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Original Article

Assessment of Spatio Temporal Changes in Landscape along Blue Green Infrastructure - Case of Bangalore City

S.N. Neetha[1], Mamatha P. Raj[2]

[1,2]*Architecture, BMS College of Architecture, Bengaluru, India.*

[1]*Corresponding Author : neetha.sn@bmsca.org*

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Abstract - *India is witnessing the highest rate of urbanization in this century. As per the 2011 census, 31.3 per cent of the country is urbanized, resulting in a change in the landscape of cities and changes in land use, causing the transition from a rural to a more urban society. As urbanization increases, it reflects the loss of vegetation, agricultural land, open space, etc. These changes in the landscape pattern significantly impact the existing ecology, like water networks and other ecosystems. An ecological layer is embedded in the urban area to support all the ecosystem services needed for the cities. This paper explores various ways to analyze the change in the landscape across different GI elements and its impact on the surrounding context in Bangalore city. GI elements in this paper refer to the town's Green Blue network like Nala and lakes and green buffer spaces along the lakes and nala. Change in the landscape is natural and inevitable. In the scenario of forced urbanization or unplanned growth, the shift in landscape patterns may adversely affect the GI elements and surrounding spaces. In the era of ever-growing cities and Globalization, it is crucial to study the diversity of GI elements and associated urban spaces to protect the characteristics of these elements and spaces. Bangalore has many essential, unique GI elements that are getting lost in urbanization.*

Keywords - *Urbanization, Water network, Valley system, Elements of green infrastructure, Spatio temporal variation.*

1. Introduction

Bangalore is the capital city of Karnataka, a state in India. This city has over five hundred years of history, which king Kempegowda founded in the 15th century. He built many lakes to support the city's water requirements. Some of the lakes constructed by him exist to this day. Bangalore's undulating topography has led to the formation of ridges, valleys, and many lakes and lake networks. Bangalore was well known for its gardens, lakes and salubrious climate.

2. Study of Valley Systems of Bangalore

Bangalore's natural water network is classified as three valley systems named Hebbal valley (area of 207 square kilometres), Koramangala – Challaghatta valley (The most significant area of 255 square kilometres), Vrishabhavati valley (area of 165square kilometres).

Koramangala – Challaghatta valley and Hebbal valley join at Nagondanahalli village (BBMP Ward 94 – Hagadur), which further flows to Dakshina Pinakini river. Vrishabhavati valley joins the Arkavathi river, a tributary of the river Cauvery. Inferences of studying valley systems of Bangalore: There are three major primary drains - Raja Kaluve defines three valley systems. The largest lakes of Bangalore, like Bellandur lake and Varthur lakes, are located along the primary drains. Secondary and tertiary drains are feeding the primary drains. Small water bodies are connected to the primary drain through secondary and tertiary drains. Dr. Shubha Avinash, a scientific officer in karnataka state natural disaster monitoring centre, in her research on Bangalore rainfall analysis, reveals that annual rainfall in central Bengaluru is significantly increasing at a rate of 1.558 mm/year. The study claims that stormwater drains of Bangalore are insufficient to carry rainwater to the lakes and rivers. In contrast, lakes and stormwater drains are encroached throughout Bangalore due to rapid urban growth.

2.1. Koramangala Challagatta Valley

This valley geographically falls in the south of Bangalore and has many essential lakes series like the Varthur lake series and the and Hulimavu lake series.

