Blue-Green Ecosystem Health Monitoring Techniques for Urban Risk Reduction

United Nations International Conference on Space-based Technologies for Disaster Risk Reduction - "**Enhancing Disaster Preparedness for Effective Emergency Response**"

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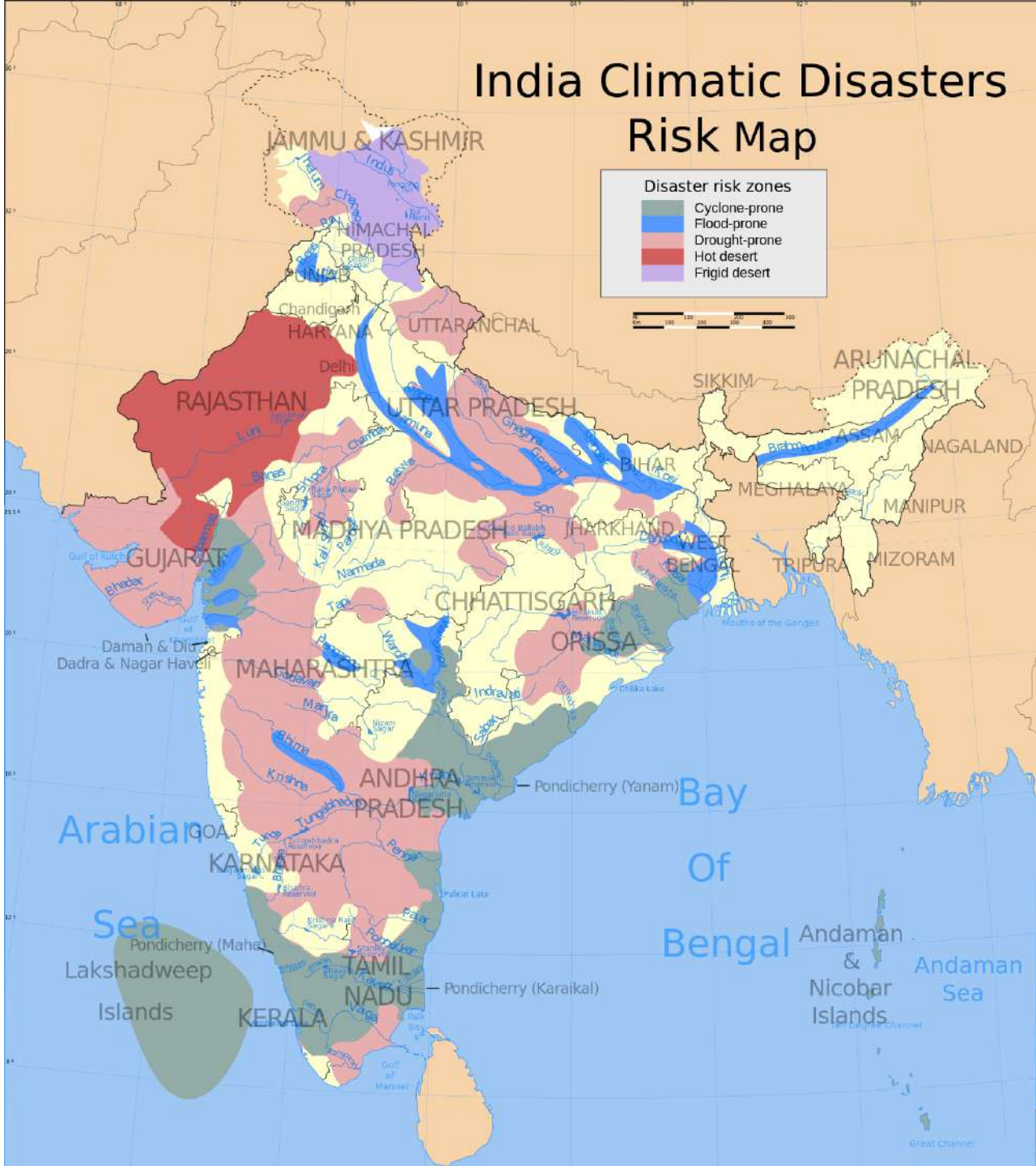
Global risk indices and South Asia

COUNTRIES	Exposure (in Per Cent) * Vulnerability (in per cent)	World Risk Index	Pinkerton Risk Score (Natural Disaster)	INFORM Global Risk of Humanitarian Crises and Disasters
Afghanistan	13.17 * 72.49	9.55 (High)	82.00%	7.2 (Very High)
Bangladesh	31.70 * 60.76	19.26 (Very High)	96.20%	5.8 (High)
Bhutan	14.81 * 67	7.71 (High)	39.50%	2.9 (Low)
India	11.94 * 57.59	6.88 (Medium)	72.80%	5.4 (High)
Myanmar	14.87 * 60.60	9.01 (High)	72.20%	6.4 (High)
Nepal	9.16 * 57.09	5.23 (Low)	59.20%	5.1 (High)
Pakistan	11.36 * 61.91	7.03 (Medium)	69.70%	6.4 (High)
Sri Lanka	14.79 * 49.86	7.37 (High)	83.30%	4.0 (Low)

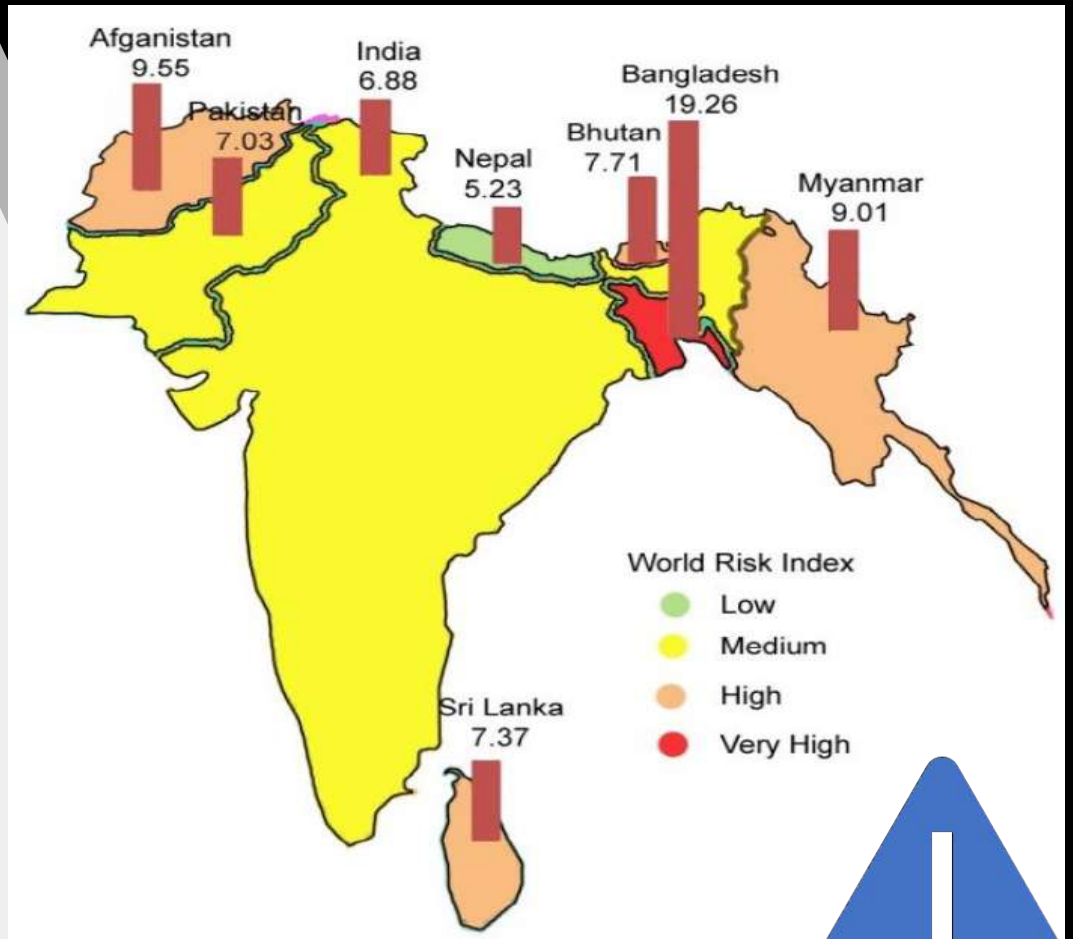
Source(s): - Wikimedia - Map by Saravask, based on map work by Planemad and Nichalp

https://upload.wikimedia.org/wikipedia/commons/thumb/3/35/India_climatic_disaster_risk_map_en.svg/1639px-India_climatic_disaster_risk_map_en.svg.png) NDMA - https://ndma.gov.in/en/vulnerability-profile.html



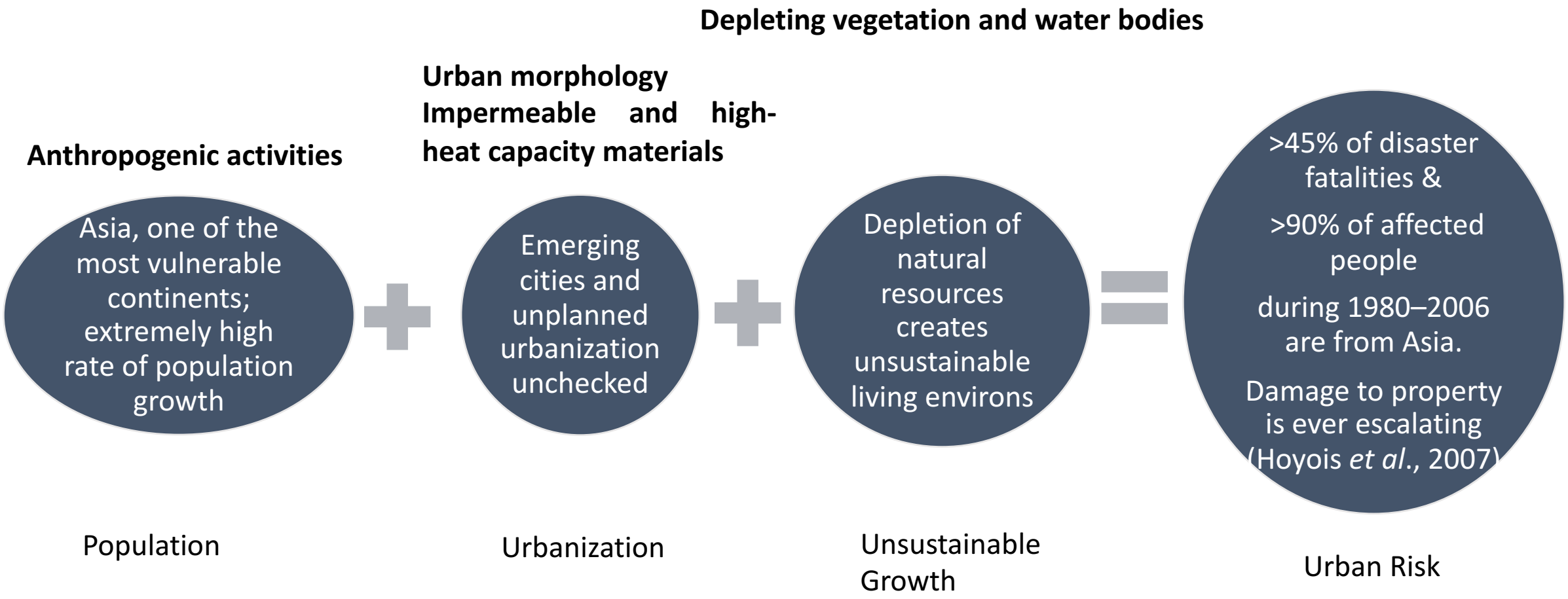
Global risk indices - India

- Ranked 78 in the World Risk Index, India is in the medium risk range against Disaster (Änderung, 2016).
- The Major cities of the countries are highly vulnerable to any human crises and natural disasters.
- According to Lloyd's City Risk Index, 2 out of 3 metropolitan cities in India have a GDP@Risk (GDP at Risk) of more than INR 20000 Crore. The following table compares the 3 cities according to Risk and Loses faced.



