SPATIO TEMPORAL EFFECT OF URBANIZATION ON LAKES OF KOLHAPUR CITY – METHOD THROUGH GIS TECHNIQUE

Goal 06- Clean Water and Sanitation

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Abstract: -
The rapid urbanization and human settlements over the years has transformed the relationship between the natural parameters such as lakes and man-made parameters as settlement. Communities which were once dependent on these water bodies has now become less dependent, an abandon due to rapid urbanization. Kolhapur once known as **"City of Lakes"** in the 18th Century which had about 24 major and minor lakes in an around the city, now vanished and converted into residential, commercial, sports stadium, water park space. As urbanization is an unavoidable phenomenon introducing drastic change in the natural landscapes the paper focuses on 0. Also, the relationship between the surface water bodies and their surrounding land use changes are identified and analysed by remote sensing (RS) and geographic information system (GIS). On this basis, the loss of water bodies and growth of urbanization and their transformation are extracted and synthesised by change detection method. This missing gap followed by significance assessment would acts as an indicator for further prevention and restoration of lakes. Thus, the aim of the research paper is to understand and trace out the transformation of lakes and provide suggestion for architects, landscape architects and urban planners for restoration of urban lakes.

Keywords: -
Urbanization, Spatio temporal, remote sensing, GIS, change detection.

INTRODUCTION: -

Water bodies are one of the most prime elements responsible for environmental sustainability in an urban fabric. Since time immemorial ancient civilization or settlement developed around the water bodies. Same way even Kolhapur city developed around such water bodies. Formation of water bodies and Ecological Sustainability of any city depends upon various natural Parameters such Topography, Geology, Hydrology, catchment area watershed area etc. The natural undulating terrain of Kolhapur, with hills majorly surrounding at the south-west side with water flowing through valleys led to the formation of lakes which captures and store rain water. As Kolhapur city is known as princely state founded by Prince Chattrapati Shahu Maharaja built lakes which stored rain water mainly for irrigation and drinking purpose. During 8th or 9th century Earthquake occurred which gave rise to natural friction of earth and hence many water pools were been created in an around the city. Through the landform of valleys and ridges, seasonal streams briefly collected water into natural depressions.

WATER BODIES OF KOLHAPUR CITY: -

The topography of the city gave rise to construction of several pools in the city. These lakes were constructed at a lower elevation were all the surface runoff of the water from the hilly areas could drain into the tanks. Shahu Maharaj constructed these tanks in 18th century for the people of Kolhapur for drinking as well as agricultural purpose. An Marathi poet has aptly described Kolhapur thus – Kolhapur is situated in a pond of water wherein Ambabai lives in bunch of flowers. Hence, Kolhapur city was known as historical city of Lakes, city surrounded by lakes. These lakes formed a place of social interaction as well as served local livelihood and also biodiversity for various flora and fauna.

Today these lakes are facing numerous threats in the form of encroachments and pollution in the form of sewage, industrial effluents and garbage accumulation. In a city where it is blessed with number of water bodies like river and lakes which actually acts as sponges for collection of rain water are now in danger. This decline of surface water sources poses a risk to the future sustainability of the city.

Lakes of 18th century:-

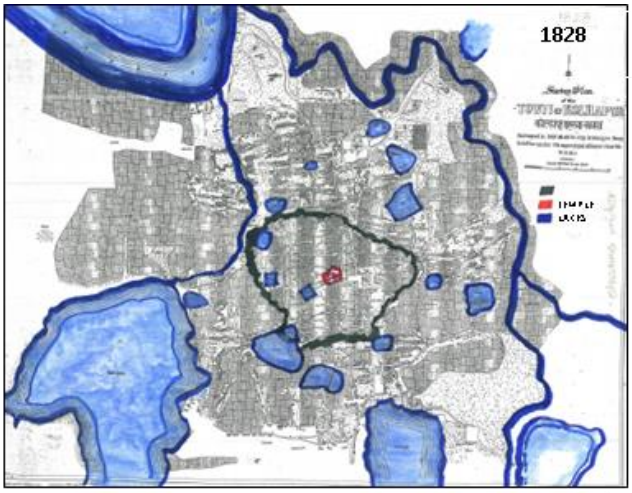


Fig 1. Old map of Kolhapur city showing Lakes in 18th century.

