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Geospatial mapping of Srinagar City

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Mapping has remarkably become an essential tool to represent the land surface processes, utility sites and the interactions of the human activities with the environment. The rapid evolution of geographic information data management and the automation of satellite image interpretation through remote sensing techniques are providing increasingly abundant ways of mapping. Geospatial approach is very useful tool to demonstrate the spatial disparity of land use land cover and the distribution of key areas, Heritage sites, and Tourist utilities. In this paper, an integrated approach of remote sensing, geographic information, GPS and field surveys was utilised to map the Srinagar city. Mapping was sub divided in three broad categories: land use land cover dynamics mapping, tourist utility mapping and cultural heritage mapping. To improve the adverse environmental impacts of urban expansion, planning regulations need to be enforced and effective coordination should be ensured to save the declining natural resource base for sustainable development and tourism.

Key words: Geospatial mapping, land use land cover, cultural mapping, tourist utilities and sustainable development.

INTRODUCTION

Land use land cover mapping

Land use is the term which is referred to human uses of the land, or direct actions changing or altering natural land cover. Land cover refers to biophysical characteristics of a particular area. The natural and socioeconomic factors and their utilization by humans in time and space determine the land use land cover pattern of a region (Zubair, 2006; Rahdary, 2008; Bhagawat, 2011; Shiferaw, 2011; Liu et al., 2014). The pace, degree and spatial range of human modifications of the Earth's land surface are unprecedented (Chunyang et al., 2005). Mankind has been modifying land cover ever since pre-history through the practice of fire to flush out game and, since the dawn of plant and animal taming, through the clearance of bits of land for cultivation and livestock. From the past two centuries the influence of anthropogenic activities on land has grown up massively, modifying entire landscapes, and eventually impacting the earth's nutrient and hydrological cycles as well as

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climate (Skole, 1994; Goldewijk, 2001; Liu et al., 2010). Land use land cover change has substantial effects on elementary practises including biogeochemical cycling, erosion of soils and in that way on global warming and on sustainable land practise (Penner, 1994; Douglas, 1999). LULC transformations are native and place specific, occurring in ways that frequently escape our attention. However, they add up to the important aspects of global environmental alterations.

Information on the rate and kind of changes in the use of land resources is essential for proper planning, managing natural resources and monitoring environmental changes and to regularise the use of such resources (Gautam and Narayanan, 1983).

Remote Sensing (RS) and Geographic Information Systems (GIS) techniques offer effective tools for examining, updating and retrieval of the land use dynamics of the region as well as for monitoring, mapping and management of natural resources in less time, at low cost and with improved accuracy (Star et al*.,* 1997; McCracker et al*.,*1998; Chilar, 2000). By understanding the driving forces of land use changes in the past, managing the recent situation with contemporary GIS tools, and modeling the forthcoming changes, one is able to develop plans for numerous uses of natural resources for sustainable development and natural management (Smiraglia et al., 2013; Jame and Jaun, 2014; Xuesong et al., 2014).

This paper aims to review the use of integrated approach of remote sensing, GIS, GPS and field surveys for mapping and status of LULC changes, heritage and tourist utility mapping in the Srinagar city.

Heritage mapping

Cultural heritage is the most commonly appreciated and uniformly spread resource in the world. However cultural heritage is under end less risk of loss or even demolition and correct monitoring is essential to reduce the risk of losing heritage or work as foundation for renovation. Cultural mapping has been accepted by national and international organisations and associations as a fundamental tool and method in preserving the world's imperceptible and perceptible cultural resources and assets of a country.

Geospatial information system is a valued tool that captures, stores, examines, manages, and presents information that is linked to places. It involves an extensive range of procedures and activities from community-based involved data gathering and managing to classy representing using geoinformatics based tools i.e. GIS, RS, global positioning systems (GPS) and web-based mapping science and tools. This allows conservation of the data of Cultural and Heritage value and compromises new exploitation potentials, like the instantaneous joining of different kinds of data for analysis, or the digital documentation of the location for its development (Summerby, 2001; Cherplan, 2013; Zubair et al., 2014).