	GDP@ Risk (In Crores)	GDP@Risk: Natural Disaster and Climate Threat	GDP Share (In Crores)
Delhi	26004 INR	12%	3120.4 INR
Mumbai	23196 INR	7.1%	1646.9 INR
Kolkata	12706 INR	17.1 %	2173.2 INR

Population and Vulnerability



Global policy frameworks and urban risk resilience

- Sendai Framework focuses on disaster risk reduction and building back better
- SDGs and New Urban Agenda too aptly stresses need for disaster resilience habitat planning

New Urban Agenda – Urban Risk Resilience

EMPHASIZE SUSTAINABLE RESOURCE USE IN URBAN PLANNING- HABITAT III

Encourage appropriate density, Polycentrism, Infill or planned urban extension

Through Mixed use planning

To achieve Enhanced resource efficiency

To achieve Enhanced Urban resilience

To achieve Enhanced Environmental sustainability

New Urban Agenda: to adopt a smart-city approach that makes use of opportunities from digitization, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery.

Adopt and implement disaster risk reduction and management, reduce vulnerability, build resilience and responsiveness to natural and human-made hazards and foster mitigation of and adaptation to climate change.

SMART CITIES MISSION

Smart City
MISSION TRANSFORM-NATION

Ministry of Housing and Urban Affairs, Government of India

- Smart Cities Mission, 2015
- Investment in critical areas of **Infrastructure Planning, Smart Urban Management and Governance**.
- Cities across the country prepared their own smart city proposals
- International consultants inducted

Infrastructure Development

Source: www.smartcity.moud.in

Urban Risk Resilience and Smart City Mission

INDIA HAS SERIOUS CONCERN ABOUT ITS URBANIZATION AND **LAUNCHED SMART CITY MISSION** (SCM, 2015)

AN INSPIRATIONAL **FUTURISTIC DEVELOPMENT** PROGRAM WITH FOCUS ON THE IMPROVEMENT OF BASIC INFRASTRUCTURE SERVICES

INFORMATION TECHNOLOGY ENABLED APPLICATION FOR SMART GOVERNANCE HAS BEEN A MAJOR PART OF MOST PROPOSALS.

REVIEW OF SCM DOCUMENT AND SMART CITY PROPOSALS (SCPS) **EXPOSES INSUFFICIENT DELIBERATION ON URBAN RISK.**

Urban Risk Resilience Integration … (2)

Urban Blue- Green Ecosystem

- Extending Ecosystem Services
- De-stressing Urban Environment
- Provisioning Resilience

Ecosystem based Urban Infrastructure Planning

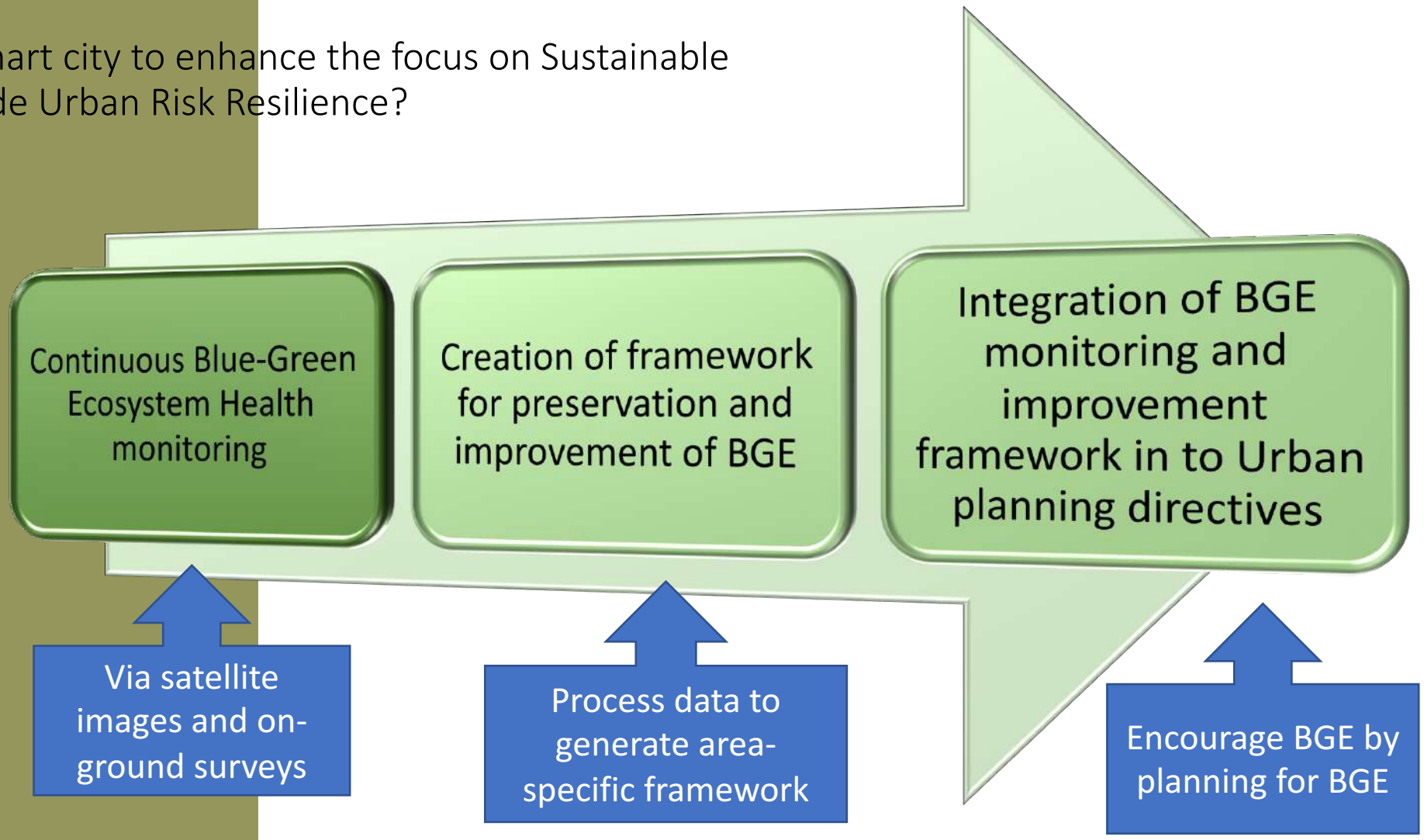
Blue-Green Ecosystem

- Blue-Green Ecosystem (BGE) in urban areas are often neglected resources, which provides multiple benefits including urban climate risk resilience.
- Ecosystem services are defined as “the benefits people obtain from ecosystems” (Costanza et al. 1997; Millennium Ecosystem Assessment 2005).
- These include provisioning services such as food and water; regulating services such as regulation of floods, drought, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, and other nonmaterial benefts (Costanza et al. 1997; Daily 1997; de Groot et al. 2002).

Urban Environment: energy and health security	Heat wave, UHI Air Pollution removal, carbon sequestration Avoidance of emissions (reduced energy use) Wind regime- strong wind, pedestrian level discomfort
Urban Water Ecology: water security	Storm-water drainage- Urban Flood, Drought Water quality - Natural treatment Water balance, Water temperature
Urban Agriculture: food security	Soil protection - Soil stabilization, Increased permeability Nutrient cycle - Waste decomposition and nutrient cycling Production
Urban Bio-diversity: habitat protection	Species diversity, Habitat and corridors.

Blue – Green Ecosystem based infrastructure services

Question:
What can be added to a Smart city to enhance the focus on Sustainable Infrastructure and to provide Urban Risk Resilience?



Answer:
Healthy Blue-Green Ecosystem through BGE Health Monitoring and Improvement Framework **(BGEHMIF)**

Data collection

- Collect historic data through previous years satellite images of the area of interest.
- Record the spatio-temporal changes of the Blue-Green Ecosystem via indices.

Analysis and inferences

- Compare the changes observed with the existing master plan or land use plan in force.
- Identify areas in dire need of immediate action and also opportunities for short-term intervention.

Action

- Take necessary steps for the immediate preservation and short-term improvement of the BGE situation
- Encourage a long-term vision based strategy while taking action and plan for the integration of the monitoring framework in to the planning process

Methodology for creation of Blue-Green Ecosystem Health Monitoring and Improvement Framework

Selected Study area – Gurugram, Haryana

Selected study area – Gurugram - Demography

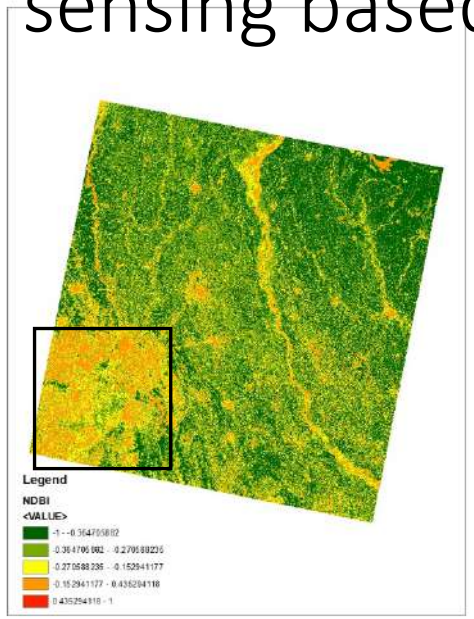
Year	Population	Area	Density (per sq km)	Growth Rate
2011	1514085	1254	1241	73.93%
2001	870539 (1660289) *	1254 (2754) *	694	44.16%
1991	603900 (1146090) *	1254 (2754) *	482	-

- In 2005, Mewat district was created out of Gurugram district with a size of 1500 km. sq. The number in brackets denotes the 2001 census population of the larger Gurugram district while the other number is the population of the current Gurugram district without the population of the new Mewat district.