Fig 2. Map showing Topography and drainage basin of city.Source:- P.T.Malshe, Kolhapur study in urban geography.sketch by Author.

Research Problem: -

Development process has resulted in change in natural settings of Kolhapur city. Rapid urbanization over the years and growing construction activities has altered the topography and the drainage networks of the study area. This has resulted into loss of the stream channels and degradation of urban streams resulting into degradation and vanishing of lakes of Kolhapur city. It has been observed that many streams are getting polluted due to the development along the streams and dumping of garbage causing their disappearance from the city. Drainage networks have changed due to enormously growing impervious layer around Kolhapur city. However, not much study has been carried out to know the impact of urbanization on natural streams and changes in the urban sprawl over a period of time.

Therefore, the study entitled: ***"Impact of urbanization on urban lakes: Case of Kolhapur city". was looked upon as a case study.***

OBJECTIVES OF THE STUDY AREA: -

i. To understand the physiographical setting of Kolhapur city.
ii. To study and understand the importance of catchment, feeders in sustenance of the lake.
iii. To examine city's spatial-temporal changes in urban sprawl.
iv. To find out impact of urbanization on drainage network of the study area.

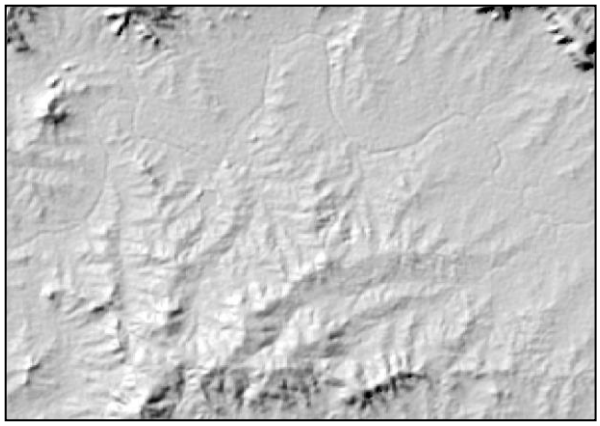
HYPOTHESIS :-

"Quality of catchment area and geomorphology of lake play an important role in sustenance of the lake".

Hence, through literature studies and the data it is understood that **urbanization** is growing rapidly all over in cities of India due to which many of the water bodies have been totally lost, some have shrunken in size, several lakes got polluted with the discharge of untreated domestic and industrial effluents some lakes are being reclaimed and are getting affected which results in the loss of carrying capacity of water in lakes and water channels getting affected due to the impervious layer in the catchment area resulting into degradation of lakes. It is also observed through literature studies that the catchment area and its quality play a vital role in sustenance of the lake.

PHYSIOGRAPHY OF KOLHAPUR CITY: -

Topography and soil have played a dominant role in the land use pattern of the city. Kolhapur city lies at a lower level due to its undulating elevations surrounded by all sides with hills. City and the plain surrounding it lies between two spurs, that emerge from the Sahyadris. Thick covering of basalt rock, which presents a step – like appearance. City is a typical example of the dominance of the physical features. It is full of ups and downs, with rocky terrains 745M at an higher end towards south-west and River Panchganga at 548M lower end towards North-east of the city. These two are the natural parameters also striking features of the city. These naturally undulating terrain of hills and valleys, led to development of lakes that can capture and store rainwater and also acts as sponges during floods in urban areas. The undulating topography has good potential of ground water development. The water emerging from ridges and valleys have been dammed at suitable locations and tanks are built for collection and storage of rainwater during monsoon which served the purpose of drinking as well as agriculture in Kolhapur city. "Kholla" means a river valley and therefore, Kolhapur means a town situated in low lying areas in the valley of rivers.



