH 37. The map also shows the location of landslides in the city which shows that some of these are near to the chronically flooded areas.



5 CEPT, 2011. Carrying capacity based Urban Development Regulations, Guwahati Metropolitan Development Authority.



Map 2 Extent of Floods and Landslide Locations



Map 3 Slopes and Landslide Locations

3.3.2 Landslides

During the consultation with ASDMA, it was informed that landslides are a frequent phenomenon in Guwahati owing to flooding and the soil characteristics. This year also (2012), 10 people died due to a land slide in the city. In the past few decades, increasing frequency of landslides have become a concern for the Guwahati city especially around the low lying hills. Encroachment due to growth in settlements on these hills has led to slope modification thereby making the land more vulnerable. According to ASDMA, among all natural hazards, landslide has caused maximum loss of life in the last 20 years. Still, a comprehensive study taking into account all aspects of landslides is yet to be made, in absence of which the policymakers and urban planners find it difficult to initiate any mitigation and management plan (ASDMA., 2012).

During the city level consultation, a ranking exercise was done with the participants to understand their perception about the most critical disaster or extreme event which is faced by Guwahati. Most of the participants ranked urban flooding as the most critical extreme event followed by landslides and then earthquake. It was mentioned that flooding has become an annual phenomenon and results in loss of life as well as property. The cost of relief and rehabilitation is also high. Still, the disaster management efforts of the city are more inclined towards landslides and earthquakes and more robust efforts are required to effectively manage urban flooding. As discussed earlier, along with changing rainfall patterns, manmade factors such as poor drainage systems and improper dumping of solid waste in the city are the factors leading to urban flooding. Even in case of landslides, along with heavy downpour, improper cutting of hills due to illegal encroachments are the triggering factors. Checking illegal encroachments on hills along with infrastructural changes can help address the challenges being faced by flooding and landslides in the Guwahati city. (Based on consultations)

4. Main findings from the Vulnerability assessment- Current Risks profile

The three components of hazards as identified have multiple impacts on the urban systems. The degree of risk to the city due to climate change related variables would be directly proportional to the current situation of the urban systems like services, infrastructure, housing and land use planning. This chapter assesses the current situation and thus the coping capacity of the key sectors that would be directly or indirectly impacted due to climate change. The chapter further provides a detailed future climate projection analysis and builds a case for a resilience strategy for the city of Guwahati.

As per the risk analysis and hazard assessment exercise, during the process of the study the following sectors have been identified as the key sectors that need to be studied to understand the present and future vulnerability of the city in the context of climate change impacts. After discussions with the city officials, sector wise gaps and problems were identified.

- Housing and urban planning
- Ecosystems and land-use
- Urban infrastructure and services
- Informal settlements and slums
- Poverty and livelihood
- Emergency response capacity

4.1 Housing

Current status

The Master plan for Guwahati CMP-2025, deals with the housing sector in terms of:

- Present and future shortage in housing stock
- The composition of housing units in terms of occupancy level
- Role of private developers in tackling housing situation and shortage
- Housing for poor

Table 1 presents the projections made in the Master Plan for increase in housing in every five year interval time till 2025. It is pertinent to note that for the interval years 2011-2015 total projected requirement of housing units has been 67,687 which is more than thrice the need for 2005.

Table 1: Housing requirement in Guwahati (2006-2025)

Year	Additional Population	Additional Houses	Total Housing requirements
2006-2010	211,129	47984	57885
2011-2015	254257	57786	67687
2016-2020	306193	68589	69589
2021-2025	368739	83804	83804
	1140318	259163	278965

Source: Guwahati Master Plan 2025

The Master Plan proposes building of about 90909 Dwelling units in the proposed new towns, about 131721 dwelling units in the new residential development within Guwahati and about 56335 dwelling units as infill development in existing residential area to cater to the housing demand and deficit. This is also noteworthy, that the housing shortage projected to be 278965 by the year 2025 does not include the slums areas. The major observations outlining the gaps for the housing sector have been listed in Table 2.

Table 2: Gaps and issues in the housing sector

Issue	Description
Bottlenecks in Master plans	The Master Plans while discussing the housing backlogs and future stock requirement does not talk about the land requirements for the same. It is pertinent to add here that the city is sprawling outwards. A lot of these areas coming under the sprawl are significant natural features like natural wetlands, watershed areas; fragile hilly areas which are not fit for development. This becomes an important issue in the light of the fact that the city faces frequent landslides and flooding during rainy seasons. In spite of the fact that the building Bye-laws do exist, the absence of their mention in an important document like Master Plan and within the section on housing is a big gap. Also considering urban flooding as one of the detriments for city, housing locations for future also need to be taken into account in the planning stage itself.
Lack of planning for slums	If a city has to be slum free, the housing needs of all the residents of the city including the poor would have to be planned and provided for while allocation of housing stock. In the absence of such an approach, the slums would continue to be built in the hazardous and vulnerable locations in the city, ever increasing the vulnerability of the residents to climate related events and natural disasters.
Construction activities	The city is not thinking of building construction that is apt for the location, for example consideration to frequent floods, climatic conditions etc. Promoting this kind of construction would not only mainstream good construction practices but also reduce the structural vulnerability for the city to various climate related disasters and events.

4.2 Urban Planning

Current status

According to city consultations, restricting construction and densification is difficult because the FSI (Floor Space Index) is already higher in Guwahati than some other cities. Also the present infrastructure is not sufficient to support re-densification. Hence the GMDA is thinking of developing satellite towns which act as counter magnets to the Guwahati city. The Master Plan talks about 3 new towns to be developed for this purpose. The satellite towns so developed need to have such activities which attract population to live and work there. However, this also means that transport planning has to be an integral part of this exercise to ensure better commuting possibilities (for example, introducing monorail) between the satellite towns and GMR. Redensification could then be attempted along these transport routes. GMDA is planning to expand the metropolitan area and identify satellite townships for not only residential complexes but also for commercial activities to reduce the commuting pressure on the existing transport system. The major observations outlining the gaps for the urban planning sector have been listed in Table 3.

Table 3: Gaps and issues in the urban planning sector

Issue	Description
Urban congestion & illegal constructions	Illegal settlements by low income groups on hills are more prone to landslides and add to the vulnerability of the city. Guwahati also faces problems of weak constructions and poorly built housing due to lack of efficient enforcement of building codes laid down by Guwahati Municipal Corporation and Guwahati Metropolitan Development Authority
Expansion in land use pattern (especially on hills)	Illegal settlements by low income groups on hills are more prone to landslides and add to the vulnerability of the city. Moreover, the people living there are mainly living in temporary structures which are more fragile. Unauthorized cutting of hills has led to silting in the downstream areas.

4.3 Ecosystem and Land use

Guwahati city is located in a valley surrounded by hills on three sides. It has large area under hillocks and water bodies. However, rapid unplanned urbanization has led to major changes in the land use pattern resulting in major repercussions on the natural landforms as well as on the entire ecosystem of the city. The major observations outlining the gaps for the ecosystem and land use sector have been listed in Table 4.

Table 4: Gaps and issues in the ecosystem and land use sector

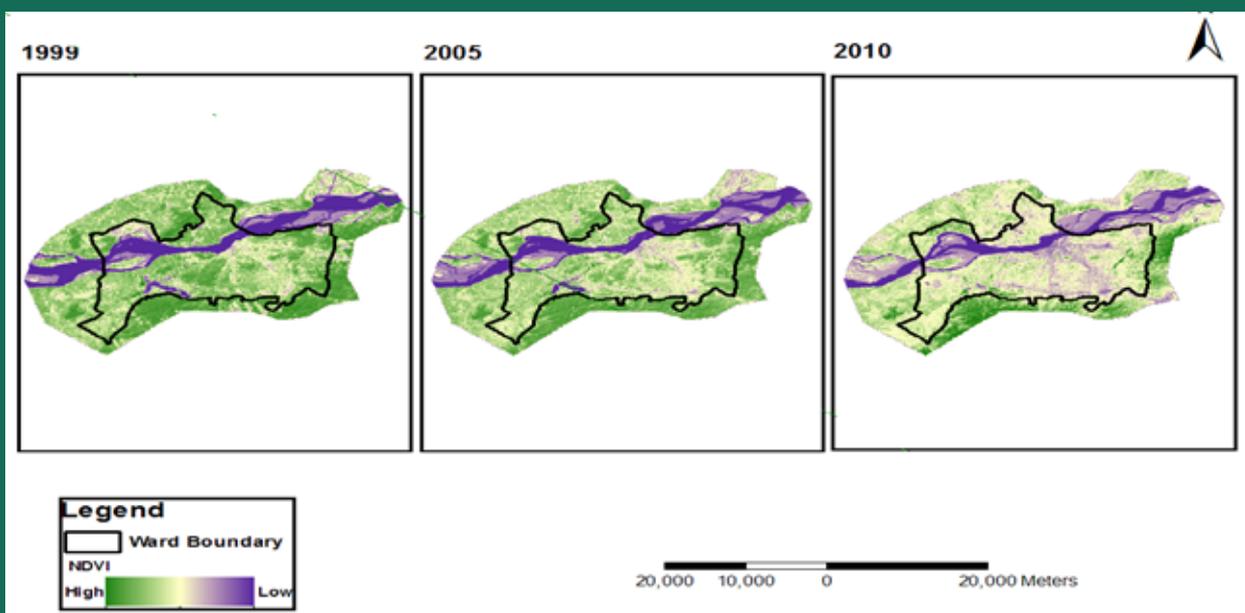
Issue	Description
Change in topography (due to external factors)	External factors such as development near Meghalaya border have also led to change in the topography. There are flash floods near agricultural university area. A lot of industries, schools, colleges etc. have been built along the border which not only threat the environment of the city (cutting of hills is a major problem) by aggravating and causing floods, siltation, air pollution; but are also putting pressures on the infrastructure and services of the city as this development is depending on Guwahati city for its requirement.
Deforestation & construction on hills	Uncontrolled deforestation and construction on the hills in Guwahati has resulted in more exposed slopes which are more prone to soil erosion as compared to the vegetation covered slopes. Increased soil erosion not only results in loss of soil fertility but also causes problems of water logging and flash flood down the slope. There is a need of regulating cutting of trees and encroachment in forest areas (Master Plan of Guwahati city 2025). During consultation exercise with GMDA, it was revealed that the Master Plan of Guwahati clearly demarcates the eco-sensitive zones where development should be restricted. Still, the hill areas and hillocks are being encroached upon.
Hill encroachments	The area covered by hills is owned by the state government (around 70%) and the rest is forest area (~20%) or owned by genuine land owners (10%). Thus, the area falls under the jurisdiction of District administration and the urban local bodies of Guwahati can't take any regulatory actions against it. A high level committee has been established within GDD to recommend solutions on the illegal encroachment of these hill areas

Issue	Description
Waste discharge in rivers	The Brahmaputra river is a major natural feature of the city. One of the important tributaries of the Brahmaputra river, the Bharalu river which flows through the city is an important channel for the drainage of the city. Due to siltation, the bed level of river Bharalu has considerably risen. A major chunk of the waste discharged from the city is directly dumped in this river. Waste water from households, commercial and business establishments, small and medium industries also ends up in Bharalu River which gets discharged in the Brahmaputra. Even in the upper reaches, the refinery waste water from the Indian Oil Corporation Refinery at Noonmati flows directly to the river (CDP). This has resulted in degradation of the water quality of the river and it has been reduced to a drain. With choking of the natural drainage, the city has become more prone to water logging and urban flooding.
Destruction of Wetlands	The expanse of Deepar Bil, which is an important water body in Assam has also been reduced drastically by 14.1% between 1990-2002. Illegal construction in the buffer zones, dumping of garbage, encroachment of the lakebed, brick kiln and soil quarrying in the lakebed are the direct threats on the wetland (Carrying Capacity Based Urban Development Regulations, Guwahati, 2011).

To understand the vulnerability of the natural environment in Guwahati city, a trend analysis was carried out for the last decade (1999-2010) using satellite imagery.

Vegetation health

Normalized difference vegetation Index (NDVI) has been used as an indicator of vegetation health⁶. NDVI is captured using the information gathered by the satellite sensors in near-infrared and red wavelength. Being normalized in nature, it is able to capture the variation in the vegetation vigor and the health. The temporal vegetation index maps reveal that the extent of vegetation cover (i.e. forest) has decreased over the period all over the city area. The vigor (vegetation health) has also degraded over the study period. The remnants of healthy vegetation have remained in the southern part of the Guwahati township.

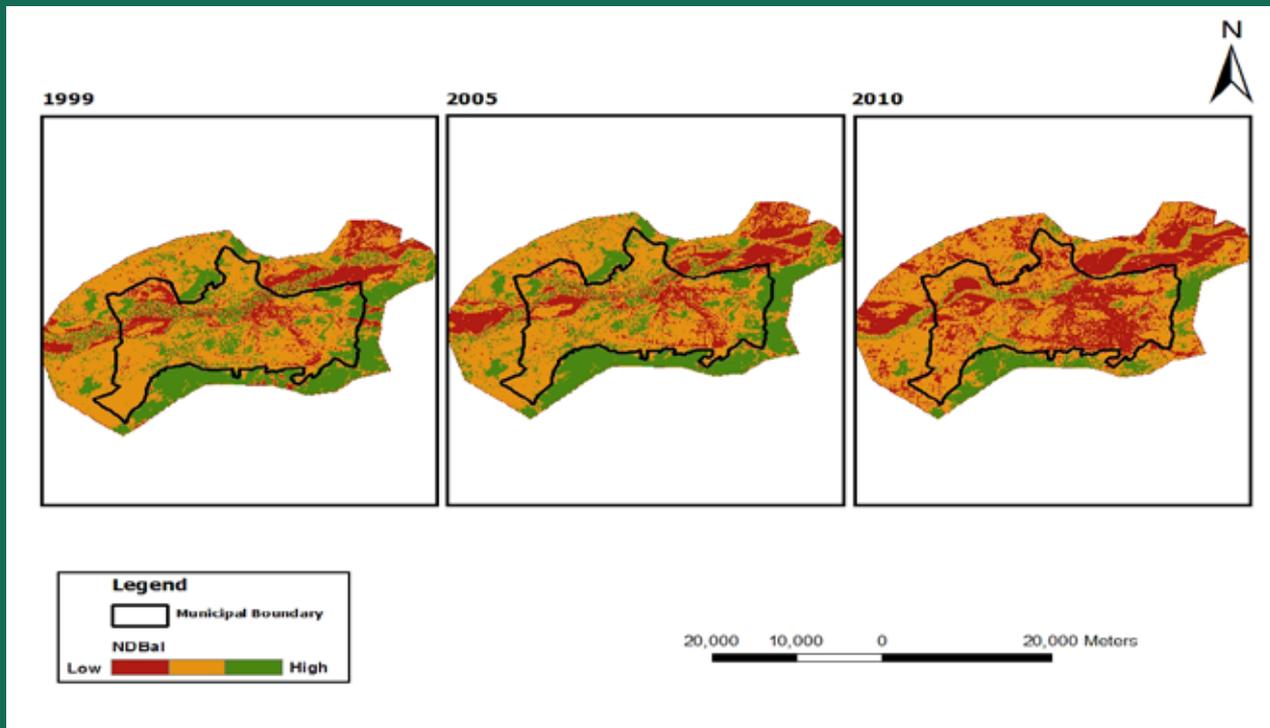


Map 4 Normalized Vegetation Index

6 The Normalised Difference Vegetation Index (NDVI) map zoomed in the Guwahati area. This index uses the NIR and Red bands. This index enhances the vegetation of an area. The healthier vegetation will show a higher value than others. It is given by: $(\rho_{NIR} - \rho_R) / (\rho_{NIR} + \rho_R)$. As can be seen from the figure from 1999 to 2010 vegetation decrease as the blue color increases. Blue color represents poor quality vegetation.