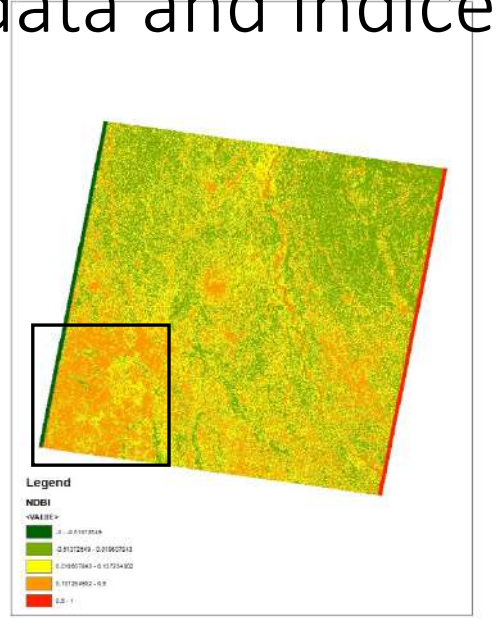
The population of the current Gurgaon district has gone up in leaps and bounds over the last 20 years with the average population growth rate of the last two decades being close to 60%.

Remote sensing based data and Indices

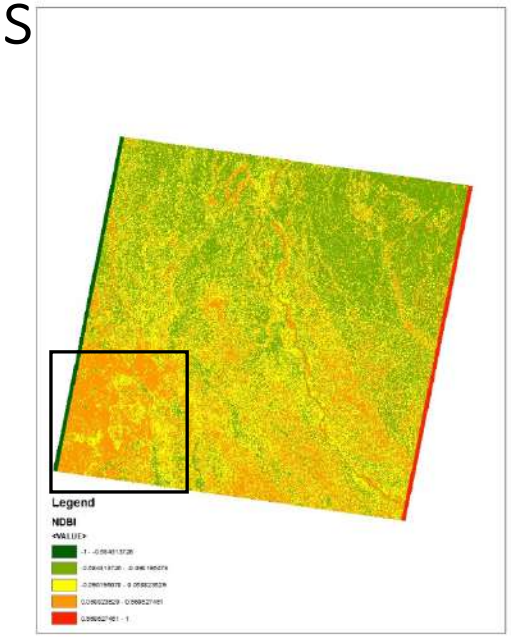
- NDBI



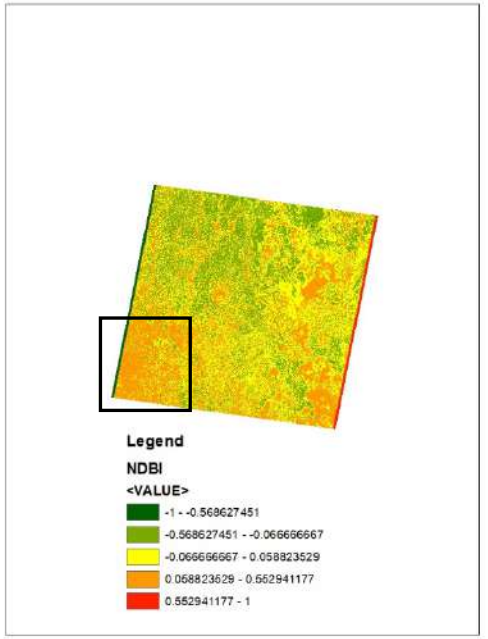
2013



2002

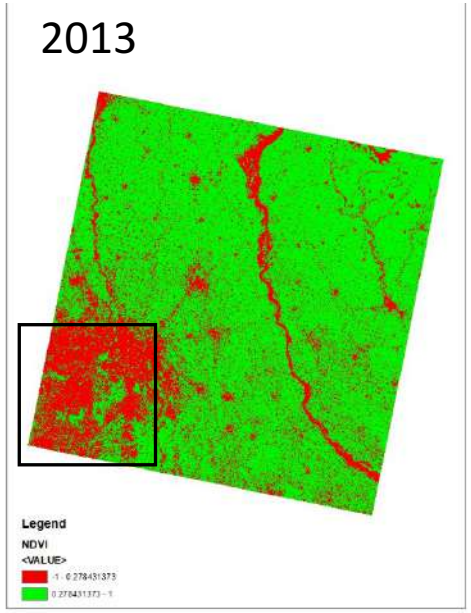


1997

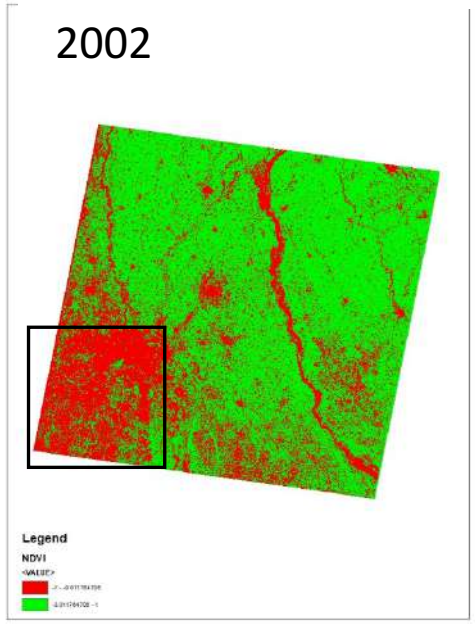


1993

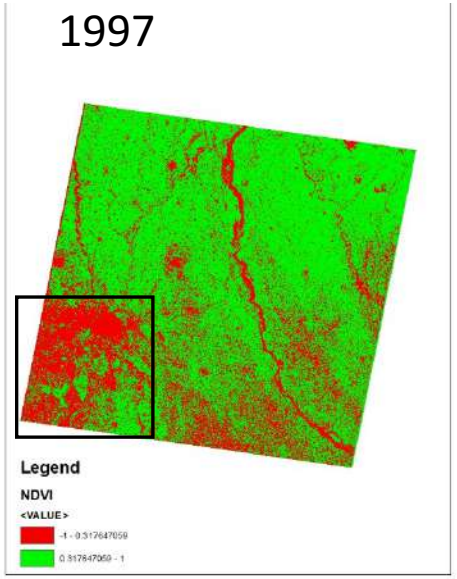
- NDVI



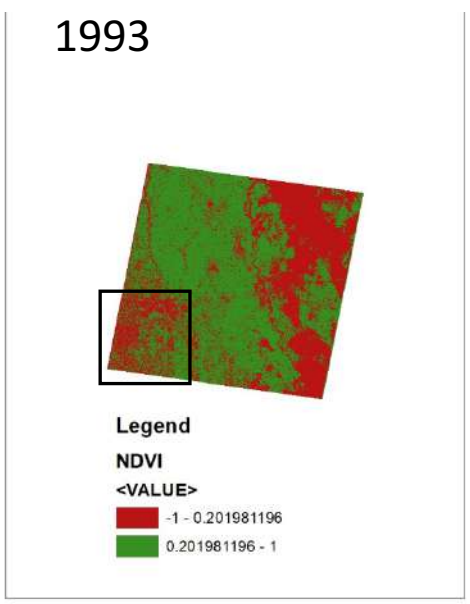
2013



2002

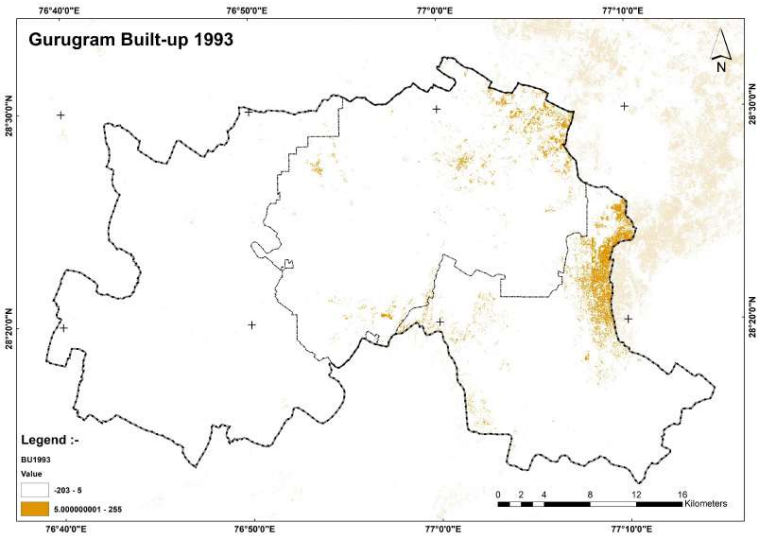


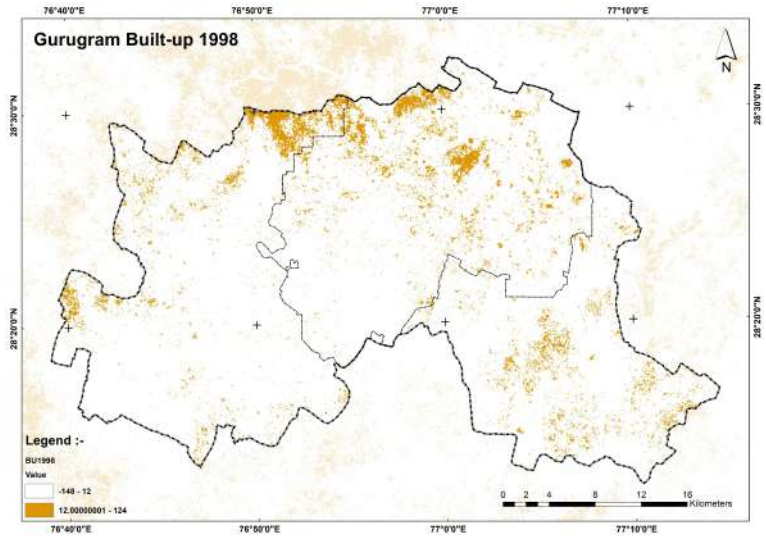
1997

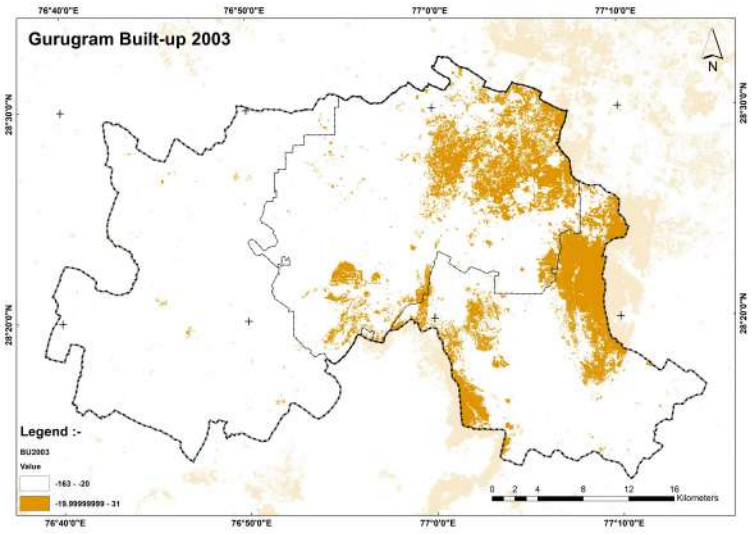


1993

Observations from NDBI – 1993 -2003

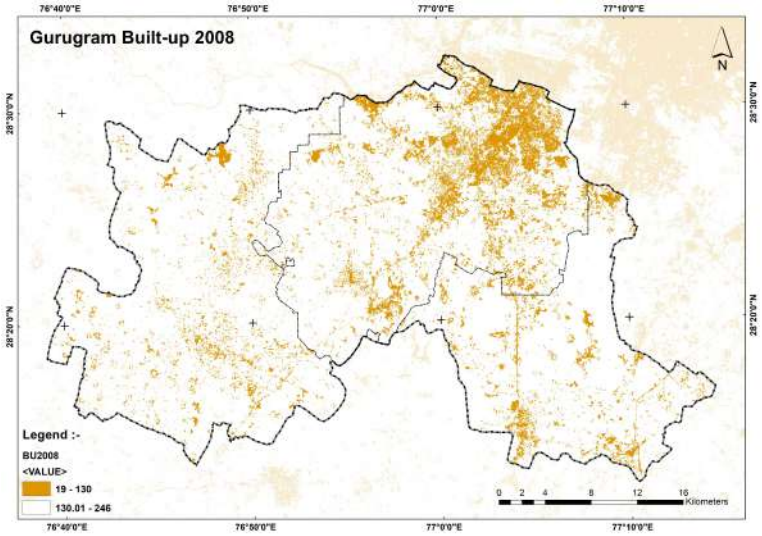


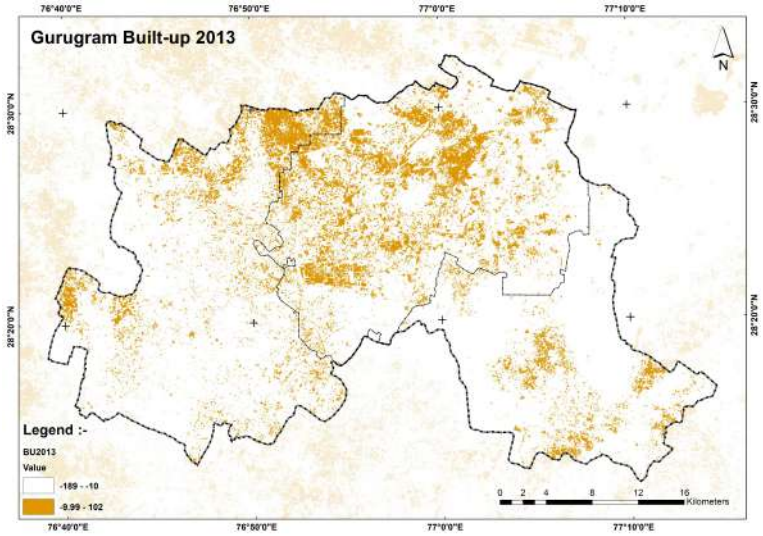


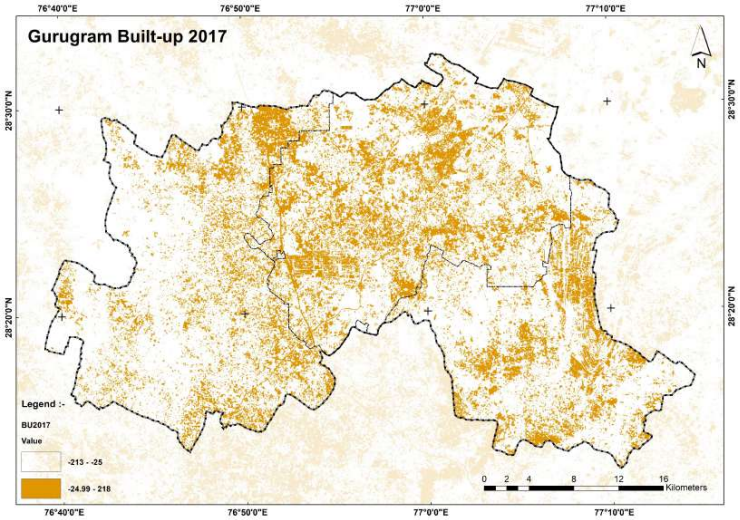


- The bolder boundary is the area of the Gurugram district while the lighter boundary inside the bolder boundary is the master planning area which is also the urban core of the city.
