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Sustainable Water Management in Bengaluru City Using GIS Analysis

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ABSTRACT: Bangalore, the capital of Karnataka, stands as a pivotal hub for social, economic, cultural, administrative, educational, and political activities in the state, renowned for its moniker as the Garden City. The city has undergone significant demographic shifts, marked by a surge in population and substantial rural-to-urban migration, consequently influencing its urban structure. Presently, Bangalore grapples with various challenges, such as inadequate water supply, disparities in service distribution, transmission losses, the struggle between production costs and recovery, escalating groundwater usage leading to a decline in the water table, compromised water quality, and the emergence of water markets. The depletion of water resources is exacerbated by insufficient recharge, attributed to the prevalence of concrete and asphalt roads. Examining historical data reveals the transformation of Bangalore's landscape. In 1981, the city boasted a verdant environment, with settlements occupying 2.18%, agricultural land covering 19.43%, and water bodies accounting for 1.03%. However, by 2021, these figures shifted significantly, with settlements expanding to 40.61%, agricultural land diminishing to 5.38%, and water bodies declining to 0.82%. Projections for 2030 indicate further changes, with settlements anticipated to reach 55.87%, agricultural land decreasing to 3.32%, and water bodies shrinking to 0.71%. This evolving scenario underscores the critical need for effective water management strategies in Bangalore, necessitating comprehensive measures to address the city's growing water-related challenge

KEYWORDS: GIS analysis, Groundwater Recharge, Rainwater harvesting, Water Conservation, Demand Assessment

I. INTRODUCTION

Water is a very valuable resource sustaining human life, as of now the city presently has litres per day but needs 1680MLD more to meet its growing water needs. Groundwater has depleted 1240 out of 10,995 borewells are at risk of drying up due to poor monsoon impacting high density areas reliant on them. There are few Bangalore areas no water problem like Koramangala, Indiranagar, Kasthuri Nagar and more but many areas do experience water problems water is a very valuable resource sustaining human life Sustainable water management means using the water in a way that meets current, social, ecological, economic needs without compromising ability to meet those need in the future. Sustainable water management is the complex issue social, economical, And environment consequences. In essence everyone in the planate should have access to an adequate water resource for drinking, sanitation purposes, and other vital uses for sustaining the life.

II. RELATED WORK

The Bangalore Metropolitan Region (BMR) comprises Bangalore urban, Bangalore rural, and Ram nagara district. It extends between 12° 14' N to 13°35' N latitude and 77°05' E to 78° E longitude with a total area of 8005 sq. km. It lies in the south-eastern part of Karnataka state. It is surrounded by the Kolar district in the east, Tumkur and Chikkaballapura to the north, Mandya district to the West, and Chamarajanagar and Tamil Nadu to the south. It has an average elevation of 920 m with the highest point in Dodda betta Halli with a height of 962 m. It experiences a tropical climate with January being the driest month and October being the wettest month with an average rainfall of 147 mm, April being the warmest month recording an average of 26.6°C, and December recording the lowest temperature of an average of 20° C.

It is predominantly covered by red soil making it possible to grow crops such as millets, pulses, fruits, rice, oilseeds, bajra, and so on. The region doesn't have any major river system but a small tributary of river Kaveri, Arkavathi originating from Nandi Hills in Chikkaballapura flows through it and joins Kaveri near Meghdutt.

III. METHODOLOGY

Data Collection: Gather data on water resources, usage, and quality. Acquire satellite imagery, topographic maps, and climate data. Obtain information on land use, urban development, and infrastructure. Establish a comprehensive GIS database integrating all collected data Organize layers for hydrology, topography, land use, and infrastructure. Conduct spatial analysis to identify vulnerable areas, water stress points, and potential sources of contamination. Use GIS tools to assess the relationship between land use changes and water availability. Develop hydrological models using GIS to simulate water flow, runoff, and groundwater recharge. Evaluate the impact of urbanization on local hydrological cycles. Demand Assessment Analyse current and projected water demand using GIS. Consider population growth, industrial expansion, and climate change impacts.



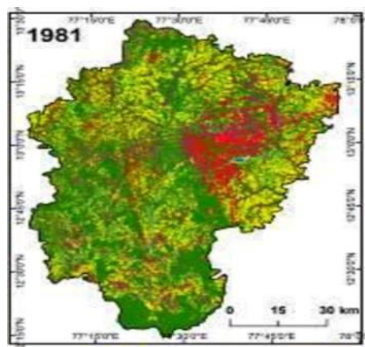
IV. EXPERIMENTAL RESULTS

Utilize data and technology, such as geographic information systems (GIS), showing figures.

