Gorakhpur Environmental Action Group (GEAG) is a voluntary organization working in the field of environment and sustainable development since 1975. Ever since its inception, GEAG has been actively engaged in implementing several development projects addressing livelihood issues of small and marginal farmers, particularly women, based on ecological principles and gender sensitive participatory approach. Besides, GEAG has accomplished several appraisals, studies, researches at the micro & macro levels as well as successfully conducted a number of capacity building programmes for various stakeholders including women farmers, civil societies groups and government officials etc.

Today, GEAG has established its identity in North India as a leading resource institution on Sustainable Agriculture, Participatory approaches, methodologies and GEnder. Acknowledging its achievement, efforts and expertise, United Nation's Economic and Social Council (ECOSOC) accorded GEAG special consultative status in the year 2000. GEAG has also been recognized recently as North India hub for Intersard, South Asia-a network to facilitate information sharing on issues of concern.

Institute for Social Environmental Transition (ISET) is an international, non-profit institute with members and advisors in both the North and the South. Individuals and organizations involved in ISET all share a commitment to environmentally sustainable development and poverty alleviation. ISET's activities combine knowledge generation, learning and the incubation of innovative strategies through pilot scale implementation. As the lead facilitation partner for the ACCCRN programme, ISET is working with country level partners to support project cities through a Shared Learning Dialogue (SLD) process that will identify resilience building activities; facilitate the development of replicable processes, methodologies, and strategies for adapting to climate change in urban settings; and support cities in developing proposals and disseminating results from their analyses in ways that inform climate adaptation at local, national, and global levels. http://www.i-s-e-t.org/

The Rockefeller Foundation supports work that expands opportunity and strengthens resilience to social, economic, health and environmental challenges—affirming its pioneering philanthropic mission since 1913 to promote the well-being of humanity.

The Foundation operates both within the United States and around the world. The Foundation's efforts are overseen by an independent Board of Trustees and managed by its president through a leadership team drawn from scholarly, scientific, and professional disciplines.

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Asian Cities Climate Change Resilience Network
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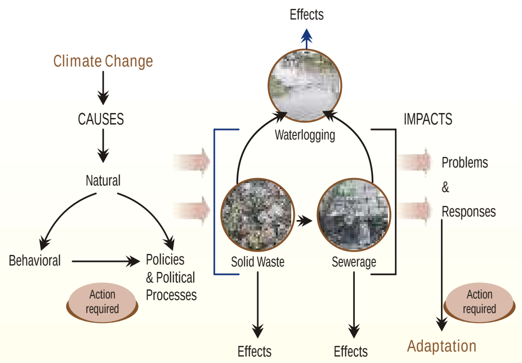
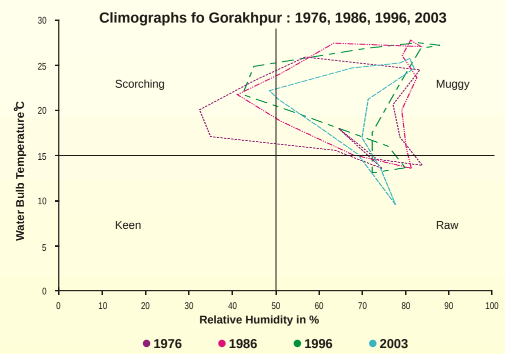
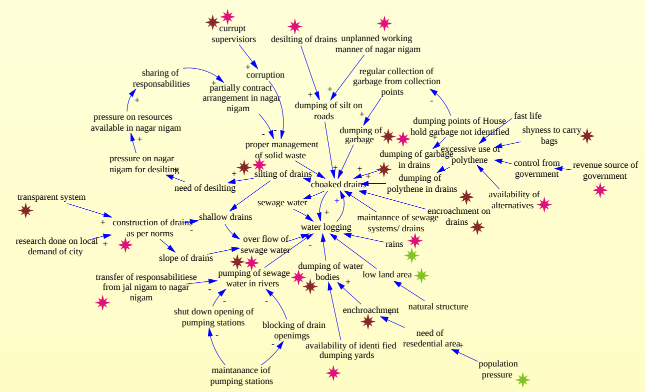
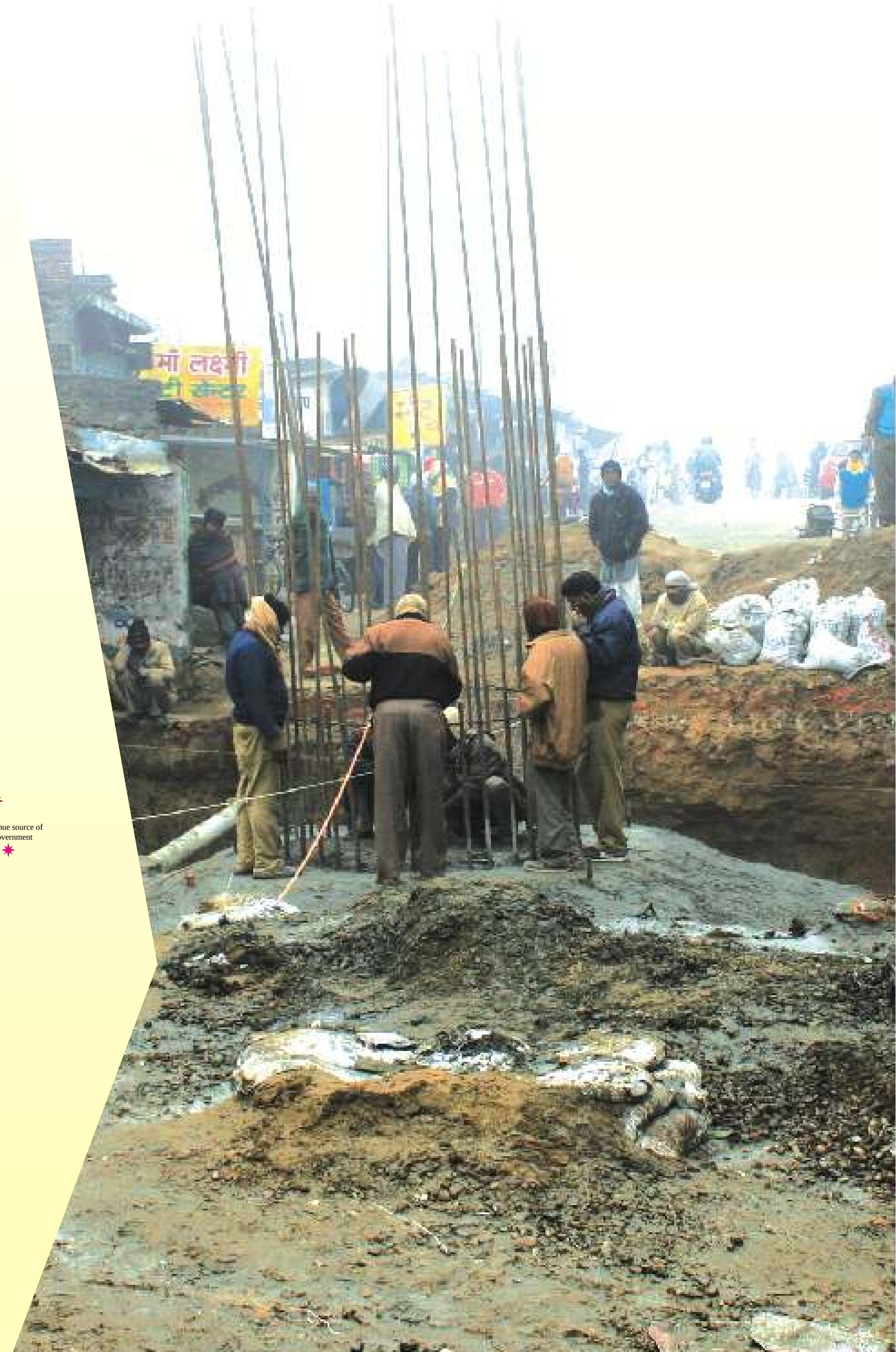
Towards a Resilient Gorakhpur









Gorakhpur Environmental Action Group

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Towards a Resilient Gorakhpur

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ISET

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Contents

List of Tables

List of Figures

List of Photos

Abbreviations

CC	Climate Change
CFL	Compact Fluorescent Lamp
CGCM	Coupled Global Climate Model
CNG	Compressed Natural Gas
CNRM	Centre National de Recherches Météorologiques
CSIRO	Commonwealth Scientific and Industrial Research Organization
EIA	Environment Impact Assessment
GDA	Gorakhpur Development Authority
GEAG	Gorakhpur Environmental Action Group
GMC	Gorakhpur Municipal Corporation
IMD	India Meteorological Department
MIUB	Meteorological Institute of the University of Bonn
PLA	Participatory Learning Action
PPCP	Private Participation Community Participation
SLD	Shared Learning Dialogue
SWM	Solid Waste Management
VA	Vulnerability Analysis

Executive Summary

Sets of complex interlinked urban systems meet the basic needs of Gorakhpur's citizens. These systems are not composed of the physical infrastructure only but reflect complex inter-relationships between social, cultural, political, institutional, economic, geographic, organizational, and bioenvironmental factors. These inter-relationships influence the population and the way they interact under "normal" conditions and during periods of stress such as those caused by major floods. Much of the population and many of the systems on which they depend are already vulnerable. These will be further challenged by changing climatic conditions both directly and indirectly.

Gorakhpur is one of the fastest growing cities in the mid-Gangetic plains. Unfortunately, the development of basic urban systems has not kept pace with its growth. At present the capacity of natural, social, institutional and infrastructure systems to provide water supply, sanitation and drainage is over-stretched. Consequently, in many parts of the city the ability of basic systems to support the quality of life for local residents, particularly the poor, is declining. Such existing challenges will be greatly exacerbated both directly and indirectly due to climatic changes, causing temperatures and humidity to increase in urban core areas and resulting in changes in the variability and intensity of extreme weather events. Flooding, waterlogging, temperature extremes, power shortages, deteriorating water quality and the spread of water and vector born diseases are already major problems of the city. Less evident to the casual observer are challenges like the inability of the urban poor to meet basic food and livelihood needs, a crisis likely to accentuate with climate change. Beyond this, fresh problems are expected to emerge as climate change affects basic systems in ways that are difficult to predict.

Flooding, waterlogging and other water related problems are the most evident current crises in Gorakhpur. Historically 103 water bodies served as natural flood storage and drainage to the city. Presently, less than a third of these water bodies are functional. As a result of several factors (the construction of embankments, drainage of ponds and river siltation) a large part of the city's elevation is now below the river during high flow periods. This has led to waterlogging of lands and periodic flooding. Waterlogging has been worsening in recent years in Gorakhpur, spurred by changes in rainfall, the degradation of water bodies, unplanned development and land encroachment. Though the total rainfall has not risen much, its average intensity in the summer months has increased. This has resulted in some areas of the city now being waterlogged for almost six months in a year.