Tourist Utility Mapping

Tourism in the form of activity affects the areas in which it is developed and received with economic, social, cultural, and environmental dimensions (Brown et al., 1997). Tourism is movement for entertainment, relaxation, or business purposes. The World Tourism Organization (WTO) defines tourist as people "travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes”. It forms occasions for occupation in the service division of the economy, connected with tourism. The service activities include transport services such as airlines, buses, taxicabs; hospitality services such as lodgings, including hotels, restaurants and resorts; and entertaining services such as amusement parks, gardens and shopping complexes. For the tourism development of an area, it is essential to consider the interest of its local masses. In terms of tourism management recently, researchers have initiated to study how local inhabitants can be involved in tourism events and get reimbursements from it. Environmental conservation plays a significant part in environment-friendly tourism development and carrying capacity assessment. Various researchers now approve that tourism management should involve a two-way connection between tourism and eco-friendly conservation (Patil and Patil 2008). Thus, tourism necessities to be developed in a planned way and GIS assists as a decision support system in the processes (McAdam, 1999; Jovanović and Njeguš 2013; Aklıbaşında and Bulut, 2014).

This paper aims to review the use of integrated approach of remote sensing, GIS, GPS and field surveys for mapping and status of LULC changes, heritage and tourist utility mapping in the Srinagar city.

Study area

Srinagar City is once called “*Paradise on Earth*”; however, the greed of mankind has converted it in to a conflict sector. The entire region is for the last several years in disorder with political, financial and social conflicts. At the same period, the city has also observed urban forces acting to alter the city landscape. Srinagar is the summer capital of the state of Jammu and Kashmir, India and is located in the valley of Kashmir at an altitude of 1,730 m above sea level. Srinagar lies between the coordinates $34^0$01` N to $34^0$27`N latitude and 74^0 36` E to $75^0$ 30` E longitude over an area of 245 km^2.The city lies on banks of the River Jhelum and is famous for its lakes and houseboats floating on them. The Dal and Nigeen lakes enhance its charming settings, while the shifting play of

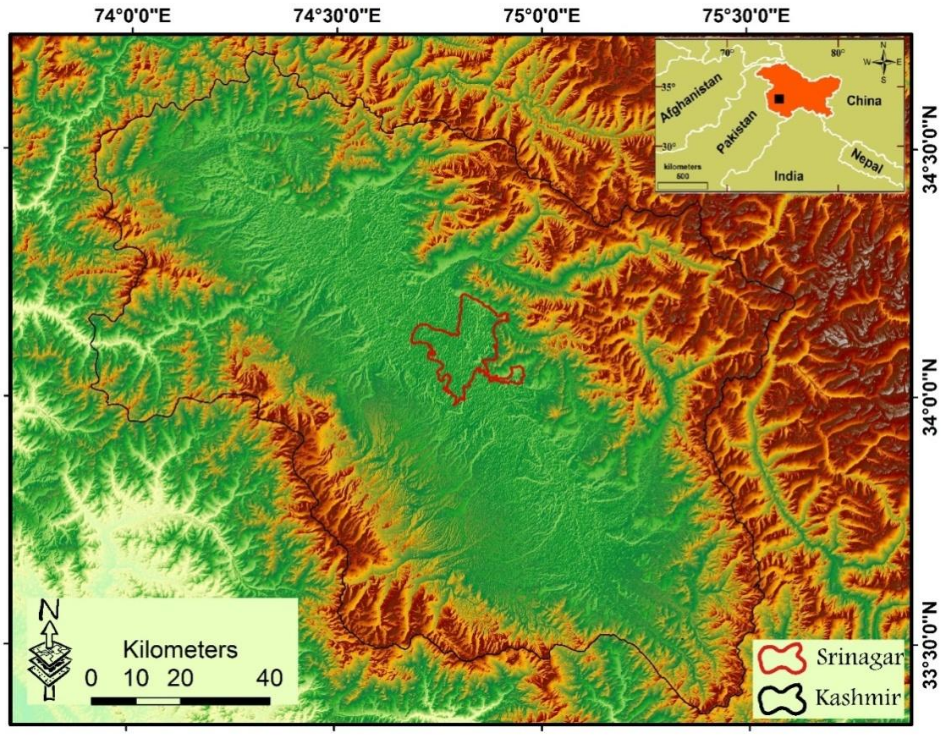

Figure 1. Location of Study area.

