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RECENT DECLINE IN WATER BODIES IN KOLKATA AND SURROUNDINGS

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Abstract: Every urban area needs water body to maintain ecological balance. Water body and wetland also reduce environmental pollution to a large extent. It is basically a part of urban hydrology. It provides valuable biotic community that directly or indirectly influences the lifestyle of man. But to run with the speed of urbanisation, these water bodies are shrinking in an alarming rate. Nowadays, it is a very common phenomena for most of the megacities in the world. Kolkata and its surroundings is one of the fastest growing megacities, affected greatly by the changing land use and land cover pattern since last few years. Area under wetland and water bodies are being rapidly replaced by the newly developed commercial or residential land. The present study tries to delineate the loss of urban water bodies in Kolkata Metropolitan Area. Here, quadrant-wise buffer zone has been generated around the main city and with the help of the orientation of mean center of urban water bodies; directional change has been assessed from the city centre using sophisticated geoinformatics techniques. The current study concludes that rapid urbanisation is engulfing the traditional water bodies at very high rate in Kolkata and its surrounding buffer zones.
Keywords: Buffer Zone, Geoinformatics, Megacity, Urbanisation.

INTRODUCTION

Water bodies are indispensable for existence mainly in the interior parts of an urban area. To ascertain our observation, Kolkata city and its surrounding places has been considered for the study. Basically, the areal difference of water body with time has been observed. It is clear from the recent work that the area under urban water body has reduced in a large scale during last decade. It is mainly because of the development of the new high rise buildings, commercial complexes, multiplex, shopping malls, educational-cum-residential plots, and for the purpose of getting new lands for agricultural use. The main objective of this study is to examine the areal change in the urban water body in Kolkata metropolitan and its surroundings. Effort has also been made to observe the direction-wise sectoral change around the Kolkata metropolis. Previously, several works have been done on this context. Xiaohui Yuan Sarma, V. (2011) who has taken an attempt on identifying hydrological features for urban planning and disaster management. Besides, Daya Sagar B.S., (2000) tried to get similarity between the probability distributions obtained from a data set that contains a large

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number of randomly situated surface water bodies and the probability distributions estimated by binomial multiplicative process. Moreover, Nagabhatla et al.,(2008) tried to apply geospatial tool to monitor changes in a micro-tidal estuary for the purpose of management planning. Hui F. et al., (2008) tried to make model to show spatio-temporal change of Poyang Lake using multi-temporal satellite imagery.

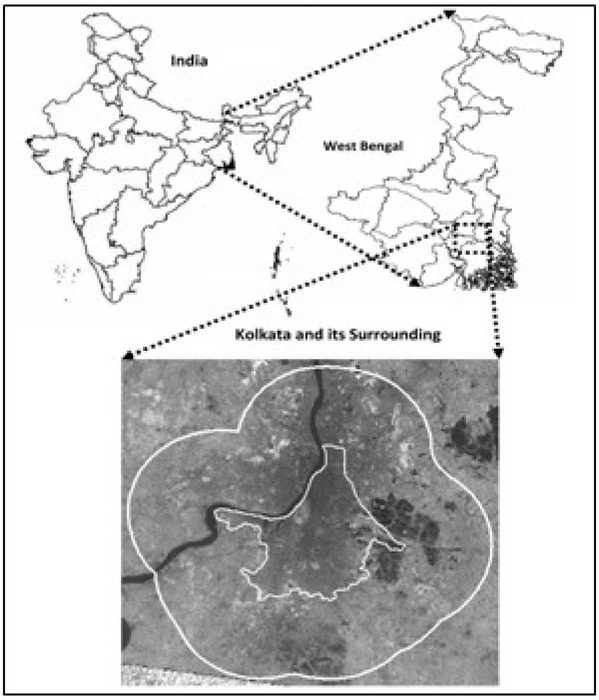


Fig.1: Location map of the study area

Kolkata metropolitan region and its surrounding places are selected as study area for this work. Initially, the administrative boundary of Kolkata city has been digitized and five buffer zones of 2km width are generated around the city. Hence, a total of 10 km width buffer zone including the Kolkata city has been identified to restrict the change within the buffer (Fig.1). An attempt has also been made to get a comparative assessment of this region on the basis of four quadrants namely north-east, north-west, south-east and south-west. Hence, there are twenty four sectors (four quadrants x six zones) available for this study. The Kolkata city covers an area of 87.31 km^2 and lies between $22^0$25'00"N to $22^0$37'02"N latitude and $88^0$14'02"E to $88^0$27'04"E longitude. The total study area including 10 km buffer area around Kolkata city extends from $22^0$21'04"N to $22^0$43'01"N latitude and from $88^0$09'00"E to $88^0$33'00"E longitude. Very recently, people in the city are facing severe water scarcity.