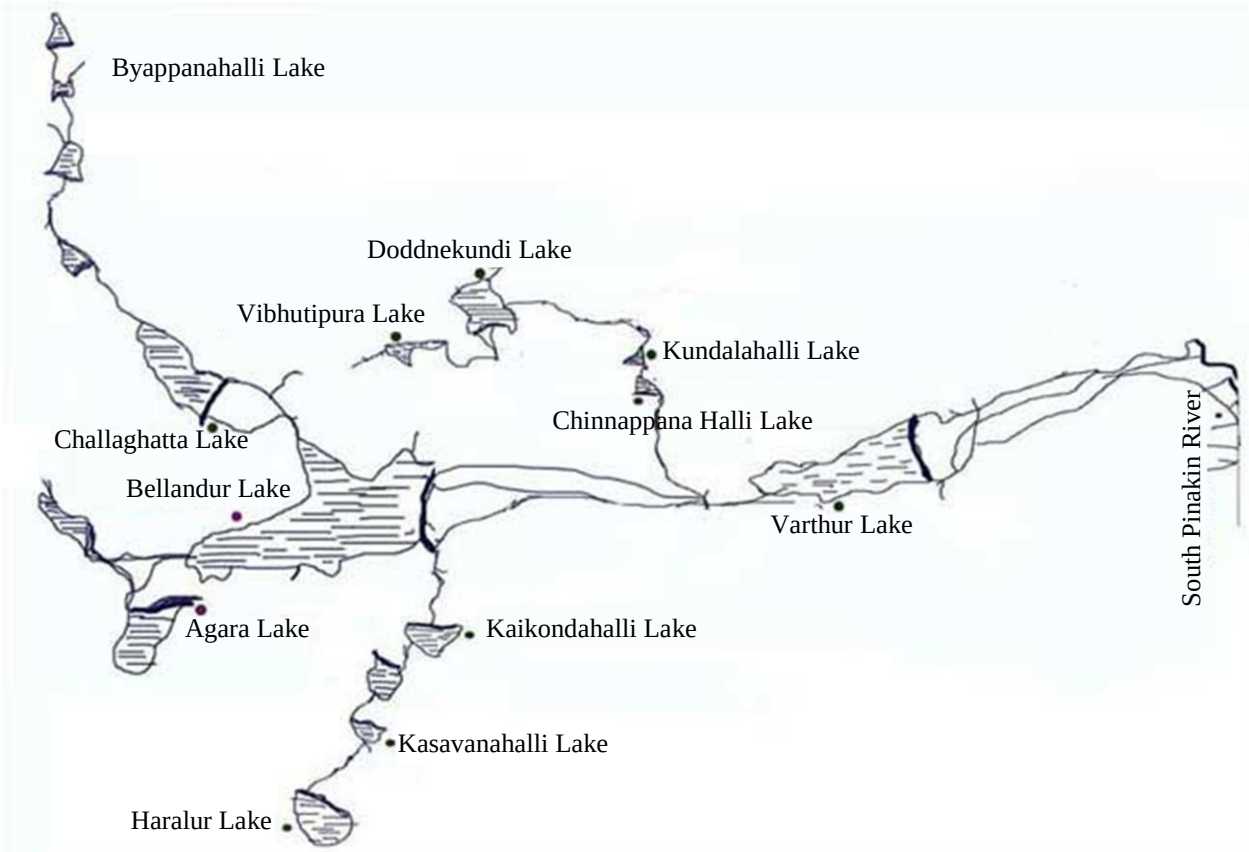

Fig. 1 Important lakes and valley system of koramangala challagatta valley
(Source: https://www.indiawaterportal.org/articles/lake-series-bangalore-maps-and-area-envis-govt-karnataka)

Important lakes are Bellandur lake, Varthur lake, Ulsoor lake, Agara lake, and Madivala lake. Bellandur and Varthur lakes are significant lakes of KC valley, each having an area of around 800 acres and 445 acres. A spatio-temporal study was done by using Google Earth by the author to understand the connectivity pattern between the lakes over many years.

around nala varies from 400m to 650m

Fig. 3 2015 - Nala connectivity is reducing due to new development along the Nala. Buffer around nala varies from 160m to 400m

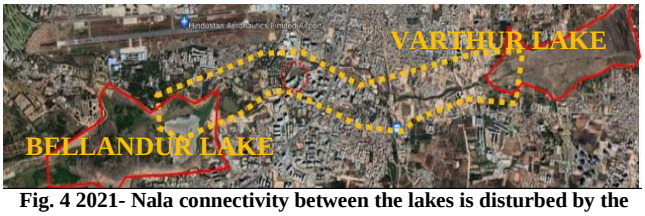

Fig. 4 2021- Nala connectivity between the lakes is disturbed by the buildings. Buffer around nala varies from 12m to 70m