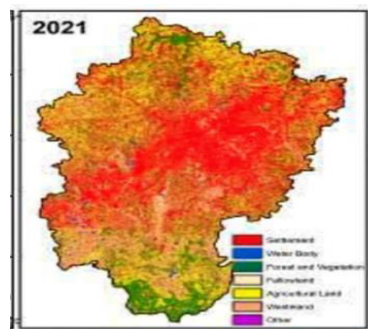
Land Use (LU) & Land Cover (LC) for year 1981

Land Use (LU) & Land Cover (LC) for year 2021

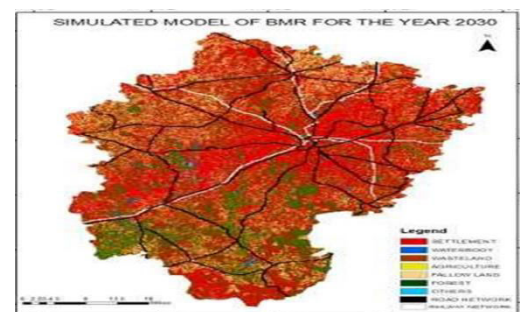
Land Use (LU) & Land Cover (LC) for year 2030 (Prediction)



(a)



(b)



(c)

Table-1: Utilize data and technology, such as geographic information systems (GIS)

LULC Class	1981		1991		2001		2011		2021		2030	
	Area (sq.km)	Area in %	Area (sq.km)	Area (%)	Area (sq.km)	Area in %	Area (sq.km)	Area in %	Area (sq.km)	Area in %	Area (sq.km)	Area in %
Settlement	174.66	2.18	156	1.95	1950.59	24.37	1954.95	24.45	3251	40.61	4472	55.87
Waterbody	81.76	1.03	14.68	0.18	94.4	1.18	94.69	1.18	65.54	0.82	57	0.71
Wasteland	622.91	7.78	1328.47	16.6	757.57	9.46	758.65	9.47	1233.13	15.41	287	3.59
Agriculture	1555.76	19.43	598.95	6.48	1088.93	13.61	1089.78	13.61	430.45	5.38	266	3.32



Fallow	3841.75	47.99	4956.94	60.67	2861.91	35.75	2858.66	35.71	1500.32	18.74	1123	14.03
Forest	1118.52	13.97	48.98	6.02	302.85	3.78	301.58	3.76	1405.85	17.56	1699	21.22
Others	609.64	7.62	647.98	8.1	948.75	11.85	946.69	11.82	118.71	1.48	101	1.26
Total area	8005	100	8005	100	8005	100	8005	100	8005	100	8005	100

The analysis of land use and land cover (LULC) classes in the BMR region reveals significant changes over the period from 1981 to 2021, as illustrated in Table 1 and in 1981, fallow land occupied the largest area (47.99%), followed by agriculture (19.43%) and forest (13.97%). Subsequent decades witnessed noteworthy shifts: 1991 marked a dominance of fallow land (60.67%), wasteland (16.6%), and agriculture (6.02%); 2001 exhibited peak areas under fallow land (35.75%), settlement (24.37%), and agriculture (13.61%). By 2011 fallow land (35.71%), settlement (24.45%), and agriculture (13.61%) retained their prominence. Notably, 2021, witnessed a substantial increase in settlement area (40.61%), fallow land (18.74%), and forest (17.56%). A discernible transition is evident in the agricultural and settlement classes. The transformation in agriculture is attributed to urbanization factors such as the expansion of commercial and residential spaces, the development of the metro line, and the widening of National Highway 209 (Varkey, 2019). Simultaneously, the surge in residential areas is driven by heightened demand due to in-migration, highlighting the dynamic interplay of urban development and demographic shifts in the region.

