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POLICY BRIEF

Gorakhpur, India

ALTERNATIVE DEVELOPMENT PATHWAYS: EXAMINING THE 2021 GORAKHPUR MASTER PLAN

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KEY FINDINGS

- The areas that are designated as open space areas in the Gorakhpur Master Plan do little to reduce the impact of flooding on Gorakhpur City—development of such areas would neither increase nor reduce flood levels.
- Open space buffers for flood prevention are critical. Reducing the impact of floods on Gorakhpur through open space buffers would require substantial changes in the location of open space areas from those proposed in the Master Plan—protected areas would need to be in low-lying locations adjacent to the river and would require improved drainage.
- Data available in existing topographic, landuse and remote sense mapsare insufficient for accurate flood modeling, as a result there is insufficient information for quantitative analysis of how future urban development and the construction of roads, waterways and other impediments will affect waterlogging and flooding.

Gorakhpur's Context

Gorakhpur is a rapidly growing city and the second largest in eastern Uttar Pradesh, India. It is located in the mid-Gangetic plains between the Rapti and Rohini river basins. The current (2011) population of Gorakhpur is close to 700,000 and the city is spread in a geographical area of about 147 sqkm, divided into 70 administrative wards. Ironically, one of the most fertile areas in the country/region is also one where poverty is high. Gorakhpur city is bowl shaped with a low to flat gradient and high groundwater tables. Historically, there were 103 bodies of water that served as natural drainage and provided buffers for storage of floodwaters within the city. With urbanisation, most of these have been filled in and less than a third currently remain. Since a large part of the city's elevation is below the river, water logging of lands and periodic flooding is a recurrent phenomenon. It regularly affects about 40% of the city, particularly in the south and west. The problem is compounded by the inadequate and unmanaged storm water drainage in the city. Water logging worsened in recent years due to changes in rainfall, encroachment and infill of water bodies, and unplanned development of large land areas. This has resulted in some areas of the city remaining waterlogged for 5-6 months of the year. Unmanaged solid waste disposal has also contributed substantially to waterlogging through the blockage of drainage channels. Prolonged water logging together with poor waste management has caused an increase in incidences of vector-borne diseases and related health problems, as well as contamination of ground water. Waterlogging also leads to disruptions in roads and other transport systems, water supply and sewerage, urban agriculture and other open-space, and property damage, thus, affecting livelihood systems and increasing the vulnerability of the poor (Wajih, S., Singh, B., Bartarya, E., Basu, S. and ACCCRN ISET Team, 2010).

Increased Extreme Rainfall

Climate change adds to existing drainage and flooding problems as more intense and untimely rainfall may occur. In recent years, floods occurred earlier than normal and caught the population unprepared, causing more damage than normal. Climate change is likely to increase the intensity of rain events throughout Gorakhpur over the next 50 years. It is projected that by 2050, small intensity rain events may increase by 10 to 20%. For more severe events, climate change might increase the intensity of these by 2 to 25%. Overall, climate change will impact rainfall patterns resulting in continued and potentially worse flooding scenarios (Opitz-Stapleton and Hawley, 2013).