the seasons and the salubrious climate ensures that the city is equally attractive to visitors around the year. Srinagar is the commercial hub of the Kashmir valley. Tourism, as well as some other economic sectors, is a major profitable economic sector in Srinagar city (Dar, 2014). As with other parts of the world, the environmental scenario within Srinagar city has tremendously changed. The rapid rise of population together with development in transport, communication, and other areas has drastically altered ecological conditions of the city and destroying the basic functionalities of environment. The reasons "local effects" which have changed altogether the ecological scenario of the city are the direct outcome of the absolute ignorance as far as our natural land use capabilities and their proper use and management is concerned. Therefore, it is necessary to develop land information databases or inventories on temporal basis that could make available information on type, location, spatial distribution, actual extent, rates and patterns of change of each category of land use, heritage and tourist destination places in the city (Rocheleau, 1995; Nightingale, 2003). Figure 1 shows the area location of Srinagar city.

MATERIAL AND METHODS

Data sources

Multi-temporal satellite data from Landsat MSS (79m) acquired in October 1972, Landsat TM (30m) acquired in October 1992, IRS LISS-III (23.5m) acquired in October 2005 and Landsat OLI (30m) acquired in 2013 were used for the analysis of land use land cover dynamics. Besides satellite data survey of India (SOI) map, field survey using hand held GPS and Google earth were also used for the accuracy assessment of the LULC maps and mapping of Heritage sites and tourist destinations.

Mapping approach

Supervised Image classification was used to classify all the satellite images from 1972, 1992, 2005 and 2013.The quality of supervised classification depends on the quality of the training sites (Palaniswami et. al 2006). All the supervised classifications usually have a sequence of operations that must be followed, defining the Training Sites, Extraction of Signatures and Classification of the Image (Perumaland Bhaskaran, 2010; Mountrakis et. al 2011). Different training sets were developed after analysis of various visual (color, tone, texture, shape, shape, size, association, convergence of evidence, etc.) and statistical characteristics (mean, standard deviation, etc.) of the data. Finally the classification methods are applied. Supervised classification was performed using an appropriate decision rule (maximum likelihood algorithm). The Gaussian maximum likelihood (GML) classifier was used in this study for three reasons. First, it is relatively convenient to implement. Secondly, the maximum likelihood decision rule is by far the most common supervised classification method and is widely used. Finally, the GML is robust and utilizes mean, variance and covariance of training site statistics, where most other decision rules are based on simpler statistics (Perumal and Bhaskaran, 2010, Murtaza and Shakil, 2014).

The authenticity and accuracy of the LULC map of 2013 was validated in the field to determine its accuracy. The accuracy estimation is essential to assess reliability of the classified map. Kappa coefficient, the robust indicator of the accuracy estimation was also estimated for the final LULC map.In addition, the overall accuracy, user's accuracy, producer's accuracy, were also computed to assess the accuracy of the LULC. This was followed by extensive ground validation in order to obtain an accurate LULC class in the field (Murtaza and Shakil, 2014). Overall classification accuracy is given by the following formula:

$$\rho = \left(\frac{n}{N}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(I)}$$

Where '$\boldsymbol{\rho}$' is classification accuracy, 'n' is number of points correctly classified on image, and 'N' is number of points checked in the field. The Cohen's Kappa statistics allows accessing the accuracy that takes into account the chance of random agreement. Kappa coefficient, the robust indicator of the accuracy estimation for the final LULC map was estimated by the following formula. The equation for κ is:

$$k = \frac{pr(a) - pr\ (e)}{1 - pr\ (e)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(II)}$$

Where Pr (*a*) is the relative observed agreement among raters, and Pr (*e*) is the hypothetical probability of chance agreement, using the observed data to calculate the probabilities of each observer randomly saying each category.

