Emission Mitigation from Urban Waste Water Sector: A Spatial Planning Approach

Dr. Manmohan Kapshe and Ms. Mrunmayi Wadwekar

Maulana Azad National Institute of Technology, Bhopal, India

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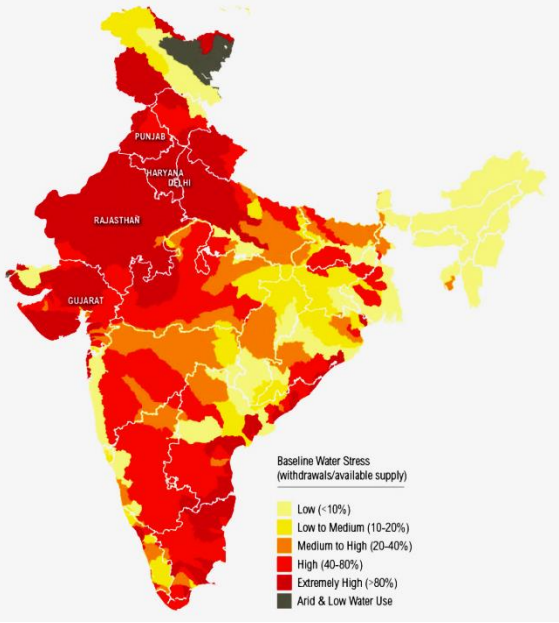
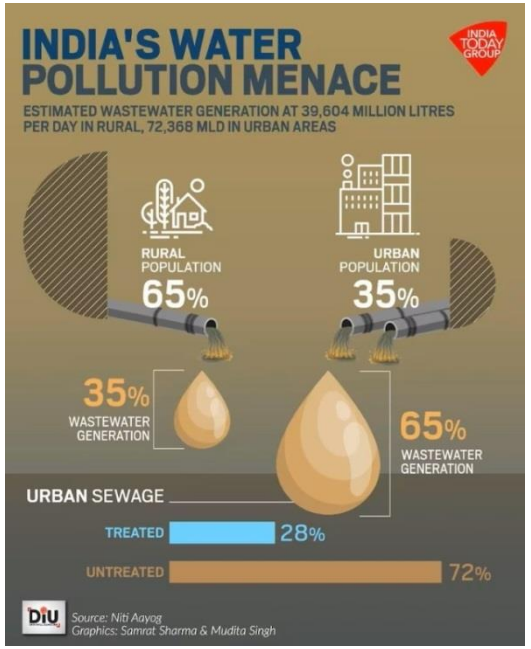
India Urbanization and Waste Water Scenario

Total utilizable water in India is about **1999.20 BCM** per year which translates to **1650.87 cu.m.** per person per year. This is expected to reduce to around **1228 cu.m per year by 2051** which is only slightly higher than the **Falkenmark Water Scarcity threshold** of 1000 cu.m. per person per year. *Central Water Commission, 2019*



- **From urban areas 72368 MLD** waste water is generated against which a **treatment capacity** of **31841 MLD is available**.
- Waste water generation from **54 million plus cities** is **23512 MLD** while operational STPs have a total capacity of **19266 MLD (81.7%).**
- **Recycled and reused wastewater** in million plus cities of India accounts for only **11,787 million litres per day (MLD)** or **17.71 %** of the total wastewater generated.

CPHEEO, 2021; Visanji et al., 2020, PIB, Ministry of Jal Shakti, Govt. of India 2021



India, at the 26th session of the United Nations Framework Convention on Climate Change (COP 26) in November, 2021, announced its target to achieve net zero by 2070. - *PIB, MOEFCC, Govt. of India, 2023*

Waste Water and Emission Mitigation: India

National Action Plan on Climate Change (NAPCC)

India's emission abatement strategies for water supply and wastewater systems focus on **reducing GHGs**—especially **CH_4, N_2O, and CO_2**—through technology, efficiency, and resource recovery. Key initiatives include:

- **Increase water-use efficiency by 20 % and Wastewater recycling & reuse**

National Framework for Safe Reuse of Treated Wastewater, released in early 2023 under the Ministry of Jal Shakti (via NMCG) Advocates -

- **Safe treated wastewater reuse**, integrated with AMRUT/Namami Gange, though implementation is state-wise
- **100% collection and treatment** of used water nation-wide
- **Reuse targets** in urban zones with sufficient treatment capacity:
  - **50% reuse** of treated wastewater by **2025**
  - **100% reuse** by **2030**
- **Urban Municipal Missions (AMRUT, SBM, etc.)** Set minimum reuse quotas:
  - AMRUT/Others call for 20% reuse in large towns and cities

These combined strategies—spanning demand management, tech adoption, infrastructure investment, and regulatory oversight— are not only expected to reduce CO_2, CH_4, and N_2O but also enhance water security and resilience, aligning India's water sector with broader net-zero goals.

While most of measures suggested for emission abatement include **technological solutions**, water sector also requires **inclusion of spatial planning measures** owing to its natural hydrological behaviour.

Assessing Spatial Variation in Water Supply

Need for the study

Wastewater generated in the city has a potential for reuse

But how to identify appropriate locations for reuse in absence of data?

Methodology

Population disaggregation using Dasymetric mapping

Urban Built form identification

Water Supply information from Local body

Results

Variation in water supply and wastewater identified on a finer scale.

Assessing Spatial Variation in Water Supply

Journal of Hydroinformatics

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Assessing spatial variation in water supply of a city using dasymetric mapping

Mrunmayi Wadwekar* and Manmohan Kapshe

Department of Architecture and Planning, Maulana Azad National Institute of Technology Bhopal, Bhopal, Madhya Pradesh, India
*Corresponding author. E-mail: ar.mrunmayi@gmail.com

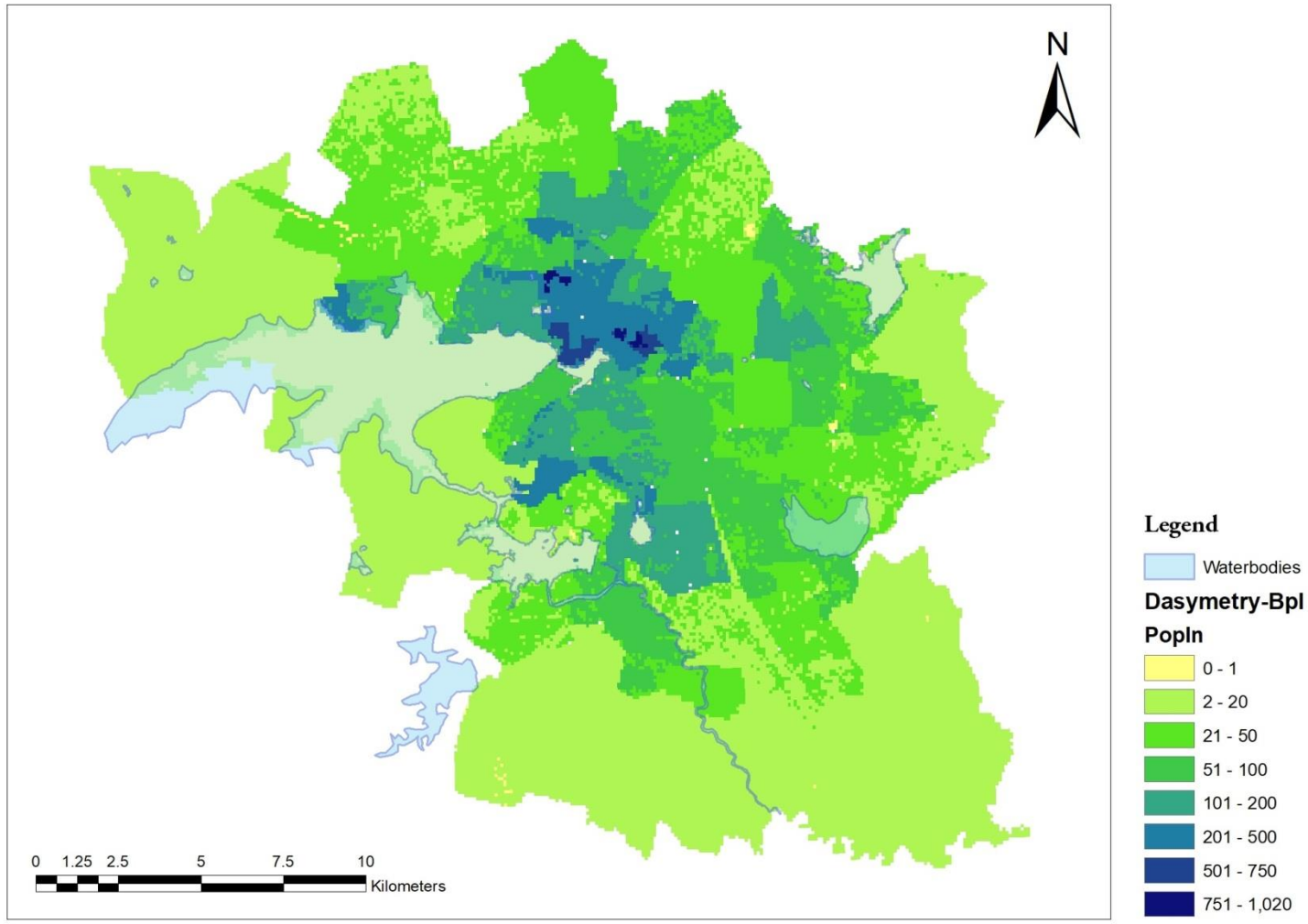
MW, 0000-0002-4814-9280; MK, 0000-0003-0555-8882