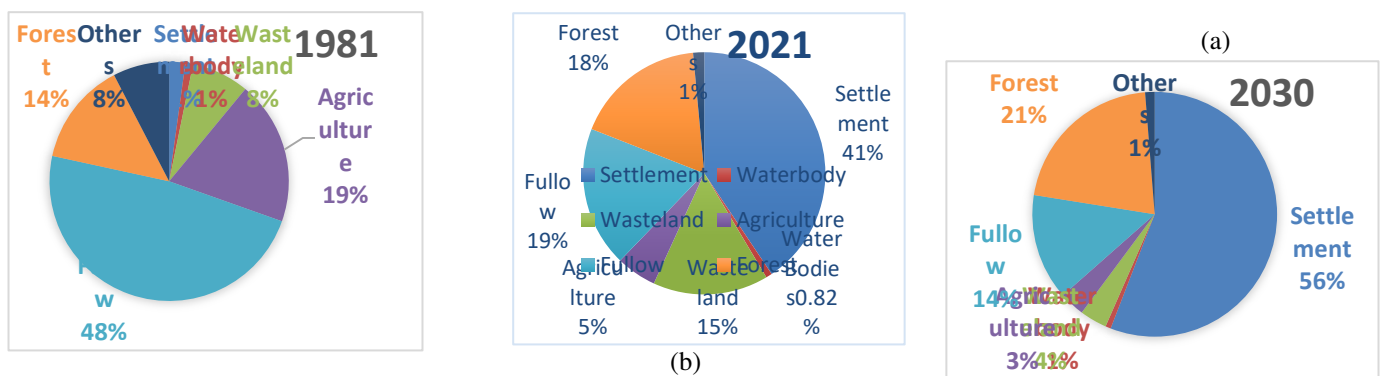
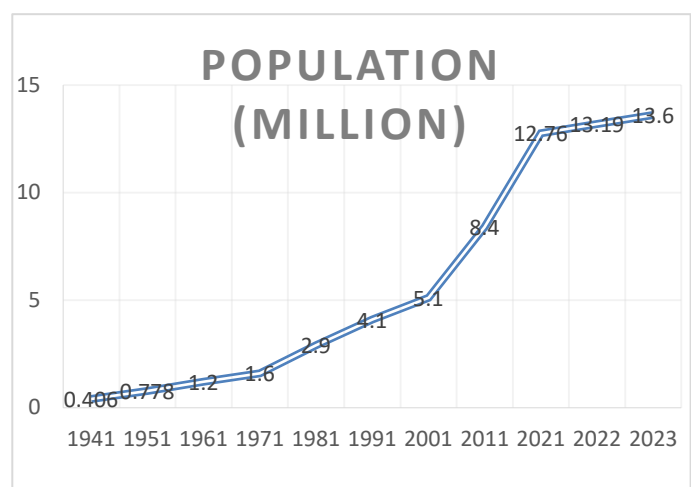


Table-2: Population Growth of Bengaluru city

Population (million)	
Census (year)	Population(million)
1941	0.406
1951	0.778
1961	1.2
1971	1.6
1981	2.9
1991	4.1
2001	5.1
2011	8.4
2021	12.76
2022	13.19
2023	13.6



WATER DEMAND AND SUPPLY

With a total population of 13.60 million as per the 2023 Census, situated at 12°58'44"N 77°35'30"E and spread across 741 sq.km (with 286 sq.mt in the core area and the remainder in the periphery), the Bangalore Water Supply and Sewerage Board (BWSSB) caters to the water needs of the populace. This includes providing 7.25 lakh water connections and approximately 15182 community taps designed to serve economically disadvantaged communities.

Despite the current water demand reaching 1342 MLD (calculated at 140 Liters per capita per day), the actual supply through the piped network stands at 950 MLD, resulting in a substantial shortfall of about 400 MLD. Consequently, the Board is currently able to provide an average of 110–120 Liters per capita per day to approximately 60% of the population.

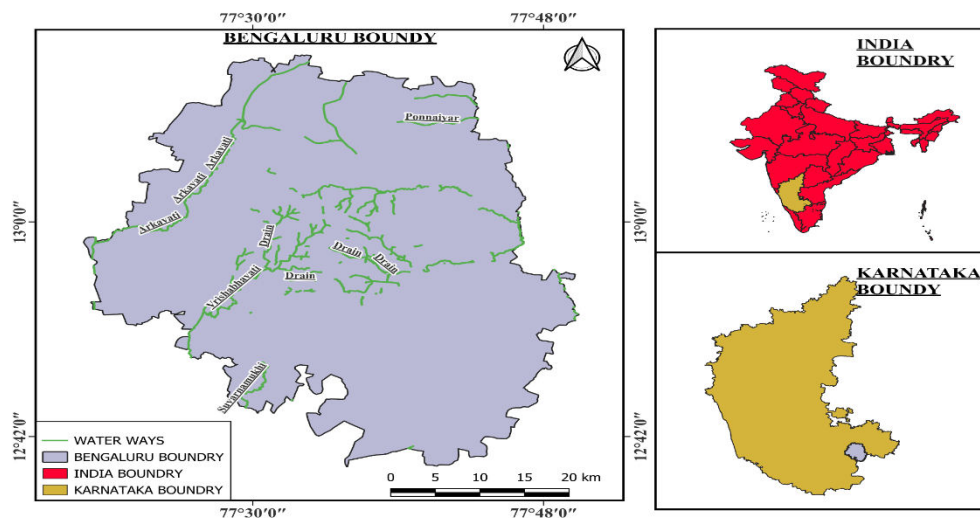
The distribution of water within Bengaluru is facilitated through a 5000 km network of pipes originating from 55 ground-level reservoirs and 47 overhead tanks dispersed across the city, collectively holding 616 MLD and 41 MLD of water, respectively. This piped supply is managed through.