Urban Planning

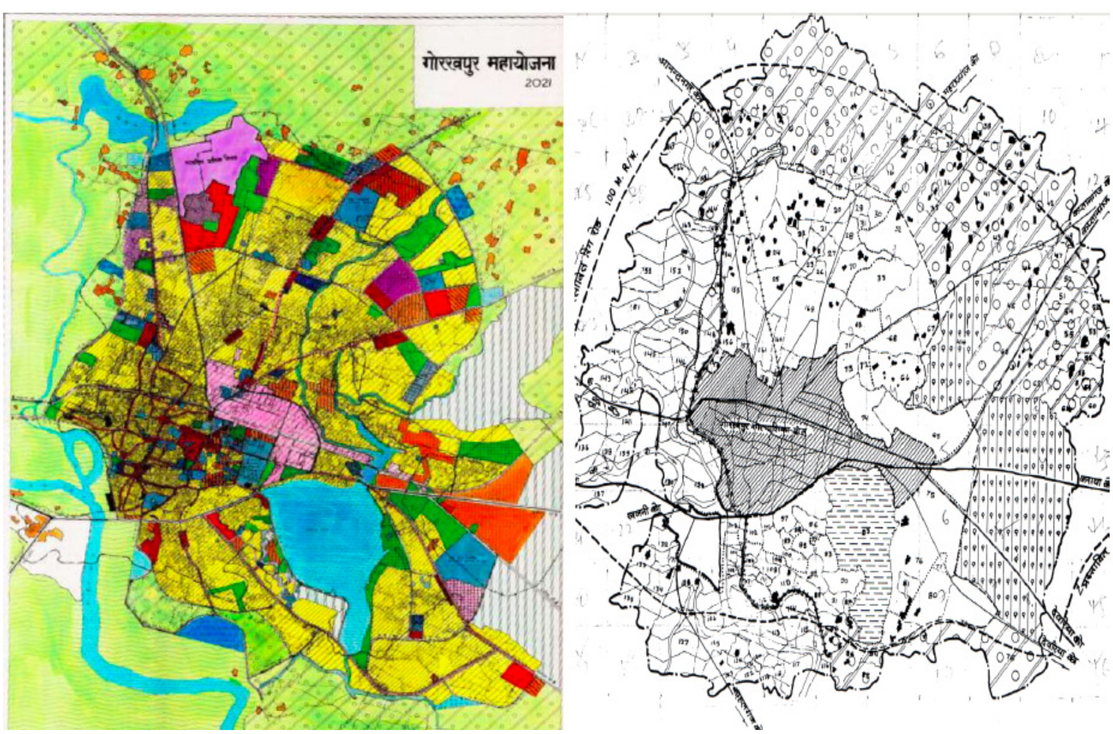
The current Gorakhpur Master Plan of 2001 to 2021 builds upon the previous Master Plan for 1971 to 2001. The Master Plan (Figure 1 below) discusses the future plans for land-use planning, transportation and shelter systems.

LAND USE

Gorakhpur is a major socio-economic, commercial, and cultural activity centre of North Eastern Uttar Pradesh. Though all types of land uses show increase in absolute terms, as a proportion of the total city area residential land use shows a particular increase from the previous Master Plan and now makes up 51.14% of the total planned area for Gorakhpur City. Industries are expect to be shifted from within the city to an industrial park outside the city limits which has resulted in a significant decrease in area allocated to industries. Interestingly, while the area of city has increased by almost 83%, the open spaces (categorized as recreation/ open spaces) have only increased by about 19%. The current

FIGURE 1

PROPOSED LANDUSE PLAN, 2021, MASTER PLAN GORAKHPUR 2021 (TCPD & GDA, 2007)



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Master Plan has also identified 7.23% of the city area as flood affected (areas near Rapti river) and the water-bodies within the city (categorized as “others”). At present, a large part of the city especially in the southern, western and central areas, faces water logging. In order to minimize water flow into the city, more than 12 km of earthen bunds have been constructed along the length of the river and about 6- 8 km have been constructed along the bank of Ramgarg Lake. In addition, four pumping stations have been established in the city to pump out the water.

TRANSPORTATION

The 2021 Master Plan proposes many new additions to the transportation infrastructure, including the building of 4 regional highways, 19 city roads, 24 local roads and 35 crossroads. Existing roads already block drainage in many areas and the proposed new infrastructure will exacerbate this problem unless it is carefully designed with drainage as a fundamental consideration.

SHELTER

The current Master Plan predicts an increase in the number of workers from the informal sector. Many of these workers would reside in informal settlements because low-cost housing is out of reach for these households. There is significant shortage of housing units in Gorakhpur as documented in reports developed by Gorakhpur Environmental Action Group (GEAG & GMC, 2009). It is estimated that the current (based upon Census 2011 data and National Housing Board data[1]) housing shortage in Gorakhpur city is about 37,481 units. The Master Plan estimates that by 2021, the total requirement of housing units would be 26,00,000 (GDA, 2006). Since the 1998 floods, housing practices shifted from traditional (*kuchha*) mud houses to modern concrete (pucca) houses. However, despite more modern houses, many modern houses are built without flood design considerations or monitored after construction, resulting in houses still remaining vulnerable to floods (Singh et al, 2013). Most of the houses within the city are pucca houses with raised plinths that are generally solid and covered from all sides. Although these houses are pucca, the living conditions are still poor for their low-income inhabitants, whom comprise 30% of the city’s population. The households are crowded with minimal ventilation, toilets, piped water supply, sewer connections or any other basic services. During the monsoon, these conditions lead to increased waterlogging, and adverse health impacts.