- The initial built structures had appeared around the edges of the current city and its master planning area.
- The built-up intensifies in the year 2003 and primarily exists outside the current master planning areas.
- This is in part due to the unregulated developments the agglomerated outside the urban areas and also partly due to the non-existence of a specific master plan for the Gurugram Urban area until 2005.

Observations from NDBI – 2008 - 2017

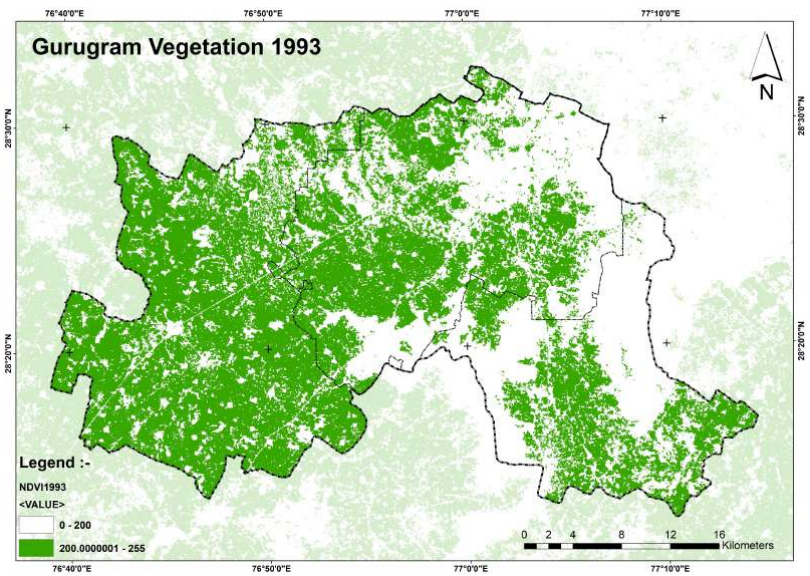


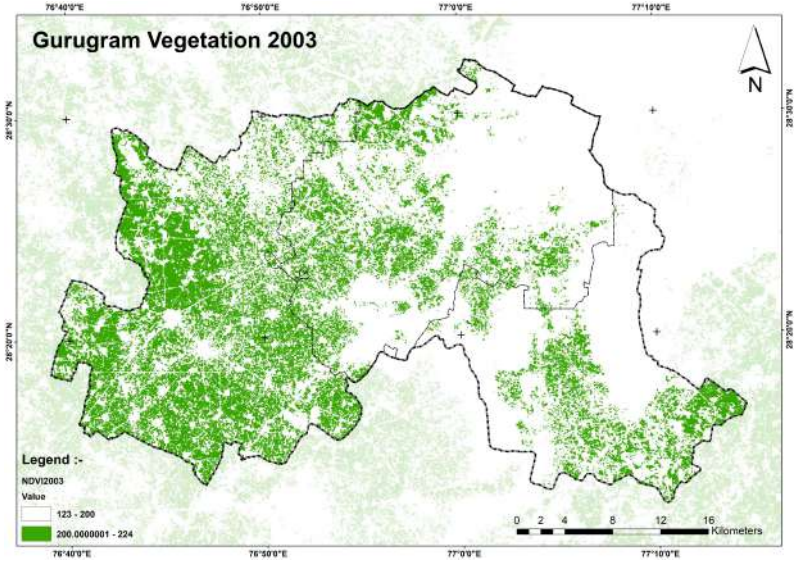


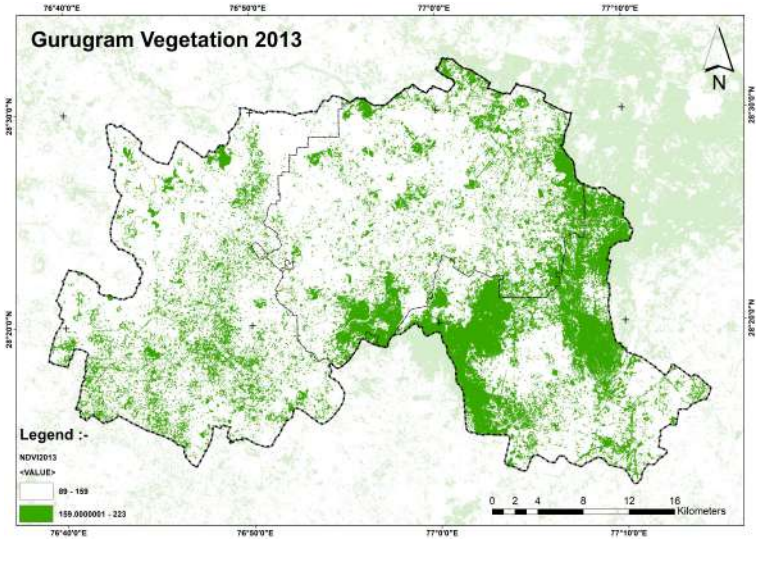


- The Built-up has centralized and focused itself within the master planning area in 2008 as the first master plan was released in 2005.
- Consistent increase of the built up can be observed within the master planning zone up to 2013 but exponential urbanization has caused building activity to increase even outside the master planning zone
- The 2017 image shows that uncontrolled urbanization has occurred all over the district and the master planning area will have to be increased to include the new built-up areas within the urban limits.

