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Geospatial Based Hybrid Water Supply and Sanitation System for Lakes in Hebbal Valley

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Abstract- Bangalore city receives uninterrupted and well distributed rainfall with an average rainfall of 970 mms annually. Rainwater harvesting involves low capital and transaction costs; besides it helps to reduce water stress of the city by over 20% in the future. Therefore, an integrated water resource management approach, combining water supply augmentation and demand management strategies is certain to improve economic efficiency of the city. In the present study Hybrid Water Supply System is proposed in Jakkur and Rachenahalli Lake sub watersheds. Sewage treatment with complete removal of nutrients and chemical contaminants can be achieved by adopting decentralized treatment plants similar to the success model (secondary treatment plant integrated with constructed wetlands and algae pond) at Jakkur lake. In addition to this, water available with efficient rainwater harvesting is about 14.8 TMC. This accounts to total of 30.85 TMC of water that is available annually would cater the demand of 20.05 TMC, provided the city administration opts for decentralized optimal water management.

Keywords- rainwater harvesting, Hybrid Water etc.

I. INTRODUCTION

As the world's population increases, water pollution becomes more complex and difficult to remove, and global climate change threatens to exacerbate water scarcity in many areas, the magnitude of this challenge is rapidly increasing.

Wastewater reuse is becoming a common necessity, even as a source of potable water, but our separate wastewater collection and water supply systems are not designed to accommodate this pressing need. Furthermore, the aging centralized water and wastewater infrastructure in the developed world faces growing demands to produce higher quality water using less energy and with lower treatment costs.

Hybrid water supply systems can be defined as systems provided for water services through a centralized water supply system in combination with decentralized water supply options such as rainwater tanks, storm water harvesting, and water reuse. These systems can be considered as part of a sustainable urban water management strategy whereby there is adoption of alternative water supply and wastewater management approaches while the predominant model of service remaining the centralized water supply system. The study brings out that there is sufficient water available in the region, but fails to understand the inability or ineffectiveness of the local administrators to sustainably manage the water resources in the region.

II. STUDY AREA

Jakkur Lake is located at latitude 13˚04' N and 77˚36' E and is located in North-East corner of Bangalore city at about 200 meters east of NH-4. Spread over an area of 65.05ha, the same is seen in SOI topo sheet No. 57 G/12 as shown in Map-4. This Lake is the main Lake in the chain of Lakes comprising Yelahanka Lake & Rachenahalli Lake, in the chain. Jakkur Lake is a seasonal Lake, it is independent of the entire system and receives water from storm and sewerage (dry weather flows) flow from the Jakkur village and the north of the Lake from Yelahanka Lake.

In the past, this Lake has been of irrigation importance to the surrounding agricultural fields. The major connectors to the Lake are from the Jakkur village, from Yelahanka village through Jakkur village and road from Sampigehalli connecting Jakkur village.

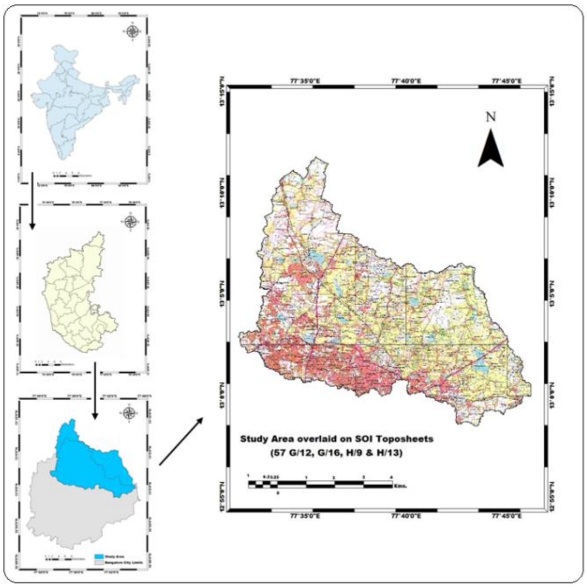

Fig 1. Map 1 - Study area.

III. JAKKUR LAKE SYSTEM AND PROFILE

The Lake system of Jakkur mainly covers Yelahanka Lake on the northern side and Allalasandra Lake on the western side. The lake is situated in a small valley with the Jakkur-Sampigehalli road as bund. The entire catchments area is about 81.7sq.km. The lake receives water from the runoffs of the surrounding area, which include developed (urbanized parts) and undeveloped parts such as fields, plantations.