1 Based on the analysis presented by National Housing Board, http://www.housingindia.info/NHBStatisticsResult.aspx?pathid%20=%20StatisticsContent/en-US/Statewise_Housing_Stock_Shortage.html

Flood Reduction and The Master Plan

Gorakhpur City is experiencing rapid development and the decadal population growth in 2001-2011 was 11.21%. As per the 2001 census, Gorakhpur has a high population density of more than 4711 persons/sq km. Low-income communities and informal laborers are creating informal settlements along the Rapti river and expanding rapidly without any plans into the designated open space areas in Gorakhpur's Master Plan and settling near and along the earthen bunds. These open space areas, earthen bunds and pumping stations have been identified as major flood risk reduction mechanisms for Gorakhpur City.

GEAG, ISET-International and ARUP investigated the potential impacts of future extreme rainfall events in Gorakhpur City. ARUP developed a flood model using extreme rainfall curves developed by ISET-International (Opitz-Stapleton and Hawley, 2013). Despite the limitations of the flood model[2], outputs suggest that the current Master Plan shows an increase of flooding levels throughout the city in relation to both historical rainfall and projected future climate conditions. The flood model investigated two scenarios: Scenario 1) 2021 Master Plan with designated green spaces untouched and Scenario 2) 2021 Master Plan with designated green spaces built up. In both of these two scenarios, flood levels throughout the city are projected to increase. Scenario 1 shows a range of flood level increases from 14 to 17%, while Scenario 2 shows a broader range from 14 to 26%.

With the changes over time both projecting flood level increases, it is critical to note that the current Master Plan's designated greens spaces actually do not prevent much flooding in Gorakhpur City. Figure 3, illustrates this using the 2050 projected rainfall curves. Overall, retention of the currently proposed green spaces only reduce flooding by 1.11% in the future over six different flood return periods.

2 Limitations of Flood Model.

*Hydraulic Model. The land survey maps are the source for ground levels, however the land survey maps (from 1979) have only a few ground levels and other ground levels have been extracted by google maps at only a resolution of 500m X 550m. Gorakhpur generally has mild variation in ground profile, but there is significant variation in the levels within the 500m X 550m resolution that have not been reflected in the model (ARUP, 2013).

**Landuse Categories. Due to limitations of the current landuse map and ground profile, runoff coefficients have been designated for each landuse category. Land use category 1 that includes builtup areas, residential, rural, roads, commercial and industrial have a fixed runoff coefficient of 0.85. This results in 85% percent of the rainfall is drained away while only 15% will infiltrate. Landuse categories 2 and 3 include open space, parks, rivers, lakes and flood plain these vary with different runoff coefficients (ARUP, 2013).

***Drainage System. The current drainage system only has carrying capacity for a 1 in 2 year event and overflows whenever rainfall exceeds the system. Therefore, the drainage system has not been considered in the overall flood model with potential for flood storage in the system (ARUP, 2013).

FIGURE 2

AVERAGE FLOOD LEVEL (M) WITH 2021 MUNICIPAL LIMITS WITH DEVELOPMENTS AS PROPOSED BY CITY MUNICIPALITY IN GORAKHPUR MASTER PLAN

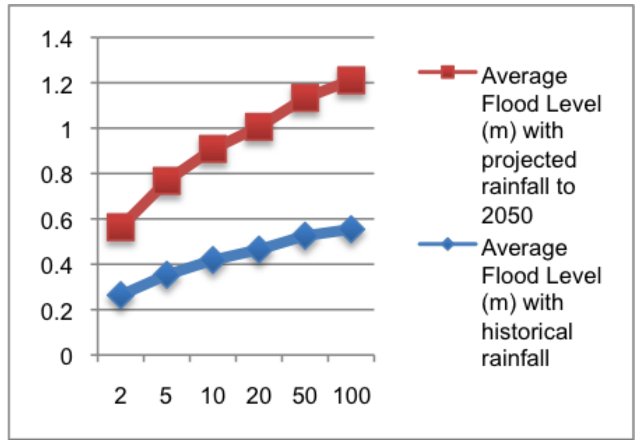


FIGURE 3

AVERAGE FLOOD LEVEL (M) WITH 2021 MUNICIPAL LIMITS WITH ALL IDENTIFIED GORAKHPUR MASTER PLAN GREEN AREAS ASSUMED TO BE BUILT UP