MATERIALS AND METHOS

In order to estimate the change in the existing water bodies in Kolkata and its surroundings satellite images of the last four decades have been used. Landsat MSS image of 17/01/1973;

Landsat TM image of 14/11/1990; Landsat ETM+ image of 17/11/2000 Landsat TM5 image of 21/01/2010 have been considered for this study. Besides these images, Survey of India (SOI) topographical sheets numbering 79B/2, 79B/3, 79B/6, 79B/7, 79B/10 and 79B/11 have also been used as reference maps. The approach and methodology used in the study has been presented in Fig.2. At first, 1973, 1990, 2000 and 2010 images have been corrected geometrically and radiometrically. The next step is to generate 10 km buffer zone around the Kolkata city. This 10 km buffer zone is further sub-divided into five equal parts, each with 2 km buffer. Then, the whole study area is divided into four quadrants viz. north-east, north-west, south-east and south-west. After that, four mean center maps are created, each of which represents a single quadrant for four different years. Finally, the water density maps are generated for northern and southern quadrants.

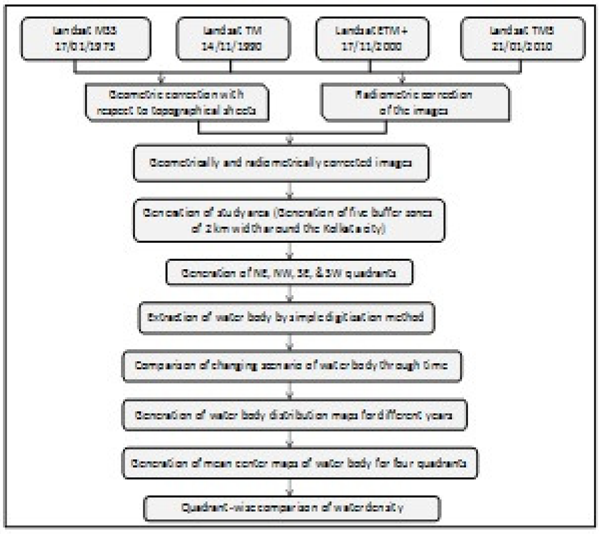


Fig.2: Flow Chart showing Methodology

RESULTS AND DISCUSSION

Quadrant-Wise Sector Based Study

In the present study, the central point of Kolkata is marked and on the basis of this central point four quadrants have been prepared along the four directions namely north-east, north-west, south-east and south-west. Each and every quadrant has six sub-divisions. So, a total of 24 sectors (4 quadrants x 6 sub-divisions) have been found for this study area. All the water bodies for each and every sector have been identified and evaluated separately (Fig.3).

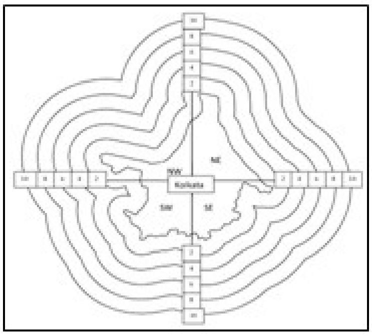


Fig.3. Quadrant-Wise Sectoral Divisions of Study Area (24 sectors)

4.2. Temporal Changes of Surface Water Bodies

Fig.4 presents the changed scenario of surface water bodies with respect to all the quadrants. The 2 km and 4 km buffer zones of north-east quadrant have more area of water body than the other buffer zones. After the 4 km buffer sector, the area under water body has gradually decreased with increasing distance. This scenario is similar in all the years considered in the study.