Extensive field survey of the study area was carried out in order to locate and map the heritage sites and tourist utilities. The coordinated data of heritage and tourist utility sites were collected using Handheld GPS and later on processed in GPS pathfinder software in order to make the data readable in GIS environment and remove errors that had occurred during the field survey. The heritage site database developed in Excel format was converted to .dbf format and integrated with the point locations of heritage sites through a joining process in GIS environment. The heritage ancillary data pertaining to heritage sites procured from different government and non-governmental agencies (INTACH) was classified into different thematic maps or layers as: Residential, Public, Religious, Natural Features, Institutional, Commemorative and Commercial. The thematic maps were stored in the Geodatabase format to generate the final geospatial database of Heritage Sites for Srinagar City. Similarly, the tourist utilities centres were classified into different thematic layers, that is, ATM, Hotels, Travel agencies, Taxi stands, Shikara Ghats, Restaurants, Guest houses, and House boats. The data pertaining to tourist utilities were collected from various governmental agencies (like Tourism Department etc.) and non-governmental agencies (like Banks Offices etc.). Only those utilities were mapped which were registered either with government or non-governmental agencies. And finally all the layers were merged into a single layer to create a final tourist utility map of the Srinagar city.

RESULTS AND DISCUSSION

Land use land cover mapping

This part of the study is focused to analyse spatial and temporal information of land use land cover dynamics. Using supervised classification, Satellite data was classified into thirteen different LULC classes; agriculture, aquatic vegetation, barren land, built-up, exposed rock, forest, horticulture, pasture, plantation,riverbed, scrub land, snow, and water. From the perusal of Table 1 and Figure 2, it is evident that Srinagar City has witnessed large-scale changes in land use land cover dynamics. Significantly, the city has witnessed major land use changes among classes such as Built-up, Agriculture and Plantation. Built-up covers almost 40% of the total land, followed by Agriculture and Horticulture cover of 23 and 15% respectively in 2013. Land cover changes in Srinagar are driven by a multitude of processes. Such as alterations in land cover due to natural changes in climate. And due to many anthropogenic activities such as, population explosion, poverty, peoples responses to social, economic opportunities which ultimately affect natural environment. However, changes of land cover driven by anthropogenic forcing are currently the most important and most rapid of all changes (Turner et al., 1990). Since, Srinagar is a commercial hub and people prefer to live around their working places in the city which ultimately lead to land cover dynamics changes. Built-up has increased by 36% from 1972 to 2013 followed by Horticulture by 12%. While, agriculture and plantation have decreased by 24 and 13% respectively during the study period. Error matrix was used to assess the classification accuracy and is summarized in Table 2. The overall accuracy was 89%, with Kappa statistics of 0.87.

Heritage mapping

Around three hundred and thirty four heritage sites were mapped during extensive field surveys in the area. The heritage data pertaining to heritage sites was classified into different thematic layers as: Residential, Public, Religious, Natural Features, Institutional, Commemorative and Commercial. Following maps were generated theme wise along with information of each heritage site in order to generate Geo-Database. The attribute information about each GPS point in different themes was mapped. Figure 3 shows the distribution of Heritage sites in Srinagar city. Eighty four residential, Seventy four religious and fifty eight religious heritage sites were among the heritage sites which were mapped.

Tourist utility mapping

Around four hundred five tourist utilities were mapped during the extensive field surveys. Tourist utilities were classified into different thematic layers i.e. ATM, Hotels, Travel agencies, Taxi stands, Shikara Ghats, Restaurants, Guest houses, and House boats. And finally all the layers were merged into a single layer to create a final tourist utility map of the Srinagar city. Figure 4 shows the distribution of the tourist utilities. Hundred hotels and eighty house boats were among the tourist utilities which were mapped. Figure 5 shows some field

Table 1. Area under different LULC classes in Srinagar.