MARSAAC, Nagpur.

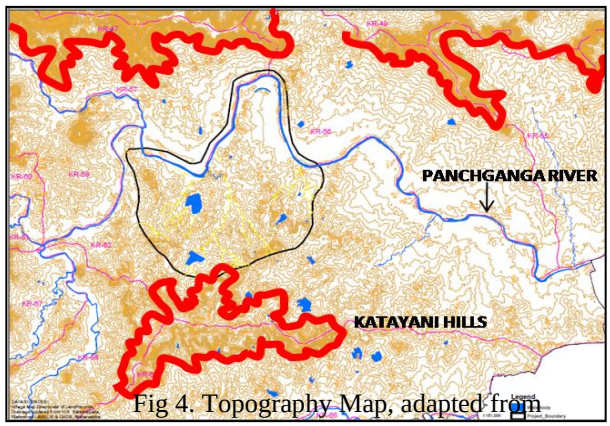


Fig 4. Topography Map, adapted from

MARSAAC, Nagpur.

Hence topography played an important role in formation of water bodies. Survival of lake depends upon the quality of catchment area ie the type of infrastructure along the lake edge also type of activities taking place Development is taking place towards the southern side as towards the river i.e. at lower end of the city towards north side as panchganaga river get flooded there's less development seen around the river. The development hence is growing towards the southern towards the ridge line.

METHODOLOGY: -

The paper attempts to understand the use of lake water from historical perspective and people dependent upon the lake as well as present details of the transformation of lake chronologically into a sports stadium. Both primary (Ground Truthing) as well as secondary data helped in understanding the transformation of lake to sports stadium.

Mix Methodology was used for the study-

In order to do this, geospatial methods with information from archival sources (Map of survey plan of town of Kolhapur, survey in year 1867-71) Survey of India top sheets, published in year 1930 along with recent images obtained from Google Earth year 2004 till 2019. These images and top sheets have been analysed on Geographic Information System (GIS) software to create maps that document changes in the landscape between these different time periods. The skeletal information provided by these maps is then supplemented with the government records archived in the Kolhapur Gazetteer also from the historical book "Kolhapurchya Paulkhuna" by Sakal publications. This method enables us to understand the changes in the landscape between different temporal periods and the existing situations.

Table No. (1):- **Research Design and Research Methodology :-**

Computed by researcher

Research Design	**Research Methodology**	**Details**
Type of Research	Preparation of Base Maps for Physiographic Determinism.	It is concerned with understanding the Physiography and geographical setting of Kolhapur city.
Nature of the Study	Qualitative Study	Focuses on qualitative methods based on scientific approach
Data Collection Approach	I) Primary Data	Ground truthing, Questionnaire, walk by observation, Informal discussions, experts opinion, Photographic survey, Activity mapping, condition mapping.
	II) Secondary Data	Data from various government offices, Archival records, Review of Literature, Historical Documents, Environmental status reports, geography thesis.
Data Collection	Preparations of Base Maps Overlay Maps and Questionnaire Design	Thematic Maps for Analysis Local Residents – Ground Thruthing to check availability of water
Analysis of Data	Software, GIS and satellite images, and statistical Tools	Microsoft Excel sheet for generating statistics and for preparation of pie charts and bar charts through findings.
Testing of Hypothesis	Statistical Tests and overlays of base maps	Correlation with the stream networks and impact of urbanization. Change detection method.