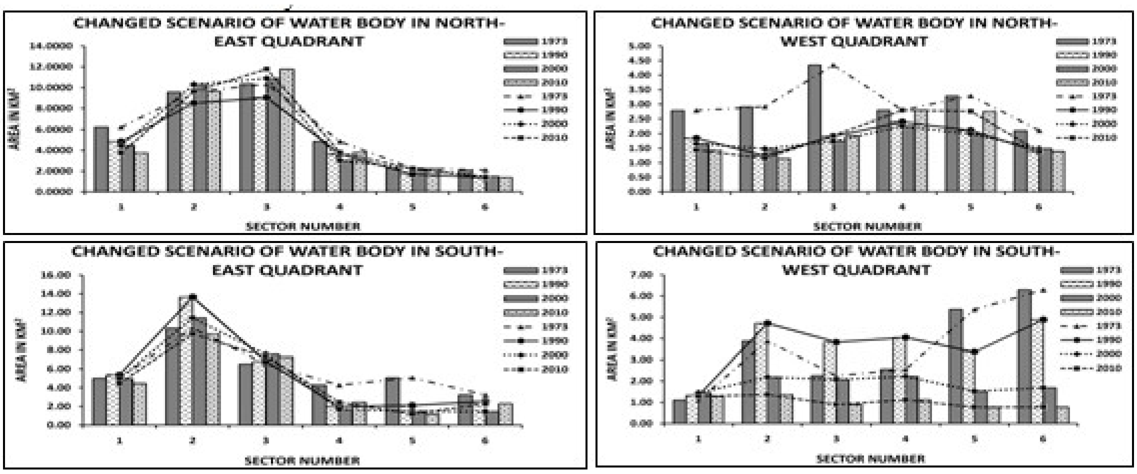


Fig.4: Sector-Wise Changed Scenario of Water Bodies in Four Quadrants

For north-west quadrant, the year 1973 indicates the maximum area under water body. Normally, the trend decreases in terms of area from 1973 onwards. But, to our surprise the picture is different for 4 km, 6 km and 8 km buffer zones. Here, the area under water body in the year 2010 has increased as it was from the year 2000 though marginally. As noticed from the south-east quadrant, maximum concentration of water bodies is seen in 2 km buffer area followed by the area in buffer zone 3 and 2. The design of the line profile of the concentration of water body is slightly winding. In north-west quadrant, almost straight line is found for 2000 and 2010, that means the sector-wise area under water body in this particular quadrant is more or less same for the aforesaid years.

Distribution and Location of Water Bodies in Different Years

Fig.5 shows the quadrant-wise distribution of water bodies in the year of 1973. Maximum concentration of water bodies is noticed in the eastern portion of the study area. In the north-eastern quadrant, maximum concentration of water bodies is found in the 2 km and 4 km buffer zones. The map depicts that with respect to south-east quadrant, most of the water bodies are situated in 2 km buffer sector. Besides this, the concentration of water bodies is shown in the south-western corner of south-east quadrant. In the south-western quadrant, water bodies are agglomerated mainly in 8 km and 10 km buffer zones. In the north-western quadrant, water bodies are more evenly distributed in comparison to other quadrants. Regarding the distribution of water bodies in the year of 1990, the scenario has changed a little from 1973. Major concentration of water bodies remains almost unchanged in north-east and south-east quadrants. In the south-western corner of south-east quadrant, the water bodies which existed in 1973 are absent in 1990. In the south-west quadrant, the numbers of small water bodies have increased in comparison to 1973. The locational distribution of water bodies in north-west quadrant remains almost unchanged. The water body concentration in the year 2000 depicts that southern part of north-east quadrant covers maximum area under water bodies and it falls under eastern part of Kolkata, its 2 km and 4 km buffer zones. The northern part of south-east quadrant also shows the maximum concentration of water bodies. In case of the south-west and north-west quadrants, the area under water body is more in the periphery region from the main city. Distribution of water bodies, as shown in Fig.5 indicates that southern portion of north-east quadrant and northern portion of south-east quadrant are under the maximum concentration of water bodies. In case of the western part, the outer buffer zones have more concentration compared to the inner buffer zones with respect to water body.