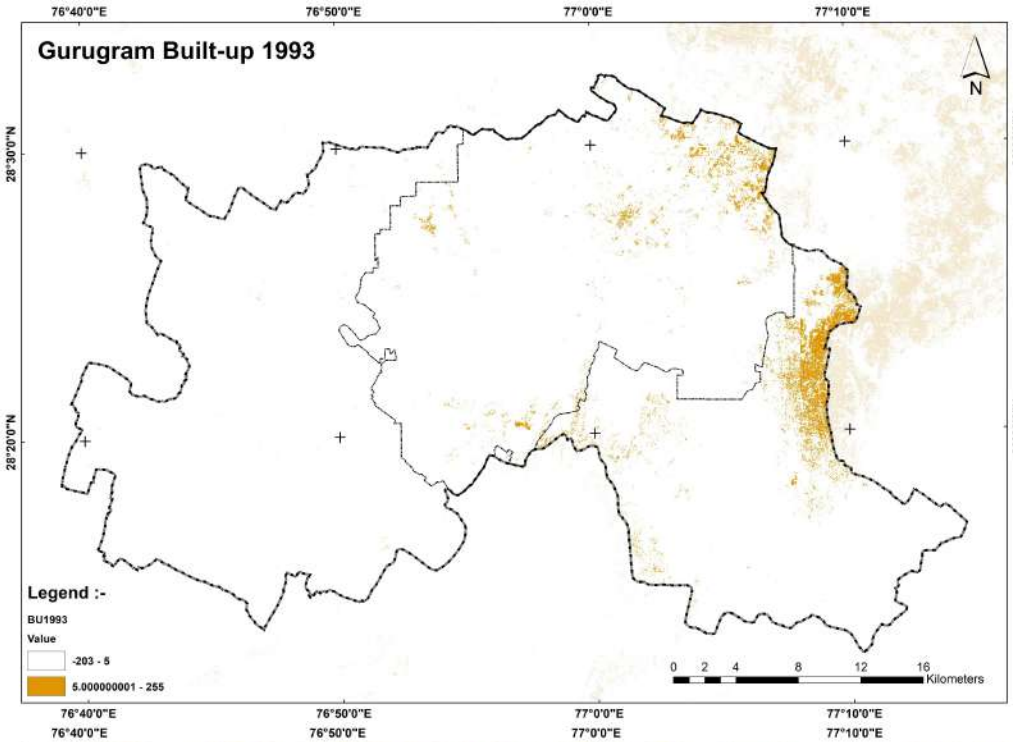
Observations from NDVI – 1993 - 2013

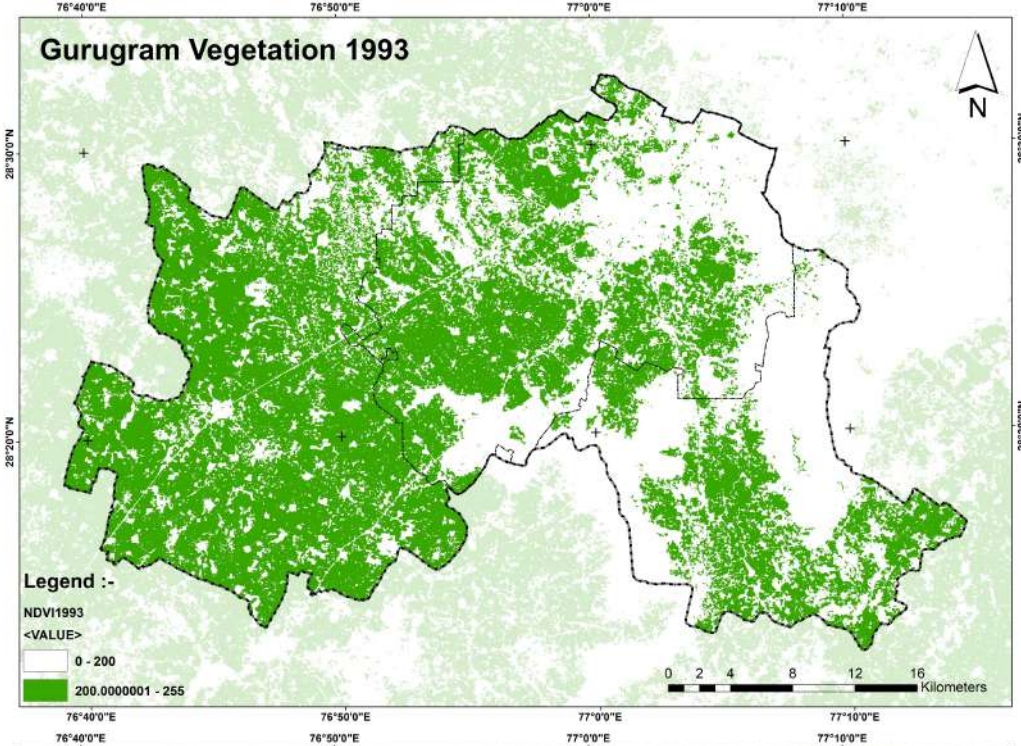




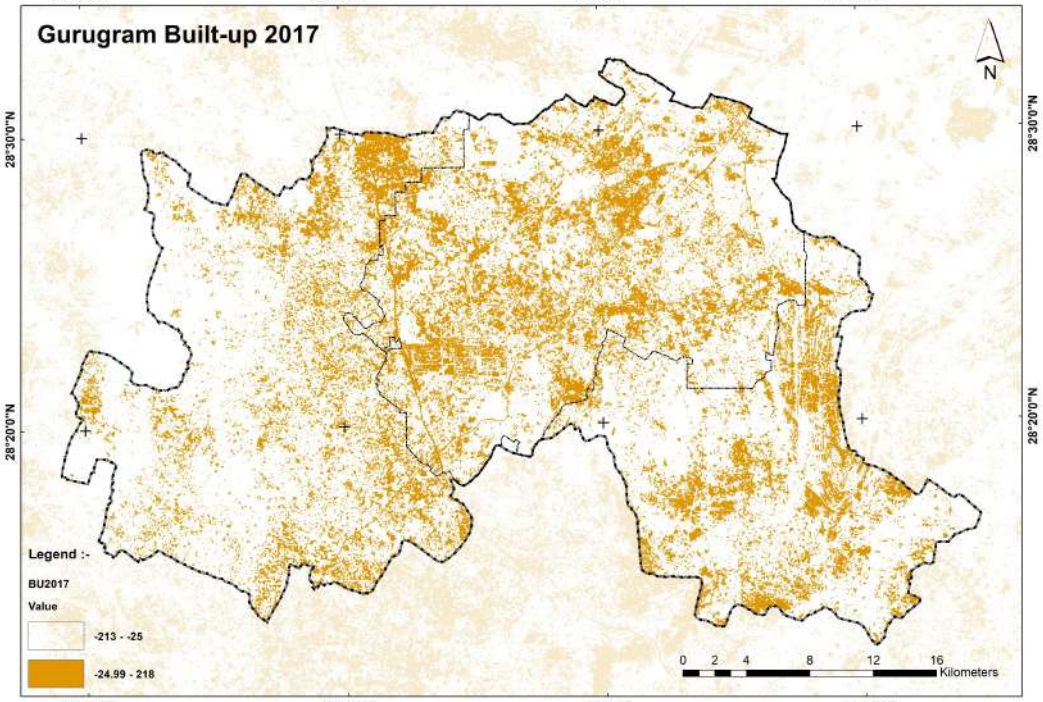


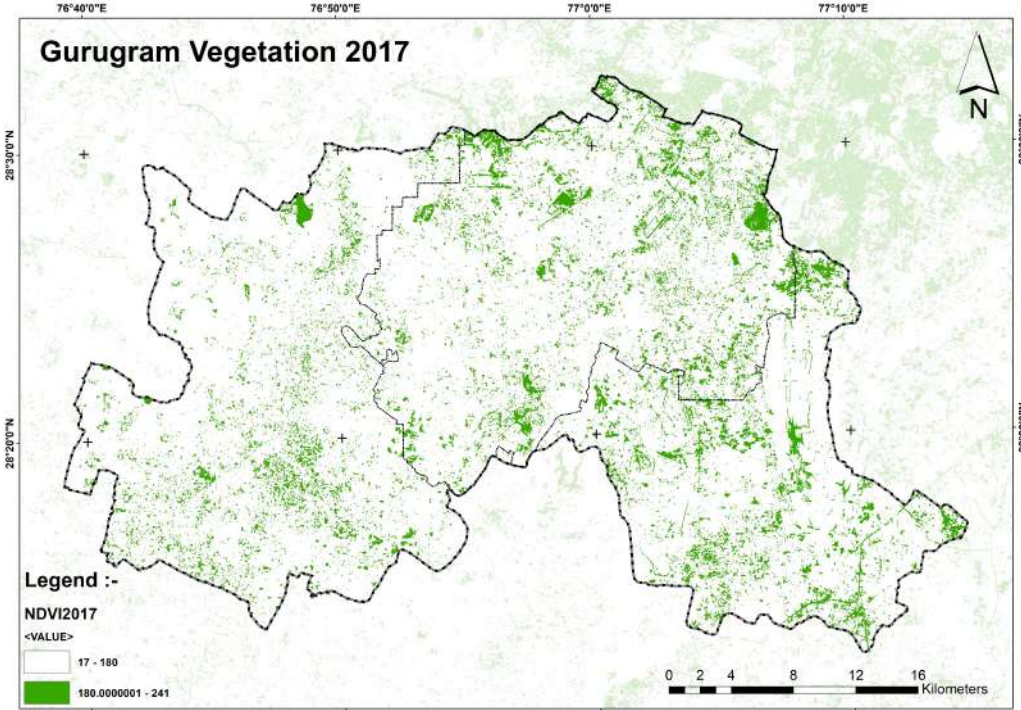
- Extensive green cover observed in Gurugram district and well in to the master planning region in 1993.
- Patches of deforestation and unregulated development have started eating in to the green cover around the district as seen from the images in 1998.
- The 2003 image clearly shows a marked difference when compared to the 1993 image. A decade has taken off more than 30% of the green cover in the area.
- The 2008 image shows a near total decimation of the green cover within urban boundary of Gurugram
- By 2013 a few areas outside the urban boundary and a small patch within the urban boundary seem to have recovered some of its green cover. Even so, the total green cover within the urban boundary showed an overall negative trend.
- By 2017, green cover both inside outside urban areas of District Gurugram reduced by more than 80%


Gurugram Built-up 1993
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
28°30'0"N
28°20'0"N
N
Legend :-
BU1993
Value
-203 - 5
5.000000001 - 255
0 2 4 8 12 16
Kilometers


Gurugram Vegetation 1993
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
28°30'0"N
28°20'0"N
N
Legend :-
NDVI1993
<VALUE>
0 - 200
200.0000001 - 255
0 2 4 8 12 16
Kilometers