ABSTRACT

Wastewater has the potential to act as a supplement when freshwater resources are limited. To utilize this, city administrators need to identify the type and quantity of wastewater generated and its various functional uses. In countries like India, where detailed data about wastewater is not available, any potential reuse proposal is difficult to design and execute. To cover this gap, this research proposes a technique using dasymetric mapping and Voronoi diagrams to estimate the quantity and spatial distribution of wastewater generated in a city, based on population data and water supply information, by mapping and identifying the variation in the supply. The developed research framework is tested in Bhopal city in India. The results suggest that there is higher water consumption in areas of high population density, whereas wastewater generation displays a greater variation based on land use. Among 217 Voronoi polygons created throughout the city, eight have wastewater generation at more than 10 litres/sq. m of area. The total wastewater generated while considering only municipal water supply was 148.32 MLD. On intersecting the Voronoi polygons with ward boundaries, it is found that six wards generate wastewater more than 50 litres/sq. m, whereas seven wards generate less than 1 litre/sq. m of area.

- The study has identified a technique to **evaluate and assess spatial variation in water supply** services and wastewater generation.
- The process of water supply from extraction, treatment, distribution and wastewater collection and treatment is governed by **spatial elements of land use, built morphology, natural terrain and topography,** etc.
- These need to be included in our understanding of **flow of resources and energy** in line with the **principles of circularity.**