Bareness

Surface Bareness has been computed through the normalized bareness Index⁷ using the information gathered by the satellite sensors in mid-infrared and thermal wavelength. It indicates the cumulative effect of vegetation content covering the land, moisture content present over the land surface and impervious surfaces/urban fabrics. The temporal maps indicate increase in bareness over the surface in Guwahati city. This is due to decrease in vegetation cover, decrease in capability of holding moisture or water and dryness over the land surface.



Map 5 Normalised Bareness Index

4.4 Urban Infrastructure and Services

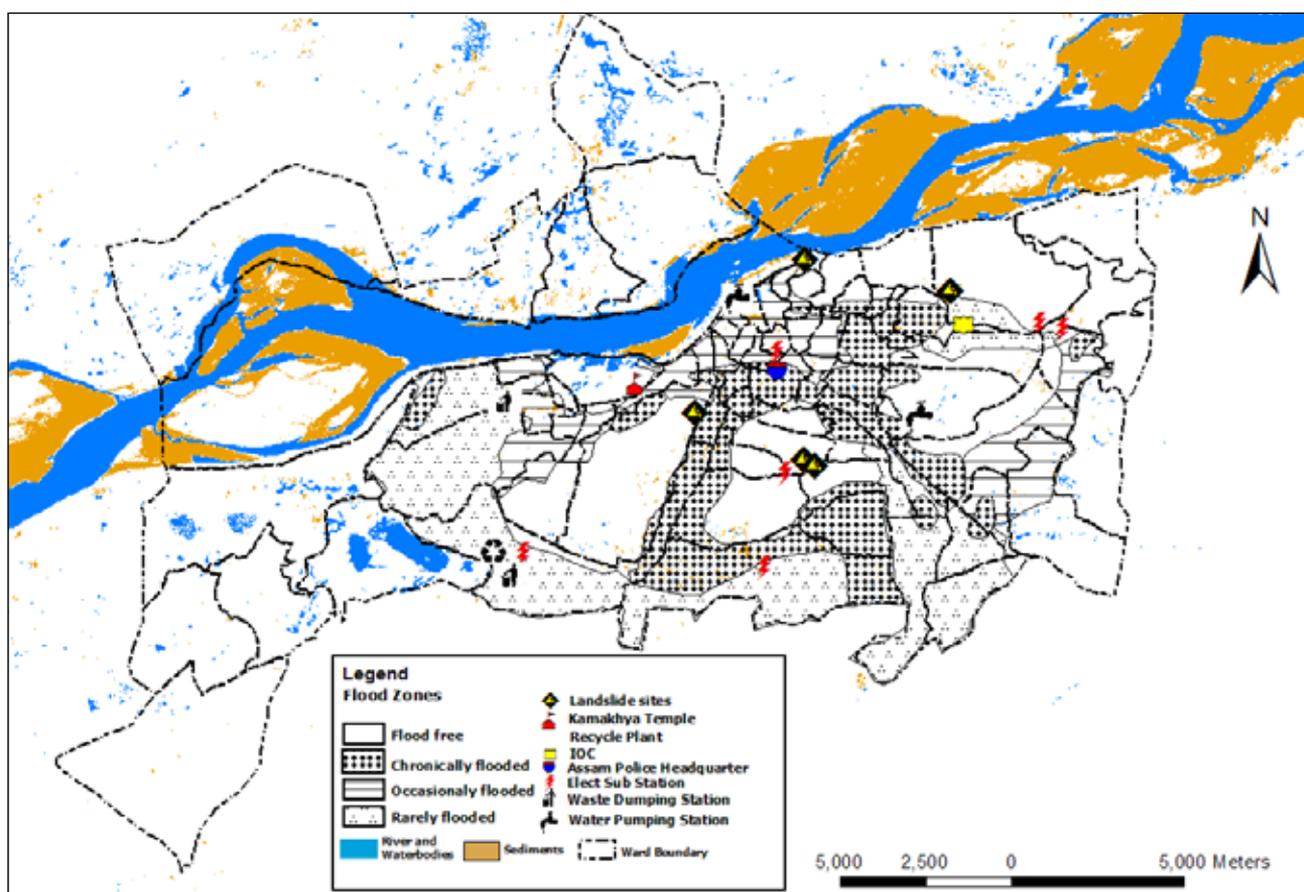
Infrastructure and services are the backbone of the city and play an important part not only in ascertaining the quality of life of its citizens but also in attracting investments thus bringing in prosperity for the city. Poor or sub-standard infrastructure services increase the vulnerability of the population to manifolds in case of disasters and climate related extreme events. Variability in climate due to climate change impacts would also have impact on infrastructure, particularly basic service provision like water and sanitation, drainage and sewerage and solid waste management.

4.4.1 Water Supply

Current status

- 35% of the city is covered by piped water supply. (Master Plan 2025) The potable water generation capacity in Guwahati is 98 MLD however; water produced is only 78 MLD as against the current demand for 132 MLD.

⁷ The Normalised Difference Bareness Index (NDBal) enhances the bareness in the region. It is increasing from 1999 to 2010. It is given by: $(\rho_{MIR} - \rho_{TIR}) / (\rho_{MIR} + \rho_{TIR})$



Map 6: Vulnerability of urban services and infrastructure

- The projected demand for the city by the year 2025 is estimated to be 425 MLD. As per the GMDA figures, 63.5% of the needed water is extracted from ground in the form of hand pumps, tube wells and wells in GMA (Carrying Capacity Based Urban Development Regulations, Guwahati, 2011).
- The major industries including the IOC’s Oil refinery, The Railways, Airport and Defence establishment at Guwahati collect treat and supply water for their own requirement on their own, River Brahmaputra being their major source. The Master Plan proposes that all the industries in future would have to manage the water collection treatment and supply on their own without any help with the Municipal Corporation.
- Only one water supply project worth Rs. 280 crores (90% funding from Centre) was sanctioned for financial support under JnNURM under water supply sector. This project covered the West Guwahati region. Besides this the South Central Guwahati and North Guwahati are to be covered by water supply schemes by JICA finding. The major observations outlining the gaps for the water sector have been listed in Table 5.

Table 5: Gaps and issues in the water supply sector

Issue	Description
Gaps in water supply network	<p>The water supply network of GMC covers about 20% of the municipal area. This system was developed in the 1950s and is facing a lot structural, pressure and quality issues due to wear and tear and lack of maintenance. The supply is also intermittent.</p> <p>The Master Plan informs that the yield of the shallow tube wells is not significant and that possibility of ground water extraction is remote due to the hard rock surface of the city. Thus, the river Brahmaputra is the main source of water for the city. The water supply duration is as slow as 3 hours during a day.</p>

Issue	Description
Inefficiency in water supply	<p>The system of AUWS&SB covers about 5-10% of the city. It is relatively new system and is metered. However, the supply is intermittent and the meters do not work as the pressure is very low. The rest of the city is using water either extracted through private bore wells or from the municipal tankers.</p> <p>The city development plan (CDP) informs that the water treatment plants are running below their capacities, currently at an average of 50% their capacity. The transmission losses are estimated to be as high as 40%. There is a grave need to augment present capacity, maintain and refurbish the old treatment plants particularly the Panbazaar treatment plant which has expired its design life.</p> <p>The CDP notes that the city is not able to update its efficiency, to be able to supply as per the stipulated norms of 150 LPCD (MoUD SSLBs) and a 24x7 supply, and thus needs to build new capacity considering the huge increase in estimated demand for water in near future.</p> <p>The CDP also identifies inadequate human resource development and training in modern utility operations as one of the gaps that leads to inefficient water supply situation in the city.</p>
Water quality	<p>The water quality of the river Brahmaputra has low organic pollution and mineral contents are optimum. However, the water quality is poor along its flow within the city. Also in the absence of a sewage system at place in the city, the municipal waste and waste from the oil refinery is discharged directly into the river leading to high turbidity, faecal contamination. The rivers like Bharalu and Deepar Bil (RAMSAR site) are under the threat of degradation due to this.</p> <p>The ground water sources are also said to be unsuitable for drinking. It is found that the ground water is inflicted by high fluoride and arsenic content.</p>
Water tariffs	<p>The water charges that are levied and billing/collection mechanisms are inadequate and hence the revenues required for repair, maintenance and replacing of infrastructure are not recovered fully. Water tariffs are being charged based on the property assessments of 1971 and have not been revised since.</p>

Guwahati Water Supply Project

In order to have a modernized, 24x7 and metered water supply system with progressive pricing covering the whole Kamrup Metropolitan Area (KMA, beyond GMC limits); the Guwahati Development Department has initiated the Guwahati Water Supply Project.

KMA has been divided into 4 zones and water supply system is developed in these through 3 different schemes funded under JnNURM (30%), with assistance from JICA (60%) and ADB (10%). The nodal agency for implementation is GMDA. The present 3 systems will become defunct once this comes into operation.

The perspective year for the water supply project is 2040 with a review planned by 2025. The planned capacity will be developed @ 135lpcd. Also, there would volumetric tariff structure with progressive pricing. A 'Jal Board' is being constituted from GMC, PHED and AUWS&SB; which will be the nodal agency for maintenance, operation, distribution and revenue collection.

4.4.2 Sewerage

Current status

The Master Plan stipulates setting up of a sewerage system in the towns, including a system for the proposed new towns as an extension to the Guwahati city limits. The CDP highlights that unplanned urban development has led to the formation of stagnant pools of waste water that cause spread of diseases. The plan calls for development of sewerage and drainage system including waste treatment facility. The system becomes very crucial as an infrastructure requirement because frequent flooding and water logging of the city due to floods.

The Master Plans estimates a generation of 225 MLD of waste water from Guwahati city and 107.2 MLD for proposed new towns. The CDP which is an older document calls for requirement of Rs 300.98 Crores for an integrated sewerage and sanitation system with additional allocation requirement of Rs 5 Crores for creating awareness. The CDP suggests a three phased approach where it proposes sewerage collection system to be

developed in short term (1-3 years), augmenting sewerage coverage as a medium term measure (2-5 years) and development of tertiary treatment and recycling facilities as a long term measure (5-10 years).

The major observations outlining the gaps for the sewerage sector have been listed in Table 6.

Table 6: Gaps and issues in the sewerage sector

Issue	Description
Lack of sewerage system	The city does not have a sewerage system at place. The city is dependent on the septic tank system the effluent is released untreated into the nearby drains and low-lying areas. The industrial waste water is also being released in the river and its tributaries untreated. The undulating and bowl shaped topography makes it all the more important to have proper drainage, sewerage and storm water system at place to avoid accumulation of water and associated hazards. The subsoil water table is very high in many areas in the city, leading to non-functional soak pits.



4.4.3 Drainage

Since urban flooding has emerged as one of the main risks, addressing drainage both natural and man-made helps in reduction of climate related vulnerability in the city.

Current status

Except for the 17km drains built by the Town and Country Planning Organization in 1970s, no other planned drainage system exists within the Guwahati Metropolitan area.

The Master plan 2025 gives a detailed account of the condition of the drainage system in the city and puts forward the need for design of a scientifically correct and feasible proposal for storm water and drainage system in the city.

A separate proposal has been made under the JNNURM scheme which is completely disjointed to what the Master Plan suggests. The JNNURM scheme while giving separate plans for each basin, gives a plan that includes rehabilitation of existing drainage system along with new drains, culverts, pumping stations and sluice gates. According to the Detailed Project Report on storm water drainage (2008), the total capital cost of all items proposed under the project is Rs. 7.5 billion.

The major observations outlining the gaps for the drainage sector have been listed in Table 7.



Characteristics of the Natural Drainage Basins

The city of Guwahati is located along the bank of river Brahmaputra with the river at the North and a series of hills all along the remaining periphery except in the west where the Deeparbeel is located, one of the RAMSAR Site- Important ecological areas. The shape of the city inside these natural boundaries is a bowl with number of hills and wetlands known as 'beels' in the local language. Two rivulets; Bharalu and Bashishtha originating from the Southern hills of Meghalaya are the natural drainage channels for the Guwahati Metropolitan Area. The Bharalu river falls into the river Brahmaputra, while the Bashishtha falls into the Deepar Beel. Deepar beel is connected to the river Brahmaputra through a stream known as Konna Jan.

In Guwahati the number of rainy days ranges from 90 to 120 days. Almost 80% of the rain occurs in the two monsoon months leading to water logging and flash floods in the city. The rising of ground water table during monsoon season, when the river Brahmaputra is rising saturates the entire area under plains and reduces percolation of excess water into ground. The rains on the hills that make the boundary of the city, including the KJ hills in Meghalaya and the isolated hilly areas in the east become the major cause of considerable amount of storm water entering into the GMA area.

Besides this the average ground level of the river Brahmaputra is higher than the rest of the city, hence preventing the gravity flow if storm water of the city into the river. Sluice gates have to be installed at the down steam areas of the Bharalu channel, Bondajan and Khonajan areas to prevent backflow from the river Brahmaputra. The GMA area is divided into 6 natural drainage basins which are all significant for planning and designing the drainage system in the city (Bharalu basin, Deepal basin, Silsako basin, Foreshore basin, North Guwahati basin, Kalmoni basin).

