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Quantification of Loss in Spatial Extent of Lakes and Wetlands in the Suburbs of Srinagar City during Last Century Using Geospatial Approach

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ABSTRACT

God has bestowed the city of Srinagar-the summer capital of the State of Jammu & Kashmir, with a large number of picturesque lakes and serene wetlands. Of these, the famous Dal and Nigeen lakes are important international tourist destinations. While as, wetlands of Anchar, Hokersar, Shalabug, Narkura and a large number of others are valued as favourite habitat of migratory ducks that visit Kashmir valley from places as far as Central Asia. These lakes and wetlands are also important socioeconomic support systems for the city inhabitants besides having nourished Kashmiri culture and civilization for centuries. In the past, these lakes and marshes had a pronounced impact on the micro climate of the city. However, due to unplanned urban expansion, there has been a tremendous change in the spatial extent of most of these water bodies as a result of which important wetlands of Bemina, Batmalloo and Arath stand already lost to other land uses.

In the present study, geospatial tools were employed for quantifying changes in the spatial extent of fragile ecosystems of some of the world's most famous lakes and wetlands located in the suburbs of Srinagar. The extent of lakes, wetlands and built-up land as depicted on the archive topographical map of the area dating back to 1911, was compared and analysed with respect to the spatial extent of lakes, wetlands and built-up land of the area as interpreted from IRS 1D LISS-III satellite imagery of the year 2004 to reveal astonishing results where more than 50 percent of the water bodies have been lost during the last century. The loss in the spatial extent of these lakes and wetlands has in fact affected the micro-climate of the city besides exposing it to flood threat.

Key words: Fragile, Ecosystem, micro-climate, Geospatial, Geomorphologic, Panchromatic, Geodetic, Resolution, Multi-spectral, rasterization

INTRODUCTION

Although land use/land cover change is a natural phenomenon and is a result of intricate and complex interaction of various environmental factors, yet this change is very often induced by increased human activity that threatens his very wellbeing. The change in land use brings a change in average annual temperature and humidity regimes, besides corroborating a simultaneous change in socioeconomic patterns of the inhabiting local populations.

Srinagar city, a century earlier, had a unique ecological setup with extensive areas under wetlands, lakes and water channels. Though, siltation brought about in the lakes and wetlands especially during floods was but natural, yet subsequent encroachment, earth filling, planting, and constructions by individuals and converting water channels into roads, presents a living example of how these valuable assets of natural landscape of Srinagar were destroyed. The comparative analysis of mean monthly maximum temperature during the period 1901-1950 and 1979-1996 reveal astonishing scenario where mean maximum temperatures have increased from 30.8º C to 32.4ºC in the months of July (Singh. G. *et al*, 2000). This is perceived to be mainly due to loss of water bodies as microclimate of the city stands altered due to undesired land use change.

In order to have a better understanding of the loss in spatial extent of lakes and wetlands in and around Srinagar city, the old/archive topographical map and moderate resolution multi-spectral remote sensing data was used to access the changes in spatial extent of all these areas in and around the city.

STUDY AREA

Srinagar city, the summer capital of Jammu & Kashmir State, lies between 34º 0´ N to 34º 15´ N latitude and 74º 45´ E to 75º 0´ E longitude at an average altitude of 1500 m above mean sea level. The city has a unique physiographic setup with steep hills in the east and north east, low lying paddy fields forming flood plain of Jhelum in the south and west and raised plateau lands in the south. Srinagar has a Mediterranean type of climate with percentage humidity varying from 90% in winter to 78% in summer months. Geologically speaking, the city lies in the middle of a great rock depression, with a volcanic hillock of Taket-*i*-Sulaiman formed during the carboniferous and Permian times when glaciers were crawling in some parts of North Kashmir (Chadda S.K, 1991).