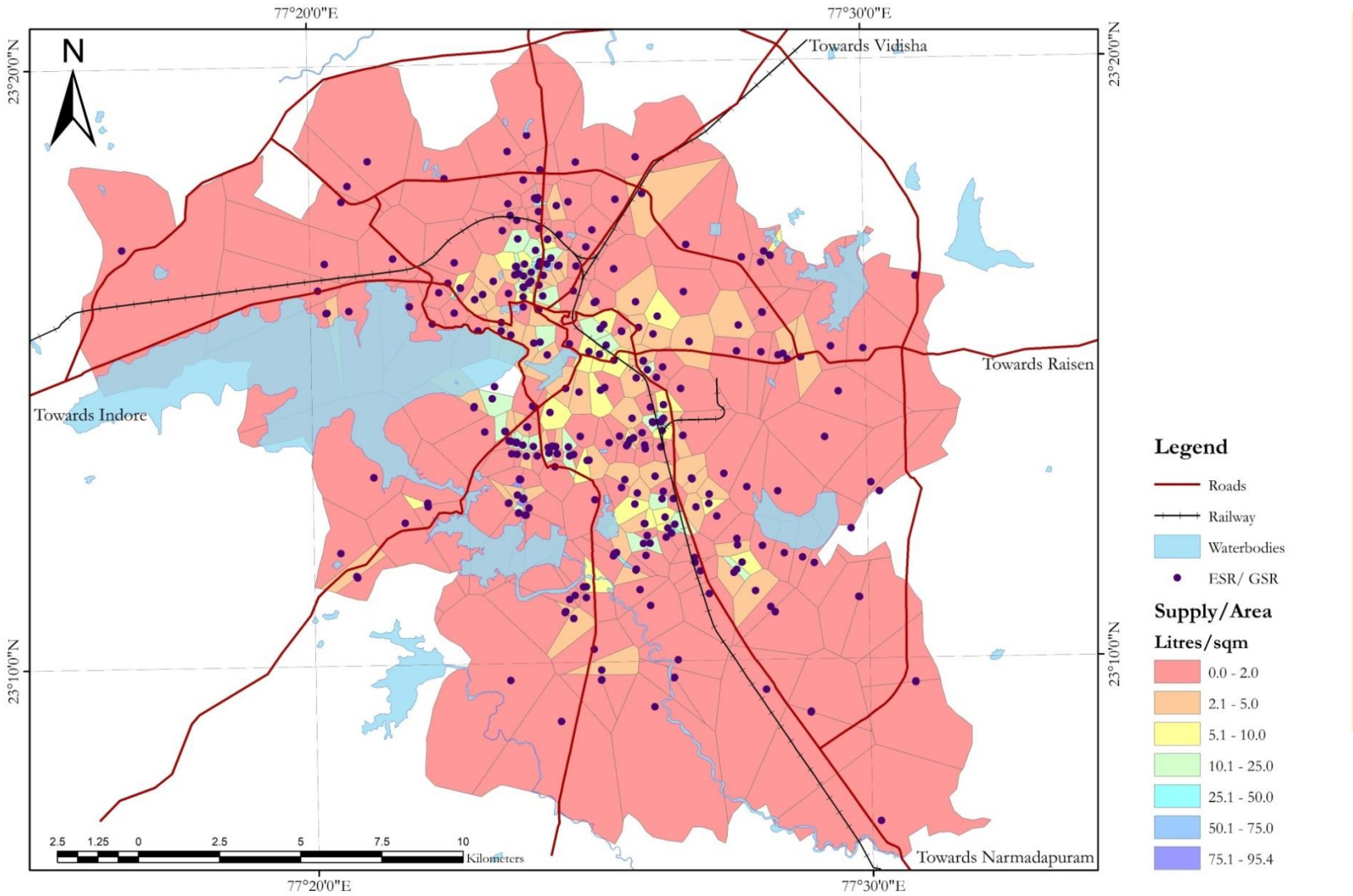
Assessing Spatial Variation in Water Supply



Dasymetry based Population map of Bhopal

- Dasymetry map was created for Bhopal city to **disaggregate the population** as per land use and evaluate the water consumption spatially.
- The Dasymetric map is helpful for administrators and planners to **understand the demographics of the urban area** in order to plan for municipal services.

Assessing Spatial Variation in Water Supply



Voronoi Mapping of Supply Reservoirs

- Voronoi diagramming was used for interpolating point level information (ESR/ GSR) to ward level information.
- A way of partitioning a plane into regions based on proximity to a set of points.
- It divides a space into areas where each area is closest to a particular point.