Source: Guwahati Master Plan 2025

Table 7: Gaps and issues in the drainage sector

Issue	Description
Inadequate capacity of existing drains	The smaller drains built along the roads do not cater to the drainage requirement of the city which is prone to heavy rainfall and flooding. Moreover, the drains have been encroached upon further decreasing their capacity to drain storm water. The silt coming from the hills and inadequate section of the outfall channel contribute to blocking of drains and overflow of water within the city, leading to floods and water logging within the city.
Built up on the natural drainage pattern	A lot of built up has emerged in the low lying areas of the city, blocking the drainage pattern. This is typically the case in the most densely populated areas of the city and poses health problems and loss to property. Many areas of the city remain water logged during monsoon months and effective drainage system is a pre-requisite to ensure a solution. Garbage dumping has resulted into blockages in the natural drainage pattern.
Topographical features	Since most of the drains fall in the upstream side of the river Bharalu, they are rendered ineffective because of the higher level of the river to that of the drains. The river Bharalu is exposed to heavy siltation and a lot of encroachment has come up on the catchment of river Bharalu endangering the entire natural drainage system of the city.
Encroachment of swamps and natural water reservoirs	The original swamps and natural water reservoirs are being filled up for development purposes leading to floods and stagnant water at several places within the city.
Uncontrolled development, deforestation and cutting of hills	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. This not only increases the storm water flow from the hills to the plains within the city but also brings in lot of mud, and suspended material to the grounds.
Lack of robust water drainage schemes	Guwahati Metropolitan Area Storm Water Drainage Scheme and the schemes prepared by the Town and Country Planning Organization have not taken up as they were envisaged. The Master Plan argues that not enough time was provided to make a scientific evaluation of the storm water drainage system requirement in the city. These schemes instead of focusing on major projects to deal with severe flooding have turned out to be piecemeal efforts leading to construction of a few drains alongside the roads.

4.4.4 Solid Waste Management

Current status & gaps

As per the CDP, the solid waste management is highly inadequate at present and needs urgent attention in the city.

Solid waste management is the responsibility of the Guwahati Municipal Corporation and has been vested to the engineering department. For operational purposes the entire area is divided into 21 zones. Each zone comprising of 3 to 5 wards. Each zone is headed by the Zonal Engineer with inspectors and supervisors to oversee the daily activities. The zonal engineers report to the Divisional Engineers. Each division supervises 4-5 zones. It is projected that the estimated generation of waste kg/per capita /per day in Guwahati by the year 2025 would be 0.8 which is larger than the norms for a class I city. To enable the city to manage such volume of waste and to make the city clean and healthy, there is a strong need for having an integrated solid waste management system at place citywide.



The Master Plan predicts that by the year 2025, the city would be generating solid waste in the order of 0.8 Kg per capita per day, while the waste generated from hospitals would be of the order of 0.5 KG/capita/day by 2025. Right now there is no separate disposal system for waste from hospitals as per norms.

The Master Plan also reveals that 90% of waste generated is organic in nature and the landfill area requirement for the city has been estimated to be 38 hectares for present capacity and is projected to increase to about 91 hectares by 2025. A 24 Hectares solid waste management site is proposed at Pachim Boragaon at Guwahati, however the exact status of this solid waste management site is not known.

The major observations outlining the gaps for the solid waste management sector have been listed in Table 8.

Table 8: Gaps and issues in the solid waste management sector

Issue	Description
Segregation and storage of waste is absent	The waste is stored in community bins, and one can easily find piles of waste on streets, roads, in the drains and in the river.
Door to door collection/ primary collection	At present there is no organized collection system at place. Street sweeping is one way by which the waste lying on roads is being picked up. Frequency of waste removal is regular along the main roads but is very irregular in other areas.
Transportation	Manual loading and carrying in open trucks
Processing and Disposal	A private initiative is present at the outskirts of the city which carries out vermin composting, but its capacity and reach is not known. Right now waste is unscientifically dumped at allocation called Sachhal. The hospitals also do not have proper solid waste management facility and the waste from hospitals is getting mixed with the domestic waste.

4.4.5 Electricity/Power

Current status & gaps

The city frequently faces power disruption, and hence during any extreme events power failure might cause problems. The Master Plans gives recommendations for the improvement in transmission and distribution of power supply, although it does not convey the responsibility to any institution.

Guwahati power zone is covered through three electrical circles, however, the Guwahati Metropolitan Area

gets its power supply through the Kahilipara sub station. The power to this grid substation is fed through 6 power stations namely; Chandrapur Thermal Power Station, MSEB Hydel System, Bongaibaon Thermal Power Supply, Namrup PS, Lokwa PS, Mobile Gas tribune.

At present there is a gap of 48 MVA between the power demand and the availability of power in Guwahati. A proposal to build three more receiving grids of total capacity of 150 MVA tapping power from Assam State Electricity Board and different power plants of the central sector has been proposed under JNNURM. The Master Plan estimates requirement of about 23 substations to cater to power demand by year 2025. However, it does not provide any phased plan which informs of how the present deficit of the power will be curbed and how the future demands for power will be met.

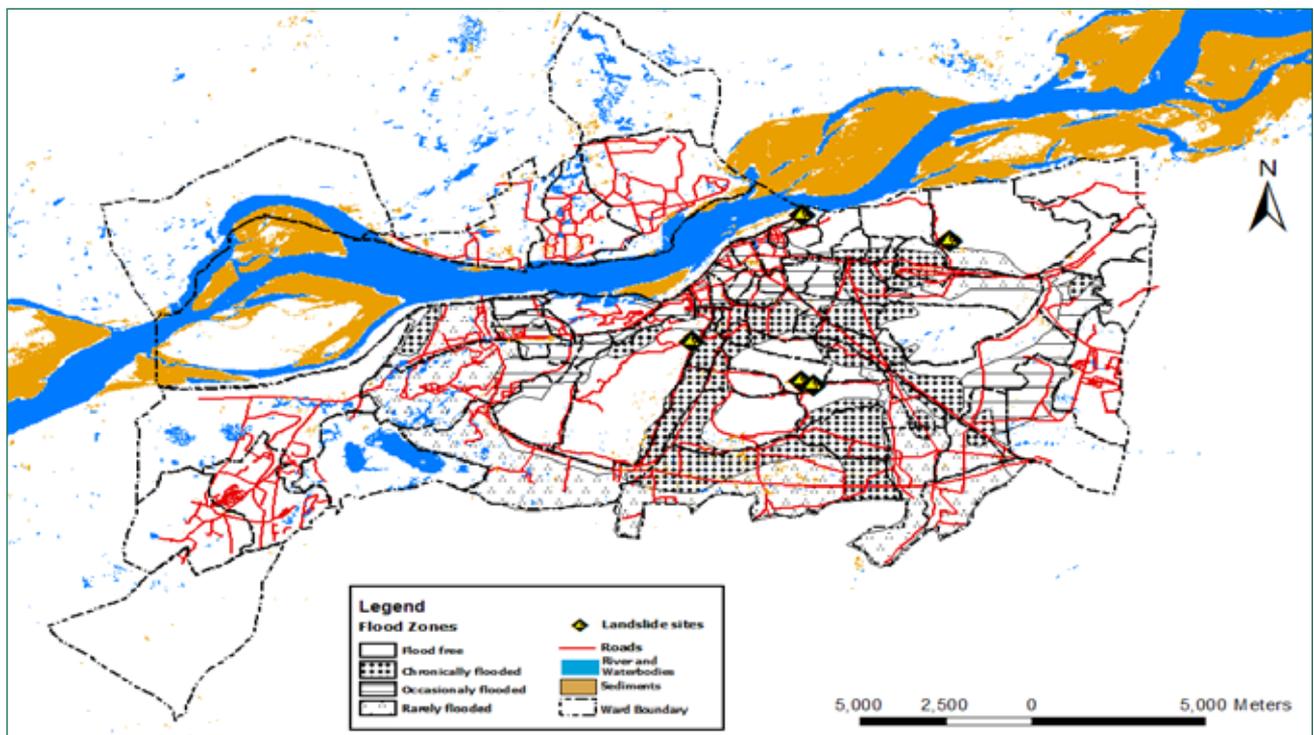
As is known, during floods the water has to be pumped out of the town and so uninterrupted power is needed during rainy season. The city utilizes diesel run generators for the same at present (as discussed during consultations). It is pertinent to note here that Guwahati is also a solar city under the JawaharLal Nehru National Solar Mission of the Ministry of New and Renewable Energy. Guwahati is one of the 60 identified cities to be developed as solar cities under the mission.

4.4.6 Transport

Present situation and gaps

The transport system of Guwahati is crucial for the connectivity of the entire north-east region. The transport system plays an important role of promoting the development of the backward regions and integrating them with the mainstream economy by opening them to trade and investment.

According to the Master Plan of Guwahati City, 171.3 km of main road network was studied. The study shows that the road network is still not very efficient as 72% of road length did not have footpaths; 40% of the road length did not have drainage facility and nearly 70% of the road length did not have street lighting facility. This eventually hinders the drainage of storm water and movement & evacuation at the time of flooding events.



Map 7 Vulnerability of roads to landslides and flooding

4.4.7 Health

Present status & gaps

Guwahati is highly prone to water logging owing to its topography, climatic conditions and lack of adequate sanitation & drainage infrastructure. As a result, the city faces high risks from diseases caused by contaminated drinking water and vectors.

With respect to the health care set-up in the city, at present there are 4 Government hospitals (including the CRPF Hospital) which house about 2430 beds. Apart from this there are 23 non-government/ private hospitals (with 1724 beds) and 24 non-government/ private nursing homes (with 696 beds). Moreover, there are 8 other government run hospitals/ medical units, 20 Urban Health Centres (UHCs, established under the NRHM) and numerous PHCs (Primary Health care Centres). As a result, availability of health care infrastructure in terms of beds is reasonable good (as compared to the prescribed norm of 5 beds per 1000 population as per the UDPFI). However, the accessibility of this infrastructure is not adequate as there is geographical disparity in their distribution as most of these hospitals are located in the core of the city (source: Master Plan for Guwahati Metropolitan Area 2025).

In order to manage emergency situations like outbreak of diseases/ epidemics in the wake of disasters, medical response has been identified as one of the Emergency Support Functions (ESF-4) under the Kamrup Metropolitan District Disaster Management Plan. The Plan defines Standard Operational Procedures (SOP) to be followed for emergency response. The office of the Joint Director, Health Services (Kamrup Metropolitan District) (JD-H) is the nodal agency for carrying out ESF-4 functions in coordination with GMC, Blood banks, Indian Red Cross Society, private nursing homes, NSS, Rotary Club, Lions Club, Ambulance Services and medicine stockiest. Apart from this, two rapid response medical relief teams have been formed in the District Head quarter (D.C. Office) and one 24 hrs. control room has been set up in the office of the Joint Director, Health Services (Kamrup Metropolitan District) for surveillance. However, the SOP focuses more on response and relief measures and needs to bring in substantial measures for preparedness and recovery.

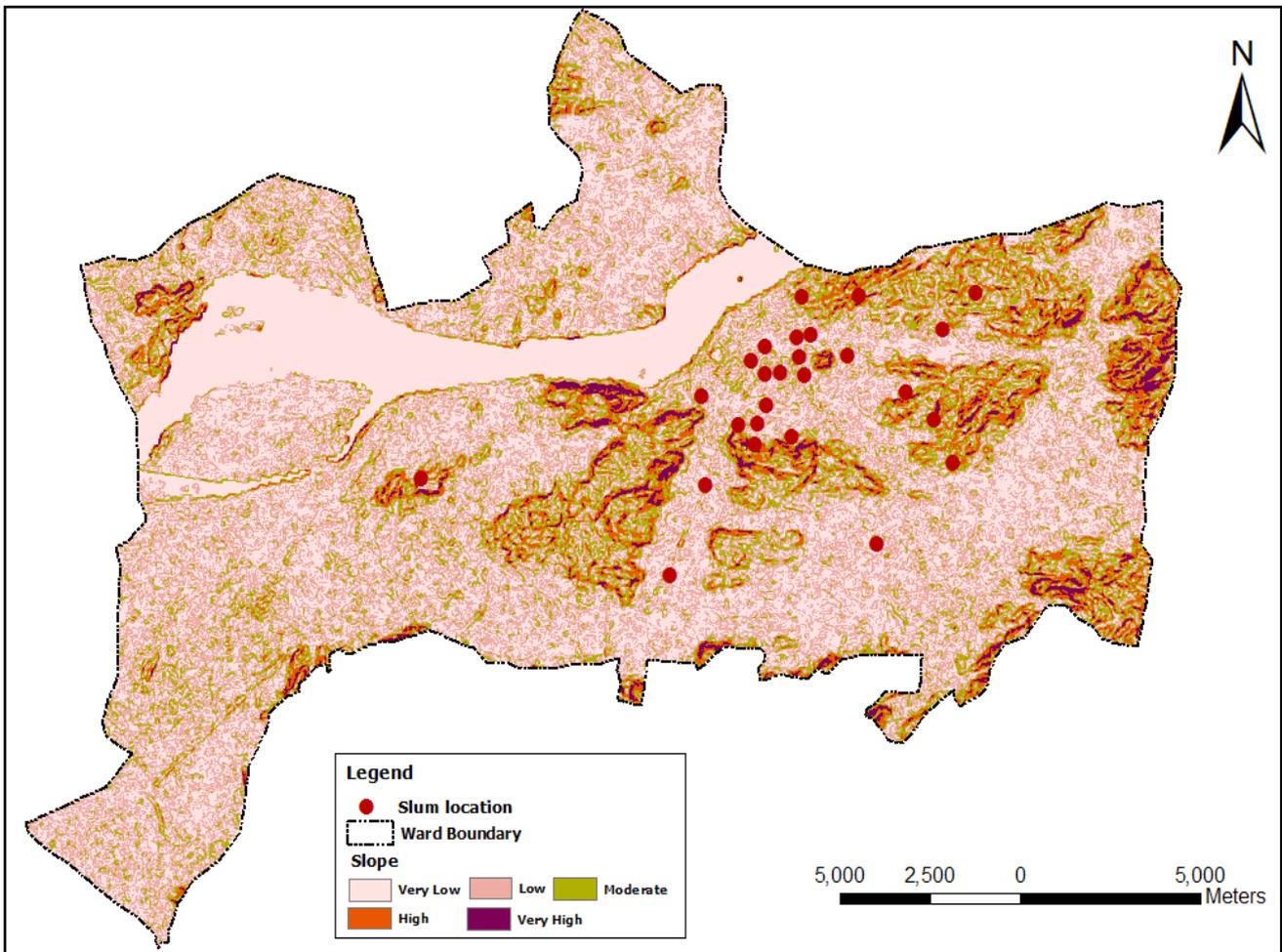
The major observations outlining the gaps for the health sector have been listed in Table 9.