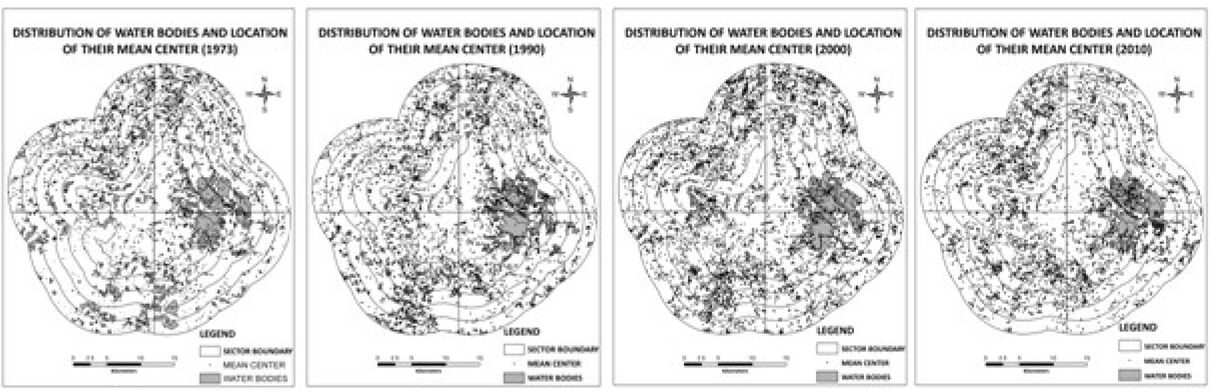


Fig.5: Sector-wise distribution of water bodies in the study area (1973, 1990, 2000, 2010)

Comparison of mean center within sectors in different years

The distributional pattern of water body concentration is analyzed by applying mean center technique. Basically, mean center is the point on which a rigid, weightless map would balance perfectly. Fig. 6 shows the location of mean center of water bodies in north-east, north-west, south-east and south-west quadrant for all the years.

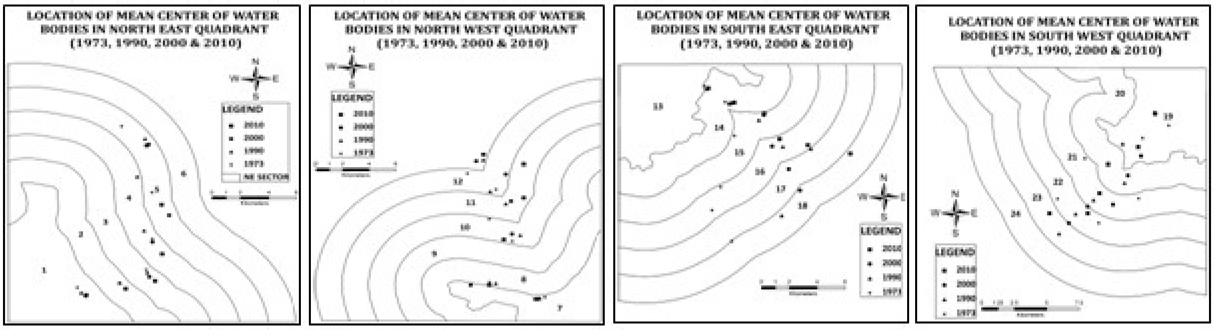


Fig.6: Comparison of mean center of water bodies in four quadrants (1973-2010)

North-east quadrant depicts that the mean center of water body has moved gradually with the time to the south-east direction for each buffer zone. The mean centers of 10 km buffer for four different years are located within the 8 km buffer zone. Again it is observed in north-west quadrant that the mean centers for Kolkata and 2 km buffer sector have been shifted to the south-west direction during 1973-2010. But, in the case of 4 km, 6 km, 8 km and 10 km buffer sectors, the mean centers have been shifted towards north-east direction. Actually, the mean center for 10 km buffer zone is found outside of this buffer zone. The mean centers for different years in south-east quadrant are being shifted in north-east direction. But this diagram depicts a special character for the deviation of mean centers. For Kolkata city, the mean center is very much concentrated but it is gradually dispersed with increase in radial distance from the city centre. 10 km buffer zone is characterized by huge gap in the position of mean centers for four different years. In south-west quadrant, mean centers for Kolkata and the 2 km buffer zone are located within the area of Kolkata city. The mean centers of the remaining four buffer zones are located in their previous buffer zones. The locational pattern of this mean center map is much more concentrated than the other quadrants.

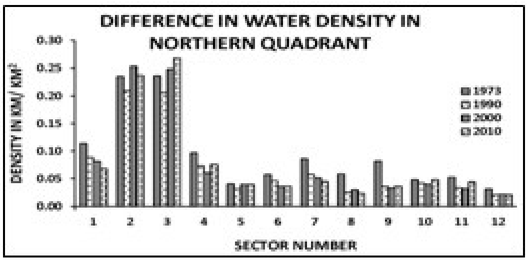
Comparison of Temporal Distribution of Surface Water Density (Sector-Wise)

Table-1 presents the sectoral distribution of surface water density for the years 1973, 1990, 2000 and 2010. For north-east quadrant, maximum density of water body is observed in 1973 and the density gradually decreased since 1973. Moreover, 2 km and 4 km buffer zones are denser in comparison to the other sectors in north-east quadrant. In north-west quadrant, surface water density is gradually decreasing from 1973 onwards. The highest density is found in the Kolkata sector for each year in this quadrant. In case of the south-east quadrant, 2 km buffer zone is characterized by highest concentration of water bodies for each year. The zone is also witnessing constant concentration of water bodies since 1973. This is a healthy trend for the people living in the zone. In case of south-west quadrant, 10 km buffer zone is the densest in 1973 while 2 km buffer zone is the densest in 1990, 2000 and 2010.