DRAINAGE BASIN AND URBAN CHANGE: -

To understand the spatial and temporal changes in the study area, analysis of impact of urbanization on stream network within municipal limits of Kolhapur city was carried out. The drainage network analysis of Kolhapur city area is adopted from Toposheet no. 47/L/1,47/L/2,47/L/5,47/L/6 shows the total number of stream orders and total number of stream lengths. Changes in the stream network over the period of years (1965, 2005, 2011, and 2019) were studied from various base maps prepared. SOI Topo sheets of scale (1:50,000) and satellite images and digital elevation model of these basins were used to understand the changes in the stream network over a period of year. Supervised classification of individual sub basins for the years 1965, 2005, 2011 and 2019 was carried out for change detection in the study area.

There was a need to understand the formation of the lakes in terms of their physiography and geohydrological linkages in order to ensure their ecological sustainability Physiographic determinism was employed as a tool to evaluate the extent of the negative impact on the environment, by superimposing the various physiographic features on the land use plans and simultaneously extracting and de-layering to establish the intrinsic suitability of land for various land uses. The study dealt with various aspects of natural features on one hand and developmental issues on the other. Extensive use of a Geographical Information System (GIS) is made for the analysis and information envisioning like producing an ecological base map of the area.

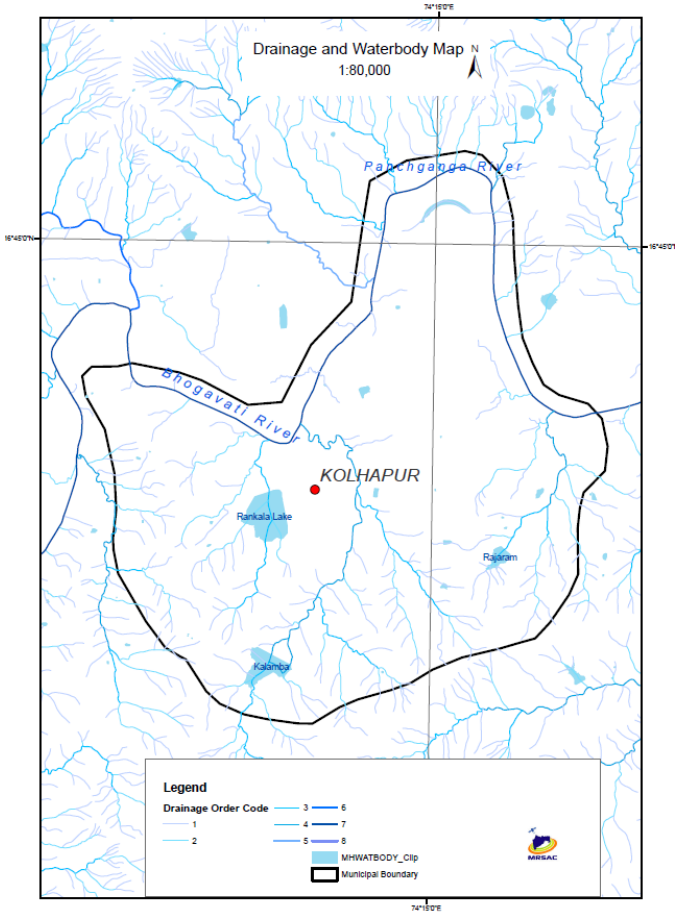


Fig 5. Map of Drainage basin and existing water bodies adapted from, MARSAAC, Nagpur.