Table 9: Gaps and issues in the Health sector

Issue	Description
High susceptibility to water & vector borne diseases	Based on the observations of the Total cases for Presumptive Surveillance in Guwahati city reported under the Integrated Diseases Surveillance Project (IDSP), on an average, about 10% of the total OPD attendance was for water and vector borne diseases. Another major share in incidence of diseases is that of respiratory problems which account for about 11% of the total OPD attendance. The data shows a definite seasonality of diseases, with an inclination towards the monsoon and post-monsoon months. Even the respiratory infections tend to increase in the post monsoon months.
Shortage of doctors	There is an acute shortage of doctors and paramedical staff in the government hospitals. As per the figures reported for IDSP in September, 2012, there are only 107 doctors (1:9000 persons) and 293 paramedical staff members (1:3300 persons) in these hospitals. In such a scenario, the city is largely dependent on the private sector for health care facilities. As a result, it becomes difficult for middle and low income groups to bear the treatment costs incurred here, making them mostly unaffordable and inaccessible to the poor. The situation is aggravated by the fact that Guwahati city is a major urban centre and state capital and a lot of patients from all over the state come to the city for availing health facilities.

4.5 Informal settlements and slums/ urban poor

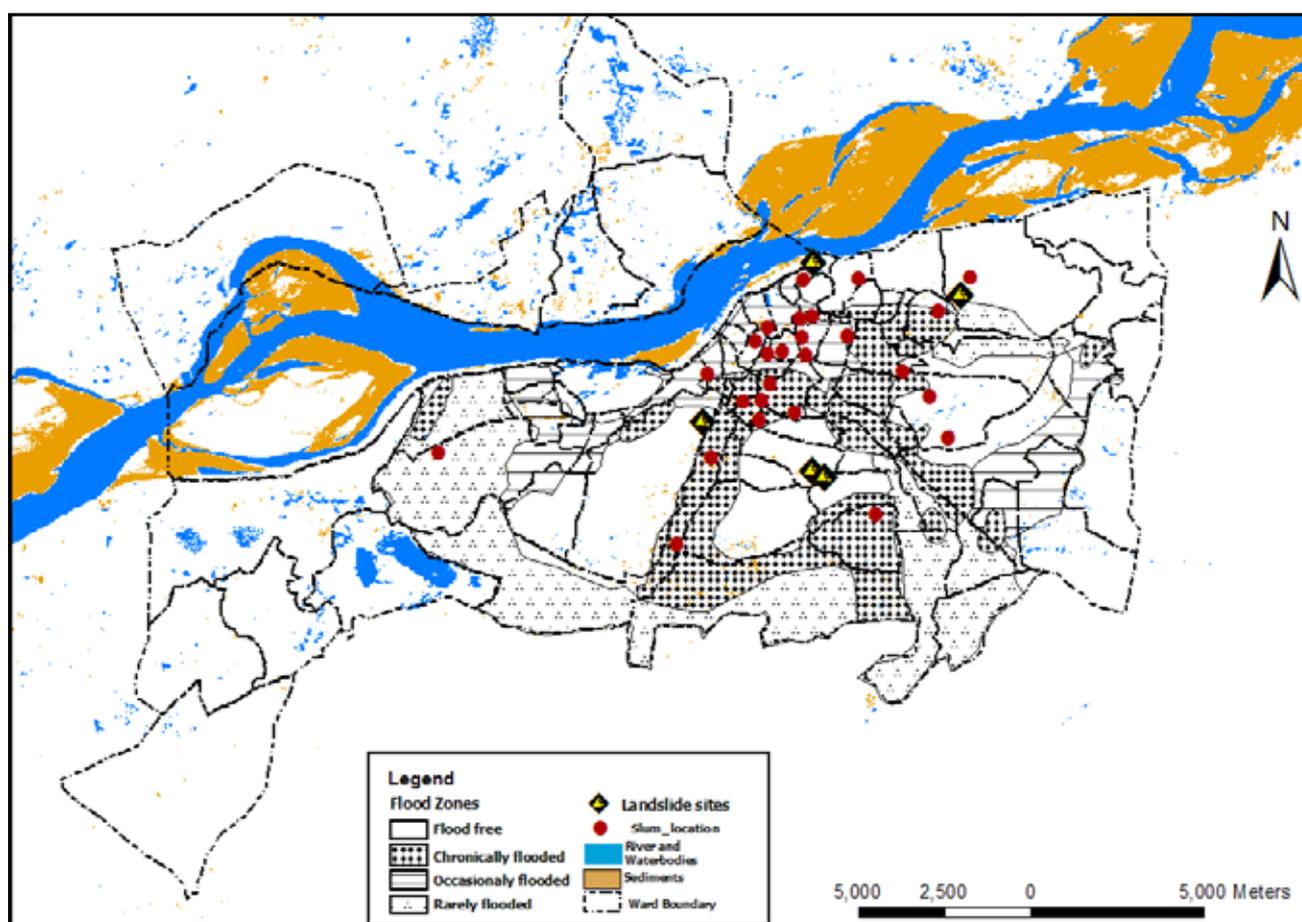
Being the commercial hub of the north-east, Guwahati attracts a large population of migrants from nearby areas in search of jobs. Poverty and illiteracy forces them to settle in slums and fragile areas which add to the vulnerability of the city. These communities and areas are the ones which are most affected in case of disasters (Saikia., 2005). Due to lack of basic infrastructural assets and basic amenities these slum pockets are more exposed and sensitive to disasters. Presence of unhygienic living conditions pose serious health hazards which get aggravated in case of hazards such as urban flooding.



Map 8: Slopes and location of slums

According to the data provided by the JNNURM cell of Guwahati Municipal Corporation (GMC), in 2009, there were 90 slums in the GMC area. In the survey of 2012 it was found that the number of slum pockets were 217. However, this drastic change in number was not only due to increase in slum population but also due to the change in definition of slums. In 2009, a pocket with 25-30 households and lacking basic amenities was considered as slum while for the survey of 2012 even a pocket with 10-15 households and without basic amenities was considered as slum. The total slum population was found to be 1.39 lakhs in 2012. Slum free city planning is being done under Rajiv AwasYojana (RAY), the flagship scheme of the Ministry of Housing and Urban Poverty Alleviation (MoHUPA). At present redevelopment and rehabilitation for slums is on-going in Fatasil, Morasoli, Solapara and Aminga.

The data provided by JNNURM on slum locations and the map on flooded areas, shows that most of these slums are located in chronically and occasionally flooded areas. Many of these lie near the flood plains of Bharalu River. Some of these are also near to the locations prone to landslides. These slums are mainly located in the core areas of the city such as near Pan Bazaar and Paltan Bazaar. This indicates the vulnerability of the city especially the slum areas in case of disasters. The city assessment report suggests upgradation of existing slums located on Government lands which are not needed for any development of any infrastructure or urban activity while it suggests relocation of slums in other pockets. In the new housing and development plans, some percentage has been reserved for the urban poor (Carrying Capacity Based Urban Development Regulations, Guwahati, 2011).



Map 9: Location of slums in vulnerable zones in Guwahati

5. Institutional Analysis

This section presents the overall institutional set-up that drives urban development in the cities in India. The sectors are divided into urban planning, environment and disaster management, and housing and infrastructure for ease of understanding. The section also presents the corresponding institutions for Assam state and for Guwahati city. Table 10 provides an overview of the sector wise institutional setups.

5.1 Urban Planning

National level framework

The function of development planning falls in the State List of the Constitution of India. The Ministry of Urban Development (MoUD) is responsible for formulating national level policies and coordinates the activities of various nodal authorities related to urban development in the country. The Town and Country Planning Organization (TCPO) functions as the technical wing of MoUD for Urban Planning and related activities.

The Model Town and Country Planning Act 1960 and the 74th Constitutional Amendment Act (CAA) 1992, recognizes the urban local governments as the third tier of the government in the country and provides for various provisions for empowering the urban local bodies and advises the State government to devolve about 18 functions including urban planning to the urban local bodies. Several key provisions of the 74th CAA are still to be fully implemented in most cases.

The Urban Development and Plan Formulation and Implementation (UDPFI) Guidelines have also been formulated by the MoUD and provide guidelines that can be used by the ULB or Development Authority for planning at city/ zonal/ neighbourhood level. MoUD and the Ministry of Housing and Urban Poverty Alleviation (MoHUPA) are jointly implementing a programme called Jawaharlal Nehru National Urban renewal Mission (JnNURM) which provides financial assistance to the cities under two basic components; (a) Basic services to urban poor (b) Urban Infrastructure provision and Governance. Under this, City Development Plans have been prepared for 65 selected cities.

The MoUD is also the nodal Ministry for implementation of the the National Mission on Sustainable Habitat (NMSH) of the National Action Plan on Climate Change (NAPCC) which focuses on planning for sustainable urban development in the country, given the future risks and impacts associated with climate change.

State level framework

The state line department for urban planning in Assam is the Directorate of Town and Country Planning (TCPD), which comes under the Urban Development Department (UDD) of Government of Assam. The other line departments under UDD are the Directorate of Municipal Administration (MAD), Guwahati Development Department (GDD), Assam Urban Water Supply & Sewerage Board (AUWSSB) and Assam State Housing Board (ASHB) which are responsible for development of housing in the urban areas of the state. The TCPD is responsible for preparation of Master Plans for urban areas in the state.

Guwahati city

At the city level (municipal area), Guwahati Municipal Corporation (GMC) is responsible for governing, developing and managing the city including grant of building permissions, provision and maintenance of urban infrastructure & services. For areas that do not fall under jurisdiction of GMC in the Guwahati Metropolitan Area, the Guwahati Metropolitan Development Authority is the nodal agency for Master Planning, planning and provision of services (water supply, sewerage/drainage facilities) and infrastructure (roads, street lighting), and Housing. However Guwahati being the state capital, a nodal department for coordination urban planning and development activities in the city – Guwahati Development Department – has been constituted.

5.2 Housing and Infrastructure

National level framework

As per the federal structure of governance in India, matters pertaining to housing have been assigned the State Governments. The Ministry of Housing and Urban Poverty Alleviation (MoHUPA) is the apex authority to formulate national level policies. The National Urban Housing and Habitat Policy 2007, aims at providing equitable and affordable access to land and shelter to the residents of the city, with cooperative action between diverse stakeholders. MoHUPA is also the nodal Ministry for implementation of the component on Basic Services to Urban Poor (BSUP) under JnNURM and the Rajiv Awas Yojana (RAY)- a scheme that targets provision of low cost housing to the urban poor.

State level framework

The Assam State Housing Board, is the nodal agency which takes up different Housing scheme, such as LIG(H), MIG(H), HIG(H), EWS(H), LIG(R), JHS(Gen), JHS(STP), JHS(S.C.), Rental Housing Scheme for Govt. Employee, Labour Qtrs. In Tea Garden etc. with the fund available from the State plan and borrowing fund from other financial Institution like HUDCO, LIC and Bank for both Urban and Rural areas of the States.

Besides, separate entities like Assam Industrial Infrastructure Development Corporation, Central Government organisations also provide for housing in their jurisdiction area.

Guwahati city

GDD is the administrative department of GMC and GMDA and also looks after the execution of various central schemes on housing including BSUP, RAY through the JNNURM cell of the Guwahati Municipal Corporation. The

Assam State Housing Board also provides for housing individually and in partnership. The GMDA is responsible for development of housing in areas under its jurisdiction. Besides this, the private sector also has its share in the overall housing sector.

5.2.1 Water supply and Sanitation

National level framework

At the national level, MoUD and MoHUPA are the key ministries implementing various programmes and schemes for Water Supply & Sanitation. The National Urban Sanitation Policy (NUSP), which aims at transforming towns and cities of India into 100 per cent sanitized, healthy spaces, ensuring public health, and clean environment was launched by MoUD in 2008. The MoUD has Standardized Service Level Benchmarks (SSLBs) for benchmarking certain indicators for key urban services such as water supply, sewerage, storm-water drainage and solid waste management.

State level framework

At the state level, Assam Urban Water Supply & Sewerage Board (AUWS & SB) is the nodal agency responsible for development, maintenance and regulation of the Water Supply, Sewerage and sewage disposal works in the urban areas of the state under the Assam Urban Water Supply and Sewerage Board Act, 1985.

Guwahati city

Currently, the water supply facilities in Guwahati Metropolitan area (GMA) are being operated by three departments, viz., GMC, Assam Urban Water Supply and Sewerage Board (AUWSSB) and Assam Public Health Engineering Department (APHED). Apart from the above, there are several Central Government organisations providing water in their areas through individual plants. The GMA does not have an integrated sewerage system. Majority of the households have septic tanks.

5.2.2 Storm water Drainage

State level framework

Assam water resources department is the nodal department for taking flood-control measures through construction of various flood and erosion control structures in the state including river bank embankments.

Guwahati city

GMDA, GMC and T & CP are the agencies responsible for Planning and Design of storm water drainage systems in the GMA; construction, operation and maintenance are carried out by GMDA and GMC.

5.2.3 Solid Waste

National level framework

The Central Public Health and Environmental Engineering Organization (CPHEEO), attached to the MoUD is the nodal agency which provides guidelines on solid waste management. Apart from this, the Hazardous Substances Management (HSM) Division of the Ministry of Environment and Forests (MoEF) is the nodal agency for safe management and use of hazardous substances including e-waste, as per the Hazardous Waste (Management & Handling) Rules, 1989. The CPHEEO Manual on Solid Waste Management, 2000; the Municipal Solid Waste (Management & Handling) Rules, 2000 have been formulated at the national level for providing standards & guidelines management of solid waste in the country.

State level framework

At the state level, Assam State Pollution Control Board (ASPCB) monitors compliance to provisions of the Water (Prevention & Control of Pollution) Act 1974, Air (Prevention & Control of Pollution) Act 1981, Biomedical Waste

(Management & Handling) Rules 1998, the Hazardous Waste (Management & Handling) Rules 1989 and the Municipal Solid Waste (Management and Handling) Rules 2000.

Guwahati city

The engineering department of the GMC address major programmes such as – Construction and maintenance, Building licensing, and SWM activities including drain cleaning.

5.3 Environment

National level framework

At the national level, the Ministry of Environment and Forests (MoEF) has been entrusted with all activities related to environment & forests.