LULC classes	Area (km^2) 2013	Area (km^2) 2005	Area (km^2) 1992	Area (km^2) 1972	Change 1972-2013
Agriculture	56.22	62.17	89.00	116.09	-59.87
Aquatic Vegetation	21.05	20.40	19.40	10.91	10.14
Barren	1.31	4.00	5.00	6	-4.69
Built up	95.76	81.42	31.81	6.00	89.76
Exposed Rock	1	0.84	0.73	0.40	0.60
Forest	4.87	8.32	11.70	16.17	-11.30
Horticulture	36.84	20.11	17.14	7.84	29.00
Karewa	0.14	1.55	3.65	5.90	-5.76
Pastures	1.1	3.01	10.05	11.43	-10.33
Plantation	12.5	28.45	40.66	44.55	-32.05
River bed	0.21	0.44	0.56	1.14	-0.93
Scrub land	1.2	0.54	0.30	0.14	1.06
Water	12.82	13.77	15.02	18.45	-5.63
TOTAL	245.02	245.02	245.02	245.02	245.02

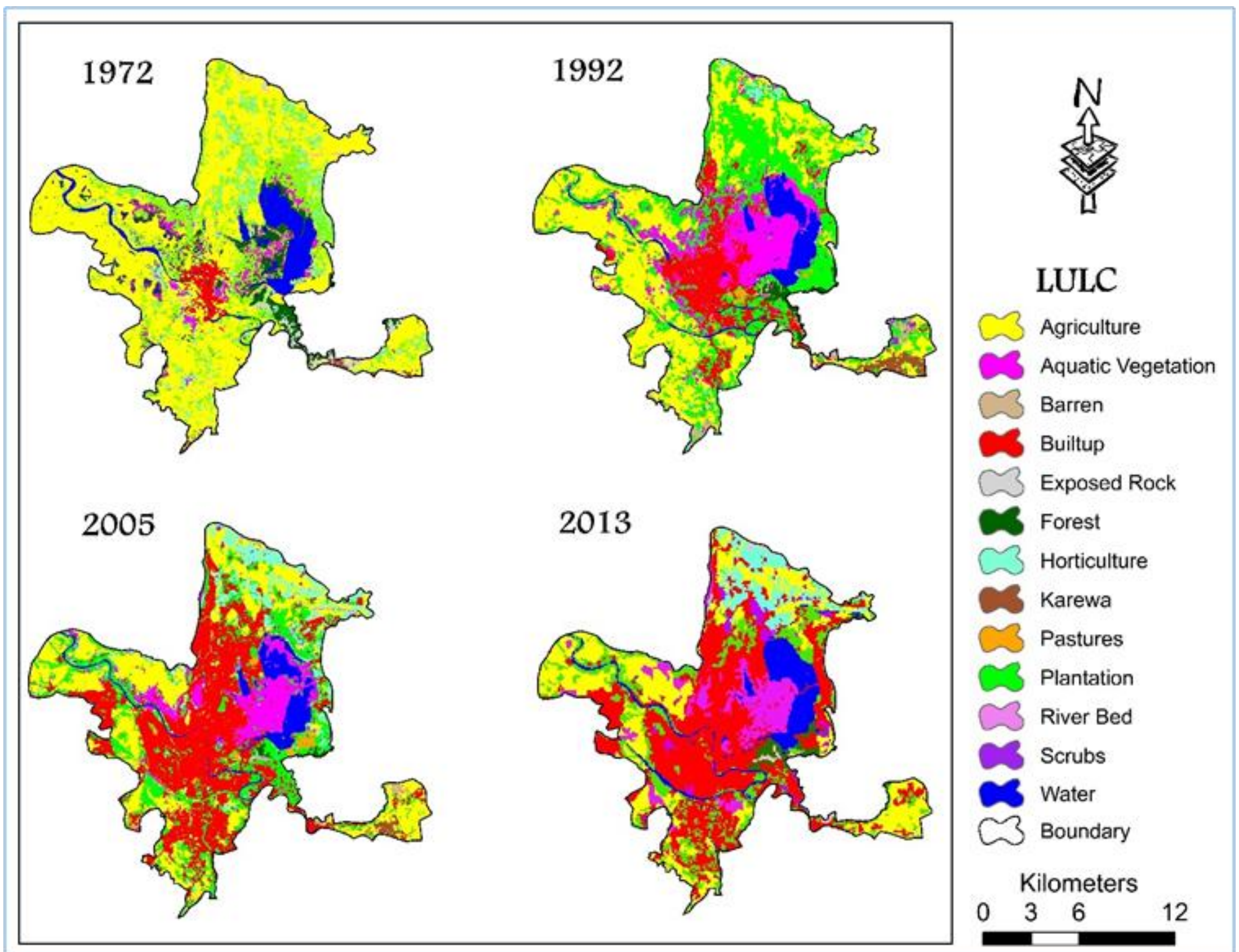

Figure 2. Land use land cover maps of Srinagar city from 1972, 1992, 2005 and 2013.