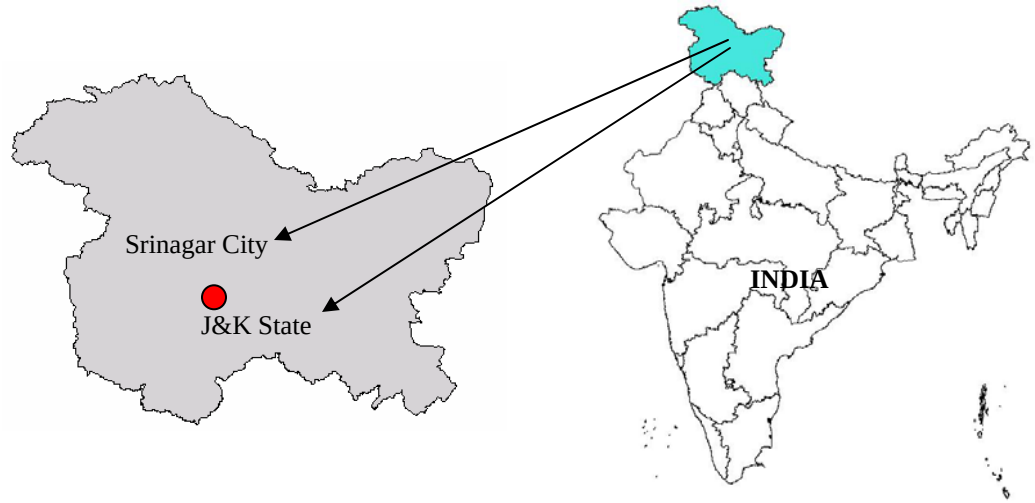

Figure1: Location of Srinagar city

PROBLEM IDENTIFICATION

During the last century, deforestation in the Jehlum basin led to excessive siltation in most of the lakes and water bodies of Srinagar and subsequent human greed brought about sustained reclamation and land use change in these assets of high ecological value. The Mar Nalla was lost to a road, Doodganga Nalla was converted into buildings and shopping malls (Fig.2&3). Bemina and Batmallo wetlands were converted into residential colonies in the past. While as the other wetlands are presently being subjected to induced land use/ land cover change (Fig.4). The objective of the present paper is to highlight loss in the spatial extent of lakes and wetlands in the suburbs of Srinagar city over the last century as a result of unplanned urbanization and to underline the impact of such loss so that efficient conservation strategies are planned to save the remaining water bodies of the city in future.

Figure3: Shopping complex on Doodganga stream

Figure 2 The Nalla Mar Road (From Mar stream to Mar road)

Figure 4: Earth filling of the stream draining into Dal Lake at Batpora in progress

MATERIALS AND METHODS

An archive topographical map of 1911 showing extent of wetlands and water bodies in the city of Srinagar was used as a historical data. An area of interest encompassing city suburbs was identified and delineated for the study. The hard copy historical data was geo-referenced with respect to the available satellite data using Universal Transverse Mercator with World Geodetic System (UTM WGS 84) projection parameters and the required features were digitized within the area of interest. The features of lakes, wetlands and built-up land were digitized to obtain a vector map which was then rasterized for facilitating overlay operations in Geographical Information System (GIS) domain (Fig. 6&7).

Figure 5:–Floods in residential areas due to drainage crisis in the city

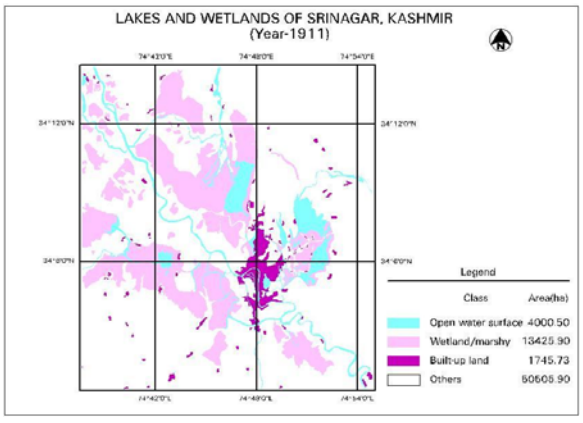

Figure 6: Lakes and wetlands of Srinagar and its suburbs (Year-1911).