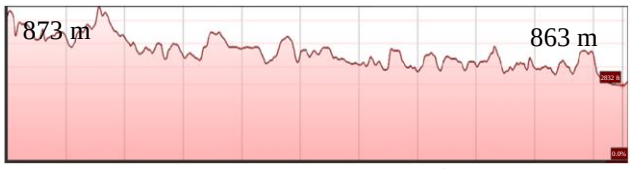

Fig. 5 Topography analysis - land slopes down from 879 m towards varthur lake to 863m
(Source: maps generated on google earth)

2.1.1. Inferences

The topography map shows Bellandur lake is at a higher level of 879m and Varthur lake is at 863 m; hence, the natural drainage system exists between the two lakes. After studying the spatiotemporal linkage variation between the lakes, it is evident that the natural approach is disturbed and vanishing due to urban growth.

2.2. Hebbal Valley

This valley geographically falls north of Bangalore and has important lakes like Yellammappachetty and Madavara. Hebbal lake, Jakkur lake, and Madavara lakes are some of the essential lakes present in this valley.

Primary drain connectivity can be seen between the lakes. Gradually, the connections are being lost due to urban growth.

Fig. 6 Topographical study between the lakes of Hebbal valley

Observations and Inferences in this valley: The approximate distance between lakes is around 1.5 km to 3 km. Ridge valley relation can be observed in the arrangement of lakes- 898 m to 891 m approximately.

Lake encroachment is minimal. Nala connectivity between lakes is under threat. Floods were reported at Hebbal valley due to encroachment of nala/drain connected to lakes.

2.3. Vrishabhavathi Valley

Vrishabhavathi valley geographically falls to the south and southwest of Bangalore city. One of the essential valleys, Vrishabhavathi valley, was chosen to study the issues and concerns in detail.

After reviewing the connectivity patterns of different nalas and lakes and the topography of the valley systems, one of the Nala was chosen to study the spatio-temporal pattern in detail.

2.3.1. Important Features of Vrishabhavathi Valley

Each valley system has many lakes connected lakes by Nala/Rajakaluve (Primary drain) secondary and tertiary drains. The unique feature of Vrishabhavathi valley is that all the gutters further connect to the Vrishabhavathi river (now turned into a sewage drain).

Vrishabhavathi river is the seasonal river of Bangalore, which origins at Bull temple, a small hillock next to Dodda Ganapathi temple in Basavanagudi, Bangalore South, due to which it is known as Vrishabhavathi river (Vrishabh meaning bull).

There is an inscription at the temple about the origin of the river at the right foot of bull.

Fig. 7 Bull temple where the Vrishabhavathi river originates

Unfortunately, there is no trace of the river or drain at this place, which is lost over time in the name of development. But the Vrishabhavathi river is seen flowing further down the valley 4 km away from this origin.

Lake series of Vrishabhavathi valley: Byramangala lake series, Madavara lake series (partial) important lakes - Hosakerehalli lake, Kempambudhi lake, Uttarahalli lake, Channasandra lake, Kommagatta lake.

The main spine of Vrishabhavathi valley runs along Mysore road. Mysore road divides the valley area into two parts – Southwest and West. Southwest part has predominantly residential land use - Basavanagudi, Girinagar, Banashankari, Hanumanth nagar, Srinagar, Rajarajeshwarinagar etc. The source/origin of the river lies in the SW Part as per scriptures.

West part has mixed land uses like residential, commercial, and industrial – Vijayanagar and Nagarbhavi (residential), Peenya (industrial), and Rajaji nagar (residential, commercial, and industrial).

A few lakes and Nala are selected for the detailed study to understand spatio-temporal variation. Most of the lakes and Nala are going through common issues. In the 1990s, lake and Nala buffer zones were visible. As the city developed, buffer zones disappeared.