State level framework

At the state level, the Department of Environment and Forests (DoEF), Government of Assam is the nodal department for matters pertaining to environment and forests, including management of forests and forest products, wildlife, prevention & abatement of pollution, conservation & protection of biodiversity and climate change issues. The ASPCB is responsible for pollution control and also carries out other key activities entrusted by the DoEF.

Guwahati city

The reserved/ protected forests are managed by the Department of Forests under the DoEF as per the provision of the Assam Forest Regulation (Amendment) Act, 1995. For the Bils, GMDA is the nodal agency for conservation and management under the Wetlands (Conservation & Management) Rules 2010, with exception to the Deepor Bil which is a Ramsar site and thus under the direct jurisdiction of the MoEF, Gol.

5.4 Disaster Management

National level framework

At the national level, the Ministry of Home Affairs has been entrusted with all activities pertaining to disaster management. The National Disaster Management Authority (NDMA), headed by the Prime Minister, was formulated in 2005 under the Disaster Management Act, 2005, to spearhead and implement a holistic and integrated approach to Disaster Management in India.

State level framework

The State Disaster Management Authority (ASDMA) is the nodal department for coordinating all activities pertaining to disaster management including preparedness, response, relief and recovery measures in rural and urban areas of the state.

Guwahati city

Kamrup Metropolitan District Emergency Operation Centre (KMDEOC), under the Office of the Deputy Commissioner, Kamrup Metropolitan District is responsible for preparation and implementation of the Disaster Management Plan for Kamrup Metropolitan District, including Guwahati city, under the provisions of the Disaster Management Act, 2005.

The KMDEOC comprises of a City Disaster Management Committee, which comprises of representatives of all important state line departments for coordination and implementation of Disaster Management Plans. The State Department of Medical Health and Family Welfare, through the District Hospital, in coordination with GMC & KMDEOC, are primarily responsible for public health management in case of outbreak of diseases in the aftermath of floods.

Table 10: Summary of the institutional set-up and windows for climate proofing for the key sectors

Institutions	Functions	Enabling regulatory framework	Window for climate proofing
Urban Planning			
Directorate of Town and Country Planning, Urban Development Department, GoA	Preparation of Master Plan for urban areas in the state. Technical advisory wing of the UDD on matters concerning urban and regional planning strategies, research, appraisal, and monitoring of central government schemes and development policies in the state.	The Assam Town & Country Planning Act, 1959	Can suggest changes in the Development Act and contents & formulation process of the master plans to integrate environmental concerns & climate proofing agenda
Guwahati Development Department	Administration department for urban development for Guwahati city. Coordinates between various city level authorities in Guwahati city including GMDA, GMC, AUWS&SB, ASHB, etc. Technical advisory wing of the UDD on matters concerning urban and regional planning strategies, research, appraisal, and monitoring of central government schemes and development policies in Guwahati city.		As the coordinating department for urban development in Guwahati, will play a key role for inter-sectoral coordination for implementation of the climate resilience plan or strategies proposed as part of various city level plans.
Guwahati Metropolitan Development Authority	Master Planning, Service(water supply, sewerage/drainage facilities) and infrastructure provision(roads, street lighting) and Housing for GMDA area (areas that do not fall under jurisdiction of GMC)	The Assam Town & Country Planning Act, 1959 Guwahati Metropolitan Development Authority Act, 1985 (as amended in 1989)	Integrating environmental concerns & climate proofing strategies as part of the master planning process
Guwahati Municipal Corporation	Grant of building permissions, provision and maintenance of urban infrastructure & services in Guwahati city (Municipal area)	The Guwahati Municipal Corporation Act, 1969	As the ULB, key role in mainstreaming & implementation of climate resilience strategy.
Housing and infrastructure			
Assam State Housing Board, Urban Development Department, GoA	Preparation of housing schemes (including infrastructure) and acquisition & disposal of land in the state. Technical advisory wing of the UDD on matters housing strategies, research, appraisal, and monitoring of central government schemes and development policies in the state.	The Assam State Housing Board Act, 1972	With powers to make rules, regulations & bye-laws, will play a key role to integrate environmental concerns & structural adaptation measures in the regulatory framework

Institutions	Functions	Enabling regulatory framework	Window for climate proofing
Guwahati Development Department	Administration department for urban development for Guwahati city. Coordinates between various city level authorities in Guwahati city including GMDA, GMC, AUWS&SB, ASHB, etc.		As the coordinating department for urban development in Guwahati, will play a key role for inter-sectoral coordination for implementation of the climate resilience plan or strategies proposed as part of various city level plans/ schemes.
Guwahati Metropolitan Development Authority	Master Planning, Service(water supply, sewerage/drainage facilities) and infrastructure provision(roads, street lighting) and Housing for GMDA area (areas that do not fall under jurisdiction of GMC)	The Assam Town & Country Planning Act, 1959 Guwahati Metropolitan Development Authority Act, 1985 (as amended in 1989)	Integrating environmental concerns & structural adaptation measures in development controls, planning & development of urban infrastructure & services.
Assam Public Works Department	Construction of roads (PWD roads in the city) Construction and maintenance of Government buildings and housing.		Co-ordination with agencies providing & managing urban utilities like water supply, sewerage, storm water drainage, ESS, etc.
Department of Power(Electricity), GoA including successor companies of ASEB and Assam Electricity Regulatory Commission	Generation, transmission, distribution of electricity and provision of power supply infrastructure Regulating electricity tariffs, procurement and efficiency in power transmission & distribution	Assam Electrical Energy (Regulation & Supply) Electricity Act 2003	Locating of power infrastructure like ESS in areas of no/low-vulnerability. Tariff structure to promote energy efficiency
Assam Public Health Engineering Department	Planning & provision of water supply and sanitation facilities in rural areas of the state and PHED area in Guwahati		With constitution of the Guwahati Metropolitan Drinking Water and Sewerage Board (GMDWSB), the role of PHED and AUWS&SB in provision of water supply & sewerage will become defunct. GMDWSB will have to be entrusted with integrating structural adaptation measures for climate resilience.
Assam Urban Water Supply & Sewerage Board	Planning & provision of water supply and sanitation facilities in urban areas of the state, including AUWS&SB area in Guwahati	The Assam Urban Water Supply & Sewerage Board Act, 1985	
Guwahati Metropolitan Drinking Water and Sewerage Board (GMDWSB)	Planning & provision of water supply and sanitation facilities in Guwahati city	The Guwahati Metropolitan Drinking Water and Sewerage Board Act, 2009 (notified in Dec 2011)	
Guwahati Municipal Corporation	Grant of building permissions, provision and maintenance of urban infrastructure & services in Guwahati city (Municipal area)	The Guwahati Municipal Corporation Act, 1969	As the ULB, key role in mainstreaming & implementation of climate resilience strategy for provision & maintenance of urban infrastructure and services in Guwahati Municipal Area

Institutions	Functions	Enabling regulatory framework	Window for climate proofing
Environment and Disaster Management			
Department of Environment and Forests, Government of Assam	Manage the Forest, Forest produces and Wildlife of the State of Assam; prevention & abatement of pollution; conservation & protection of biodiversity and climate change issues	Environment (Protection) Act, 1986 Assam Forest Policy, 2004 Assam Forest Regulation(Amendment) Act, 1995 The Assam National Parks Act, 1968 Wetlands (Conservation & Management) Rules, 2010 Ramsar Convention , 1971	Can suggest changes in various acts at state level and bring forth state environment policy to integrate environmental concerns, including protection & conservation of forest areas and wetlands, and climate proofing agenda for urban areas in the state.
Assam State Pollution Control Board	Pollution control, river water quality conservation, industries	Environment (Protection) Act, 1986 Water (Prevention and Control of Pollution Act) 1974 Water (Prevention and Control of Pollution) Rules 1975, Hazardous waste (management and handling) amendment rules 2003, Air (Prevention and Control Act) 1971,	Can play a major role in pollution control in water bodies and green areas of the city (including solid waste management infrastructure) which becomes a causal factor for poor drainage and water logging in the city and subsequent health issues.
Guwahati Municipal Corporation	Sanitation and hygiene	The Guwahati Municipal Corporation Act, 1969 Municipal solid waste management and handling rules, 2000	As the ULB, key role provision of solid waste management, sewerage and storm water drainage for flood control and consequent health issues.
Brahmaputra River Board	Preparation of Master Plan for the control of floods and bank erosion and improvement of drainage in the Brahmaputra Valley, including project planning and construction of dams	The Brahmaputra Board Act, 1980	Inter-state co-ordination for flood control and management at regional/ basin/ sub-basin level
Assam State Disaster Management Authority	Disaster Management, preparedness and response	Disaster Management Act, 2005	As the nodal agency for disaster management in the state, can suggest revision of design parameters to include adaptation measures in urban utilities like water supply, storm water drainage and sewerage and can play a key role in mainstreaming city level climate resilience in urban planning and development reprocess.

Institutions	Functions	Enabling regulatory framework	Window for climate proofing
Kamrup Metropolitan District Emergency Operation Centre	Disaster response mechanism, flood risk reduction in Guwahati city	Disaster Management Act, 2005	As the nodal agency for urban risk reduction in Kamrup Metro including Guwahati city can play a key role in management and response mechanism for floods in the city; including suggestion of structural adaptation measures for drainage and flood control Inter-departmental coordination for disaster risk reduction and response mechanism, including provision of essential services, urban services and public health management
Office of Jt Director Health- Kamrup Metro	Public health/ Medical response in case of disasters	Disaster Management Act, 2005 Assam Health Service Rules 1995	Medical response has been identified as one of the Emergency Support Functions (ESF-4) and should have a Standard Operational Procedures (SOP) and Plan for response in case of earthquakes. Can suggest and prepare a SOP for flood response

Resilience strategy



Resilience strategy

6. City resilience strategy

The resilience strategy for the city of Guwahati is essentially an integrated plan for the development of four major components:

- Housing
- Ecologically sensitive urban planning
- Urban infrastructure and services

These sectors are substantiated by an overarching component on disaster resilience which will help build resilience of the city to disasters like urban flooding, land-slides and earthquakes. The premise is that while the 3 components are being envisaged to build city's resilience within the short, medium and long term timelines (Please refer to chapter 9 on Summary of recommendations); disaster resilience would be a continuous and integrated component of these plans.

The components of resilience were defined as per the following questions:

- What are the critical assets in the city which might be at risk due to flooding or any other disasters?
- What are the sectors impacted by the 'future and current risks'?
- Which are the vulnerable classes subjected critically to risks?
- What are the governance parameters that can help build resilience?

It is pertinent to add here that a basin-wide assessment for floods has not been conducted in the study and hence it is difficult to predict with certainty how the pattern of flooding will change over a period of time. The occurrence and magnitude of floods would depend on multiple factors; other than the change in precipitation. TERI's recommendations are based on the variation in precipitation only. Besides this, detailed impact assessment is required to ascertain the nature of risks that each sector would be exposed to.

6.1 Housing and buildings

In this section, housing and buildings have been interchangeably used. Strategies suggested in this section cover the entire gamut of buildings such as residential (of all types), slums, offices, institutions, hotels, hospitals, colleges, etc.

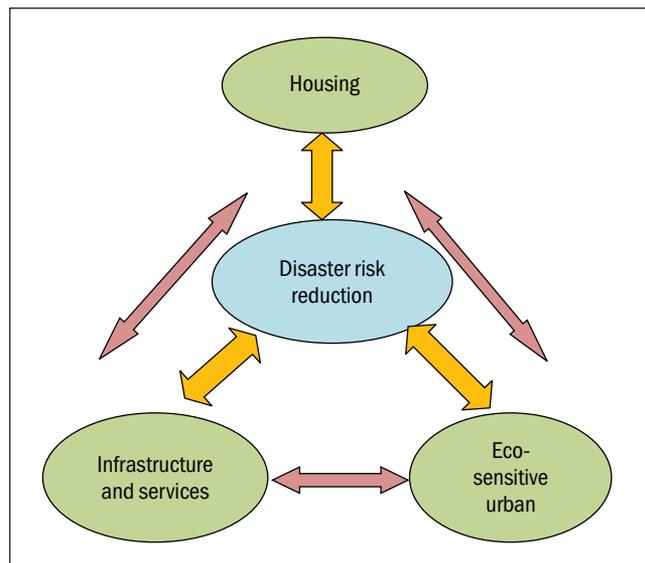


Figure 9: Components of Guwahati Climate Resilience Strategy

Guidelines for construction of buildings on slopes

No construction should be allowed on slopes greater than 20% (Steep slopes). Steep slopes⁸ are most unstable and if disturbed are less forgiving of construction errors. This causes damage not just in the vicinity but lead to soil erosion, trigger landslides and hampering the development in the valley. While constructing on slopes, certain measures like enforcing proper roads layout; establishing contours and gradients; minimising the amount of cuts and fills; retaining natural vegetation; phased land clearing; proper storm water drainage management plan should be adopted.

Soil erosion and sedimentation control for construction in non-hill GMA areas

As per soil erosion statistics quoted in the consultation meeting held in Guwahati on 20th Dec, 2013, an estimated 5-10 ton/ha/year is lost as soil erosion. Some measures to counter this could be adopted: Staging areas⁹; Collect drainage water runoff from construction areas and material storage sites; Construct temporary drainage channels, perimeter swales; Construct Sedimentation basin

Basements should not be allowed in any new construction happening in any of the area most prone to flooding. For areas which get occasionally flooded, basements in new construction may be allowed only on conditions as given in Section 46 of the New Revised Building Byelaws for GMC-2006.

Septic tanks/Soak pits

Section 56 of 'Building Bye-laws for GMA 1998' and 'Revised Building Bye-laws-2006 for GMC' states necessary provisions and precautions to be followed for septic tank/seepage pits/dispersion trenches. As a resilience strategy, it is suggested to propose 'improvised septic tanks' for all new construction and/or DEWATS/other suitable decentralized grey water/black water treatment systems which are not capital intensive.

Existing Buildings/Colonies

- For all existing building colonies and neighbourhood, it is proposed to intercept the storm water drains (wherever available) and build recharging wells of appropriate depths along with filtering media. Recharging structures should be accompanied with suitable filtering systems to prevent any contamination. However, adequate study of sub-soil structure is essential before designing for any of these recharging strategies.
- For existing buildings/colonies/market areas decentralized sewage treatment systems could be proposed depending on the applicability on scale/building typology, starting with few demonstration projects. Wherever feasible, the existing septic tanks could be converted to improvised septic tank to prevent the static flow of sewage leading to no treatment of sewage after a certain time, thereby leading to pollution.
- While locating such structures, care should be taken to maintain appropriate distance from the tubewells/borewells/recharging structures/rainwater harvesting for storage, etc.
- For the existing slums, it is proposed to follow the success story of Kachhpura in Agra where Decentralized, natural – three - step bioremediation process is being used to treat 50kl of wastewater, linking 8 slums¹⁰. Currently, there are 26 slums in the city, in which sanitation programs need to be executed mainly for construction of toilets and drains.