ESR/GSR – Elevated Surface Reservoir
GSR – Ground Surface Reservoir
Ward – Smallest administrative unit

Assessing Water Use Efficiency and Waste Water Reuse Potential

Wastewater reuse is a viable alternative towards reducing the demand for raw water resource

Needs a robust and detailed policy mechanism and the policy should be flexible towards different users and uses

- The study uses a temporal element to the water use performance indicators for an enhanced assessment.
- The urban water use efficiency of Bhopal is studied using performance indicators based on the principles of urban metabolism approach.
- Shortcomings in the existing water policies of India are identified.
- Measures that can be added to existing policies to promote wastewater reuse on the urban scale are proposed.

Assessing Water Use Efficiency and Waste Water Reuse Potential

Official Journal of the World Water Council
Water Policy

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Assessment of water-use efficiency for enhancing urban wastewater reuse – a case of Bhopal, India

Mrunmayi Wadwekar * and Manmohan Kapshe

Department of Architecture and Planning, Maulana Azad National Institute of Technology, Bhopal, India
*Corresponding author. E-mail: ar.mrunmayi@gmail.com

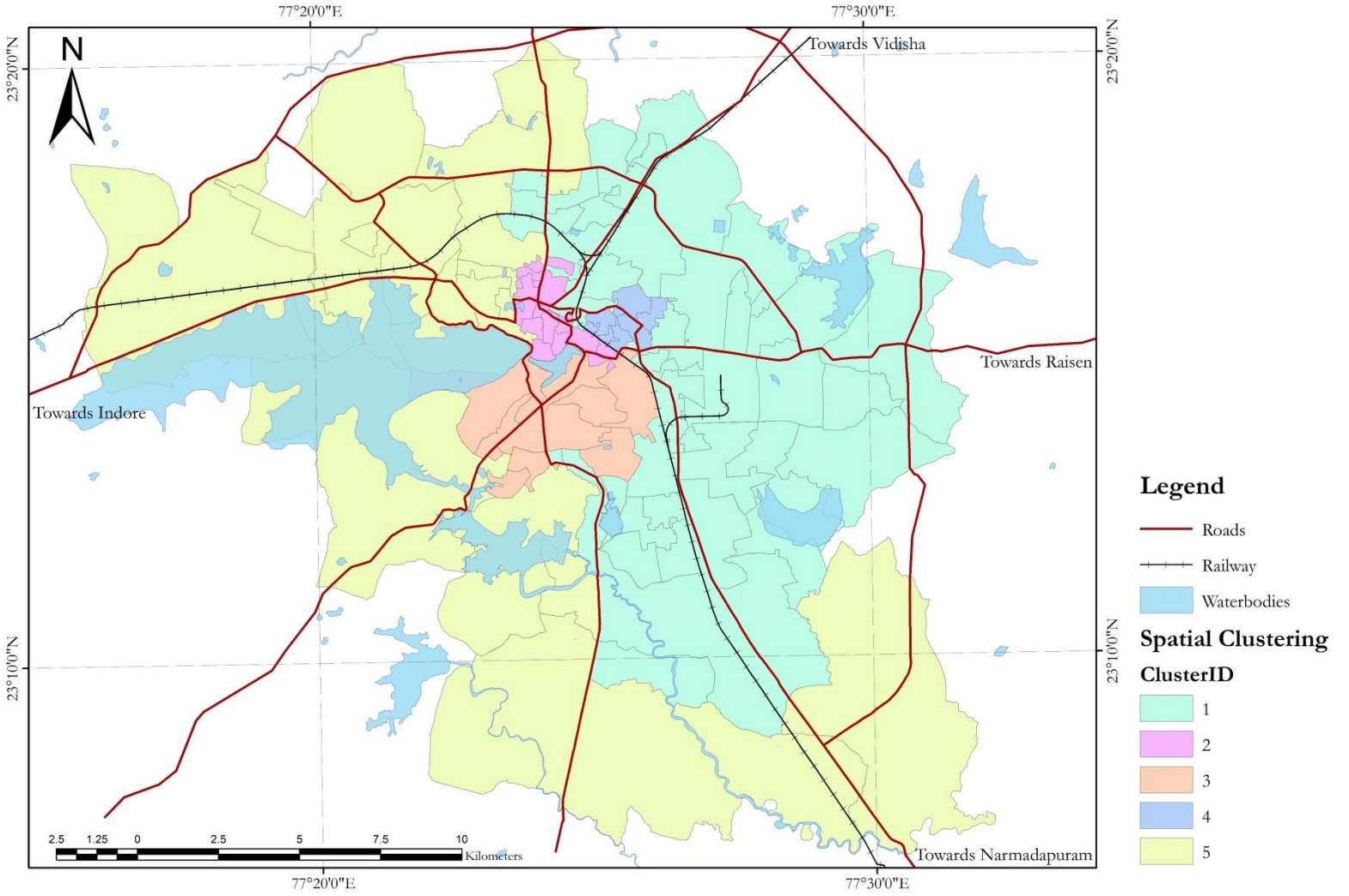
MW, 0000-0002-4814-9280; MK, 0000-0003-0555-8882