Unmanaged solid waste disposal and faulty drainage channels, particularly in low lying areas, increase waterlogging and the associated burden of diseases. With no incinerator or water treatment plant, the problem of solid waste, siltation of drains and pollution of water bodies has become acute. Prolonged waterlogging together with poor waste management has caused an increase in the incidence of vector borne diseases as well as contamination of ground water. Malaria and dysentery have historically been problems. The recent years have seen a rise in diarrhea, hepatitis, fluorosis and Japanese encephalitis.

The proposed resilience strategy for Gorakhpur recognizes that responding to climate change will necessitate integrated action to address a combination of institutional, behavioral, social and technical issues that undermine the ability of interlinked urban systems to meet the basic needs of Gorakhpur's residents, particularly the poor, and respond flexibly as climate change occurs. Gorakhpur's urban systems are, however, complex and many of the impacts of climate change cannot be fully predicted. As a result, an evolutionary strategy for building resilience in the city has been developed. It will focus on problems that, while clearly related to climate change, are also immediate, tangible and of concern for the residents and managers of the city. With this focus, the strategy emphasizes the growth of capacity to address the multiple technical, institutional, social, cultural and other dimensions: first of the problems that are selected as an initial strategic focus and second on the gradual incorporation of additional problems and the additional capacities required to address them. To create a ripple effect that builds resilience over time in multiple arenas, the strategy will utilize targeted interventions that build knowledge, provide demonstrated examples, assist the development and build the capacity of organizations and create pressure for change at behavioral, institutional and political levels.

As a point of entry the city resilience strategy focuses on the flooding and water related problems. This initial focus is intended to serve as a basis for both immediate action and building the capacity to respond to the other, difficult to predict, challenges that will emerge as a consequence of climate change. Hence, as part of the resilience strategy, actions to directly address challenges associated with the known climatic change impacts like increase in waterlogging are proposed. Simultaneously, developing greater understanding of uncertain climate impacts, like the new landscape of diseases and livelihood systems, through research and interventions that foster generation and management of relevant knowledge on a continual basis is also proposed. The net result is a multi-pronged, multi-scale strategy targeting diverse groups and stakeholders to build resilience. It will entail feasibility studies, action oriented research, capacity building and advocacy. Such activities will be implemented at both the local (ward) and city levels.

The proposed resilience strategy is based on:

1. Targeted physical and institutional action to improve drainage, housing, health and communication systems in selected areas of the city.

2. Information, data and knowledge focused activities to build the evidence base required for long-term planning, emergency response and social advocacy among diverse groups of residents, city authorities, NGOs, academics, politicians and other actors.

3. Analytical and advocacy activities designed to raise public and political awareness of emerging problems thereby generating the social pressure required at the behavioral, organizational and political levels for solutions to emerge and be implemented.

Underlying all of these will be a focus on developing the institutions and governance mechanisms required to implement activities and strengthening the critical systems that contribute to resilience and enable adaptation.

More specifically, to address multiple challenges at a local level, building on existing consensus regarding the importance of flooding, solid waste management and resilient housing, detailed micro-resilience plans will be completed and implemented in a few wards. This will demonstrate what can actually be achieved by community institutions established at the ward level.

Another proposed action is to develop a Resource Centre that will help in maintaining a database of information related to generic (physical, infrastructural, climate, policy, schemes, behavioral) and sectoral (health surveillance, basic services drinking water, solid waste, sewage and sanitation and so on) issues influencing the climate change vulnerability of the city and the people. The data / information can be utilized for generating awareness, advocacy, planning and capacity building and other actions for building resilience to current and future climate risks. The proposed set-up will also help in packaging and dissemination of information in specific user friendly formats to cater to diverse needs / groups, especially the vulnerable communities.

Following the development of the resource centre, a specific set of activities has been proposed to develop the capacities of select groups of citizens (children, youth and citizen groups). A responsible citizenry will facilitate citizen's action and also influence the accountability of government and administration and promote effective governance. This will improve the urban systems and quality of life of the poor and the vulnerable.

SECTION : I

City’s Vulnerability to Climate Change

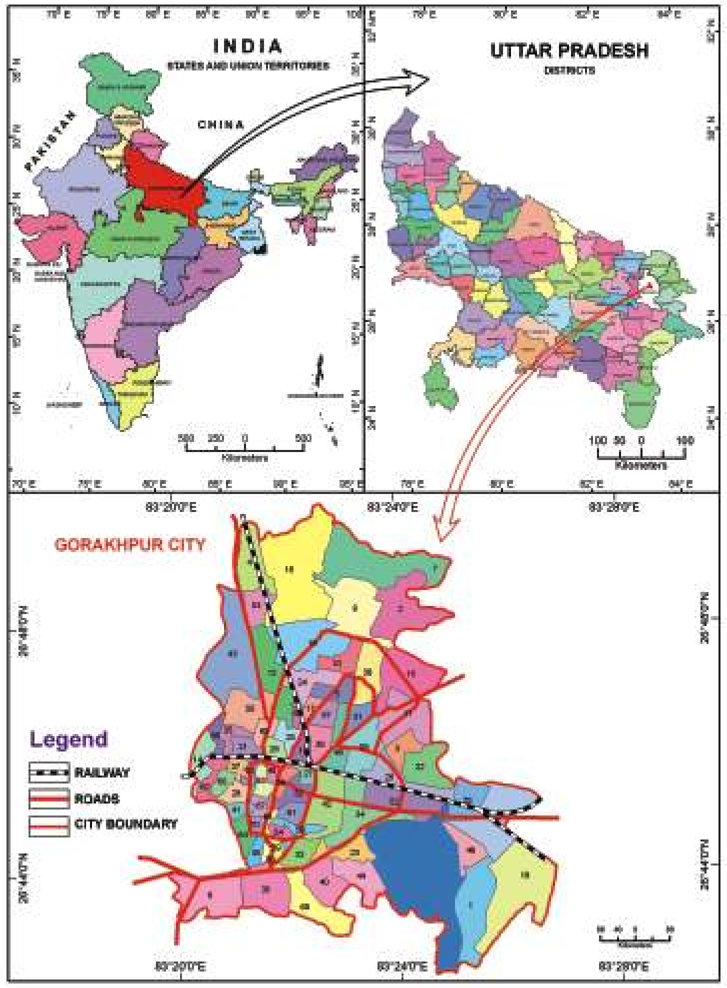
Background

Gorakhpur is located in the Terai[1] belt of Eastern Uttar Pradesh, India. Due to its pleasant climate it was considered a mini hill station by the British. After the 1970s with the establishment of the Northeastern Railway Headquarters and other infrastructural developments, major changes have taken place in every sector.

In terms of population growth, it is at present the second largest city, after Varanasi, in Eastern Uttar Pradesh. Geographically, the city is situated on the left bank of the river Rohin at the confluence of the rivers Rapti and Rohin. The city's 147 sq.km is divided into 70 administrative wards[2] (Fig. 1).

The topography of the city is largely plain with a marginal gradient / slope from north to south. The slope decreases from the middle of the city both east and westwards. The height of the city ranges from 75 to 85 meters above the mean sea level (msl), with the western part higher than the eastern. There are numerous water bodies within the city and the biggest Ramgarh tal (lake) is situated in the south-eastern part of the city (ibid: pg. 9).

Figure 1 | The Study Area



Source: Wajih et al, 2009

1 The Terai (“moist land” or "foothill"), is a belt of marshy grasslands, savannas, and forests at the base of the Himalaya range in India, Nepal, and Bhutan. Above the Terai belt lies the Bhabhar, a forested belt of permeable rock, gravel, and soil eroded from the Himalayas where the water table lies from 5 to 37 meters deep. The Terai zone lies below the Bhabhar. It is composed of less permeable layers of clay and sand that brings groundwater nearer the surface so there are many springs and wetlands. The Terai zone is inundated yearly by the monsoon-swollen rivers of the Himalaya (http://www.en.wikipedia.org/wiki/Terai) (last accessed on September 27, 2010).

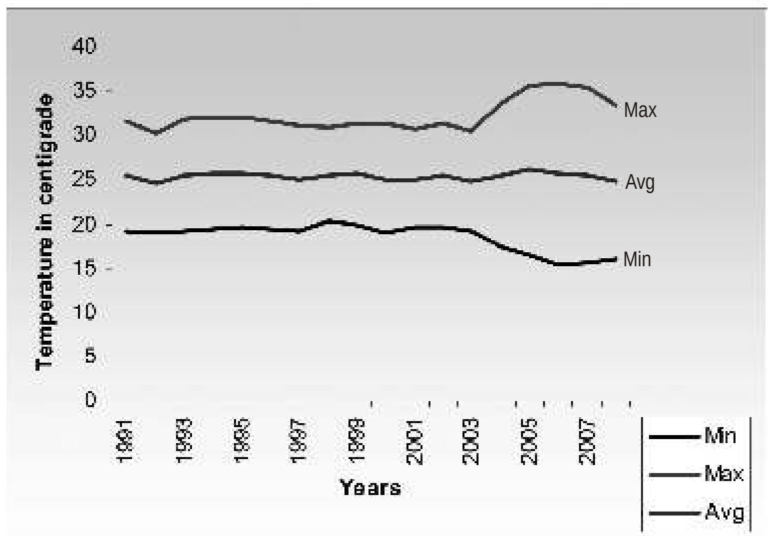
2 Wajih et al, 2009: pg 8.

The city has a total population of 622701 (Census, 2001)[3] with an average density of about 4559 person / km, which is lower than other faster growing municipal corporations like Varanasi, Kanpur, and Allahabad. During the last three decades, however, the population of the city has increased rapidly with a record growth during 1981-1991 (64.1 percent), due to the incorporation of 47 villages into the municipal area. The population is spread unevenly in the city with a high density in the older wards, while the newly constructed wards in the north of the city have a low density of population. The rapid influx of population from the nearby rural areas (as well as from outside the state) to the city has exerted tremendous pressure on its infrastructural capacity. This has led to the development of numerous slums, with living conditions within the city deteriorating by the day. Currently, there are about 110 slums, accommodating around 33 percent of the population (ibid: pg 13).

Gorakhpur is considered the largest commercial centre of the region, with both retail and wholesale markets of commodities ranging from agricultural products to home based cottage industries (ibid: pg 16).