Even though the catchment can extend to 81.7sq.km, it is constrained by the large urban developments, including the flyover over the rail, rail tracks and road developments. Today it is effectively around 19 sq. km that contributes to the runoffs. Rerouting of the storm water and disturbance of the terrain can reduce the effective catchment of the lake.

To analyze the macro and micro features surveys have been got conducted by BDA, electronic total station surveys were used to map the lake and immediate surrounds at scale of 1:1000 with 0.5m contours and block leveling at every 20m or wherever there are level changes.

The levels have been carried from the nearest Benchmark (BDA control points) so as to get the elevation to the mean sea level (MSL).

IV. METHODOLOGY

GIS application provides functions for development and preparation of accurate spatial digital information as input into data for the network design optimization model, which included network layout, connectivity, pipe characteristics and cost, pressure gradients, demand patterns, cost analysis, network routing and allocation.

The model illustrates, the methodology of creating WDN through GIS software, it is a set of Geo-database model objects with relations and behaviors for distribution network made of object classes, layers includes (polygons, lines and points) as shown in Flowchart.

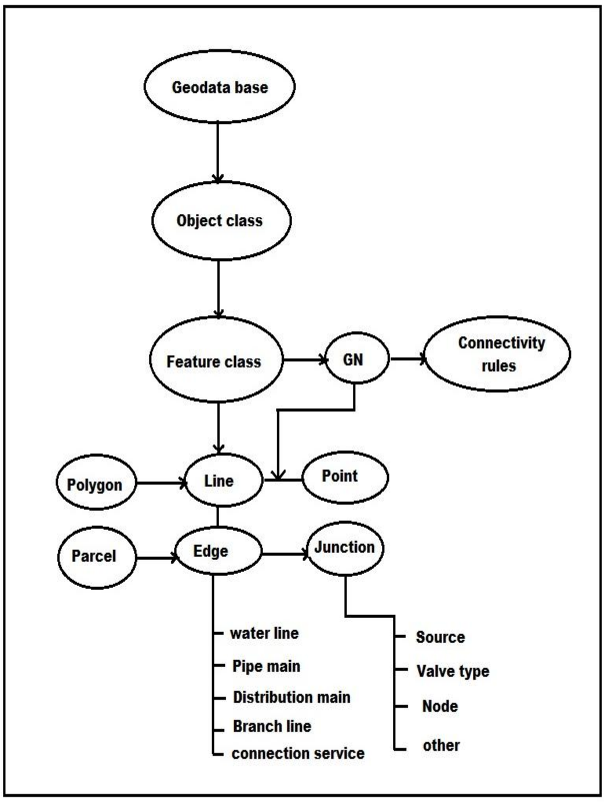

Fig 2. Flow chart of Distribution Network Analysis.

V. RESULT AND DISCUSSION

1. Water distribution Network:
To manage and control WDN we need to create Geo-database and knowledge-base in order to store water background data layers with features in ArcGIS and manage WDN. Therefore, GIS is comprehensive and multifunctional computer-based software being used in water transmission and distribution systems in modern and systematic water supply.

However, it is the best application to manage, manipulate and maintain geospatial data and to develop and sustain asset management for today's water utilities in worldwide. Though for the targeted area there was no previous data available on water supply, no distribution lines, and service connection information as well as with no service population and sewerage system network the entire situation is unmapped.

We have produced three hierarchical Geo-databases separately The Geo-database structures indicate main, geometric network and topology Geo-databases consisted of feature data sets. Water supply background data (vector data and raster data) collected from various source in the study area.

We designed a proper WDN created in GIS then imported to EPANET to be analyzed and simulated in order to approach the objectives and successful consequences.

In this study, we have considered two closed-loops of the network using two fundamental hydraulic principles such as continuity and energy conservation equations. The statement of this valuable method is first the sum of pipe flows into and out of a node equals the flow entering or leaving the system through each node applied to all pipes.

And second, the algebraic sum of pressure drops around a closed loop must be zero we applied it to all the nodes. Some of the given parameters include water demand at each node, diameter of pipe and pipe length as well as pressure at the first node and pipe roughness.

We need to find corrected water flows at pipes, this happens by reducing head loss around loops, finally we will also get the pressure at all nodes.

2. Distribution System and System of Supply:
For efficient distribution it is required that water should reach to every consumer with required rate of flow. Therefore, some pressure in pipe lines is necessary, which should force the water to reach at every place. Depending upon the methods of distribution, the distribution system is classified as Gravity system, pumping and Dual system.

The water may be supplied either continuously for 24 hours of the day or may be supplied intermittently only for the peak periods during morning and evening. The intermittent supply system may sometimes lead to some saving in water consumption due to losses occurring for lesser time and more vigilant use of water by consumers.