Table 2. Error matrix showing per class accuracy of 2013 land cover data.

Classes	HT	PL	RB	FT	BU	AG	SB	PS	WT	AV	ER	TT	U A
HT	26	1	-	-	-	2	-	-	-	-	-	29	89.66
PL	2	21	-	-	2	-	-	-	-	1	-	26	80.77
RB	-	3	6	-	1	-	-	-	-	-	-	10	60
FT	-	-	-	15	-	-	-	-	-	-	-	15	100
BU	-	-	-	-	60	-	-	1	-	-	-	61	98.36
AG	1	1	-	-	1	18	-	-	-	-	-	21	85.71
SB	-	1	-	1	-	-	8	-	-	-	-	10	80.00
PS	-	1	-	-	1	-	-	10	-	-	-	12	83.33
WR	-	-	2	-	-	-	-	-	7	-	-	9	77.78
AV	-	-	-	-	-	-	-	-	-	3	-	3	100
ER	-	-	-	-	-	-	-	-	-	-	4	4	100
TT	29	28	8	16	65	20	8	11	7	4	4	200	
P A	89.7	75.0	75.0	93.8	92.3	90.0	100	90.9	100	75.0	100		

Where; HT-Horticulture, PL-Plantation, RB- Riverbed, FT-Forest, BU-Built-up,AG-Agriculture, SB-Scrubs, PS-Pasture, WR-Water, AV-Aquatic Vegetation, ER-Exposed Rock, TO-Total, PA-Producers Accuracy and UA-Users' Accuracy.