Rainwater harvesting-storage and/or recharging

Section 65 (i)(b) in the New Revised Building Byelaws for GMC- 2006 provides for terrace water collection and connected to a sump or the well in all group housing schemes / apartment and commercial complexes/institutional buildings. This is a very good provision if implemented properly and should rather be mandated instead of the optional provision. Capacity building support and awareness generation is also required for wider implementation.

⁸ The characteristics that influence the stability of slope include geology, slope drainage, slope topography (shape and steepness), soil type and changes to the slope (placing soil or removing soil from the slope).

⁹ Staging is dividing a construction area into two or more areas to minimize the area of soil that will be exposed at any given time.

¹⁰ www.urbanindia.nic.in/programme/uwss/CSP/Draft.../Agra_CSP.pdf last assessed on May 1, 2012

Models such as the one implemented in the multi-storied residence of Mr G Patowary, Jt. Secretary, to Govt of Assam, Health(Rtd.), Zoo Japarigog area may be replicated¹¹.

Section 65(i)(a) in the New Revised Building Byelaws for GMC- 2006 has compulsory provisions for Percolation pits for all group housing schemes/apartment and commercial complexes/institutional buildings. This mandatory provision need to be revisited given the fact that there is high sub-soil water. Also, due to poor connectivity of sewerage network and provision of septic tanks/soak pits a more detailed precautionary approach is required instead of a blanket provision.

Provision for mandatory pervious pavers or adoption of Sustainable Urban Drainage Systems(SUDS) for all group housing/large projects/industrial projects

It is strongly recommended to reduce hard paving on site to reduce stormwater runoff attenuation and infiltration and reduce Heat Island Effect. It is important to ensure that the storm water management system is based on the principles of Sustainable Urban Drainage Systems (SUDS). Refer to <http://www.susdrain.org/> for more guidance on implementing SUDS

Integration of Energy Efficiency in new and existing buildings

It is recommended to integrate possible ECBC (Energy Conservation Building Code) recommended measures (passive and active) related to building envelope, energy efficient appliances and lighting system, suitable for Guwahati area, in the bye laws.

Housing shortages and housing provision

- Master Plan for GMA 2025 states housing shortage of 19,802 dwelling units in 2005 and likely to increase to 2,78,965 dwelling units. A multi-pronged approach is proposed with components like upgradation of slums on government land, provision of at least 30% of total housing in new housing schemes for one rooms, part of which will go to the urban poor. Night shelters are also proposed as part of new development schemes to cater to the migrants.
- New models of PPP (Public Private Partnership) for provision of affordable housing may be tried. The State is traditionally known for usage of bamboo for housing construction but the trend is declining specially in the urban areas. New materials made of bamboo such bamboo mat corrugated sheet (a very good alternative to asbestos sheets; it is eco-friendly, tough, resilient and ductile), veneers, bamboo composites and bamboo housing system(as demonstrated in several projects developed by IPIRTI ¹²and TRADA) may be taken up at a larger scale for few slum redevelopment/new projects. These are ideal for low rise mid-high density development and are cost-effective, durable thus making them ideal solution for affordable housing.



Figure 10: Bamboo Mat corrugated sheet and bamboo house (Source: BMTPC, IPIRTI)

¹¹ Bipin Chandra Patwary, Rain Water Harvesting: an indigenous effort sustained in Guwahati City, Vol 1: Issue No. 12, Focus Global Reporter.

¹² Indian Plywood Research and Training Institute, Bangalore

Promotion of Renewable energy at Buildings and Neighbourhood scale

There are various incentives for integration of solar photo-voltaics at building scale (for off-grid and on-grid electricity generation) offered by the Ministry of New and Renewable Energy. Integration of solar water heating with the bye-laws especially for specific buildings such as hotels/guest houses, should be mandated. GDA may request for further suggestions from the Assam Energy Development Agency.

Institutional and regulatory support: Housing and buildings for other uses

The Assam State Housing Board (ASHB), Urban Development Department, GoA has the powers to make rules, regulations & bye-laws under the provisions of the Assam State Housing Board Act of 1972. There is a need to amend and customize the building regulations for resilience building in the sector. TERI suggests some modification in building byelaws and regulations which have been highlighted in Table 11.

Table 11: Mainstreaming the strategies for the housing sector

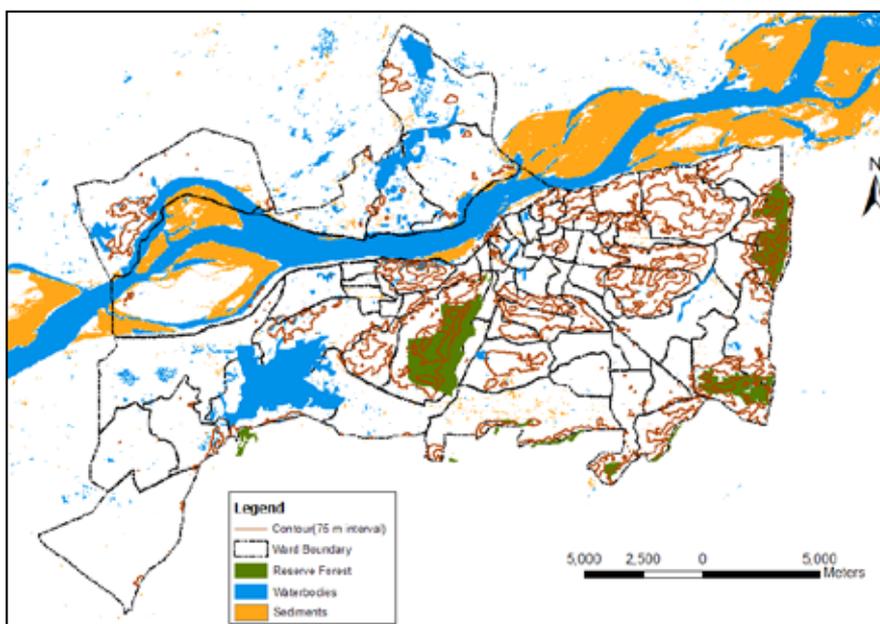
Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Guideline for construction of buildings on slope	Section 61 on 'Special regulations for construction in hilly areas' in the Building Bye laws for Guwahati Metropolitan Area need to integrate these points. A Project on 'Slope Analysis of Hills' has recently been commissioned by GMDA to Assam Engineering College As informed during the city consultation workshop. It is strongly recommended to integrate the outcomes of this study with the proposed Master Plan for GMA 2025 and subsequent revisions	Section 61 on 'Special regulations for construction in hilly areas' in the Building Bye laws for Guwahati Metropolitan Area need to integrate these points	Short to medium term
Structural stability of buildings in hills and for the entire GMA	Reference guidelines/tip-sheet appropriate o the construction style of Assam	Chapter III, section 19 , Building Bye Laws of GMA 1998 and Building Bye Laws of GMA 2006	Short to medium term
	Intensive micro-zonation studies to be conducted to identify vulnerable areas as per the sub soil conditions of GMA.		Short term
Soil erosion and sedimentation control for construction in non-hill GMA areas		Norms to be introduced in the Building Bye Laws of GMA 2006	Short to medium term
Precautions and technical details for use of Septic tanks and Soak-pits		Section 56 of 'Building Bye-laws for GMA 1998' and 'Revised Building Bye-laws-2006 for GMC' states necessary provisions and precautions to be followed for septic tank/ seepage pits/dispersion trenches	Short to medium term
		The 'Manual on norms and standards for environment clearance of large construction projects', Ministry of Environment and Forests	

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Rainwater harvesting for storage		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 With respect to the location of recharge points for rainwater harvesting, as discussed earlier, there is a need to carry out a detailed assessment for locating such points instead of a blanket provision due to impending water logging problems and high sub soil water.	Short to medium term
Provision for mandatory pervious pavers or adoption of sustainable urban drainage systems(SUDS) for all group housing/large projects/industrial projects			

6.2 Ecologically Sensitive Urban Planning

Considering the present situation of encroachment and construction on hills and natural wetlands, beside the urban sprawl; there is acute need to revisit the planning practices adopted in the city. Urban planning practices for the future would have major role to play in building resilience of the city to increased temperature, extreme rainfall events and overall reduced rainfall.

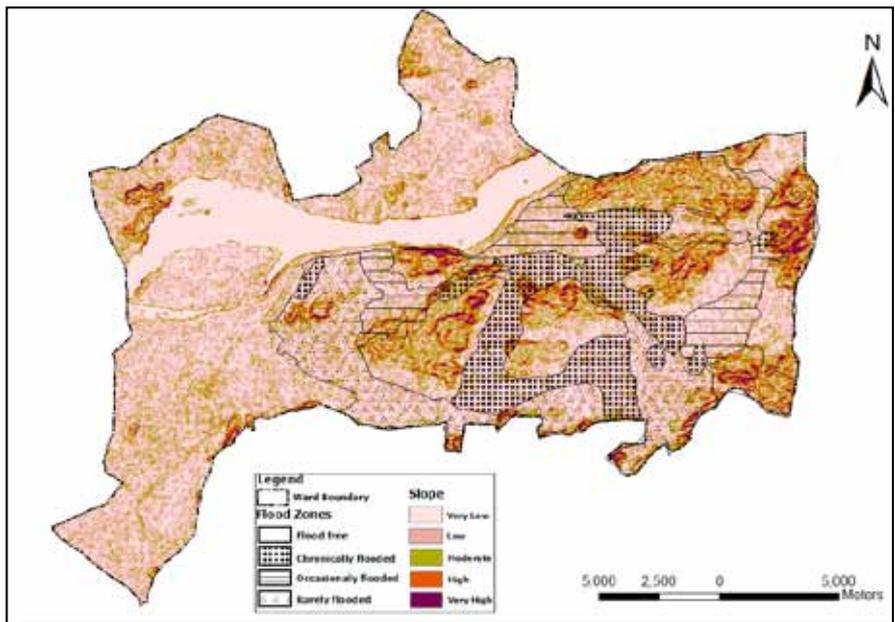
- The last decade has seen a tremendous growth in built-up area in Guwahati and this trend is likely to continue in future. There is a need for proper planning to facilitate further growth in increase in built-up without adversely affecting the ecosystem. The overall land use planning regime needs to incorporate these aspects. One of the examples can be focusing new developments away from the low-lying areas which can help in addressing urban flooding.
- Revisiting the land-use plan of the city to consider locating areas fit for construction and development activities and identifying ecologically sensitive hot spots for conservation and protection.
- Bringing in sustainability parameters in the planning for the three proposed satellite towns which are envisioned to



Map 11 Eco-sensitive zones

act as counter magnets to the parent city of Guwahati. Simultaneously plan for proper transport network and public transport/mass transport system to enable people to commute between these centres. This will help in decongesting Guwahati and would help in reduction of illegal encroachment.

- Creating a mechanism for monitoring of compliance of the development/master plan of the city so that the development follows the Master Plan and not vice versa.
- GMC and GMDA should take into account the location of the water bodies, green/ open areas, parks, etc. while allocation of land uses. These areas should ideally be marked for low built/ no development zones with green/ recreational uses for conservation of natural ecosystems
- It is important to protect hill and natural wetland areas and regulate conversion of green fields, especially in case of Guwahati as they also act as buffers for flood management. Planting of high water requirement vegetation in and near the low lying areas has been an effective measure to minimize water logging occurring as an aftermath of floods. The option could be explored after making appropriate analysis of its feasibility in Guwahati’s case. In Gorakhpur city, under the resilience building activities a project on development of peri urban agriculture has been explored to act as the buffer for urban flooding. Similar interventions could be explored for specific locations within the city of Guwahati.
- Proper land use planning integrated with a scientifically designed sewerage /drainage system and solid waste management system would reduce the city’s vulnerability immensely.



Map 12 Slopes and flood prone areas

- Integration of future climate projections and climate resilience strategy into the Master Plan of the city would enable implementation of the strategy proposed and also help build the resilience of the city .This will also enable climate planning in becoming a regular feature in the subsequent plans for the city. It was suggested during the city consultation that ward level resilience planning should also be attempted for Guwahati city like the other ACCCRN city of Gorakhpur. Focusing on ward level requirement would not only tackle the problem at grass root level, but would also have a positive effect on the community with increased sense of ownership.

Table 12 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 12: Mainstreaming the strategies for the urban planning sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
URBAN PLANNING			
Demarcate eco-sensitive areas in the city as low/ no built up areas	Change in land use zoning and development regulations	Guwahati Metropolitan Development Authority through Guwahati Metropolitan Development Act 1985,	Short term(0-3 years)

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
	Amendments in the Law to incorporate this measure	through Guwahati Metropolitan Development Act 1985,	Long Term(6 to9 Years)
	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	Guwahati Metropolitan Development Authority	Short term(0-3 years)
Bring in principles of climate resilient urban development based on environmental parameters like conservation of natural ecosystems, natural drainage patterns	Revisit Guwahati Metropolitan Development Plan(2025), commission an expert study	Guwahati Metropolitan Development Authority and Guwahati Development Department(GDD)	Short term(0-3 years)
Planning of 3 new satellite towns on the principles of sustainability	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.	Guwahati Development Department(GDD)being the nodal Department at State level for the development of the city and its surroundings	Medium term(3-6 Years) (subjected to the launch of NMSH)
Main stream climate resilient strategy	Integration of future climate projections and climate resilience strategy into the Master plan of the city.	GMDA/GDD can suggest required amendments in the GMDA Act/Rules	Medium term(3-6 Years)
	Notification for preparation and implementation of climate resilient strategy	Guwahati Development Department(GDD)	
Ward level resilience planning	Pilot case be prepared for a few wards to act as demonstration	Guwahati Development Department(GDD)	Medium term(3-6 Years)
		Enactment of 74 th Amendment Act by the Stat Government of Assam(Urban Development Department)	Long Term(6 to9 Years)
Bring in monitoring and evaluation mechanism in urban planning process	Amendments in the Law to incorporate this measure	through Guwahati Metropolitan Development Act 1985,	Long Term(6 to9 Years)
	Coordinating this activity	GMDA, GMC and GDD	Long Term(6 to9 Years)
ICT measures	Construct dynamic geo-spatial information system	GDD's intervention. GMDA could establish such a database system	Medium term

6.3 Urban Ecosystem – Management and Conservation

1. Integrated watershed management approach

Ecosystem is a larger concept than a city as it involves several factors which are beyond the administrative boundary of a city. For a city like Guwahati, natural features such as water bodies and hills form a crucial and integral part of the ecosystem. These features are inter-linked and together provide the ecosystem services in the city. Thus, it is essential to have an integrated watershed management approach to address the different problems which the city is facing. As part of an integrated approach the following factors can be considered:

- a. **Preservation and restoration of water bodies (beels/wetlands)**
- b. **Restoring and maintaining green areas**

2. Assessment of climate variability on biodiversity

A proper assessment of biodiversity in the city should be carried out in order to understand the impacts of climate change and climate variability on biodiversity. There is also a need to carry an assessment of existing land use pressures on biodiversity, such as the extent and level of fragmentation between vegetation communities, and identifying areas that will provide climatically suitable habitat for these species after considering the current climate trends as well as future climate projections. Special attention should be taken for biodiversity hotspots and protected areas for understanding stresses and taking measures to reduce these stresses.