The Climate Scenario -

Figure 2 | Gorakhpur City : Temperature Scenario (1991-2008)



Source: Wajih et al, 2009

Temperature

Historically, Gorakhpur and its surrounding areas had a pleasant climate[4]. However, in the past few years there has been a rapid alteration and unexpected changes in the climate. Coupled with a speedy population growth, this has deteriorated the environment of the city. The average temperature is 25.68oC, but during the summer months, the maximum temperature shoots up to 31.95oC; whereas the minimum is above 19.57oC. The city receives an annual average rainfall of about 119.2 cm[5]. During the last decade the city has experienced significant ups and downs in temperature as well as rainfall. Since the year 2003, there has been a continual change in the annual maximum and minimum temperatures.

There has been a 9.51 percent increase in the maximum temperature during 2003-2008; whereas, on the other end, the annual minimum temperature has recorded a decreasing trend. In 2002, it was 19.63°C which has now dropped to 15.98°C (Fig 2).

3 http://www.censusindia.net (last accessed on September 27, 2010).

4 District Gazetteer, Gorakhpur, 1909.

5 Wajih et al, 2009: pg 10.

Consequently, there has been a 22.84 percent decrease in the minimum temperature during 2002-2008[6], with both summers and winters becoming more severe (Table 1).

Table 1 | Gorakhpur City : Climatic Characteristics

	Temperature in Degrees Centigrade		
Year	Max	Min	Average
1991	31.69	19.27	25.48
1992	30.34	19.02	24.68
1993	31.76	19.22	25.49
1994	32.11	19.52	25.82
1995	32.13	19.56	25.85
1996	31.67	19.54	25.61
1997	31.23	19.11	25.17
1998	30.91	20.29	25.60
1999	31.32	19.98	25.65
2000	31.37	19.02	25.19
2001	30.71	19.63	25.17
2002	31.45	19.63	25.54
2003	30.6	19.2	24.90
2004	33.6	17.41	25.51
2005	35.73	16.5	26.12
2006	35.98	15.31	25.65
2007	35.53	15.69	25.61
2008	33.51	15.98	24.75

Source: Indian Meteorological Department, Gorakhpur

Though these shifts are not necessarily the outcome of CO_2 induced anthropogenic climate change, they are evidence of present changes in climate patterns that are affecting the lives of people now. People in their daily lives comment on these change, thus lending credence to their unique nature. Such awareness also eases introduction of the concept of climate change in the stakeholder engagement process.

Future Temperature Scenario

From the analysis of different climate models such as CGCM3[7], CNRM, CSIRO[8], MIUB, it is predicted that the maximum temperatures are likely to increase in all four seasons. Further, the oscillation of temperature will be most pronounced in winter and summer. This fluctuation in temperature and its potential impact on precipitation could have significant impacts on local agriculture and urban water management for Gorakhpur, while the increased temperature, per se, can change the pattern of occurrence and incidences of water and vector borne diseases[9].

The range of possible variation in temperature might be as follows (Table 2 and Figure 3):

6 Verma, 2009: pg 14.

7 General Circulation Model (GCM) is a mathematical model of the general circulation of a planetary atmosphere or ocean. These equations are the basis for complex computer programs commonly used for simulating the atmosphere or oceans of the Earth. Atmospheric and Oceanic GCMs (AGCM and OGCM) are key components of Global Climate Models along with sea-ice and land-surface components. GCMs and global climate models are widely applied for weather forecasting, understanding the climate, and projecting climate change. Versions exist for decade to century time scale climate applications. http://www. en.wikipedia.org/wiki/Global_climate_model (last accessed on 27 September, 2010).

8 According to Opitz-Stapleton, 2009, the CGCM3 CNRM, CSIRO, and MIUB are the General Circulation Models which are best fitted for analysis and projection of the climate scenario of Gorakhpur.

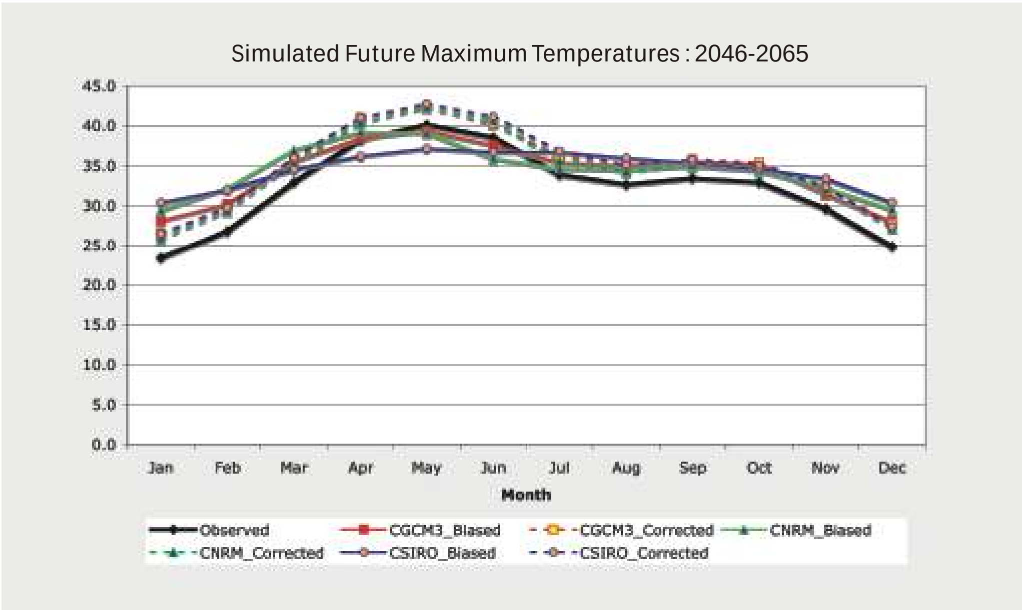
9 Opitz-Stapleton, 2009

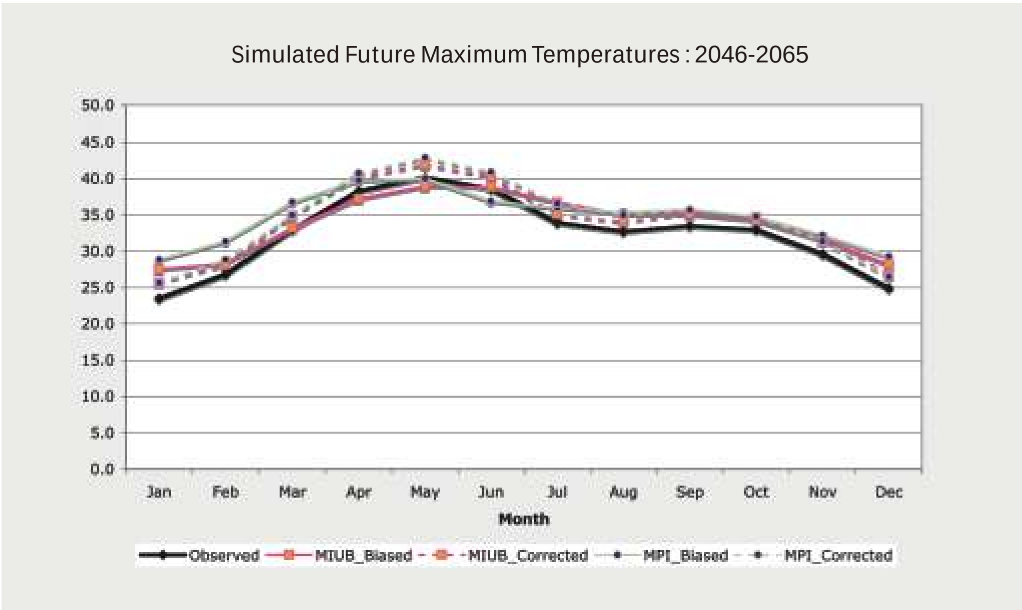
| Table 2 | Gorakhpur City : Future Ranges of Max. Temperature in degrees Centigrade (2046-65)

January- February	March-May	June-September	October-December
1.8 to 5.9	-0.9 to 3.2	1.3 to 2.7	1.6 to 2.7

Source: Opitz-Stapleton, 2009

| Figure 3 | Gorakhpur City : Simulated Future Maximum Temperatures (2046-65)





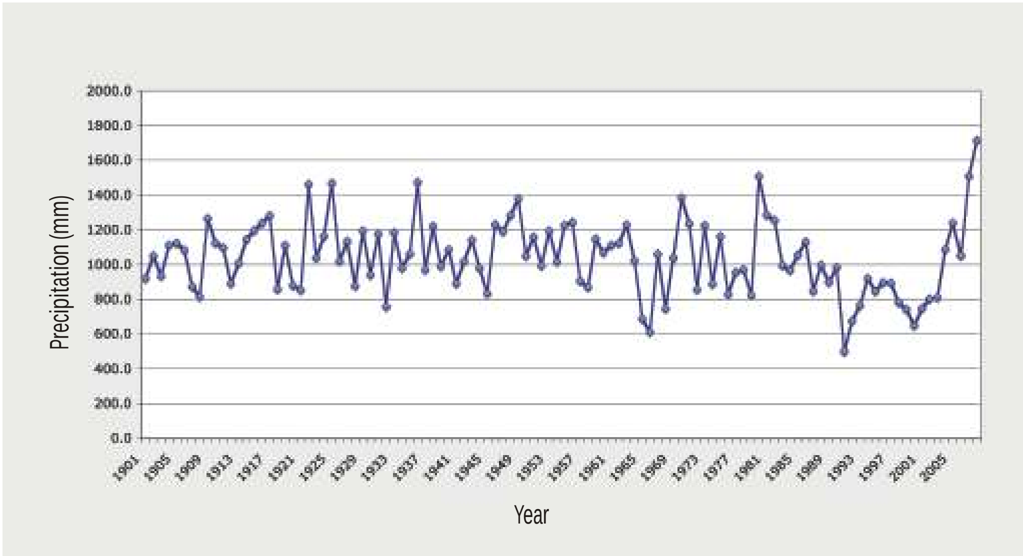
Source: Opitz-Stapleton, 2009

Note : The black line represents historic, observed temperature from 1961-2000. The solid colored lines represent the biased simulations, the dotted lines the corrected simulations.