The intermittent supply system is largely employed in India. Map-4 and 7 shows the downstream area s of Jakkur lake and Rachenahalli lake for analysis and proposal of Hybrid water supply and sanitation network is analyzed.

VI. DESIGN PARAMETERS

In conventional sewerage system sewers are designed for the period of 30 years (CPHEEO, [2 1 4]) such long periods capture economy and maintains of sewer in low flow conditions. While in case of simplified and small bore this period is reduced and these can be designed for 10- 30 years.

1. Proportional depth of Flow:
This parameter is based on the properties of circular sections and expresses the ratio between the depth of flow in the pipe and the pipe diameter. It is used during the design to check if the depth of flow is high enough to ensure the transportation of solids at peak flow and if it is low enough to guarantee sufficient ventilation at the end of the design life.

Therefore, the minimum and maximum values for the proportional depth of flow (d/D) are: $0.2 < d/D < 0.8$

- Minimum depth of flow in pipe: 0.2 times pipe diameter
- Maximum depth of flow in pipe: 0.8 time pipe diameter

3. Minimum Gradient:
The necessary slope is required to move the solids. Design a sanitary sewer with a slope that achieves the specified minimum self-cleaning velocity for the

expected design flow. For pipe expected to flow at depths less than full use the peak design flow rate to establish a slope to achieve this velocity.

In conventional sewerage system the pipe is laden deeper for moving the solids.

- For a 2l/s peak flow slope should be 0.006 (CPHEEO, [214])
- For 30l/s the slope may reach up to the 0.001.

While in simplified sewerage system the minimum sewer gradient is (1/167) recommend for getting self cleansing velocity. Minimum sewer gradient is (1/225) recommended for tractive tension.

4. Velocity:
The velocity of the waste water is an important parameter in a sewer design. A velocity must be maintained to reduce solid deposition in the sewer. Minimum velocity for the conventional sewer is 0.6m/s (CPHEEO) while for simplified sewerage system the velocity 0.5m/s recommended.

5. Pipe Diameter:
The minimum pipe diameter recommended by the ten standards is 200mm these ten state standards are adopted by ten specific states (Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Wisconsin, and Illinois) 150 mm minimum pipe diameter is recommended in India (CPHEEO).

100mm is usually recommended as the minimum diameter for pipes applied in simplified sewerage designs. While for small bore this diameter is less than the 100mm. 75mm diameter pipe have been successfully used in Scandinavia. In these system solids are not transported these are previously settle.

6. Depth of Sewers:
Two parameters are mainly responsible for the shallow depth of the sewers: layout and gradient. In comparison with conventional systems, simplified sewerage layouts allow a reduction in the overall length of the sewer lines, which is especially true in backyard condominium layouts. The sewer gradient may be directly related to the flow velocity or to the shear stress.

In simplified sewerage system typical sewer depth are 0.6m below the sidewalk and 0.9 to 1.5 for the residential streets. The minimum cover criteria adopted will depend on local factors, in particular on the pipe material used.

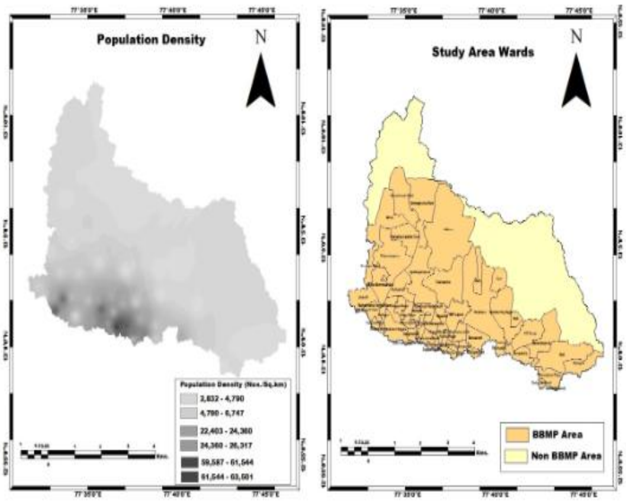

Fig 3. Map -2: Population Density. Map -3: BBMP and Non-BBMP area.