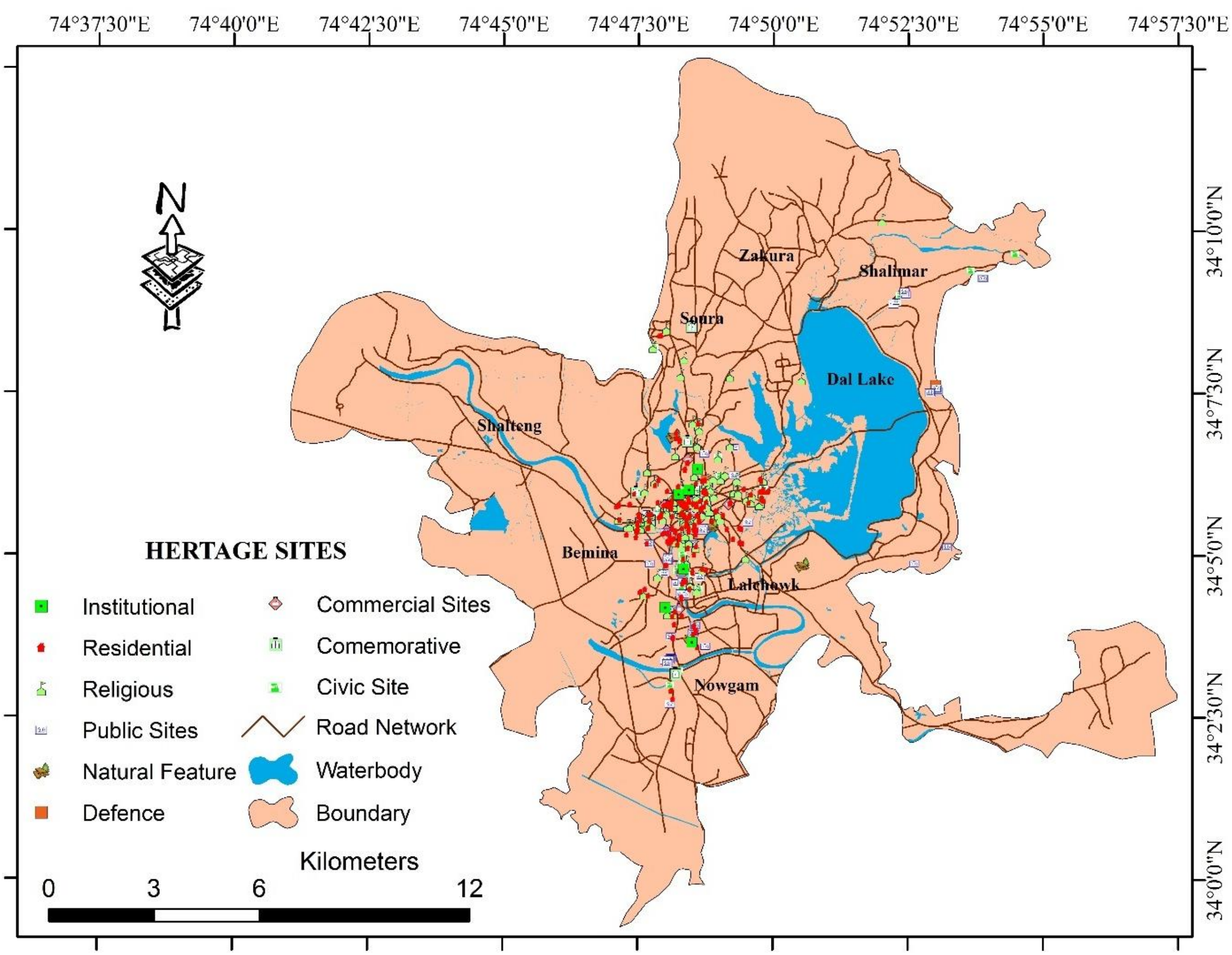

Figure 3. Distribution of Heritage sites.