Rainfall

Gorakhpur has the most rains during June to September. October is a transition month in which monsoon rains and flooding continues in some years. There are sometimes winter rains in January and February. There is a considerable variation in the annual rainfall (Fig 4). An apparent trend of slightly increasing annual rainfall is shown for the post-2004 period.

| Figure 4 | Gorakhpur City : Variations in Annual Rainfall (1901-2008)

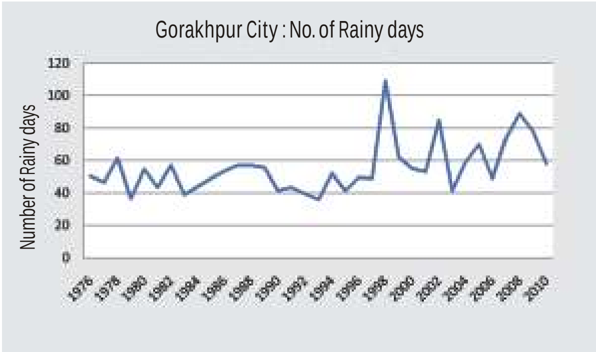


Source: Opitz-Stapleton, 2009

Apart from the years 2002, 2003 and 2006, the trend shows a continual increase. In 2001, the total rainfall was 132.4 cm; whereas in 2007, it was 137.6 cm and in 2008, 194.1 cm. Moreover, the heaviest annual rainfall was recorded in 2008, which was 62.83 percent more than the normal[10]. Besides the rainfall amount, the number of rainy days is also crucial in affecting the rainfall scenario. The normal average annual number of rainy days (days with rain of 2.5 mm or more) is 54 days.

The numbers of rainy days since 1976 are shown in Fig 5. It is apparent that the number of rainy days was not uniform during 1976-2010. Overall, Gorakhpur experienced an abnormal growth in the number of rainy days after 1998. In 1998, the number of rainy days was the highest (100 days) but there was a shortfall in 2001. It rose to 92 days in 2002. After a decrease in the years 2003-05, it increased in 2008 (Ibid: pg 16).

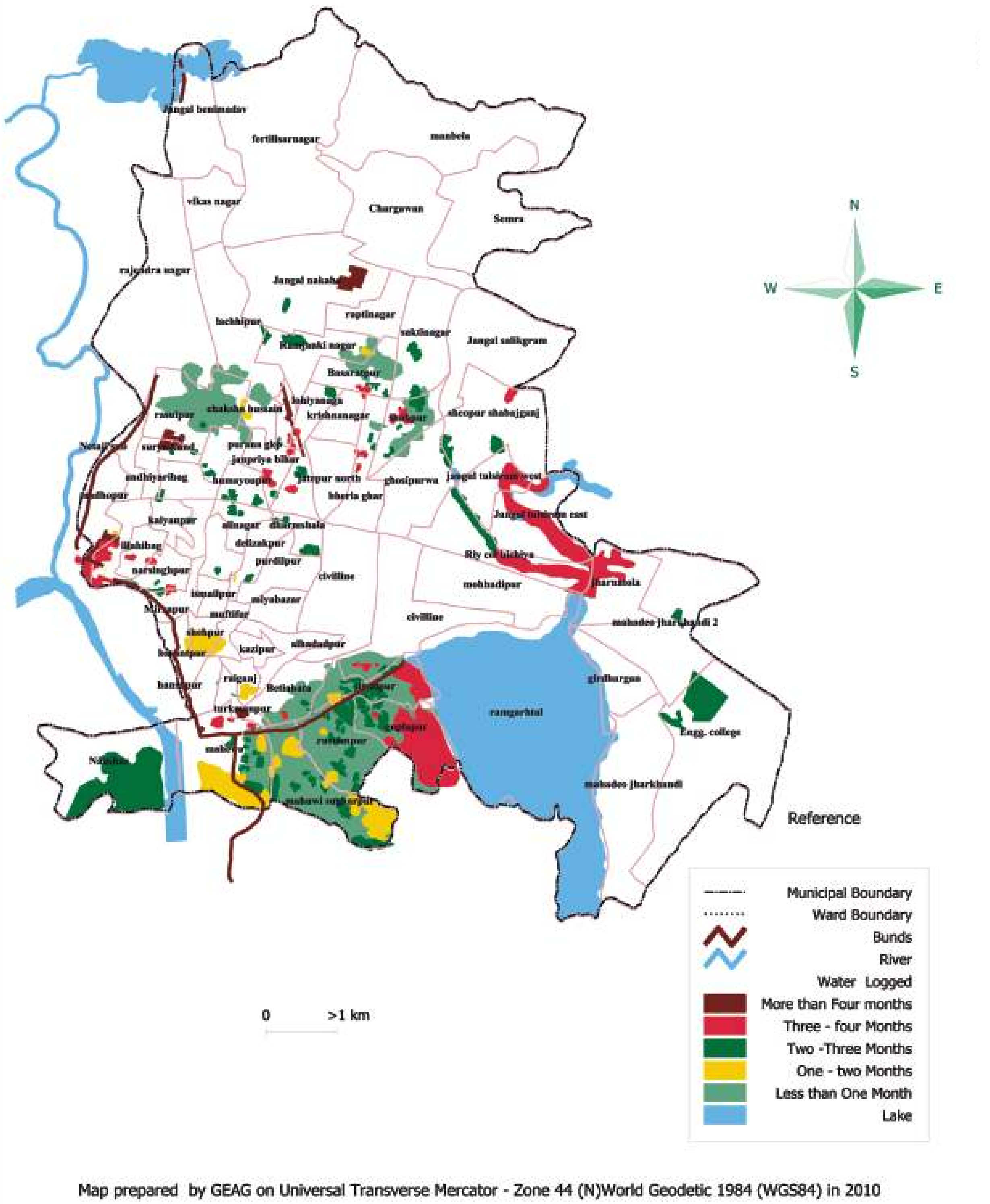
| Figure 5 | The number of Rainfall Days (1976-2010)



Source: Wajih et al, 2009

10 Verma, 2009: p 15.

| Figure 6 | Gorakhpur City : Waterlogged Area, 2008



Source: Wajih et al, 2009

Waterlogging during an extreme Rainfall Event

Waterlogging during the monsoons is rampant in the city. From the community consultation and vulnerability analysis, it is concluded that if the present development process continues, the situation of waterlogging would be chronic and horrific. The vulnerability analysis and sectoral study indicate that irregular topography, gentle slope and unplanned development are the main causes of waterlogging.

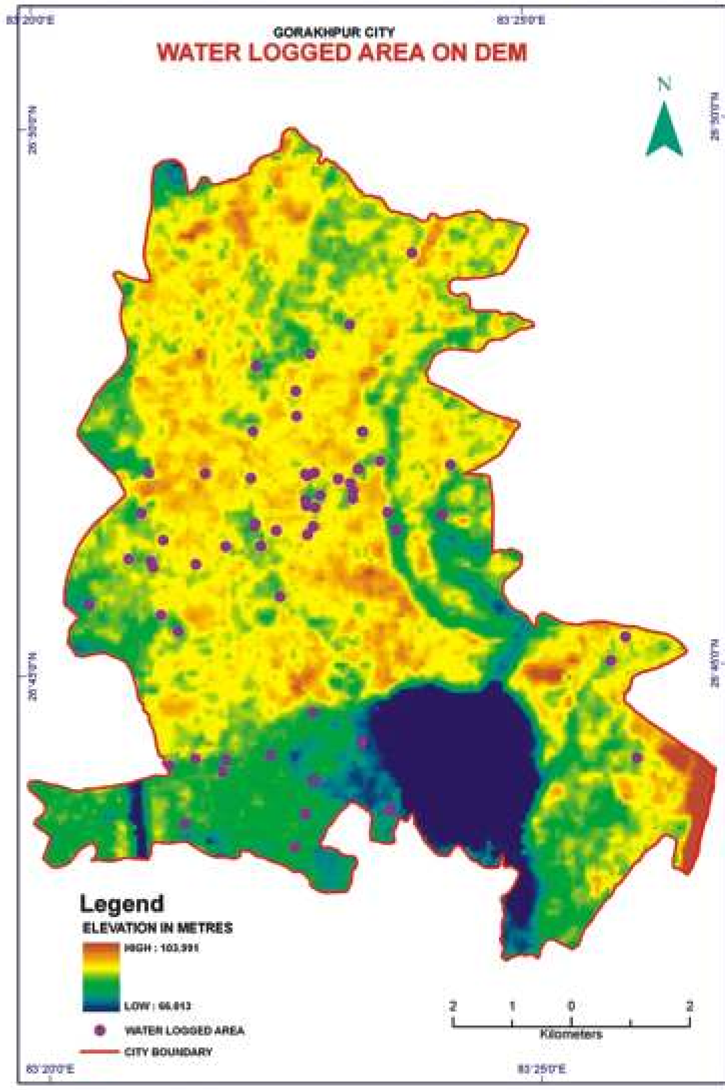
The year 2008 was the highest rainfall year. During the monsoon, most parts of the city were inundated for several months. A large expanse (18.64 percent) of the city (approximately 24.0 sq km) was inundated from one month to more than four months (Figure 6). Figure 7 shows 59 waterlogged points in different parts of the city identified by the Municipal Corporation of Gorakhpur in 2008 (ibid: pg 40).

The city is naturally vulnerable due to its physical attributes. Due to the frequent meandering of the Rapti in the past, the topography of the city was badly affected (ibid: pg 36). Some parts of south and south east of the city came to be lower than the river bed of Rapti during the monsoons. Along with this, waterlogging in the city is also aggravated by poor sanitation and solid waste management.

At present, the southern part of the city especially the areas Mahewa, Mahuwisugarpur, Rustampur, Betiahata, Goplapur and Ttaramandal, which are still not incorporated in the municipal boundary, face waterlogging from one month to four months.