ABSTRACT

Wastewater reuse, a known alternative, lacks strong policy and institutional framework in India. There are various non-potable uses in urban areas that can be supplemented with treated wastewater for reducing the pressure on freshwater resources. The current policies in India promote use of treated wastewater for agricultural irrigation and industrial use, but they suggest no measures for reuse of the same in urban areas. The research aims to identify whether the water available in an urban area is used sufficiently and fulfils the needs of the city residents in a sustainable manner and advocates wastewater reuse as a possible option for improving its use efficiency. The study reviews the water-use efficiency of Bhopal city using performance indicators. The results suggest that Bhopal city receives enough supply for its needs; however, it is majorly dependent on its external resources. It is thus imperative that the city reuses its water efficiently and looks for wastewater as an alternative source. The research suggests a measurability framework for the local administration to set and identify targeted water use and reuse options within its periphery. The study also identifies certain shortcomings in existing policies and suggests measures to promote judicious reuse of wastewater in urban areas.

- This study analysed the city of Bhopal for its water use efficiency on three parameters based on **Urban Metabolism principles**.
- The concept suggests that the urban area can **improve its "metabolism"** by processing the resources better, thereby reducing the demand for the **"intake" of raw water** and reduce the quantity of "disposal" of wastewater.

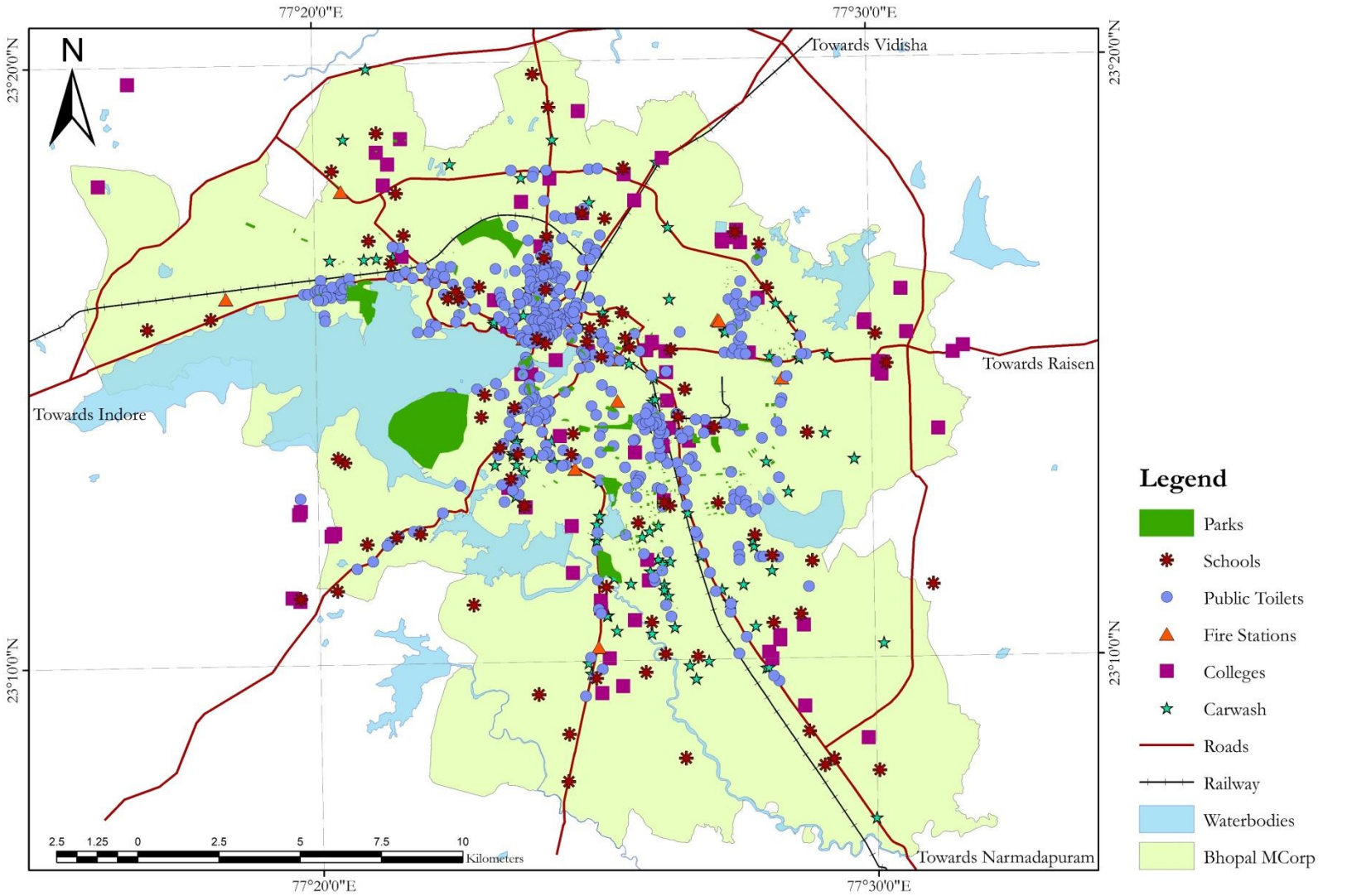
Assessing Water Use Efficiency and Waste Water Reuse Potential



Spatially Constrained Multivariate Clustering

- The study focused on **deriving clusters** of similar character where the treated wastewater can be reused for non potable purposes in accordance with the national policy.