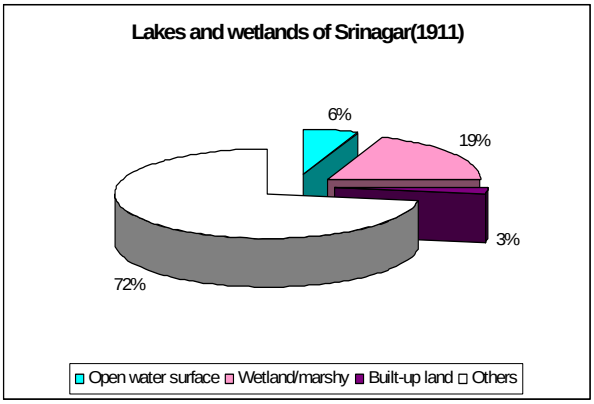

Figure 7: Pie diagram showing extent of water bodies of Srinagar suburbs (Year-1911).

Indian Remote Sensing satellite (IRS1D LISS-III) Satellite data was processed using Earth Resource Data Analysis System (ERDAS) Imagine 8.4 and other digital image processing and Geographical Information System (GIS) software packages. Unsupervised classification algorithm using 15 spectral classes with 15 iterations was used to obtain the classified map for water bodies, wetlands and built-up features in and around Srinagar city. Misclassified pixels were assigned to the correct spectral class using local knowledge and recoding technique. The 15 spectral classes were recoded and clubbed together to obtain four spectral classes representing open water surface, Marshy/wetland, Built-up land and rest of the land cover features were clubbed under 'others' category (Fig.8&9).

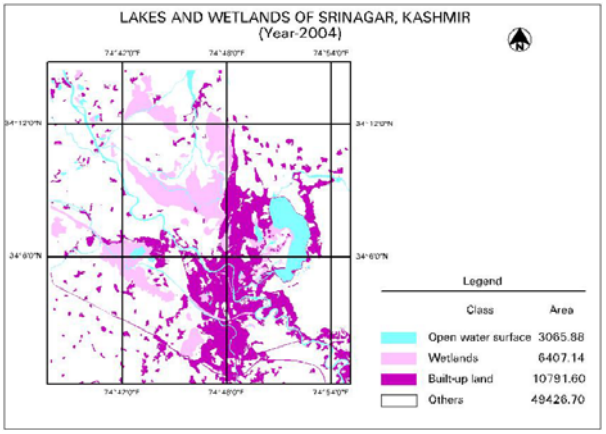

Figure 8: Lakes and wetlands of Srinagar and its suburbs (Year-2004)

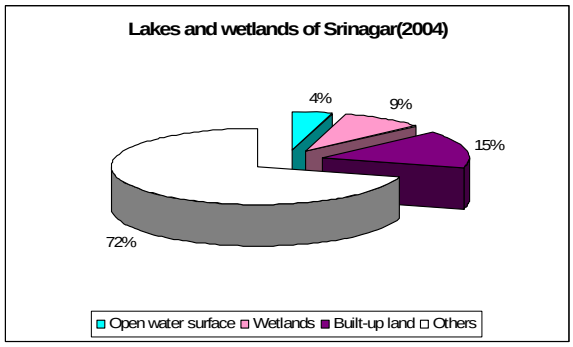

Figure 9: Pie diagram showing extent of water bodies of Srinagar suburbs (Year-2004).

After the maps for year 1911 and 2004 were generated, these were subjected to change analysis and a water bodies change analysis map was generated for the period 1911-2004 (Fig. 10&11). The map depicts change of open water surface and wetlands into built-up and other categories of land use.