Besides this, the central, northern and western parts of the city which has both the older and newly settled areas are plagued with acute waterlogging. In these areas, water stagnates for more than four months

| Figure 7 | Waterlogged points of Gorakhpur



Source: Verma, 2009

Future Rainfall Scenario

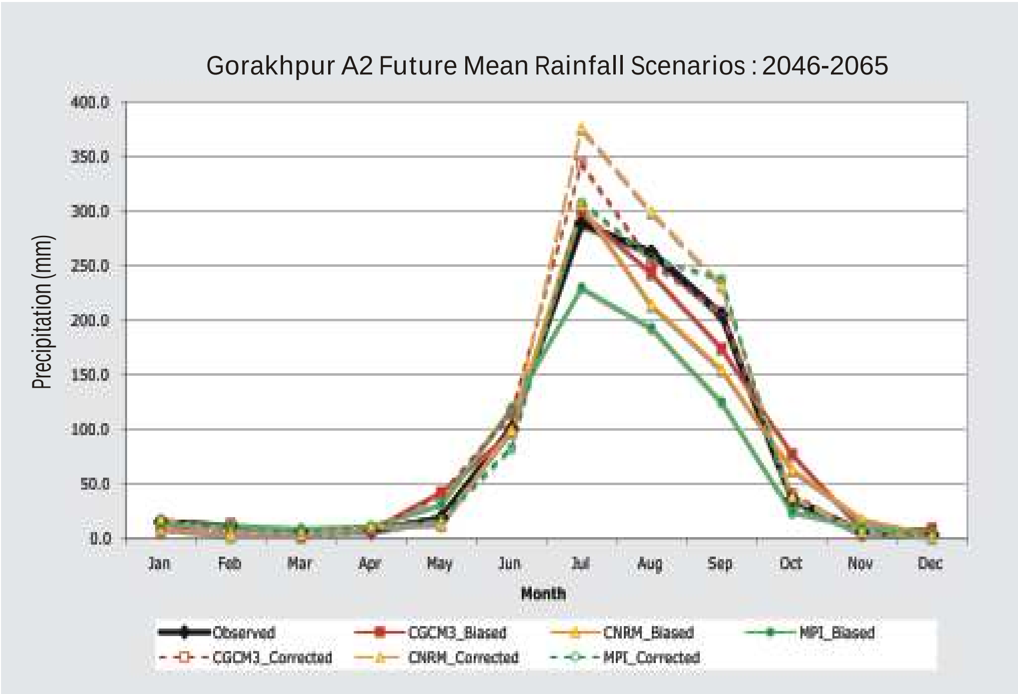
From the observation of past data and different simulation models on rainfall, it is deduced that there is a high uncertainty about rainfall in the future. It is projected that in each season, the rainfall might either increase or decrease. Moreover, precipitation might *decrease* in December, January and February and might *increase* in March, April, May, October and November. Figure 8 depicts the future rainfall simulations for Gorakhpur. There is not enough model agreement for the monsoon months to draw any conclusions about trends in rainfall[11]. In the present study, the General Climate Model of CGCM3, CNRM and MPI have been considered. These projection models give us the following ranges of possible rainfall changes in different seasons.

Table 3 | Gorakhpur City : Future Ranges in Rainfall (in mm) (2046-2065)

January- February	March-May	June-September	October-December
-17.9 to -1.4	-77 to + 23.8	-900 to + 104	-31.1 to + 76.6

Source: Opitz-Stapleton, 2009

Figure 8 | Gorakhpur City : Future Rainfall Scenario for 2046 - 65



Source : Opitz-Stapleton, 2009

Note: The solid colored lines are the scenarios before bias correction. The dashed lines are the scenarios after bias correction.

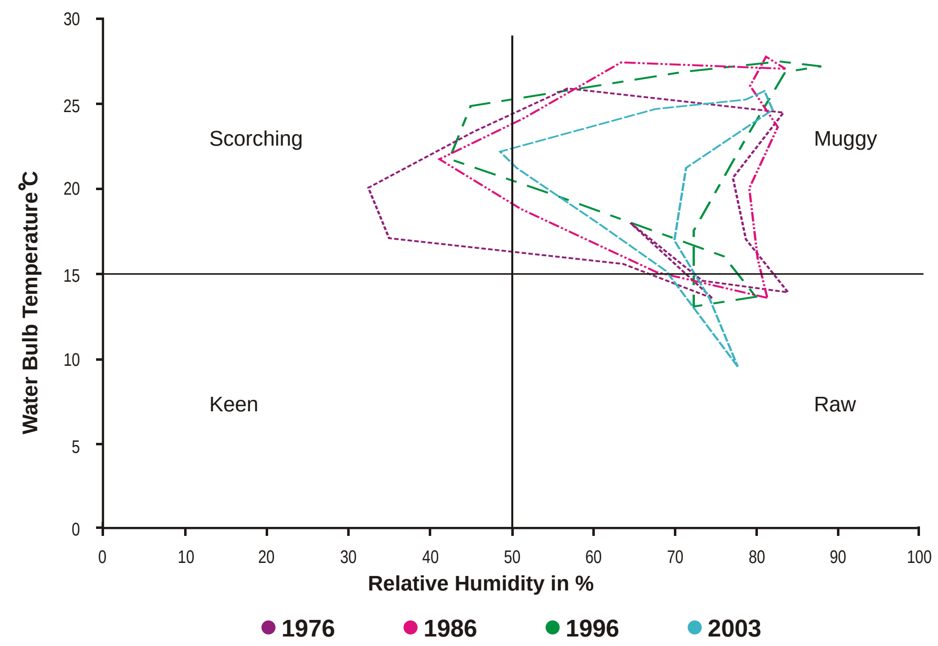
Humidity and Temperature Changes: Evidence through Climograph

A climograph is a diagrammatic representation of climatic data. They graphically represent qualitative human comfort levels with a given humidity and temperature condition. Analysis of historical climographs of Gorakhpur shows that during the last three decades, there has been a shift towards a `muggy climate' (more moisture and more temperature in the atmosphere). This shifting of graph towards the muggy climate also gives an indication of more rainfall in the future (Fig 8).

11 Opitz-Stapleton, 2009

Besides this, the shape of the climograph indicates a wet bulb temperature[12] and relative humidity in the atmosphere during different months of the year. The moisture content in the atmosphere during the pre-monsoon period has increased while in the post-monsoon period, it has reduced drastically. This reduction in relative humidity in the post-monsoon period (October to January) has had a direct impact on the temperature of the city[13].

Figure 9 | Climograph of Gorakhpur, 1976 to 2003



Source : Verma, 2009

The decreasing temperature in the winters and high temperatures in summers is mainly due to the low relative humidity in the post-monsoon period. On the other hand, the rise of relative humidity in the pre-monsoon period makes the summer months (April-May) sweatier. During the last six decades, the date of arrival of the monsoons (15th June) is gradually shifting towards early June[14].

From the past trends, it might be predicted that in the coming years the climograph will totally be in the muggy quadrant (more hot and more moisture). In that situation, the relative humidity will increase; which will have a direct impact on health and agriculture, especially on the *rabi* crops[15] in the surrounding areas of Gorakhpur. Less winter rainfall will affect the groundwater table, which will lead to water stress during the pre-monsoon period and more moisture in the summer will be a favorable environment for the proliferation of vector diseases.

12 The `wet-bulb temperature' is a type of temperature measurement that reflects the physical properties of a system with a mixture of a gas and a vapor, usually air and water vapor. Wet bulb temperature is the lowest temperature that can be reached by the evaporation of water only. It is the temperature you feel when your skin is wet and is exposed to moving air. Unlike dry bulb temperature, wet bulb temperature is an indication of the amount of moisture in the air. http://www. en.wikipedia.org/wiki/Wet-bulb_temperature (last accessed on 27 September, 2010).

13 Verma, 2009: p 17

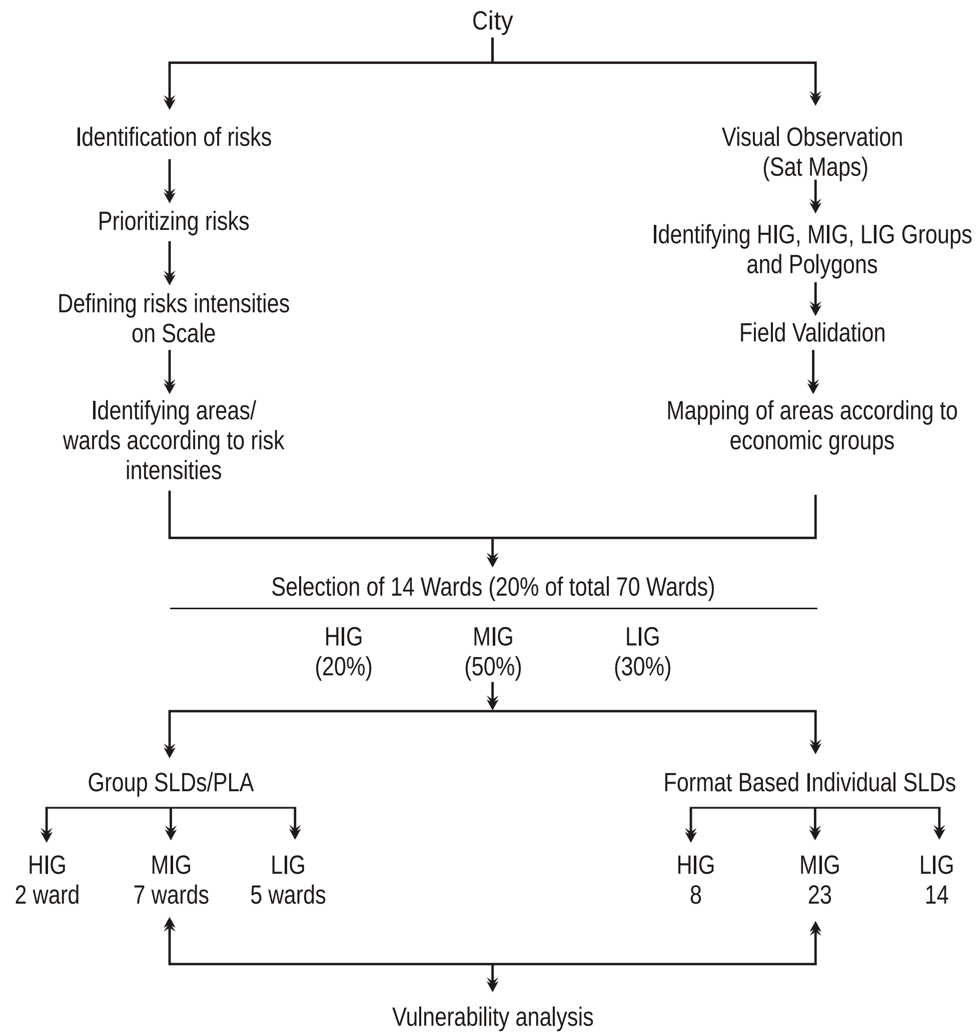
14 Wajih et al, 2009: pg 34.

15 Crops that are sown in the beginning of winter (October November).

Vulnerability of the City: Results from Vulnerability Analysis and Sectoral Study

GEAG has developed a methodology to analyze the vulnerability and risks of the city. The present study on vulnerability is primarily based on the analysis of primary data collected through community and household questionnaires, participatory methodology tools and shared learning dialogues (SLD). Secondary data has also been used occasionally. The entire process of risk identification and area selection and tools employed in the study is presented schematically in Figures 10 and 11.