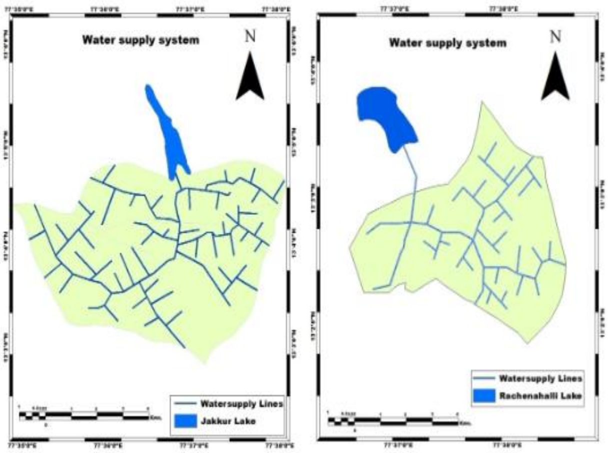

Fig 4. Map-4: Proposed Hybrid Water Supply Network in the downstream of Jakkur and Rachenahalli Lakes.

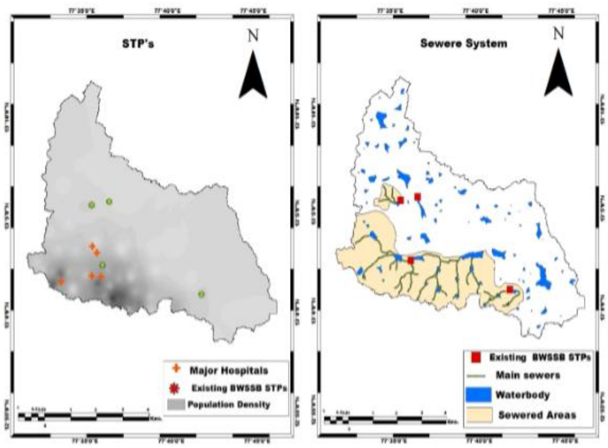

Fig 5. Map- 5: STPs. Map -6: Sewerage System.

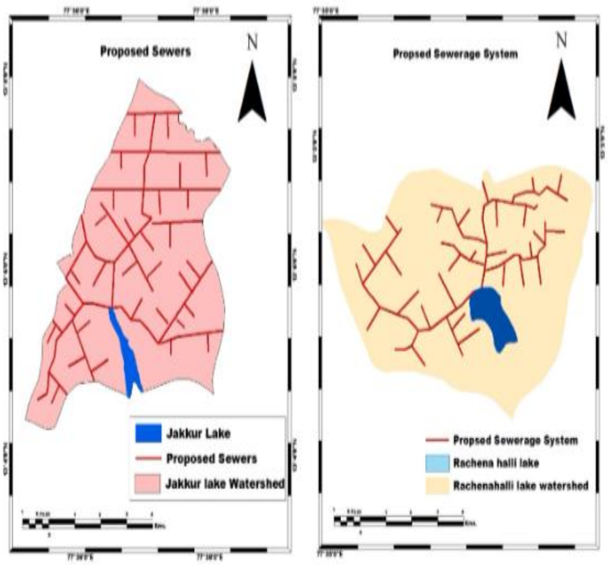

Fig 6. Map -7: Proposed Sewers Network in the downstream of Jakkur Lake and Rachenalli Lakes.

7. Sewer Network:

In conventional design layouts, trunk pipelines should be built in the streets around the house blocks to potentially allow individual connections for all the households. On the other hand, simplified systems are designed in a way that the wastewater from households in the same block is collected by a shallow and small diameter pipeline and then, delivered to the trunk sewers by a single (or just a few) connection as shown in Map-4, Hybrid sewerage system proposal in Jakkur and Rachenahall is shown in Map -7.

VII. CONCLUSION

In the present study Hybrid Water Supply System is proposed in Jakkur and Rachenahalli Lake sub watersheds. Sewage treatment with complete removal of nutrients and chemical contaminants can be achieved by adopting decentralized treatment plants similar to the success model (secondary treatment plant integrated with constructed wetlands and algae pond) at Jakkur lake. In addition to this, water available with efficient rainwater harvesting is about 14.8 TMC.

These accounts to total of 30.85 TMC of water that is available annually would cater the demand of 20.05. TMC, provided the city administration opts for decentralized optimal water management through; (i) Rainwater harvesting by rejuvenating lakes - the best option to harvest rain water is through interconnected lake systems, (ii) Treatment of sewage generated in households in each locality (opting the model functional since 2010 at Jakkur lake – STP (Sewage Treatment Plant) integrated with constructed wetlands and algal pond; (iii) Conservation of water by avoiding the pilferages (due to faulty distribution system); (iv) Ensuring water supply 24x7 and (v) Ensuring all sections of the society get equal quantity and quality of water. Rejuvenating lakes in the region helps in retaining the rain water.

Treating sewage and options to recycle and reuse would minimize the demand for water from outside the region.

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