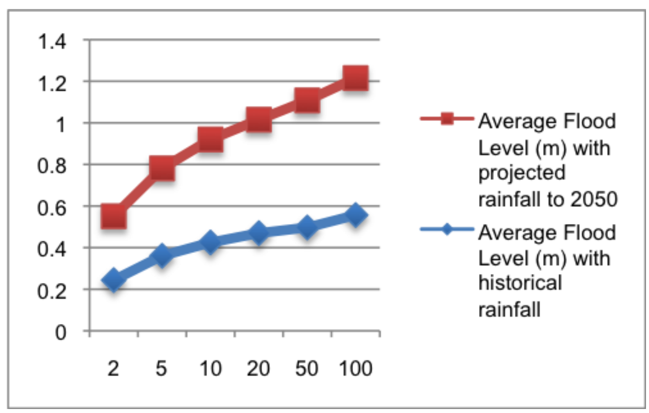
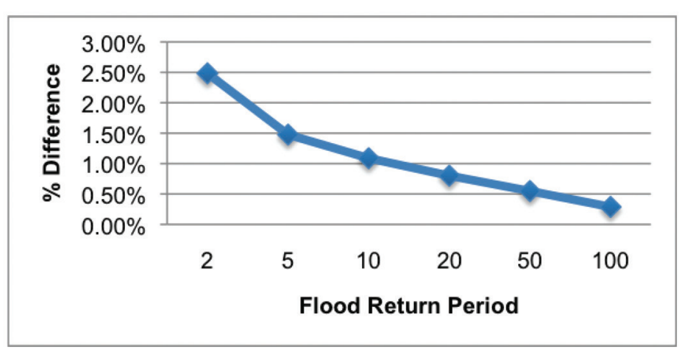


FIGURE 4

PERCENTAGE DIFFERENCE OF PROJECTED FLOOD LEVELS (M) BETWEEN SCENARIO 1 AND SCENARIO 2

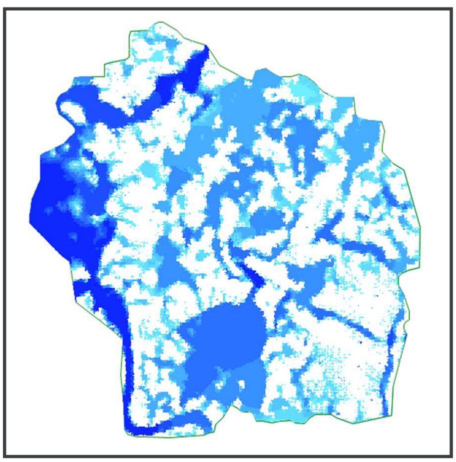


The flood model (ARUP, 2013) shows that by 2050 protection of the green spaces designated under the current Master Plan will not have a significant impact on actual flooding levels. Figure 6, below, illustrates the inundation levels expected from a 20-year, 50-year and 100-year flood return period for Gorakhpur city. These maps take into consideration future extreme rainfall events that might occur by 2050. The darker shades of blue illustrate deeper flood depth levels and where the flooding will most likely occur in the future. The areas most affected are situated in the western and southern part of the cities where waterlogging is already a major problem. With increased extreme rainfall, flooding and waterlogging, flood levels will continue to increase despite the Master Plan's attempt to address potential flood retention areas. Open space areas are a critical feature to address the waterlogging and flooding issue and identification of the appropriate open space areas that provide the most buffer are vital to reducing the problem. As a result, in order to address future flood risks the Master Plan would need to be changed substantially so that green open-space land could be protected in low-lying areas and along the river where it could have a major impact on flood levels. Drainage within the city would also need to be improved.