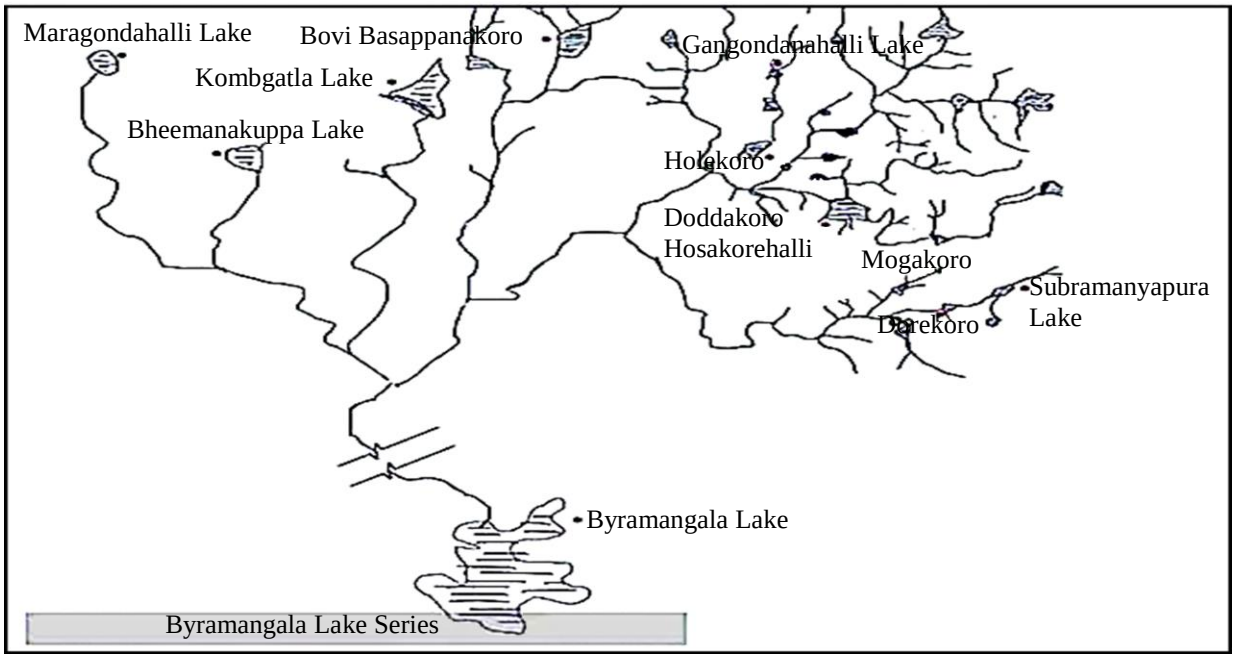

Fig. 8 Byramangala lake series

(Source: https://www.indiawaterportal.org/articles/lake-series-bangalore-maps-and-area-envis-govt-karnataka)