3. Increasing awareness on ecologically sustainable development of the city

There is a need to increase awareness on issues related to negative impacts of unplanned urbanization on ecosystem. Communities as well as policy makers need to understand these issues and accordingly take measures to improve coping capacity of fragile areas and also the overall ecological health of the city.

Table 13 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 13: Mainstreaming the strategies for the urban ecosystem sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Urban Ecosystem Management and Conservation			
Conservation of green areas/wetlands/beels- <i>Inside the jurisdiction of GMDA</i>	Preparation of Conservation and management plan for wetlands	As per the Wetlands(conservation and management) Rules 2010.I Nodal agency GMDA	Medium term
	Preparation of inventory and demarcation of natural water bodies and green areas	Nodal agencies for provision of environmental infrastructure- The GMC, GMDA,GMDWSB,ASPCB under the Guwahati municipal Corporation Act 1969, Guwahati Metropolitan Development Act 1985,Newly enacted Guwahati metropolitan drinking water and Sewerage Board Act,2009, and Pollution Abatement(under the Environment protection Act,1986) respectively.	Short term
	Mapping, demarcating, implementing the above	Coordinated by GDD	Short term
Conservation of Biodiversity in the city	Commission an assessment study to understand the impact of climate variability and change on biodiversity and measures to address the same	Coordinated by Environment and Forest Department, Government of Assam, inputs from GMDA, ASPCB,GMC, Forest Department, Government of Assam(for reserved forests and protected forests areas)	Short term
Assam State Environment Policy recommending conservation standards ,guidelines for mainstreaming of climate change and sustainability concerns in urban planning and development	Draft, Enact and enforce	Environment and Forest Department, Government of Assam	Medium term

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Community awareness	Capacity building programs	Department of Environment and Forests ,GDD as coordinating agencies.GMC and GMDA as the facilitating agency with involvement of NGOs,and other community based organization like RWAs , self help groups etc	Should be a continuous process.To begin within a short term timeline

6.4 Urban Infrastructure and Services

Urban Infrastructure and Services are considered to be the backbone of the city system, however these are the ones which are worst affected during a disaster or a calamity crippling the whole city and its systems. It is essential therefore, that the infrastructure and services, particularly basic services are built and developed as robust systems which are adequate and efficient. The strategy therefore provides recommendations for the improvement of urban infrastructure and services in the city.

6.4.1 Water Supply

Climate projections indicate increased temperature for the city of Guwahati as one of the consequences of climate change. This might have impact on the availability of water. The major recommendations for improving the present water supply systems are as follows:

1. Augment the piped water supply network in the city

- The city must consider provision of piped water supply in phased manner to the entire city. The proposed modernised system with 24X7 metered water supply that is being developed in the city must see to ensure the following:
 - Efficient supply
 - Good quality of water
 - Proper metering system and bill collection system at place
- A centralized monitoring system to monitor the quality and efficiency of water supply should be created in the city. The system should be connected to a data base management system which is linked to the service level benchmarks proposed by the Ministry of Urban Development, Government of India.
- The city is in the process of constituting a Jal Board which will be responsible for planning design construction, operations and maintenance of the water supply system in the city.¹³ The Jal Board will be a centralised agency and should be vested with the role to ensure that all the above recommendations are complied with.

2. Augment the water treatment capacity of the city

The city's treatment capacity is only 78 MLD as compared to the current demand of 132 MLD, whereas the future demand projection for the year 2025 is 425 MLD. There is, therefore an urgent need to augment present capacity, maintain and refurbish the old treatment plants particularly the Panbazaar treatment plant which has expired its design life.

3. Rainwater harvesting

- TERI recommends, mandating rain water harvesting for storage purposes in the city. Public buildings and large industrial establishment should be encouraged to store and use the rain water.
- For recharge purpose of rain water, a feasibility study ascertaining the suitable pockets of land within the city would be beneficial. These measures would also reduce dependence of the city on Brahmaputra River for its water requirements.

¹³ Right now these activities are vested with 3 different organizations namely the PHE- Public Health Engineering; AUWSSB- Assam Urban water Supply and Sewerage department; GMC- Guwahati Municipal Corporation.

4. Ground water withdrawal

- It is recommended that the city government should impose a ban on unauthorized withdrawal of ground water in the city.
- The city government should also demarcate suitable and safe ground water withdrawal sites within the city and should develop a regulating mechanism wherein strict quality control is practiced for using the water after proper treatment.
- For using ground water for supply of water to the city, the Jal Board could assist the Corporation to do quality monitoring and assessments on specific locations of bulk withdrawal of water for the purpose of supply and also at certain destination locations. This would help locate flaws in the supply system if any that cause health hazards.
- In parallel to this the GWD could help regular monitoring of ground water quality and quantity from various locations in the city. For places where the municipal supply is not available and individual boring is being carried out, water quality should be tested at destinations itself, for example from various residential colonies, slums, LIG locations etc.

5. Control over the private withdrawal and supply of water

Strict quality control should be practiced over the private withdrawal and supply of water in the city.

6. Transmission losses

- The transmission losses in the city have been estimated to be as high as 40%. TERI recommends the following options for reducing the transmission losses:
 - Reducing water loss through pressure management
 - Introducing metered water supply and making use of efficient metres
 - Reducing UFW through asset management, improving present water supply network
 - Actively controlling leakage to reduce unaccounted for water UFW
- As per TERI's earlier study on sustainable provision of urban services (2009, An exploration of sustainability in the provision of basic urban services in Indian cities , TERI Press) all the above-stated initiatives to reduce UFWs in the system can well be addressed by developing DMAs (district metered areas). DMAs are integrated way of systematically analysing and addressing the issues in a designated area through better monitoring.

7. Capacity building and awareness generation

A strong capacity building program for the population must be organised to create awareness about conservation of water.

8. The Master plan proposes to leave for integration points between adjacent networks to prevent dead-ends and to ensure availability of water in case if repair and maintenance in any one zone. This is an important recommendation and would have the potential of unhampered water supply during disasters/ flooding/extreme events even if certain pipelines have to be shut down.

Table 14 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 14: Mainstreaming the strategies for the water supply sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Water supply			
Augmenting the water supply system in the city	Geo-hydrological studies for new projects	Guwahati metropolitan drinking water and Sewerage Board under the Guwahati metropolitan drinking water and Sewerage Board Act,2009	Medium term

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Regulating withdrawal of ground water and rain water harvesting	Dynamic repository of data on ground water resources	Guwahati Metropolitan Drinking Water and Sewerage Board under the Guwahati Metropolitan Drinking Water and Sewerage Board Act,2009 in consultation with Central ground water authority	Medium term
	Conduct exploratory studies for establishing new withdrawal points	Guwahati Metropolitan Drinking Water and Sewerage Board through the recently prepared Assam Ground Water Bill	Medium term
Mandating rainwater harvesting for storage purposes		GDD	Short term
Water quality monitoring and control	Centralized monitoring system through a quality monitor team	Constituting quality monitor team within the Guwahati Metropolitan Drinking Water and Sewerage Board	Medium term
	Monitoring water quality for surface water and Ground water wells	Quality monitor team Coordination with State Pollution Control Board	Medium term
	Prescribe periodicity of water quality monitoring	Assam Ground Water Bill	Medium term
Water Conservation	Metered supply	Proposed Guwahati Water Regulatory Authority under the Guwahati metropolitan drinking water and Sewerage Board as per the provisions of Guwahati metropolitan drinking water and Sewerage Board Act,2009	Long Term(phased program)
	Minimizing transmission losses	Establishing District Metered Areas(DMAs) by the Guwahati Metropolitan Drinking Water and Sewerage Board	
	Capacity building	Central Ground Water Board carries out water management training and awareness program Ground water bill may identify a nodal agency at city level which can involve NGOs , schools, volunteers	

6.4.2 Sewerage

At present many parts of the city are dependent on soak pit systems, however, the soak pit become dysfunctional during monsoon due to flooding and water logging.

- In a city like Guwahati a separate storm water and sewerage system (known as the dual system) is beneficial. However, this system is expensive and can be developed in phases. It is recommended that the city builds its sewerage system in phases, however, leaving the treatment facilities and the recycling facility as a long term strategy would not provide desired benefits. Zonal systems could be created and developed which are fully functional and close the loop. For example, North Guwahati sewerage system is developed with treatment facilities and recycling facilities and so on.
- In some newly development areas or where the land is being developed the city can go for decentralized systems (DEWATS). This could be planned at the level of residential pockets or ward level. However, it is recommended that the technical feasibility be studied before implementation. The CPHEEO manual on sewerage and sewage treatment gives a detailed account on design features of such systems. Besides this the manual on 'Norms and Standards for environment clearance of large construction projects, Ministry of Environment and Forests,

Government of India gives many technological options available.

- The industrial units must be mandated to provide for treatment of the effluent released by them. It should be mandated for the industrial establishments to provide for sewerage and sanitation facilities as well as treatment facilities. Disposal of untreated waste into the river bodies should be banned.

Table 15: Mainstreaming the strategies for the sewerage sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Development of a sewerage system in the city	System development	Guwahati Metropolitan Drinking Water and Sewerage Board under the Guwahati Metropolitan Drinking Water and Sewerage Board Act,2009	Medium to long term(phased program on priority)
	Norms and standards for sewerage management and disposal	UDPFI guidelines, Service level benchmarks of the Ministry of Urban Development; CPHEEO manual for Sewerage and Sewage Treatment; Manual for norms and standards for environment clearance of large construction projects, Ministry of environment and Forest; prescribed limits for disposal of waste water by CPCB under Water (Pollution and Control) Act	Medium to long term
Monitoring water quality at disposal points		Water quality monitoring team of the GMDWSB in coordination with the Assam SPCB and the GMC.	Short to medium term
	Strict enforcement of the Water (Prevention and Control of Pollution) Act of 1974, there under Rules, 1975 (Assam Rules 1977), the Water (Prevention & Control of Pollution) Cess Act of 1977	State and city level authorities	Short term

6.4.3 Natural Drainage

The solution to the drainage problem of the city has to be provided through integration of the following two approaches:

- At a macro level where specific drainage basins and their role is identified for draining excess waters during monsoon and subsequent flooding
- At a micro level to see the status of availability/capacity of storm water drains within the city and their connectivity with the larger drainage basins.

Scientific assessment of drainage pattern

- It is suggested to conduct an extensive study of the natural drainage system of the city along with the slope analysis using GIS platform for the entire city and find out outlet paths for the flood waters in the city. The study would be beneficial in identifying the storm water routes and would help in identifying areas where storm water drains have to be installed. This study should also focus on identifying the most flood prone areas/zones in the city (Refer map No 3) and then designing the capacity of storm water drains to be installed in these areas.
- All new drains and old drains should be provided with silt catching devices and regular removal of the silt from the same should be in operation.

Protecting the natural drainage pattern

- TERI recommends devising and implementation of strong regulations based on scientific study of the topographical features of the city, including the natural drainage patterns and water bodies.
- Land-use regulations should be stringent and should be enforced and monitored. The internal systems of sanctioning the maps need to be checked and the norms should be strictly followed. Special encroachment drives have to be launched within the city with the cooperation of the municipal corporation, the development authority and the police department.

Uncontrolled development, deforestation and cutting of hills

- 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. It was brought out during consultation that most of the hill land falls under the jurisdiction of the district government. TERI recommends bringing this issue up at the level of the State Government wherein the District Government and the City Government take collective decision in the interest of the city and its population.
- Resettlement programs should be devised through community participation wherein the people are included and involved in the decision making process to gain their trust and confidence.

6.4.4 Storm water drainage

The resilience strategy recommends that the city should take up storm water management plan in the city with immediate priority. This would involve integration and coordination between GMDA, GMC and T CP Departments as well as the private developers.

- The proposed storm water drainage system should be separate from the sewerage system which is being undertaken in the city currently, in order to avoid the mixing of storm water and waste water which would mean an added required capacity of the drains and the sewage treatment plants.
- It is always beneficial to have a decentralized storm water drainage system where the drains may eventually lead to recharge points for ground water recharge. However, such points should not be located in the water logging prone areas in the city and should be identified based on a detailed technical assessment.
- A periodic cleaning and maintenance of the storm water drains may be carried out by GMC with strict regulations for ban of solid waste disposal and plastics for an efficient system.
- Polythene is already banned in the city; however, due to lack of enforcement, the city is still grappling with the problem of polythene. The government must impose heavy penalties on shopkeepers and commercial establishments on the use of polythene.
- Awareness generation through mass media is another way to educate people towards the nuisance caused by the use of polythene.