Figure 10 | Process and Tools adopted for the Vulnerability Analysis



Source: Wajih et al, 2009

Figure 11 | The PLA Tools

Participatory Leaning Action Tools

Objective of PLA	Tools	Information collected
Situation Analysis	Transect walk Satellite images Social Mapping Service Mapping	▪ **Nature of Houses:** Single House (separate),Double Storied, Multistoried, Rented/Own house, Flats,Wall Types (bricks, Stone, Mud/ earth) ▪ **Socio Economic status of community: SEC identification, Inter class variability,** ▪ **Available services in area- Health, PDS, Education, Toilets, Sanitation, etc.** ▪ **Major risks of area: Water Logging, Sewage, Solid Waste Management, Drinking water, Electricity, etc** ▪ **Livelihood pattern** ▪ **Insurance and Debt pattern**
Trend analysis	Trend Diagram FGD	▪ **Changes occurred in physical area over a period of time : constructions, settlement pattern, etc** ▪ **Changes occurred in services and choices over a period of time: Livelihood choices, health, education, PDS system, etc.**
Preference and choices	Preference ranking and scoring Matrix Preference ranking Chapati diagramming	▪ **Preference of different services and causes: Livelihood, Health, Education, PDS, Toilets, Electricity, etc** ▪ **Prioritization of problems associated with services: Access and availability** ▪ **Distance of services** ▪ **Distances from risks: Water logging, Sewage, Solid Waste** ▪ **Responses towards services providers: Municipal corporation, Electricity board, Jal Nigam, etc**
Problem analysis	Casual Loop Diagramming Problem Tree FGD Seasonalities of problems	▪ **Structure of problems: Water logging, Sewage, Solid Waste Management** ▪ **Interconnections and mutual contributions: linkages between diferent risks** ▪ **Reinforcing and Balancing nature of factors prevailing problems** ▪ **Seasonality of availability of services** ▪ **Seasonality of risk intensity** ▪ **Seasonality of demands**

Source : Wajih et al., 2009

Risks :

Waterlogging

Unplanned developments, poor infrastructure, localized underground sewerage, lack of solid waste management contribute to the city's waterlogging. During the last few decades, waterlogging has become chronic in many parts of the city. If the present development situation continues the people of Gorakhpur will have to face serious consequences in terms of livelihood, health and infrastructure in the future. At present, as the vulnerable assessment[16] shows, 18 percent of the city, especially the southern, western and central areas, faces acute waterlogging. In these areas, water stagnates for more than three to four months, deteriorating health conditions and increasing health hazards.

Photo 1 | Problem of drinking water during waterlogging

© GEAG Resource Centre

16 Wajih et al, 2009

Sewerage and Sanitation

The coverage of sewerage network in Gorakhpur is very poor. Presently, only 22 percent of the total area is provided with an underground sewer network (a total length of about 55 kms)[17]. The existing sewer networks cater primarily to the old city area. There is no sewage treatment plant in the city. The sullage is directly ejected either into the river or into the water reservoirs, leading to further pollution and increasing siltation of the river bed.

Due to improper maintenance, most of the open drains are badly ruined and packed with silt and garbage. The gray water of the city generally flows through open drains, reducing their carrying capacity drastically.

Solid Waste

Another important concern of the city is poor solid waste management; especially plastics. The municipality has no solid waste management plans presently. Collection of garbage from streets is not regular. Due to the lack of formal dumping sites, the entire solid waste generated in the city is disposed either along the roads or used as land-filling material for low lying areas. From the vulnerability analysis it was deduced that the prevalent use of plastics is one of the important causes of water stagnation in the city.

Photo 2 | Solid Waste

©Amit Mitra

17 Verma, 2009: pg 40-41

Vulnerabilities of the Poor

Resilience of the community depends on the infrastructure that supplies them essential services like roads, housing, drinking water, waste management, electricity, transportation and telecommunication. The risk of waterlogging in Gorakhpur is increasing every year, damaging the infrastructure and affecting society as a whole; particularly the unprivileged people, who neither have the capacity to respond nor do they have the option of moving to safer places. They are the most vulnerable and suffer the most. Table 4 depicts the vulnerable groups/ sectors and their vulnerabilities.

Table 4 | Gorakhpur City : Vulnerable Sectors and Vulnerabilities

Vulnerable Groups/Sector	Current Vulnerabilities
Inundated population	- Exposure to waterlogging - Access to livelihood affected - Poor access to basic services - Asset loss - Loss to houses - Increased health hazards - Inhuman living conditions
Household-based traditional livelihoods including weavers, craftsmen et al	- Loss of raw material and products - Livelihood affected - Low profit - Production cost increases - Storage of products affected Indifference towards traditional livelihood options
Slum population	- Exposure to waterlogging - Unhygienic living conditions - Asset loss - Poor access to basic services - Increased health hazards Inhuman living conditions
Health	- Susceptible to water-borne diseases - Pressure on health delivery system - Vector-borne diseases increase - Skin infections increase - Stress increases
Basic Services	- Deterioration of access to services - Extra burden on governance for services and expenditure - Community clashes - Conflict between community and administration
Water supply	- Water quality deteriorates - Water-borne diseases increase - Contamination of groundwater - Water demand increases - Groundwater table decreases - Incidence of deep boring increases

Sewerage and drainage	- Backflow of sewer water - Overflowing of drains - Contamination of groundwater - Breeding ground for mosquitoes and other pests
Solid waste management	- Clogging of drains - Waterlogging - Pollution - Breeding ground for mosquitoes and other pests - Methane gas emission - Foul smell
Industries and commerce	- Damage of raw materials - Production cost increases - Production affected of workers living in waterlogged areas - Increased energy consumption
Housing	- Waterlogging - Entry of water into houses - No outlets for storm water - Asset loss - Increase in construction cost - Increase of damp - Increased maintenance cost
Ecosystem (water bodies)	- Waterlogging increases - Decline of groundwater table - Change in biodiversity
Energy -	
Electricity	- Power cuts - Loss of electrical infrastructure - Pathetic civic conditions - Electricity consumption increases - Consumption of cooling devices (AC, cooler, refrigerator) increases - Emission of CFC gases increase - Increase in heat emission
Fossil fuel	- Increase in fossil fuel consumption - Air and noise Pollution - Increase in heat emission
Transportation	- Traffic jams - Road damage increases - Increase in heat emissions

Source : Computed from SLD

Future Climate Scenario

Given the uncertainty associated with the climate change projections, especially with the time series of precipitation values also indicated by the literature on climate change projections we relied more on the trends and changes in future precipitation patterns. It was seen that the minimum monthly totals, especially in the monsoon months, show an increase over corresponding values in the past, while the maximum monthly totals show a decrease.
The implications of such changes were discussed in an SLD focused on developing climate scenarios. The participants included personnel from the Indian Meteorological Department (IMD), the Irrigation Department of Uttar Pradesh, members from the ISET[18] and the GEAG Team. From the discussions, it was deduced that the focus needs to be on addressing challenges associated with increased "wetness" during the monsoon months that could cause increased flooding. Similar findings from an in-depth modeling exercise in the past on another project[19] for the same area indicate an increase in the frequency of small-magnitude floods (the 10-year flood events projected to becoming 5-year ones). Hence, given the ease of recalling the flood scenario of 2008 (high flood year in the recent past) through interviews of key stakeholders from various wards, the discussion in the SLD centered around developing a flood / waterlogging map for the year 2008 to strengthen the resilience of the city. It emerged from the same SLD that another key consequence of increased wetness and increase in temperature was an *increase in humidity* in the monsoon months, which is likely to pose additional challenges to the health sector.

The Urban Scenario

Photo 3 | Shared Learning Dialogue with Stakeholders

Despite some progress in the infrastructural developments of the city, it is not at par with the population growth; the latter far outstripping the former. Consequently, this exerts a pressure on the infrastructure and affects the service delivery system. Keeping this in mind, another SLD was organized on April 1, 2010 of key stakeholders like personnel from the IMD, the Municipal Corporation of Gorakhpur, the Fisheries Department, Gorakhpur Development Authority, informed citizens and academics of the city, to discuss the scenario of urban growth in the future. From this, various drivers / key factors of past and future urban

18 Institute for Social and Environmental Transition, Nepal.
19 Kull et al, 2008.

growth of Gorakhpur were deduced and categorized into political, economic, social, technological, legal and environmental (PESTLE) factors[20].

Future Vulnerability and Sectoral Scenario

As part of the resilience planning process, a third SLD was organized on April 3, 2010 to discuss emerging future vulnerabilities by overlaying the two climate scenarios with the urban growth scenario. The proceedings of this SLD show how various sectors are vulnerable to future climate change impacts and the specific action areas that need to be focused on sectorally. The primary risks are from waterlogging and increased incidences of water- and vector-borne diseases that have implications for actions in key sectors housing, urban basic services, energy and transportation (see footnote 20).

20 The various issues that emerged from the discussions at the SLDs have been tabulated and computed (see Table 5).

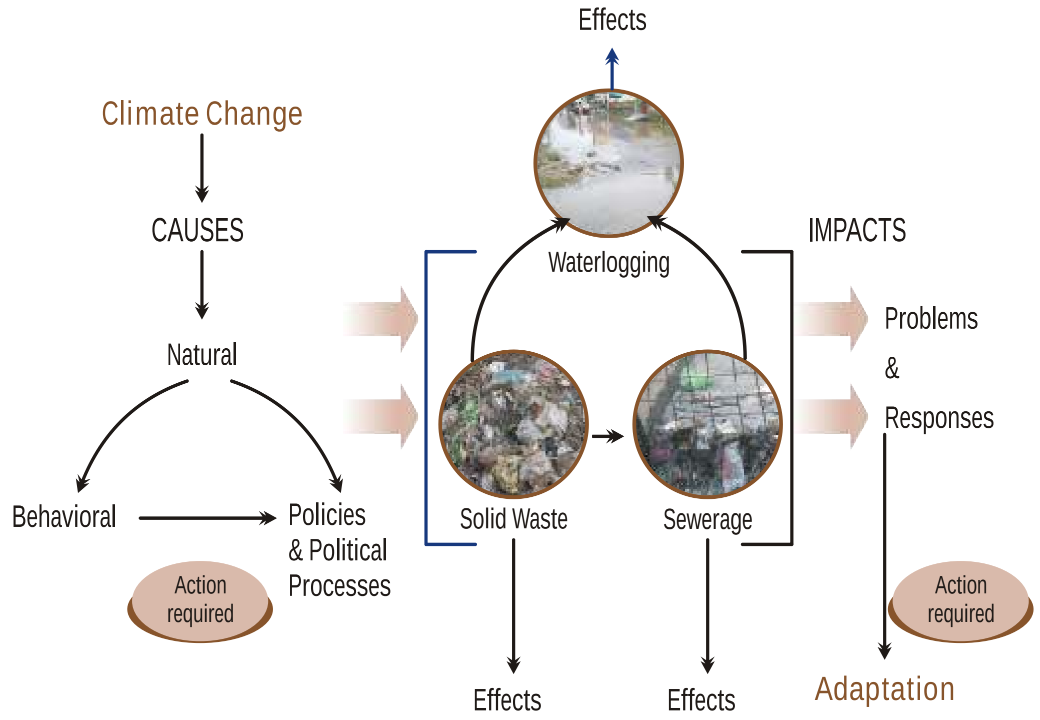
SECTION : II

Resilience Planning and Strategy

The Risk Frame

The Risk Frame, evolved in the context of changing climate conditions, through shared learning dialogues with primary stakeholders, emerged as follows:

| Figure 12 | Gorakhpur City : The Risk Frame



Source : Wajih et al., 2009

The major problem, contributing to the vulnerability of the city as a whole, is waterlogging. The lack of basic services especially sewerage and solid waste management contributes to the problem of waterlogging.