RESULTS

The study involved mapping of nearly 69677 hectares in and around the city centre of Srinagar. The analysis of the historical data set revealed that nearly 13425.85 hectares was lying under marshy area while as nearly 4000.50 hectares was covered by open water surface during 1911 A.D. making a total of 17426.36 hectares. It is the period when Srinagar had a network of lakes and wetlands. The built-up land was mostly on either banks of river jhelum and running North-South of the city centre and its spatial extent was estimated to be 1745.73 hectares (Table 1).

Table 1: Spatial extent of Lakes and wetlands of Srinagar during 1911

S. No.	Class	Area(ha)
1	Open water surface	4000.50
2	Wetland/marshy area	13425.86
3	Built-up land	1745.73
4	Others	50505.88
	Total	**69677.97**

Similarly, analysis of satellite data of the year 2004 revealed that nearly 6407.14 hectares was estimated to be lying under marshy area while as nearly 3065.88 hectares was estimated to be lying under open water surface during the year 2004 making a total of 9473.01 hectares. Besides, there has been tremendous growth in the built-up category during this period which was estimated at 10791.59 hectares running noth-south and towards east of the city centre (Table2).

The urban expansion has not only been at he cost of productive crop land and orchards but also at the cost of important lakes and wetlands which had lot of importance in maintaining the local ecological balance.

Table 2: Spatial extent of Lakes and wetlands of Srinagar during 2004.

S. No.	Class	Area(ha)
1	Open water surface	3065.88
2	Wetlands/marshy area	6407.14
3	Built-up land	10791.59
4	Others	49413.37
	Total	**69677.97**

The analysis of the changes that have taken place in the spatial extent of lakes and wetlands here during the period 1911-2004 reveals that nearly 1955.23 hectares of open water surface and 4918.87 hectares of wetland/marshy area have remained unchanged during the period. While as, nearly 9119.92 hectares of open water surface and wetlands has been totally lost to other land uses during the period (Fig.10&11). This shows that more than 50% of the lakes and wetlands of Srinagar have been lost to other land use/ land cover categories.

Table 3: Change Analysis of lakes and wetlands of Srinagar (1911-2004).

S. No.	Class	Area(ha)
1	Unchanged open water surface	1955.23
2	Open water surface to marshy	878.57
3	Open water surface to built-up land	313.86
4	Open water surface to others	852.25
5	Marshy to open water surface	556.13
6	Unchanged marshy	4918.87
7	Marshy to built-up land	537.06
8	Marshy to others	7416.75
9	Built-up land to open water surface	26.78
10	Built-up land to marshy	49.65
11	Unchanged built-up land	1484.18
12	Built-up land to others	189.62
13	Others to open water surface	527.73
14	Others to marshy	560.04
15	Others to built-up land	8456.49
16	Unchanged others	40954.75
	Total	**69677.97**

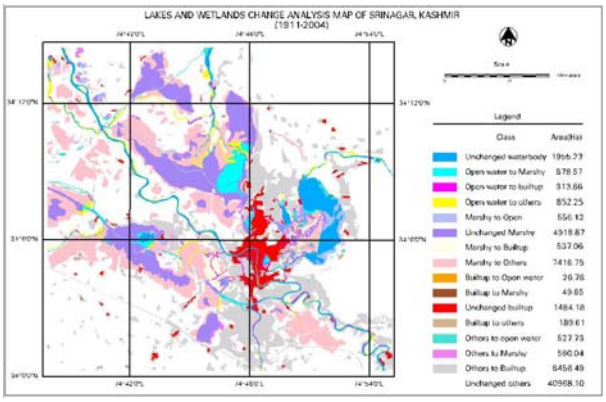

Figure 10: Spatial Change Analysis Map of lakes and wetlands of Srinagar and its suburbs (1911-2004).