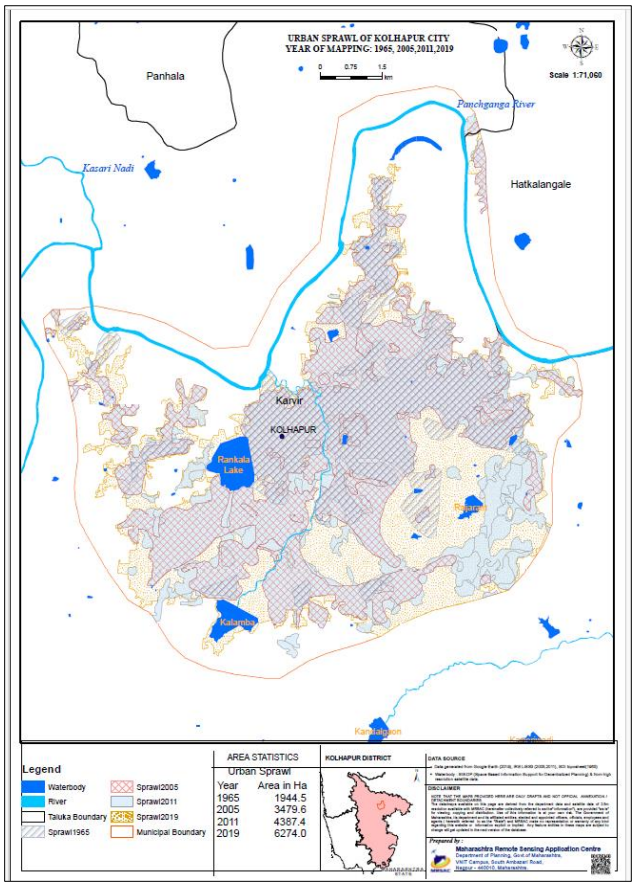


Fig 6. Change detection overlay of land use and drainage basin adapted from, MARSAAC, Nagpur.

Table No. (2):- **Urban sprawl of Kolhapur city :-**

Overall Urban Sprawl	Year	Total no. of Area in Hect.
Kolhapur Municipal Area	1965	1944.5
	2005	3479.6
	2011	4387.4
	2019	6274

In year 1965 the total area of Kolhapur city was 1944.5 hect, which increased to 3479.6 hect in year 2005, to 4387.4 hect in year 2011 and finally 6274 hect in year 2019. This showed the growth of urbanization and the impervious surface over a period of time.

Table No 3 : - Overall status of stream orders in year (1965, 2005, 2011, 2019) and urban sprawl of the city through change detection method.

Base Year- (Toposheet 1965, SRTM data DEM)				
Overall status of streams	**Year 1965**	**Stream Order**	**Total no. of Streams**	**Original Length of streams (Km)**
Kolhapur Municipal Area		1	164	107.96
		2	93	48.752
		3	39	23.55
		4	27	17.184
		5	2	3.94
		6	0	0
Panchganga River		**7**	1	23.747
			326	**225.133**

Note: - 6th order streams does not exists in municipal area, *7 th order stream is Panchganga River which is at the lower end of the city.

COMPARITIVE ANALYSIS CHART OF YEAR :- (1965 -2005 - 2011 - 2019)											
Overall status of streams	Year	Stream Order	Total no.of Streams	No.of streams Vanished	No.of streams Remaining	Original Length of streams (Km)	Total no.of Affected length of Streams (Km)	Existing length of streams remaining in (Km)	Vanished Length of streams (%)	Existing Stream (%)	Vanished no Stream (%)
Kolhapur Municipal Area	1965	1	164	15	149	107.96	11.41	96.55	10.56	90.85	9.14
	2005	1		62	102		38.87	69.09	36	62.19	37.8
	2011	1		87	77		53.27	54.69	49.34	47	53.04
	2019	1		121	43		74.002	33.96	68.56	26.21	73.8
TOTAL											
	1965	2	93	6	6	48.752	5.08	43.67	10.42	93.54	6.45
	2005	2		21	21		12.7	36.05	26.21	77.41	22.58
	2011	2		34	34		18.09	30.66	47	63.44	36.55
	2019	2		57	57		27.46	21.29	66.45	38.7	61.29
TOTAL											
	1965	3	39	5	34	23.55	3.5	20.05	14.86	87.17	12.82
	2005	3		15	24		7.71	15.84	32.73	61.53	38.46
	2011	3		20	19		11.055	12.5	47	48.71	51.28
	2019	3		29	10		15.659	7.9	66.45	25.64	74.35
TOTAL											
	1965	4	27	7	20	17.184	7.99	9.19	46.5	74.07	25.92
	2005	4		13	14		8.56	8.62	49.9	51.9	48.14
	2011	4		16	11		10.72	6.46	62.36	40.74	59.25
	2019	4		20	7		13.34	3.84	77.64	26	74.07
TOTAL											
	1965	7	1	0	1	23.747	1.06	22.68	4.46	100	0
	2005	7		0	1		1.06	22.68	4.46	100	0
	2011	7		0	1		1.4	22.34	5.9	100	0
	2019	7		0	1		3.923	19.82	16.52	100	0
TOTAL											
Note :- *5th order stream though existing in the municipal limit still not affected, 6th order stream does not exists in municipal area, 7th order stream is River Panchaganga.											