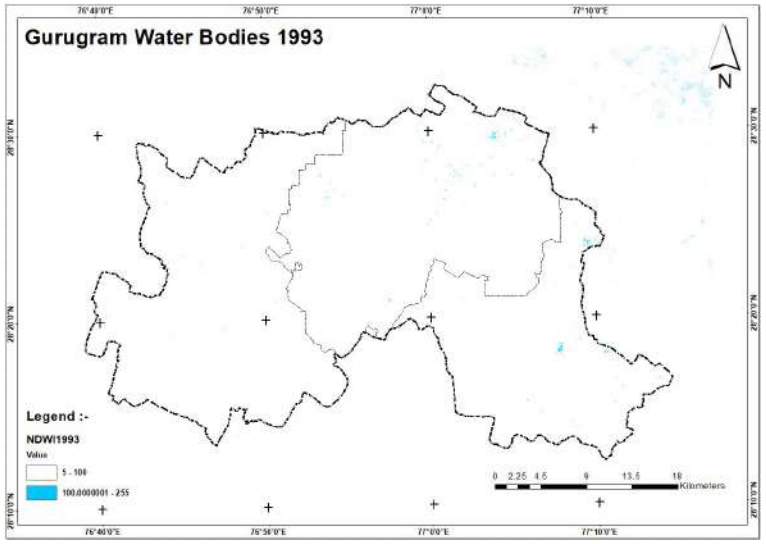
- NDBI

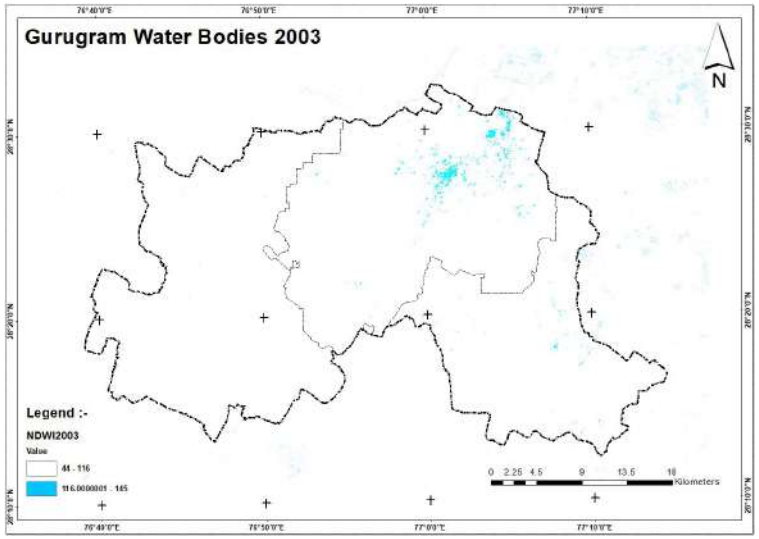

Gurugram Built-up 2017
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
28°30'0"N
28°20'0"N
N
Legend :-
BU2017
Value
-213 - -25
-24.99 - 218
0 2 4 8 12 16
Kilometers

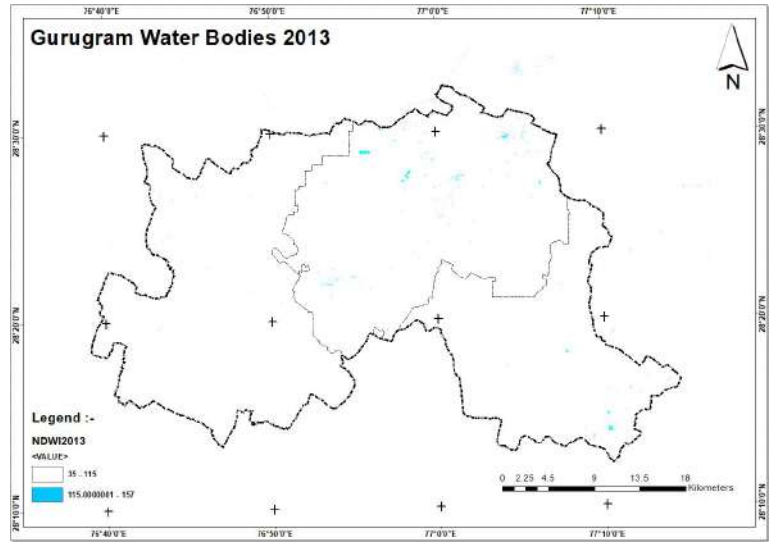

Gurugram Vegetation 2017
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
28°30'0"N
28°20'0"N
N
Legend :-
NDVI2017
<VALUE>
17 - 180
180.0000001 - 241
0 2 4 8 12 16
Kilometers