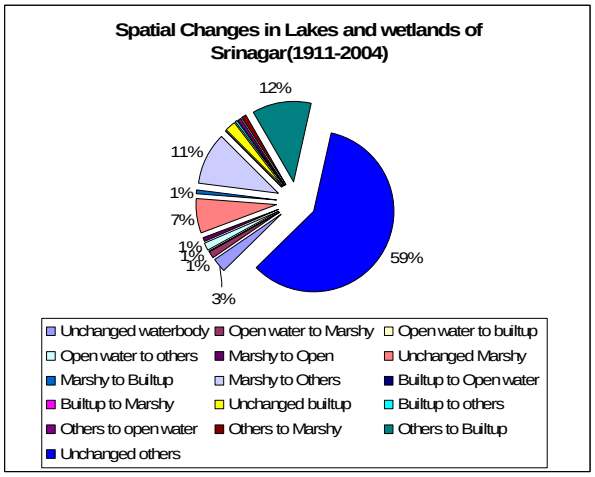

Figure 11: Pie diagram showing changes in spatial extent of Water bodies of Srinagar and its suburbs (1911-2004).

CONCLUSION

The comparative change analysis of the two maps based on the year 1911 and 2000 reveal that wetlands like Batmalun nambal, Rekh-i-Gandakshah and Rakh-i-Arat and Rakh-i-KhanKhan besides streams of Doodganga and Nalla Mar have been completely lost while as other lakes and wetlands have experienced considerable shrinkage during the last century.

The loss of water bodies of Srinagar city and its suburbs is attributed to heavy population pressures (Fig.12). Besides, siltation brought about as a result of wanton deforestation in the catchments of Kashmir, has also been an important factor that enhanced the land use/ land cover change.

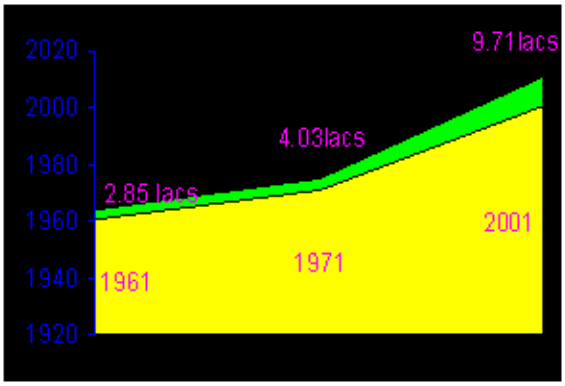

Figure 12: Population growth trend of Srinagar city.

The loss of water bodies of Srinagar has in fact, a bearing on the microclimate of the city as meteorological data recorded during the last century suggest a rising trend in the mean maximum temperatures during the summers (Singh, G.C *et al*, 2000). On July 15, 1973, the highest temperature ever recorded in Srinagar was 35.5 degrees celsius and on July 7, 2006, it was recorded at 39.5 º C (Annon.2006). It is suggested that the rise in mean annual temperature in the area is mainly due to loss of water bodies, since a considerable amount of evapotranspiration with a cooling effect might have been taking place in the past due to these valuable ecological assets during summers. Also, the increase in the built-up land leads to increase in the temperatures during summers due to impact of urban heat Islands.

Another important impact of the loss of water bodies comes in the form of problems relating to drainage. The Srinagar city is facing an acute problem of drainage since these wetlands and lakes acted as sponges during floods. Over the years, it has been observed that with a continuous rain for two to three days in Kashmir valley, the city is threatened with floods in river Jehlum. While, nothing would happen with this much of precipitation two to three decades back. Further, it has also been observed during the last decade that residential areas which never had floods in the past are getting inundated during floods in river Jehlum (Fig.5). This is because; there are hardly any wetlands to hold the excess water and to act as sponges during floods.

Lastly, the study reveals that picturesque Lake Anchar , Gilsar Lake, Khushalsar Lake and Brar-i-Nambal water bodies lying in the core area of the city are ecologically degraded and under tremendous pollution load. These present a pathetic condition that demand immediate rehabilitation measures and attention of governmental and non-governmental organizations before it is too late.

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