The study gave a brief idea of changes in the stream numbers, stream length, and stream percentage area is affected drastically due to urbanization which is threatening to physical and urban setup of the study area. This shows there is significant change in the length of streams of the present study area.

FINDINGS AND CONCLUSION:-

Hence, after analysing the data, results indicate the reduction in stream numbers and stream length over a period of time due construction activities and urban sprawl.

1) In year 1965 out of total number (326 nos.) of streams, total 33 no. of streams vanished, total 111 streams in year 2005, total 157 no. of streams vanished in year 2011 and total 227 no. of streams vanished in year 2019. Hence, Total no. of streams remaining out of (326 nos) in year 1965 only 293 streams existed, year 2005, 215 no of streams existed, year 2011, 169 no. of streams existed, whereas in year 2019, total 99 streams are existing.
2) Whereas, in year 1965 out of total length of stream (225.33 km), 29.04 km reduced in year 2005, 68.9km vanished, and in year 2011 total stream vanished 94.53km and 134.38 streams vanished in year 2019. Hence, total length of stream remaining in year 1965 is 196.08 km out of (225.133 km), in year 2005 total length of stream remaining is 156.22 km, in year 2011 total length of streams remaining 130.59km, in year 2019 total stream length remaining is 90.74 km.
   - Hence, overall, the total percentage of stream length affected increased gradually from year 1965, was 10.56% to 68.56% in year 2019.
   - The total no. of streams reduced during year 1965 out of 326 no of streams were only 15 no. of streams which increased to 227 nos and only 99 no. of streams are remaining.

   This shows the significance change in the stream number and stream length from year 1965 to 2019. The increase in the urban sprawl has resulted in decreasing of streams. The urban sprawl in year in 1965 was 1944.5 hect which increased upto 6274 hect in year 2019.

   i. Thus, hypothesis proved that *"**Quality of catchment area and geomorphology of lake play an important role in sustenance of the lake."***

CONCLUSION:-

- Present growth trend towards rapid urbanization and the increase in the land value has shown little regard to the importance of spatial planning concepts based on integrated ecological and hydrological patterns of the region.

- Encroachments to be restricted along the lake bed and buffer of plantation to be provided along the lake bed for percolation of water into the lake.
- The development towards the ecological sustainability and usability of the lake will have to be undertaken at regional as well as micro level stage.
- Since the lakes are now not fed by natural streams in their catchments, it is necessary that the storm water from the surrounding reaches the lake. But this storm water carries all impurities like dust, oil, grease etc. and hence small grease natural filters should be designed throughout along the storm water channels.
- Kolhapur Municipal Corporation should take initiative to revive the urban lakes and conserve this heritage asset for public use so that people feel connected and keep it integral for future generations.
- Comprehensive development policy plan should be prepared for understanding the geomorphology and importance of drainage networks and to integrate these aspects in the City Development Plan.
- Environmental department to regularly monitor the water quality of all the lakes, and wherever possible use of small techniques like bioremediation techniques, soils cape filters and Phyto-remediation techniques to be implemented for purification of lake water.

Hence to stop such type of situation there should be awareness created among the people and understanding of such situation exists and provision made in development plan for preservation and conservation of such type of natural assets.

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