The causal factors of the vulnerability are:

a. Natural/Topographical: The city is naturally vulnerable due to its location in the Terai belt of the Nepal Himalayas. Low lying areas, large number of water bodies, low slope gradients, high groundwater table and an infrastructure based on such natural conditions accentuate the vulnerability.

b. Behavioral: The city has strong links with rural livelihoods and a floating population, comprising mainly of the lower middle income group with a low literacy level. There is a general lack of responsible behavior towards the upkeep of city's services.

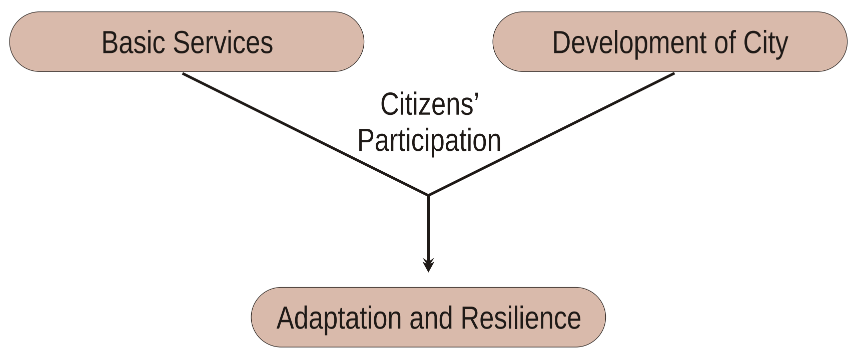
c. Policies/Governance: A faulty masterplan, poor governance and administration of basic services are some of the key issues influencing the city.

The three causal factors are interdependent and interrelated in influencing the vulnerability of the city.

The Resilience Framework and Strategy

The resilience framework is based on the core components of developing the city by developing the basic services through citizens' participation to build up resilience and adaptation to climate change (Fig 13).

Figure 13 | The Resilience Framework



Based on this framework, a preliminary resilience strategy was developed. This strategy is dynamic, with built-in feedback mechanisms for continuous responses to changes as they occur. The strategy is outlined in Figure 14.

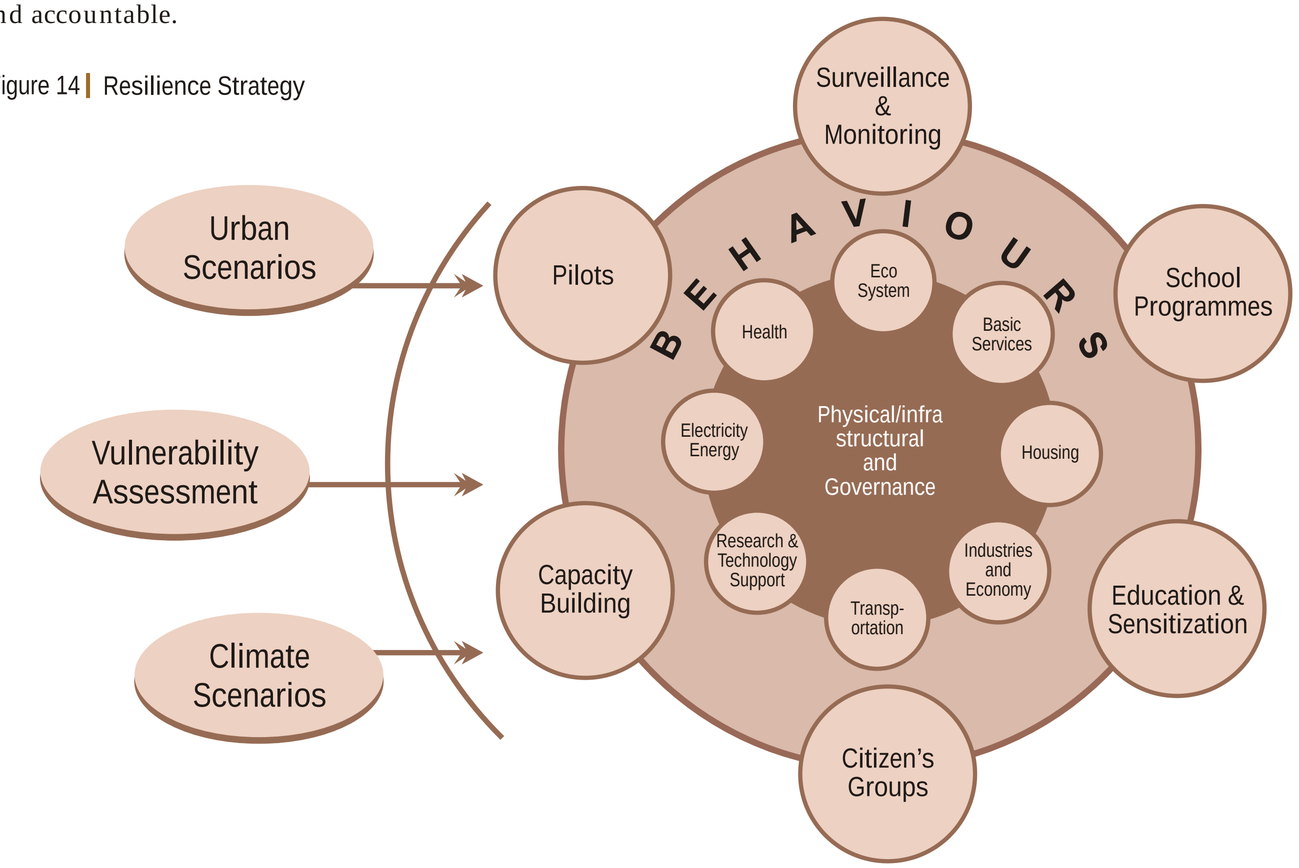
The strategy needs to be detailed for the various identified sectors and groups vulnerable to climate change (inner, smaller circles in Fig 14). It is crucial that the city government plays a pro-active role in developing the resilience of the city. The citizens too need to be organized and sensitized for ownership and partnership in the city's development. Though technical assistance and capacity building of government institutions are important for evolving local solutions and resource mobilization, the role of responsible citizenry will be crucial too. The development of the city's basic services for the citizens (especially vulnerable groups) will strengthen the resilience of the city and its population.

The areas identified for the development of Gorakhpur and basic services to vulnerable communities are:

- *Basic Services: Sanitation, hygiene, drainage system and safe drinking water;*
- *Housing: Appropriate houses to vulnerable communities and housing designs for waterlogged situations. This entails understanding and planning the habitation patterns;*
- *Industries and Economy: Industrial development, pollution free environment, safe work places for household-based livelihood activities, housing for industrial workers;*
- *Health: Health services, preventive health and health surveillance mechanisms;*
- *Energy/Electricity: Energy for living, production/livelihood and public purposes specially during the monsoon and post monsoon periods, alternate energy;*
- *Transport: Effective transport mechanisms mitigating climate change causes and reducing pollution;*
- *Ecosystems: Conservation of public land and water bodies.*

The outer bigger circle in Figure 14 emphasizes the behavioral aspects of the people. It determines the priority of actions and is expected to address the inner core (physical, infrastructural and governance issues) and make them more responsive, transparent and accountable.

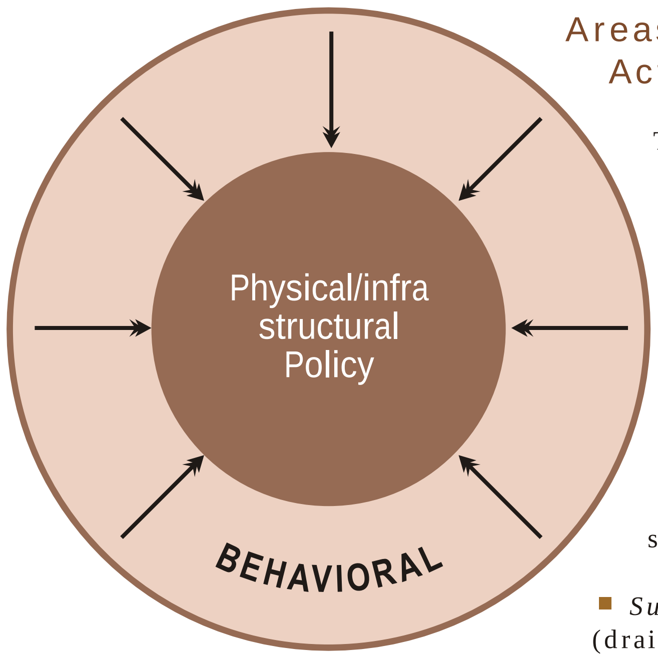
Figure 14 | Resilience Strategy



Priority sectors and related areas of action have been identified during the first phase of the project which is explained in Table 5 and Fig.14. Necessary capacity building of the city's government functionaries and technical support to them will be helpful. Special attention will be needed for vulnerable groups and difficult locations. Good governance and policies are integral to this process. Planning of the city, taxation, service rules and related factors are important as is addressing the behavioral aspects of the citizens. A conscious, participative and responsible citizenry can influence the city government for effective and meaningful development of the city according to local situations and priorities. This will help build the people-government synergy for developing the city and its resilience capacities in the long term.

The behavioral aspects maybe considered as the circle of influence and the robustness of this area is expected to gradually reduce the circle of concern; that is, the larger (stronger) the area of influence; the smaller will be the area of concern. The latter in the proposed approach are the physical, infrastructural and governance aspects. Therefore, the approach towards resilience planning of the city will be to focus on the behavioral aspects and to address the physical, infrastructural and governance factors through a sensitized, informed and concerned citizenry. Hence, it will be imperative to invest in developing capacities, surveillance and monitoring, informed and pro-active citizenry and responsible governance (Fig 15).