- NDVI

Observations from NDWI – 1993 -2013

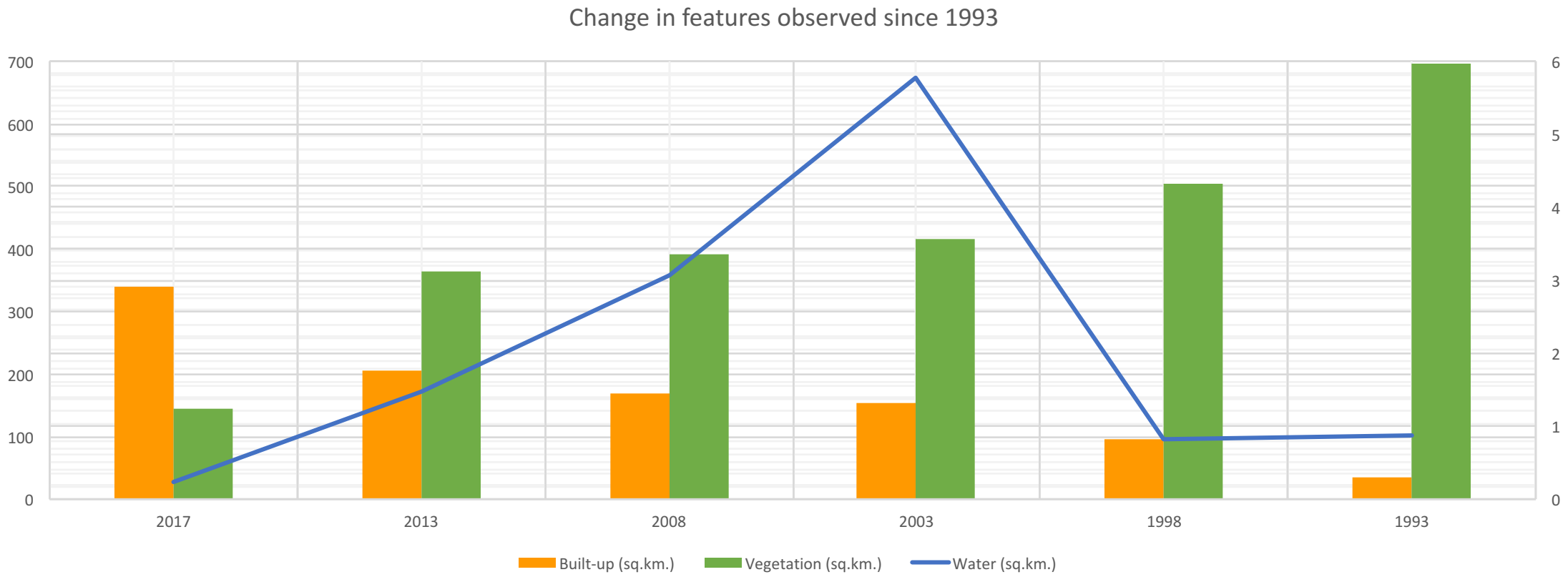




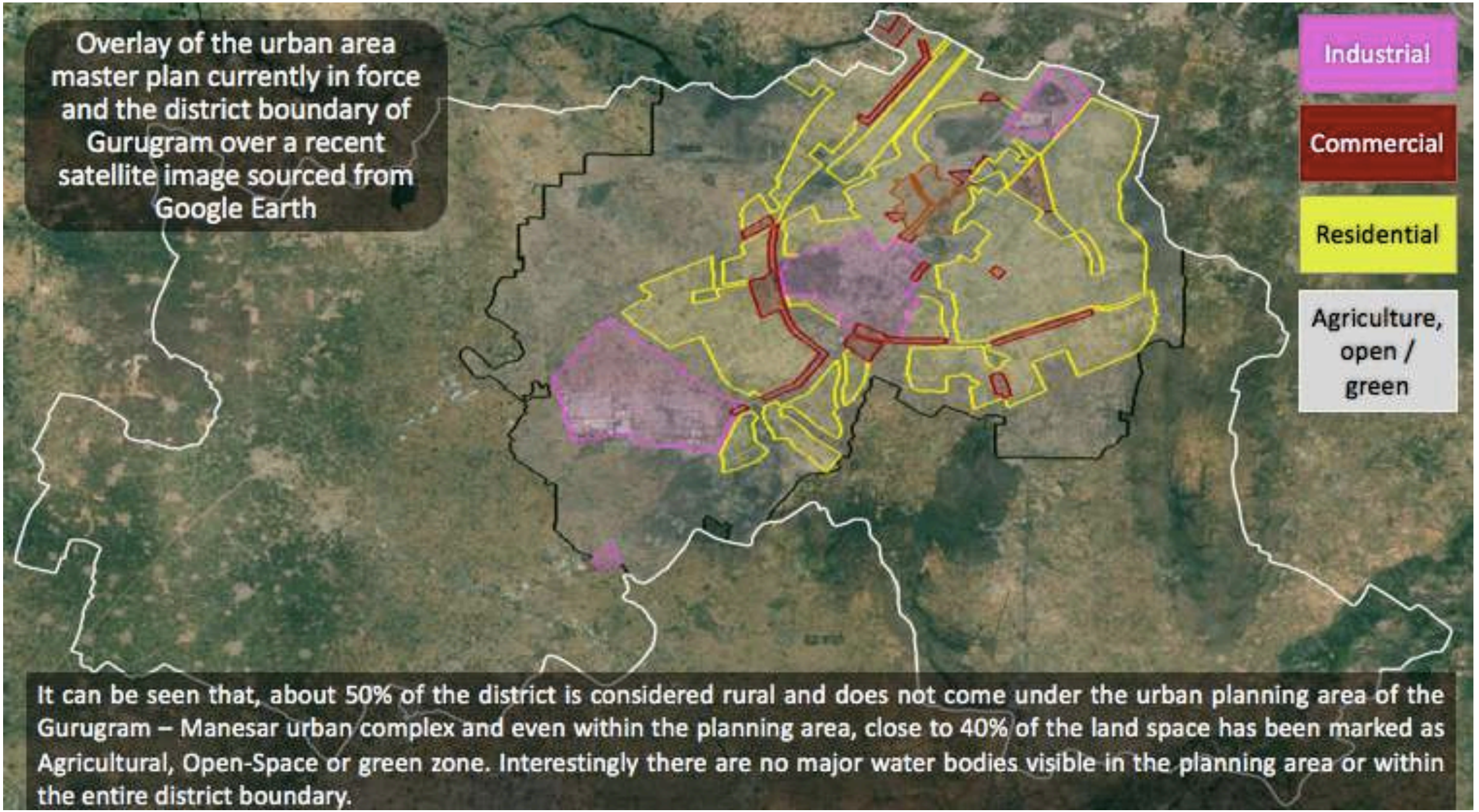


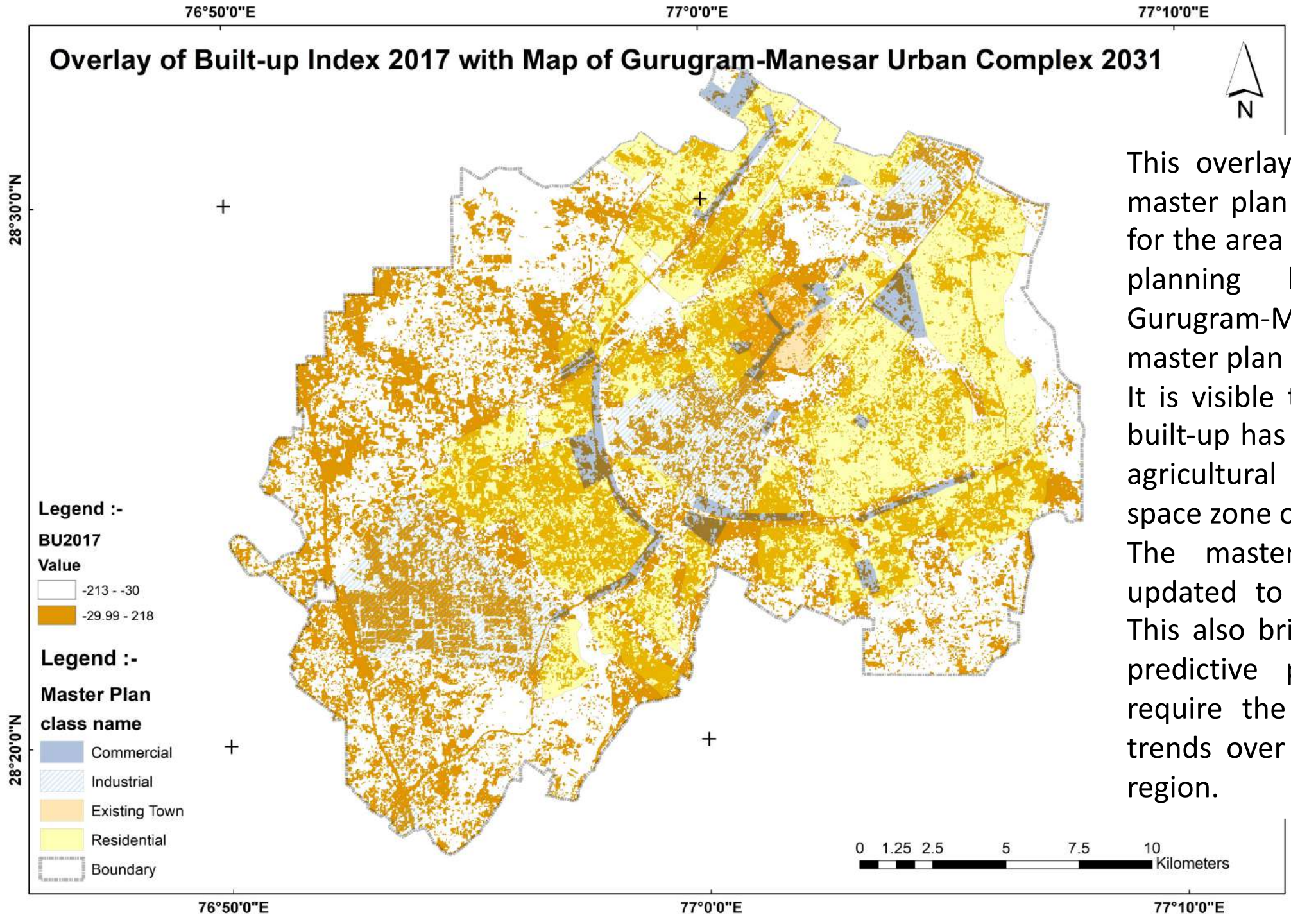
- The NDWI was not able to find any significant traces of water body within the entire region.
- A few traces turned up within the urban master plan area in the 1998 and 2003 images.
- Excessive rainfall may have caused brief water-logging in these periods which may have lead to the higher signatures
- The decrease observed in vegetation can be highly influenced by the lack of surface water sources
- The NDWI over the last ten years shows almost no significant water bodies within the master planning boundary.
- The serious lack of surface water accumulation has caused drop in the underground water resources (CGWB, MoWR 2017)
- High built-up has also caused extreme flash flood events increasing the urban risk.

Last three years July 28, 2016 , June 17, 2017 and Aug 28, 2018 recorded extreme flooding even during moderate rainfall



Changes observed within urban boundary of Gurugram district via indexes derived using RS imaging


Overlay of the urban area master plan currently in force and the district boundary of Gurugram over a recent satellite image sourced from Google Earth
Industrial
Commercial
Residential
Agriculture, open / green
It can be seen that, about 50% of the district is considered rural and does not come under the urban planning area of the Gurugram – Manesar urban complex and even within the planning area, close to 40% of the land space has been marked as Agricultural, Open-Space or green zone. Interestingly there are no major water bodies visible in the planning area or within the entire district boundary.



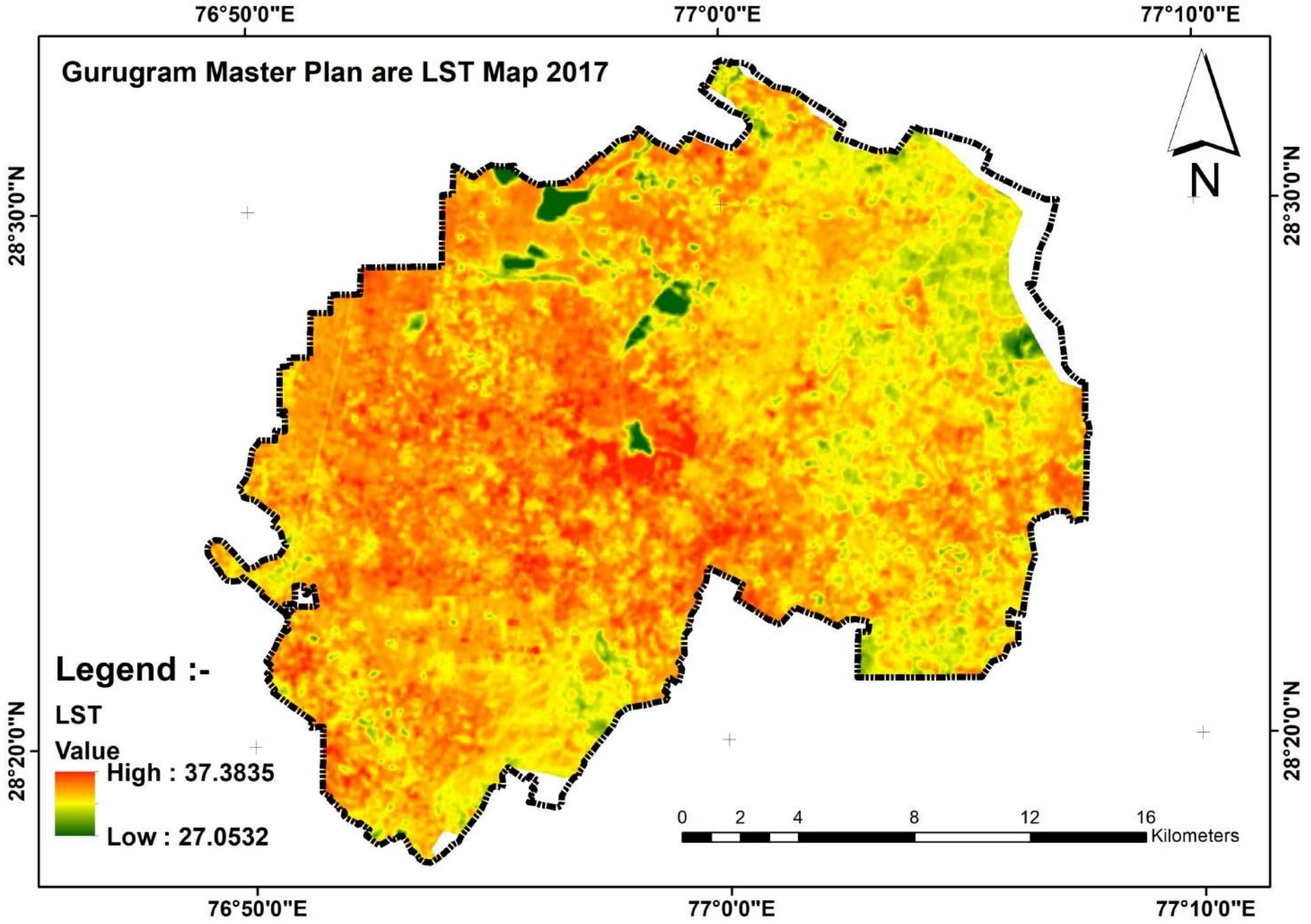
This overlay compares the current master plan with the NDBI of 2017 for the area under the urban master planning boundary with the Gurugram-Manesar Urban Complex master plan proposed for 2031.

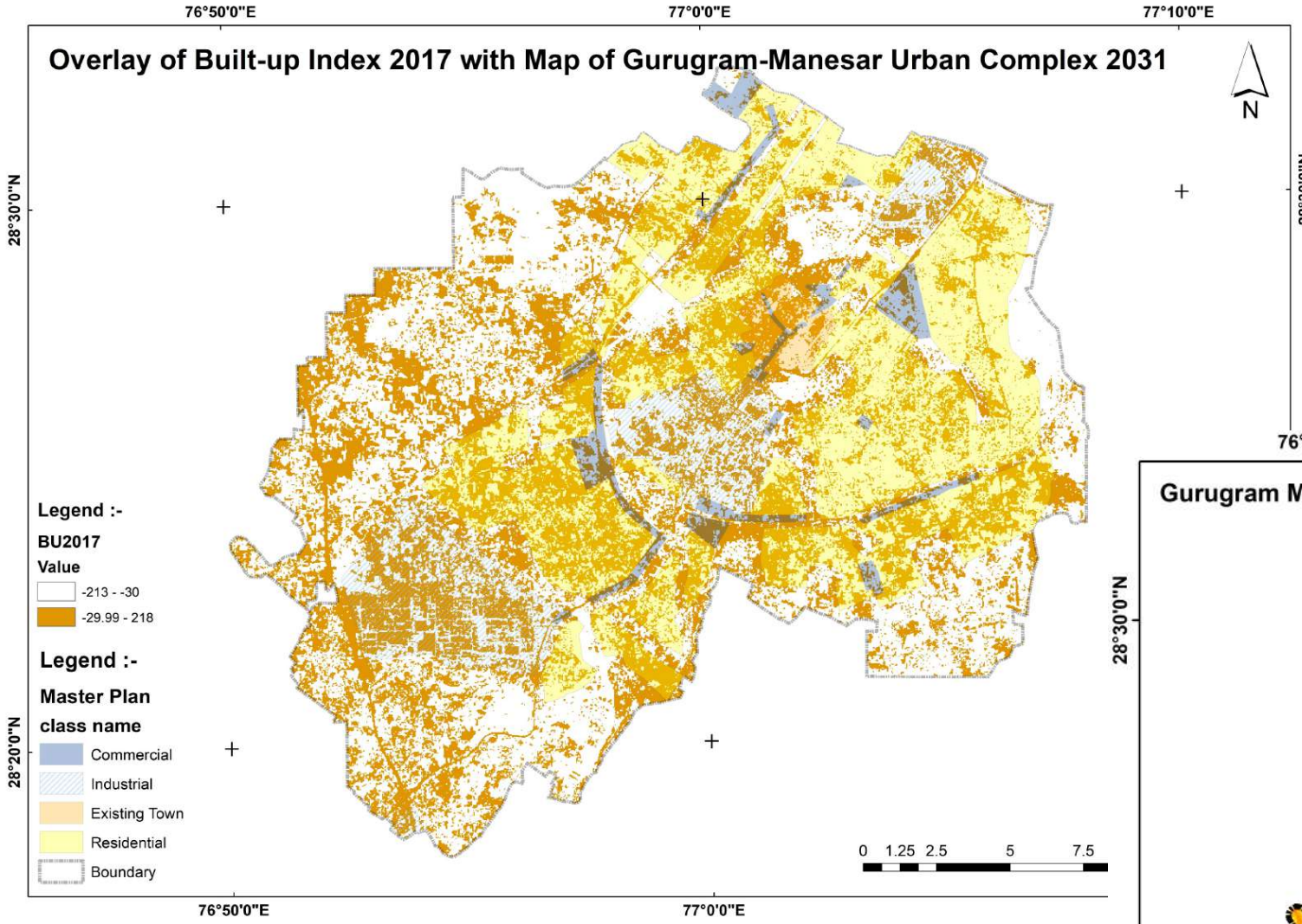
It is visible that almost 35% of the built-up has already occurred in the agricultural and green or open space zone of the master plan.