- The identification of clusters was based on **SKATER algorithm** which uses physical, demographical and spatial planning parameters to isolate the clusters.

Assessing Water Use Efficiency and Waste Water Reuse Potential



Potential Users/Entities in Bhopal city

- The study mapped **Potential users and especially bulk user entities** such as Public Toilets, Schools and Colleges, Police Stations, Offices and Municipal parks were identified.

- These **user entities** can be supplied with treated wastewater for their **flushing needs, municipal irrigation, etc.**

Summary and Findings

The framework is focused on **spatially linking the wastewater generation with its usability**; in doing so, the framework has laid down a process which will help **locate the generation points/clusters with the end user/land uses** improving the water use efficiency.

The system identified in this framework is **scalable and flexible** to accommodate increasing population and change in land uses/ user entities as also the **upgradation of the physical infrastructure** of sewerage and septage management. The framework also keeps the **option open for converting to potable use** if need arises in future.

Treated wastewater is a **known alternative** which can be used for non-potable uses such as irrigation, industrial cooling, etc. It is an alternative source, especially in areas of water deficit.

Reclaimed water is a **trusted and reliable source with less or even no seasonal fluctuations** as compared to conventional water sources and their variability.

Policy initiatives should focus on identifying and assessing the **need to reuse** treated wastewater in the **immediate vicinity of the city** instead of deploying it for uses away from the city, thus **reducing its cost for transportation** and laying out of the **infrastructure**. A solution such as this will ensure that the **water is recirculated within the system at a faster and shorter pace** and may contribute directly and indirectly to GHG reduction.

Thank you..

For further details please contact -
kapshem@manit.ac.in, ar.mrunmayi@gmail.com