Figure 15 | Resilience Strategy Approach



Area of Concern

Area of Influence

Areas for Strengthening Resilience and Action

The vulnerability analysis indicates that the problem of waterlogging has wide impact on the infrastructure of the city. Table 5 captures the sectors / groups that are vulnerable, the areas to strengthen resilience and necessary actions to address them.

The proposed resilience strategy for Gorakhpur recognizes that responding to climate change will require integrated courses of action to address a combination of institutional, behavioral, social and technical issues. Hence, the areas identified for strengthening resilience and respective action can be summarized as:

- *Surveillance and Monitoring*: Quality of services (drainage / waterlogging, drinking water, sanitation), health / vector-water born diseases, pest and other such factors.
- *Pilots*: Towards technical solution of challenging issues (drainage of waterlogged areas) and linkages / scaling with larger city level interventions (drainage plan of the city).
- *School Programs*: Sensitizing school children of the vulnerabilities and resilience of the city vis-à-vis climate change and the role of citizens.
- *Organizing Citizens*: Mobilizing, sensitizing and bringing various citizen groups and

Table 5 | Vulnerable Sectors and Required Actions

Sectors	Areas to strengthen Resilience	Actions
Housing	Effective master planning and proper enforcement	Ward level micro-resilience plan developed and institutionalized review of masterplan (1a)
	Awareness amongst citizens	Sensitizing various citizens' groups (1b)
	Water harvesting	Sensitizing architects, builders and citizens (1c)
Industries and Commerce	EIA Measures	Orientation/sensitization of industries and commercial establishment for EIA, energy efficiency, waste management and organized housing (2)
	Effective monitoring of waste treatment	
	Organized housing for industrial workers	
Basic Services	Quality of drinking water Monitoring and awareness generation	Establishing multiple channels of data collection and reporting water quality (public water analysis laboratory, quality monitoring and mapping weekly) (3a)
	Effective drainage system according to geo-hydrology of the city	Making the proposed drainage system more effective and energy efficient (3b)
		Pilot testing the above; an effective micro level (identified ward) green energy efficient drainage system (3c)
	Decentralized community owned solid waste management (SWM)	Designing a city-wide community based SWM system based on pilot PPCP model (3d)
	Community Sensitization	Sensitizing various citizen groups on delivery and maintenance of services delivery. Strengthening data collection (3e)
Transportation	Planned transport systems for city	Designing for a green and resilient transport system for the city (4)
	Public transport system to be enhanced	
	CNG vehicles to be introduced	
Energy/ Electricity	Alternate energy sources	Sensitizing industries and commercial establishments to adopt energy efficient measures (5)
	Conversion to CFL in private and public place	
Health	Effective health surveillance systems	Establishing and running city wide health surveillance system (6a)
	Preventive health measures	Identifying and promoting preventive health measures and practices for water and vector borne diseases; Strengthening data collection (6b)
	Sensitization and education	
Household based livelihoods	Insurance mechanisms	Designing and testing an asset insurance product (7a)
	Designing of homes for proper storage	Microfinance (7b)
Ecosystems	Conservation of water bodies	Mapping, demarcation and conservation (8a)
	Plantation and public land to be protected	Promoting public land plantation (8b)
	Sensitization and education	School education program (8c)

Source: Computed from the discussions in the SLDs institutions (trader groups, chamber of industries, service clubs, NGOs and the rest) on a common platform for the city's resilience. The platform will also work as a 'think-tank' and pressure group for measures to be taken by the city government.

- *Education and Capacity Building*: Sensitization, Education and Capacity Building of various groups/institutions for effective service delivery, technical solutions and organizing citizens.
- Developing the City's database Resource Centre.

SECTION : III

Actions for Resilience Building

Steps for Selection of Action Points

Developing resilience in the system and amongst people is a slow long term process, with an intense interplay between the system and the people. Consequently, an integrated approach is essential to develop resilience. Hence, for the present purpose, an evolving strategy for building resilience in the city has been developed. It will focus first on problems that are closely related to climate change and have a higher concern for the residents and managers of the city. With this focus, the strategy emphasizes the development of capacity to address the technical, institutional, social, cultural and other dimensions: first, of the problems that are selected as an initial strategic focus and second, on the additional problems and the additional capacities required to address them. To create a ripple effect that builds resilience over time in multiple arenas, the strategy will utilize targeted interventions that build knowledge, provide demonstrated examples, assist the development and build the capacity of organizations and creates pressure for change at behavioral, institutional and political levels.

Photo 4 | Citizens march for a better tomorrow

©Amit Mitra

As a point of entry for work, the city resilience strategy focuses on the flooding and water related problems that are likely to be aggravated with climate change. This initial focus is intended to serve as a basis for both immediate action and building the capacity to respond to the other, difficult to predict, challenges that will emerge as a consequence of climate change. Hence, as part of the resilience strategy, actions that will directly address the challenges associated with the known climate impacts like

increase in waterlogging are proposed. At the same time, actions to develop a greater understanding of uncertain climate impacts like new forms of diseases and livelihood systems through research and interventions that foster generation and management of relevant knowledge on a continual basis are also proposed. The net result is a multi-pronged, multi-scale strategy targeting diverse groups' and stakeholders' approach to build resilience. It will entail feasibility studies, action oriented research, capacity building and advocacy. Such activities will be implemented at both the local (ward) and city levels. The proposed resilience strategy has the following broad foundations:

Photo 5 | Cleaning up drains

©Amit Mitra

1. Targeted physical and institutional actions to improve drainage, housing, health and communication systems in selected areas of the city. This is to be done in ways that directly demonstrate how improvements in drainage, health systems and green buildings can address current and climate related problems at the local (ward) level while also building the social and institutional capacity to take action at that level.

2. Information, data and knowledge focused activities to establish the evidence base required for long-term planning, emergency response and social advocacy among diverse groups of residents, city authorities, NGOs, academics, politicians and other actors. Of particular importance across all activities will be the development of geographic information and other visualization systems for communicating information on systems and climate change scenarios to diverse users. These information and knowledge focused activities are intended to catalyze the growth of capacity within diverse sets of actors and institutions.

3. Analytical and advocacy activities designed to raise public and political awareness of emerging problems, thereby generating the social pressure required at behavioral, organizational and political levels for solutions to emerge and be implemented.

Table 6 | Proposed Actions for Resilience Building

S.No.	Final Action Items	Actions addressed	Vulnerable sector/ Groups addressed	Duration
1.	Ward level micro-resilience plan developed and institutionalized	1a, 3c	All vulnerable sectors and groups would be targeted and would benefit	Long term (>36 months)
2.	Resource Center for Gorakhpur City climate resilience established	3a, 8a	Basic services, ecosystems	Medium term (up to 36 months)
3.	Public health surveillance and management system	6a, 6b	Health	Medium term (up to 36 months)
4.	Building responsible citizenry for climate resilience of Gorakhpur city (advocacy, awareness and training programs)	1b, 1c, 2, 3e, 5, 8b, 8c	Housing, industries and commercial establishments, basic services, energy, ecosystems	Medium term (up to 36 months)
5.	Making the proposed drainage system more effective and energy efficient (review of the proposal)	3b	Basic services (drainage)	Short term (< 6 months)
6.	Review of masterplan	1a	Housing and basic services	Medium term (up to 12 months)

Source: Computed from Table 5

Underlying all of these will be a focus on developing the institutions and governance mechanisms required to implement activities and strengthen the critical systems that contribute to resilience and enable adaptation.

The Way Ahead

To address the multiple challenges at a local level, building on existing consensus regarding the criticality of flooding, solid waste management and green buildings, detailed micro-resilience plans will be completed and implemented in a few wards. This will demonstrate what can actually be achieved by community institutions established at the ward level to address waterlogging, flooding, and related issues. These ward level micro-resilience plans will be complemented by a technical feasibility study for improving the drainage system of Gorakhpur at a city level. This study will be carried out in collaboration with the water supply department. It will utilize as a starting point the drainage plan that has already developed by the water supply department but will strengthen that by incorporating climate information, improving the technical evaluation and incorporating results of the actions implemented locally.

Another proposed action is to develop a resource centre to maintain databases of information related to generic (physical, infrastructural, climate, policy, schemes, behavioral) and sectoral (health surveillance, basic services - drinking water, solid waste, sewage and sanitation) issues influencing the vulnerability of the city and the people due to climate change. The data / information can be utilized for awareness, advocacy, planning and capacity building and other actions linked to resilience building on current and future climate risks. The proposed set-up will also help in packaging and dissemination of information in specific user friendly formats to cater to diverse needs / groups, especially the vulnerable communities.

Climate change has direct impact on health. Public health surveillance and management systems at the grassroots to provide data and early warning information to decision makers and administrators to develop their capability to predict and monitor disease outbreaks and provide adequate health support is crucial. The proposed action will strengthen the public health surveillance and management systems by assessing the risk factors of the diseases and issue early warnings. This will in turn increase the capability of decision makers and city governance to predict diseases and provide effective health support in remote areas and among unprivileged groups.

Following the development of a resource centre, the proposed activities would seek to develop the capacities of select groups (children, youth and citizen groups).

Widespread inundation and non availability of outlets have a direct impact on the livelihood of the poor and unprivileged people. The technical feasibility study for a low-cost and low-energy (green) drainage system in specific low lying and

Photo 6 | Construction of bridge

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Photo 7 | Community participation on lake conservation

© GEAG Resource Centre

waterlogged areas will pave the way for providing technical support to the city to implement the drainage masterplan[21]. It will also determine the feasibility of up-scaling the design for other waterlogged areas.

Further, it will be essential to review the city's masterplan in the perspective of climate change and incorporate necessary modifications based on sharp factual analyses. Reviewing the masterplan will reduce the gap between the existing and proposed development situation, and will promote achieving resilience to climate change impacts.

21 A comprehensive Drainage Masterplan Proposal for Gorakhpur had been prepared by the *Jal Nigam* (Water Supply Corporation), Gorakhpur and submitted to the UIDSMT (Urban Infrastructure Development for Small and Medium Towns), two years ago for financial support. This has not been approved and sanctioned yet due to some technical setbacks.

GEAG has conducted a technical feasibility study too, for a low cost and low energy drainage system of Rasulpur (a small, low laying area in the city) with the help of ARUP, an international organization providing technical engineering support, and partner of the ACCCRN process. This technical study will support the master drainage plan and would also be an example of drainage design for low lying areas.