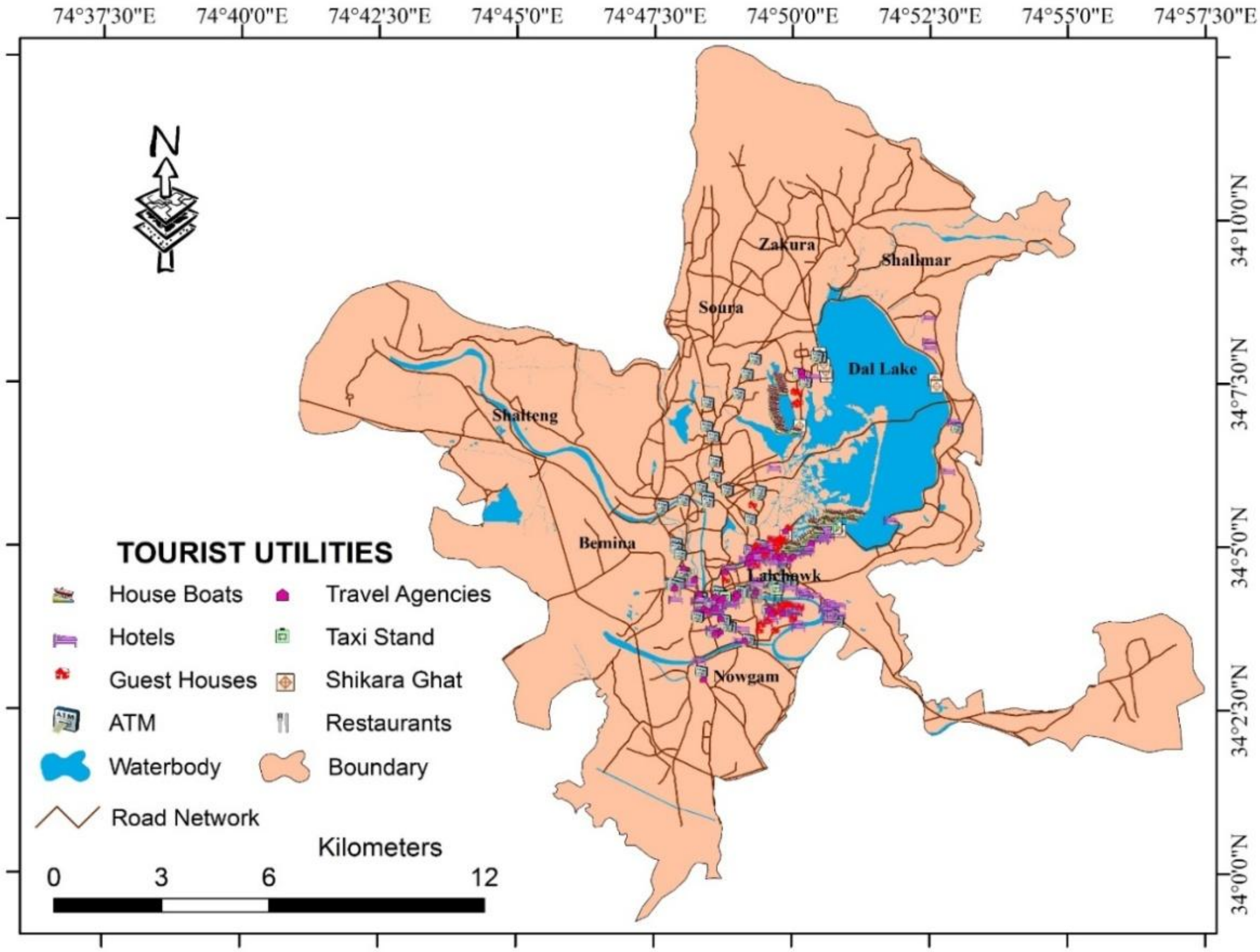

Figure 4. Distribution of tourist utilities.

photographs of land cover, heritage sites and tourist utilities in Srinagar City.

Conclusion

In this study, thematic maps are produced to demonstrate the spatial disparity of land use land cover and the distribution of key areas i.e. Heritage sites, and Tourist utilities in Srinagar city. This research demonstrates the use of an integrated approach utilizing remotely sensed data, field observations and ancillary data for mapping the Srinagar city. Mapping demonstrates that the analysis of land cover potential is the foundation of land planning. The result revealed that land use land cover in study area has under gone significant changes over the 39 years; in particular, the areas of forest and agriculture have been decreasing while as built-up and horticulture land have been increasing. The change of land use land cover in Srinagar city is probably driven by the growth of population, reckless deforestation, and unplanned urbanization, changes in quantity and quality of water resources, economic and social developments. Similarly, heritage sites and tourist destination are under constant threat of destruction and environmental degradation due to unplanned management of these resources. Satellite remote sensing is an advanced technique for obtaining land cover dynamic information while a GIS is very useful to help analysts to carry out data management and analysis and GPS is an efficient tool to map the utility sites. To improve the adverse environmental impacts of urban expansion, planning regulations need to be enforced and effective coordination should be ensured to save the fast declining natural resource base for sustainable development. Spatial information is easy to understand and useful to policy makers to focus upon surfacing the strategies that safeguard sustainable use of our land resources. The maps presented in this study are expected to serve as a guide for the subsequent regional planning, thus promoting future studies on mapping land

Figure 5. Some field photographs of heritage sites, tourist utilities and land covers.

cover dynamics, tourist utilities and heritage sites.

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Conflict of Interests

The authors have not declared any conflict of interests.

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