Table 16 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 16: Mainstreaming the strategies for the drainage sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Natural Drainage			
Protecting and managing natural drainage systems of the city	Improvement of drainage in the Brahmaputra Valley and Barak Valley, including project planning and construction of dams, flood control and bank erosion measures.	The Brahmaputra River Board and the Water Resources Department, Govt. of Assam	Short to medium term(continuous process)
	Management of Beels	GMDA	

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
	Protection and management of drains including removal of garbage and encroachments.	GMC	
Commission scientific assessment study to ascertain feasibility of an integrated natural drainage plan for the city as proposed within the Master Plan 2025		Wetland (Conservation and management) Rules 2010.GMDA coordinates with inputs from expert organizations like IIT, Pollution Control Boards, NEERI, TERI etc.	Short Term
Restricting waste disposal in Bharalu and Bashishtha rivulets	Identify points of drainage blockage/encroachment in the rivulets	GMC	
	Special cleaning drives	GMC with GMDA	
Storm Water Drainage			
Prepare and implement a storm water drainage plan		GMC, GMDA,TCPO	Medium to long term(phased program)
Decentralized storm water system		GMC, GMDA,TCPO	Medium (phased program)
Assessment of the estimated storm water volumes in view of the climate variations as projected by this study		Coordinated by GMDA and GMC. 'Manual on norms and standards for environment clearance of large construction projects', Ministry of Environment and Forests, Government of India gives many technological options available for development of sustainable drainage systems.	Short to medium term

6.4.5 Solid Waste Management

The CPHEEO¹⁴ Manual on 'Solid Waste Management'¹⁵ introduced in the year 2000, by the Ministry of Urban Development is the most elaborate manual giving guidance to urban local bodies to set up an integrated solid waste management system (ISWM) in their cities. It covers all aspects and components of an ISWM and is a ready reckoner for the ULBs to plan their SWM. It should be referred while designing a detailed solid waste management plan for Guwahati city.

Refer to MSW Rules 2000 for detailed stepwise methodology to manage solid waste under the following categories:

- **Door to door collection and segregation:** Schedule II, Point 2 of the MSW Rules 2000, stipulates the municipal body to organize awareness generation programmes and undertake phased programmes ensuring community participation in waste segregation, hence, alternatively, such an arrangement could be made in the city.
- **Primary collection centres:** Primary collection could be set up at zonal levels depending upon the wards covered under each zone. Each zone could have more than one primary collection centre depending upon the population to be catered. The upkeep and operation of the primary collection centre, including waste segregation would essentially be the responsibility of the municipal corporation.

¹⁴ Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, Government of India

¹⁵ Available at http://www.indiawaterportal.org/sites/indiawaterportal.org/files/Manual%20on%20municipal%20solid%20waste%20management_%20MoUD_GOI_2000.pdf

- **Treatment and disposal:** The non-biodegradable, inert waste and waste not suitable for recycling or biological processing should be sent to the landfill site.

It is recommended that the city utilizes the site at Pachim Boragaon to set up waste segregation, disposal and recycling mechanisms at the site. It should also consider potential climate impacts in making decisions for landfill sites and location of SWM plant.

Table 17 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 17: Mainstreaming the strategies for the solid waste management sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Solid Waste Management			
solid waste management and disposal system	development of infrastructure for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes	As per the provisions of the Municipal Solid Waste (Management and Handling) Rules, 2000, GMC make an application for grant of authorization for setting up waste processing and disposal facility including landfills from the State Pollution Control Board(Section 4, MSW Rules, 2000) and shall follow the implementation schedule as laid out in the 'schedule I' ¹⁶ of the said rules	Medium to long term
	identify the landfill sites and hand over the landfill sites to the municipal body for development , operation and maintenance	schedule III of MSW rules, GMDA	Medium term
	enforcement of the provisions of the MSW rules within the territorial limits of their jurisdiction ¹⁷ (Section 5, MSW Rules,2000).	District Magistrate or the Deputy Commissioner	Medium to long term
	the compliance of the standards regarding ground water, ambient air, leachate quality and the compost quality including the incineration standards	The State Pollution Control Board under schedule II, III and IV ¹⁷ of the MSW rules, 2000	
	Biomedical wastes	in accordance with the Bio-medical Waste (Management and Handling)Rules 1998	Medium term
	Hazardous wastes	Hazardous Waste (Management and Handling) Rules 1989(Schedule III, MSW rules 2000).	Medium term
	Norms and standards for solid waste management and disposal:	The CPHEEO ¹⁸ Manual on 'Solid Waste Management' ¹⁹ introduced in the year 2000,by the Ministry of Urban Development	-

16 Schedule I(MSW Rules,2000) is the Implementation schedule for the MSW rules including setting up waste processing and disposal facilities, monitoring the performance of the facility, improvement in existing and selection of future land fill sites.

17 In case of metropolitan cities the in charge for enforcement shall be the Secretary- In -charge of the Department of Urban Development of the State or the Union Territory.

18 Schedule I(MSW Rules,2000) is the Implementation schedule for the MSW rules including setting up waste processing and disposal facilities, monitoring the performance of the facility, improvement in existing and selection of future land fill sites.

Schedule III(MSW Rules 2000)- Specifications for landfill sites in terms of selection of landfill sites, facilities to be provided at the site, specifications for land filling, pollution prevention, water and ambient air quality monitoring, closure of landfill site and post care.

Schedule IV(MSW Rules 2000)-Standards for composting, treated leachates and incineration.

19 Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, Government of India

20 Available at http://www.indiawaterportal.org/sites/indiawaterportal.org/files/Manual%20on%20municipal%20solid%20waste%20management_%20MoUD_GOI_2000.pdf.

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Community awareness program for facilitating door to door collection and segregation of waste		The GMC may involve NGOs, RWAs and other community based organizations	Short to medium term

6.4.6 Electricity/Power

The Master Plans gives recommendations for the improvement in transmission and distribution of power supply to cater to current deficit.

In the case of extreme rainfall events as predicted by climate projections, the power situation has to be robust. As is known, during floods the water has to be pumped out of the town and so uninterrupted power is needed during rainy season. The city utilizes diesel run generators for the same at present (as discussed during consultations). It was also revealed during the consultations that although most of the substation fall under flood prone zones, the structures are safe. In order to mitigate the impacts of urban flooding on power supply infrastructure, the new 11/33 kv sub stations (transformers) are being constructed on higher platforms. The platforms have also been raised for old sub-stations falling in the areas which frequently face water logging in the city.

Other recommendations have been listed below. Table 18 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 18: Mainstreaming the strategies for the power sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
promote energy efficiency urban land uses	employ fiscal measures like a progressive and use based tariff structure to promote energy efficiency	Department of Power (Electricity), GoA	Short term
	enforcement of energy efficient building code (ECBC) or GRIHA guidelines for energy efficiency in HVAC systems in buildings, particularly under institutional and commercial uses		Short to medium term
improvisation of efficiency of motors/conversion to SPV based pumps for pumping out the flood waters from the city and development/operation and suggesting location of power infrastructure like ESS in areas of no/low-vulnerability		The Kamrup Metropolitan District Emergency Operation Centre (KMDEOC)	Medium term
Allocation of space for future infrastructure	allocated in the land use plan	GMDA Based on KMDEOC's recommendations	Short to medium term
	Set up the infrastructure.	Department of Power (Electricity), GoA	Short to medium term
Promoting use of renewable energy sources:	Implementation of Solar City Plan under the Jawaharlal Nehru National Solar Mission (as part of NAPCC).	GMC	Short to medium term

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
	technical inputs and capacity building programs for the benefit of the city level agencies and local community to promote use of renewable sources of energy, especially in institutional and commercial buildings	GMC may coordinate with the Assam Renewable Energy Development Agency (AREDA) at the state level	Short to medium term

6.4.7 Health

To tackle the health related vulnerabilities in the city of Guwahati as identified above, following resilience measures are recommended:

1. Health Surveillance System

Public Health Surveillance is a critical tool to prevent outbreaks of diseases and develop appropriate, rapid responses as it provides real-time, early warning information to decision-makers about health problems that need to be addressed in a particular population.

- **Data Collection** – The first step in surveillance would be data collection and monitoring of cases. The Office of the Joint Director, Health Services (Kamrup Metropolitan District) (JD-H), which is the nodal agency for public health in the Guwahati, houses a control room for surveillance of diseases to be reported under the IDSP. Integration of the 20 urban health centres (UHCs) established under the NRHM in the system will help to build a large scale network for monitoring and reporting of cases of infectious diseases. Provided with adequate infrastructure and man power (doctors, paramedicals, etc.), they will also act as control rooms for emergency situations.
- **Reporting** – The continuous data collection and monitoring done in step 1 should feed into an Early Warning System (EWS). The Standard Operating Procedure (SOP) under the KMD Disaster Management Plan should mandatorily require reporting of all cases of vector & water-borne diseases, from the JD-H Office to District Administration, on a daily basis in the monsoon and post monsoon months. In case of outbreak of a disease, these numbers should be shared with the Municipal Corporation and ASDMA for taking preventive measures.
- **Preparedness** –An assessment of the required health infrastructure in the city has been done by the Master Plan for Guwahati Metropolitan Area- 2025. This exercise may be built upon by the office of the JD-H with inputs from ESF-4, District Administration or through consultants. Accordingly, the SOP can chalk out a deployment plan for manpower and infrastructure in case of emergency situations.
- **Response** – As per the SOP, when occurrence of any infectious diseases is reported, the rapid response medical team, verifies it and reports to the office of the JD-H as well as GMC for preventive and control measures. Public helplines and information & communication technology (ICT) based mediums like sms, public portals, etc. will also help in reporting occurrence of cases as well as disseminating information in case of emergencies. This kind of system may be managed through the e-governance cell of the GMC.

2. Preventive Health measures and practices

A two pronged approach is required to deploy such measures – at the level of the administration as well as at the level of the community.

- **Sanitation and Hygiene** – It was found out during the City Consultation exercise that there is an acute lack of man power in the GMC Health Department leading to lapses and inadequacy in the sanitation and hygiene works in the city. Therefore, large scale intake of sanitary workers, to carry out regular sanitation activities, at least in the vulnerable monsoon and post-monsoon months, is required on the part of the GMC. Also, the local NGOs can play an important role in this process.
- **Public awareness** – Generation of public awareness to adopt preventive health measures and practices can act

as a long term step towards an effective Public Health Management System. This may prove quite beneficial especially in case of slums, urban poor/ squatter settlements, etc. NGOs, schools, volunteers may be involved by the District/ City administration to take up such initiatives.

Table 19 outlines the institutional and regulatory back up to mainstream the strategies for this sector.

Table 19: Mainstreaming the strategies for the health sector

Strategy	Vehicle	Institutional/regulatory Back up	Timeline
Health			
Preventive health measures		Health Department of the GMC, under the Guwahati Municipal Corporation Act, 1969	Short to medium term
	Public awareness initiatives	NGOs, schools, volunteers may be involved by the GMC, office of JD-H and KMDEOC to take up public awareness initiatives	Short to medium term
Public health management and surveillance system:		The JD-H is the district level administration officer for public health and the nodal public officer overseeing implementation of government schemes, missions and public health care set-up including PHCs, UHCs, Medical units	Short to medium term
Emergency medical response		The office of the JD-H is also the nodal agency for preparing and enforcing the SOP of ESF-4 under the KMD District Disaster Management Plan prepared under the provisions of the Disaster Management Act, 2005	Short to medium term

6.5 Disaster Resilience

The city of Guwahati is prone to multiple disasters owing to location and topography. These primarily include floods, landslides and earthquakes. The last decade has also seen a tremendous growth of the city accompanied by typical set of challenges that come up with unplanned urbanization. This has increased the vulnerability of the city in the event of these disasters with impacts on the overall quality of life.

The state of Assam has been identified as Seismic Zone V and experiences low intensity earthquakes frequently. Acknowledging the importance of disaster risk reduction in the city, the District Administration has in the recent past initiated a number of activities with support from the state government (ASDMA) and non-governmental and research organizations. ASDMA can suggest revision of design parameters to include adaptation measures in urban utilities like water supply, storm water drainage and sewerage and can play a key role in mainstreaming city level climate resilience in urban planning and development process.

As per the provisions of the Disaster Management Act of 2005, the Kamrup Metropolitan District Emergency Operation Centre (KMDEOC) under the District Administration is the nodal agency for all activities pertaining to disaster management and risk reduction in the district including the Guwahati Metropolitan Area. It can play a key role in management and response mechanism for floods in the city; including suggestion of structural adaptation measures for drainage and flood control.

As part of its mandate KMDEOC has recently prepared the Disaster Management Plan for Kamrup District to prevent/minimize the loss and also to facilitate faster recovery during an emergency. It addresses all disasters including urban flooding and has identified 14 Emergency Support Functions (ESF) to be carried out by the District Administration (KMDEOC) in coordination with various state line departments and city level public agencies including the GMC. The Standard Operational Procedures (SOPs) for all ESFs are being prepared phase wise by the various coordinating agencies identified by the Plan and will soon be shared with various stakeholders (Source: KMDEOC, ASDMA). However, the Plan is yet to be enforced and therefore little can be commented on its

effectiveness.

- Apart from this, other initiatives for flood management, disaster management, disaster risk reduction include:
- The Integrated Urban Flood Management Project for GMA by the KMDEOC, with support from ASDMA but it is in a very preliminary stage and not much work has been done till now.
- ASDMA also has a MoU with Columbia University under the UNDP funded Risk Reduction Program. Under this MoU, Columbia University has initiated a study for urban flood resilience in Guwahati.
- ASDMA with assistance of NE Space Application Centre, is undertaking a project 'Hazard Risk Vulnerability Analysis for Guwahati city, Dibrugarh and Silchar as part of the UNDP funded Risk Reduction Program
- Landslide risk mitigation project for Guwahati - a multidisciplinary task force for proper implementation of the action plan prepared under this project was also formulated.
- GDD has commissioned a study to Assam Engineering College for carrying out the slope analysis of hills in GMA in order to understand the land suitability for zoning of vulnerable areas.
- Health surveillance in terms of monitoring and recording occurrence of diseases in post-flood scenarios is done by NRHM unit in Guwahati under the Integrated Disease Surveillance Program (IDSP).

7. Way Forward

The study shows that the existing vulnerabilities are too strong for the city and addressing these now, will also help in building resilience in the long run. The city resilience strategy (Section 6) has prioritised some sectors for undertaking the outlined actions. It is now pertinent that the city formally adopts some of the recommendations made by TERI and the various departments adopt the sector specific action points suggested by TERI. The state government could support some of the suggested adaptation strategies and projects within their existing schemes and resources.

A mainstreaming plan has been provided by TERI to implement the sectoral strategies. The resilience strategy also highlights the existing windows through which the city can initiate climate action immediately, without waiting for a mandate or a policy from the state or the national government. However, since climate resilience is closely related to the developmental goals and priorities of the city, a policy support from the state and national government will not only ensure sustainability of the initiative but will also open up new avenues for channelizing these strategies towards implementable actions.

Once the city starts implementing these pilot strategies, in the long run, learnings derived from these experiences will feed into the existing system. This would lead to identification of missing regulations and institutional setups at various levels of the government and pave a new path for reforms resulting in initiation of new laws and regulations to support climate resilience.

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