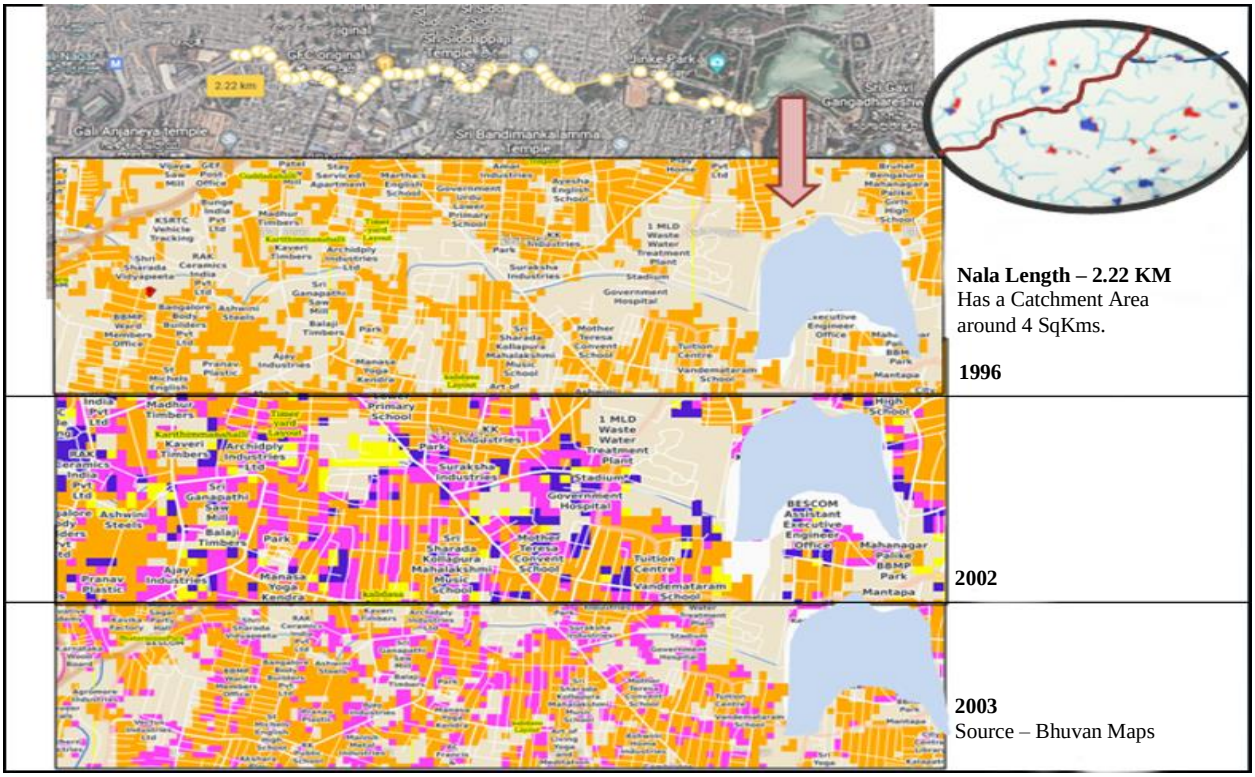

Fig. 9 Spatio temporal variation of nala 1 - spatio temporal variation along one of the important Nala/ Raja Kaluve in Vrishabhavathi valley

Fig. 10 Existing conditions of Nala at different points

3. Spatio Temporal Variation Study of a Lake and Its Network

Kempambudhi lake is one of the essential historical lakes present in the Vrishabhavathi river. It is connected through a Primary drain to other lakes and the Vishabhavathi river.

This lake and its network lie in the oldest neighbourhood. The case of this lake and network is taken to study the variation of Nala connection and buffer zones next to the lake and its nala. Figure 9 explains the diminishing and disappearance of Nala connectivity to the lake due to urban development, with a series of maps generated over the years 1996, 2002 and 2013.

The Nala shown in Figure 9 Connects from Kempambudhi Lake to Vrishabhavathi river at Gali Anjaneya Temple at the other end. The Nala length is 2.2 Km and has a catchment area of around four sq. km. The maps show that Urban development has affected the Nala width and buffer zone around the Nala over the years. Figure 10 explains Nala's situation: Nalas are covered and encroached on near private properties. In Nala, which flows next to the roads, buffer spaces are available but used for parking, garbage dumping, etc.

4. Conclusion

Green infrastructure elements which authorities and public neglect. The edges are used for parking and garbage dumping. Almost the same condition prevails throughout the nala. The open drains present in the area are helpful only for carrying sewage water. There is no proper channel for stormwater to enter the Nala.

Buffer zones are encroached. The concrete base of the Nala doesn't allow for stormwater recharge. Nala, which is present in the dense urban fabric, if treated well, can protect the drainage network and provide various ecosystem services like stormwater management, groundwater recharge, stop encroachments, recreation opportunities for citizens, etc. and can enhance the image of the surrounding wards and the city.

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