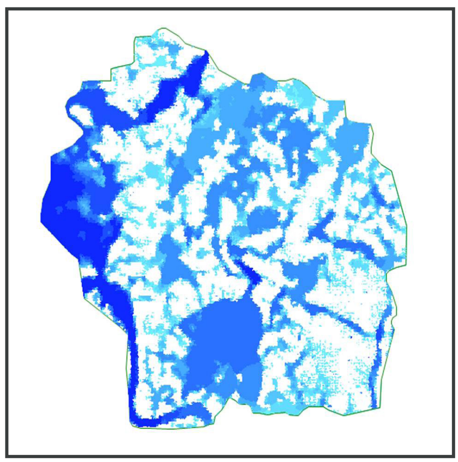
FIGURE 6

Future Flooding Impacts for Gorakhpur City by Return Period

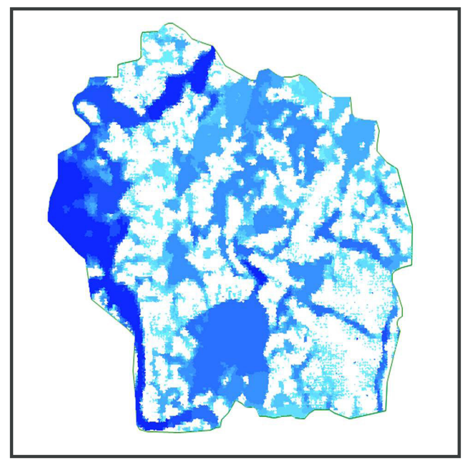
Scenario 1: 2021 Master Plan with designated green spaces untouched



20 year

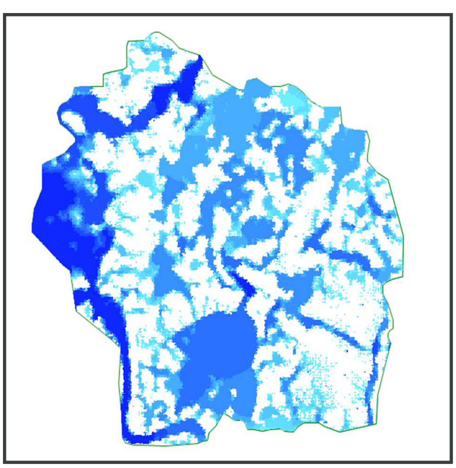


50 year

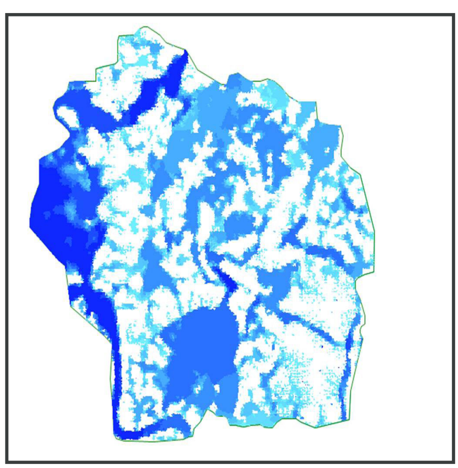


100 year

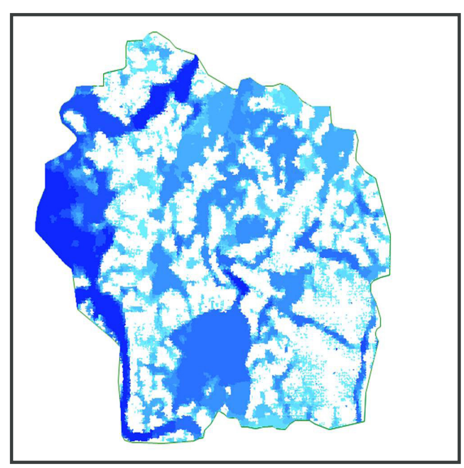
Scenario 2: 2021 Master Plan with designated green spaces built up



20 year



50 year



100 year

Resilient Approach

The current 2021 Master Plan will not prevent increased flooding for Gorakhpur city, the GEAG, ARUP and ISET-International team are working to engage key stakeholders in a series of visioning dialogues to alter the future flood impacts in Gorakhpur city. These visioning dialogues are slated to begin 2014 and will develop a vision for a Resilient Gorakhpur focusing on three critical development pathways.

TRANSPORTATION

Transportation systems strongly influence where people settle and what areas can be kept as open space—both of which are key factors influencing exposure. The actual transport systems (bus, train, etc.) will not be investigated, but the placement of transportation infrastructures will directly influence the settlement patterns of poor and vulnerable households, which serve as pathways to explore.

HOUSING

Housing structures greatly influence the direction water flows during flooding events. Commercial and industrial parks will not be analysed, but major residential and community-use areas will be looked at to see how resilient alternatives in housing design structure and built-up areas can reduce overall flooding and waterlogging.

LAND USE AND STORM MANAGEMENT

Flood management systems can be broken down into two different categories, 1) structural elements (embankments, polders, storm water drains), and 2) non-structural (early-warning systems, zoning, etc.). The team will investigate newly planned flood mitigation systems and determine if those systems will reduce overall damages or increase damages during major flooding events. Alternative locations for the protection of open space and potential improvements in drainage will be a particular focus in this second element.

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