If the observation is made on quadrant basis then it is vividly clear that south-east and north-east quadrants are more dense than the remaining quadrants. So, more area under water body is found in the eastern quadrants in comparison to the western quadrants. Nevertheless, it is difficult to conclude about northern and southern quadrant. For 1973, the average density in northern quadrant is 0.095 while the average density in southern quadrant is 0.102. For 1990 these values are 0.072 and 0.102 respectively. In 2000, the northern and southern quadrant shows the same value (0.077). Finally, in the year of 2010, the northern and southern quadrant reflects the values of 0.079 and 0.065 respectively. Hence, the density is almost equal in case of both the quadrants as shown in Fig. 7.

Table-1: Temporal Distribution of Surface Water Density (Sector-Wise)

Sector ID	Quadrant	Density (1973)	Density (1990)	Density (2000)	Density (2010)
1	NE	0.1137	0.0882	0.0813	0.0685
2	NE	0.2358	0.2096	0.2538	0.2370
3	NE	0.2364	0.2062	0.2484	0.2688
4	NE	0.0975	0.0731	0.0609	0.0761
5	NE	0.0407	0.0307	0.0398	0.0398
6	NE	0.0574	0.0471	0.0358	0.0364
7	NW	0.0863	0.0572	0.0515	0.0448
8	NW	0.0587	0.0251	0.0299	0.0232
9	NW	0.0819	0.0361	0.0329	0.0366
10	NW	0.0486	0.0417	0.0392	0.0485
11	NW	0.0527	0.0339	0.0320	0.0442
12	NW	0.0313	0.0203	0.0221	0.0207
13	SE	0.1173	0.1258	0.1166	0.1048
14	SE	0.2587	0.3414	0.2860	0.2433
15	SE	0.1662	0.1738	0.1933	0.1858
16	SE	0.0972	0.0450	0.0383	0.0554
17	SE	0.1011	0.0424	0.0300	0.0240
18	SE	0.0575	0.0449	0.0259	0.0408
19	SW	0.0233	0.0280	0.0306	0.0272
20	SW	0.0888	0.1079	0.0502	0.0313
21	SW	0.0507	0.0859	0.0466	0.0203
22	SW	0.0531	0.0841	0.0463	0.0234
23	SW	0.0994	0.0624	0.0284	0.0145
24	SW	0.1048	0.0814	0.0282	0.0130



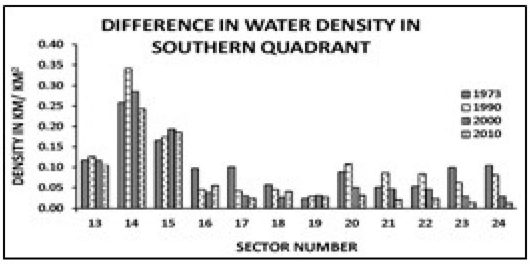


Fig.7: Temporal Difference in Water Density for Northern and Southern Quadrants

Conclusion

Kolkata and its surroundings are being changed rapidly in terms of land use and land cover. The area is increasingly covered by concrete building and roads replacing traditional water-bodies and agricultural land. From the different types of analysis carried out on the distribution and density of water-bodies in Kolkata and its surroundings, it can be concluded that 2 km and 4 km buffer sectors are more concentrated. Eastern zones have more density of water body in contrast to the western side. Location of mean centers has shifted with time. It is clear that there is a constant reduction of area under water body in the last four decades. This is partially due to the planned and unplanned development of high rise residential as well as commercial building. Some water bodies are converted into agricultural lands. This process of loss of water body may pose severe threat for the Kolkata metropolitan region and its surrounding areas. The ecological imbalance, increase environmental pollution, change in weather condition and water scarcity of both surface and ground water few possible dangers caused due to the loss of traditional water bodies. To create a sustainable environment in the city and its surrounding zones, dwindling water bodies must be prevented and restored by the concerned authority through building wide-spread awareness amongst the people living in the region.

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