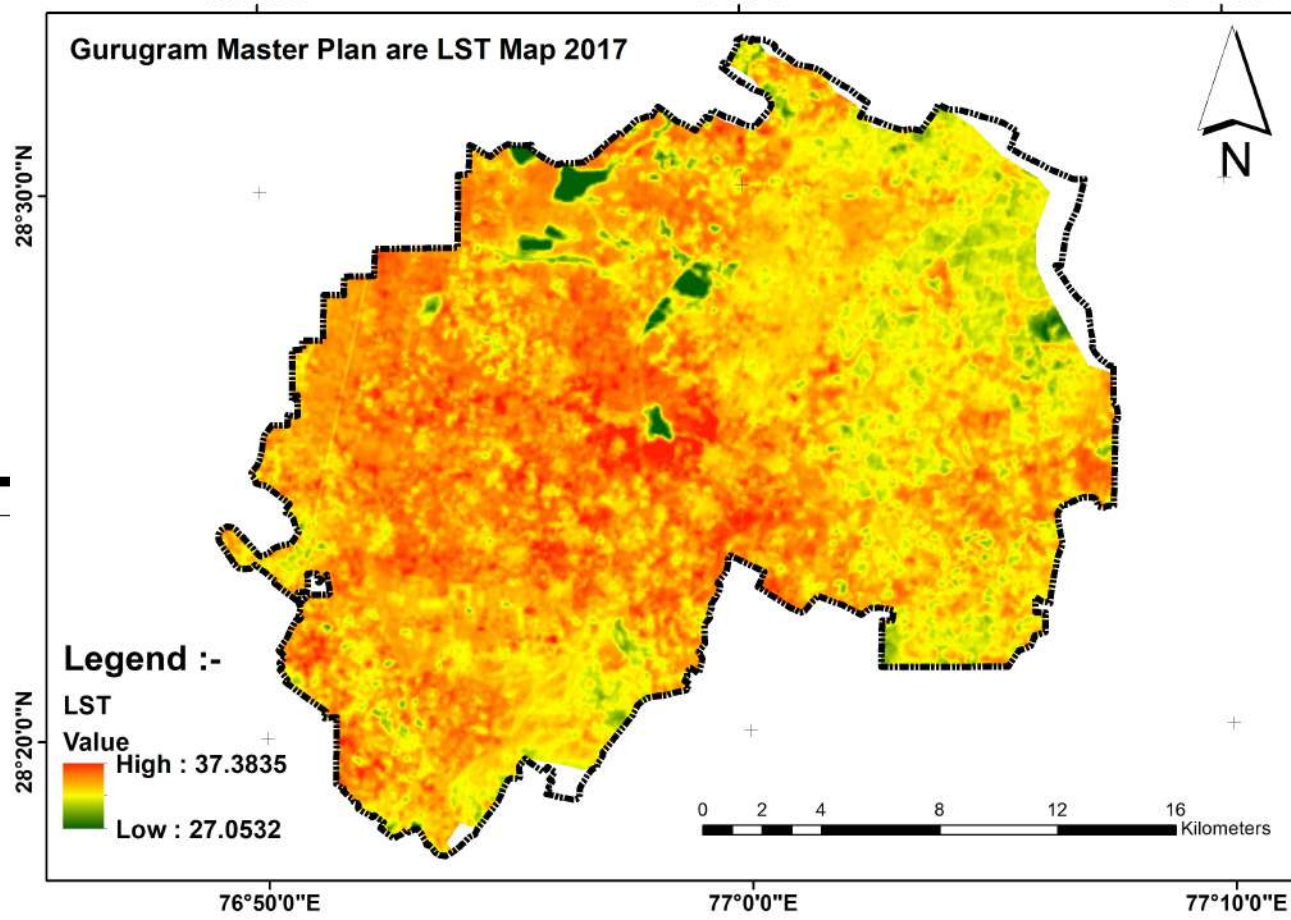
The master plan needs to be updated to reflect these changes. This also brings up the question of predictive planning which might require the study of the Built-up trends over the larger surrounding region.

Land Surface Temperature of Gurugram region 2017 April (Summer)

The LST mapping of Gurugram region in the April of 2017 shows distinct areas with low LST as areas with green cover or stagnant polluted discharge water with algal bloom cover. Even these water features have reached a temperature of 27 degrees Celsius which does not bode well for the Urban micro-climate.




Overlay of Built-up Index 2017 with Map of Gurugram-Manesar Urban Complex 2031
76°50'0"E
77°0'0"E
77°10'0"E
28°30'0"N
28°20'0"N
N
Legend :-
BU2017
Value
-213 - -30
-29.99 - 218
Legend :-
Master Plan
class name
Commercial
Industrial
Existing Town
Residential
Boundary
0 1.25 2.5 5 7.5


Gurugram Master Plan are LST Map 2017
76°50'0"E
77°0'0"E
77°10'0"E
28°30'0"N
28°20'0"N
N
Legend :-
LST
Value
High : 37.3835
Low : 27.0532
0 2 4 8 12 16
Kilometers

Cyclic monitoring of status of BGE via satellite and on-ground monitoring

Regular collection and Analysis of RS images	Ground-truthing via geolocated imagery of the situation on-ground obtained by site-visits

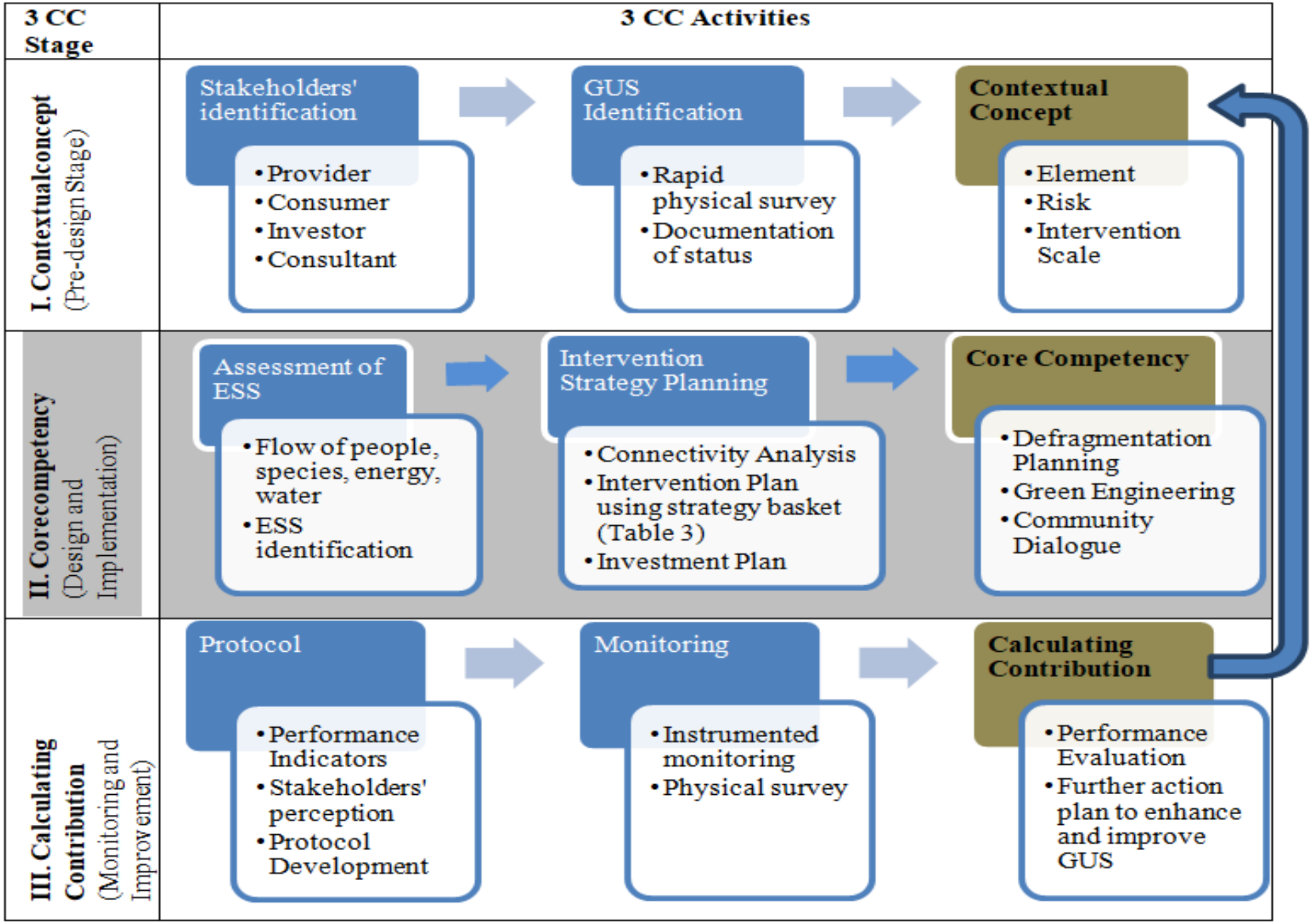
Creation and regular updating of statistical and GIS database of the BGE in planning area

The database can be used to analyze spatio-temporal changes and see the health of the BGE over time	The database can also be used to understand the factors positively and negatively influencing the health of BGE

Formulation of urban planning directives to achieve necessary goals

Directives encouraging actions to boost BGE health while discouraging measures that are detrimental to BGE	Identification of locations where the BGE can be created or enhanced to generate inherent urban risk resilience.

Integration of the BGEHMIF in to urban planning directives to achieve resilience planning



GUS-3CC Model

c (2018).

'Urban green space as a countermeasure to increasing urban risk and the UGS-3CC resilience framework',

Mukherjee, M & Takara, K.

International Journal for Disaster Risk Reduction, Volume 28, June 2018, Pages 854-861

Contextual Context to introduce the Blue- Green Infrastructure

Once upon a time it was a flowing Channel! It can be revived like Cheonggyecheon River in Seoul

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