COMPREHENSIVE PLAN FOR BENGALORE CITY

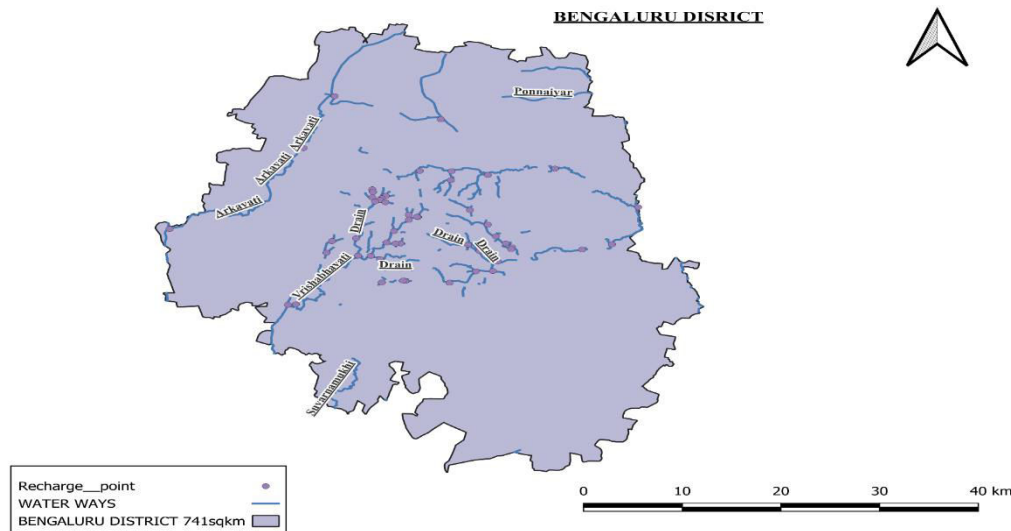


Bengaluru city's location being in the semi-arid peninsular plateau makes it naturally water scarce and does not have any source in the neighbourhood. The city's water sources include both surface water and ground water. Surface water is mostly from Cauvery River and a small portion comes from Arkavathi River.

WATER WAYS OF BENGALURU CITY USING (QGIS) SOFTWARE.



WATER WAYS WITH RECHARGE PITS INDICATIONS USING (QGIS) SOFTWARE.



(a)

RECHARGE PITS

A recharge pit, often referred to as a recharge well or infiltration pit, is a simple, effective method designed to enhance the recharge of groundwater.

Enhances Groundwater Recharge: Directly contributes to replenishing groundwater levels, which is especially crucial in areas facing groundwater depletion.

Reduces Surface Runoff: Helps in managing runoff during rainstorms, thus reducing erosion and the risk of flooding.

Improves Water Quality: The filtering action can improve the quality of the water infiltrating into the groundwater.

SOLUTIONS FOR THE FEASIBLE OPTIONS FOR SUSTAINABLE WATER SUPPLY

1. Roof top rain water harvesting
2. Usage of treated waste water
3. Rejuvenating lakes
4. Tree plantation can raise groundwater table in Bangalore city
5. Diversion of west flowing rivers

OUTCOMES

- GIS can be used to map and analyse the existing water sources in and around Bangalore, including lakes, rivers, and groundwater aquifers.
- Utilize GIS to analyse land use patterns and urban expansion to identify areas where development may impact water resources.
- Implement GIS-based on water quality monitoring systems to track pollution sources and identify areas with poor water quality.
- Utilize GIS to delineate and analyse watersheds to understand the flow of water across different areas.
- Develop adaptive strategies

V. CONCLUSION

In conclusion, employing GIS analysis for sustainable water management in Bangalore City is essential for addressing the growing challenges of population increase, changing land use patterns, and escalating demands on water resources. The integration of GIS technologies facilitates a comprehensive understanding of the spatial dynamics related to water availability, distribution, and usage patterns. Through this approach, decision-makers can develop targeted strategies to optimize water resource allocation, enhance conservation efforts, and implement efficient infrastructure development.



By adopting a sustainable water management plan supported by GIS analysis, Bangalore can mitigate water-related issues and ensure the long-term resilience of its water supply system in the face of urbanization and population growth.

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