Geospatial Analysis of LULC in the Srinagar Region of Jammu and Kashmir using Sentinel-2 data

ABSTRACT

Geospatial analysis based LULC mapping finds great utility in Himalyan region in order to carry proper assessment, evaluation and sustainable management of the existing resources. With the aid of remote sensing (RS) and geographic information system (GIS), the current study on LULC mapping was conducted in district Srinagar of Jammu and Kashmir for the year 2022. European Space Agency (ESA) based Sentinel-2 satellite was used as a data source. By using the technique of visual image interpretation, the study area was demarcated into 11 LULC classes viz, agriculture, forest, forest scrub, built-up, TOF, grassland, wasteland, waterbody, wetland, snow and horticulture. The findings of the study revealed that from the delineated LULC classes highest percentage (19.61%) of area was covered by forest and least (2.17%) was covered by wetland. Moreover, the values obtained for overall classification accuracy and kappa statistics were 89.09% and 0.88 respectively. The findings of the current study might be useful in devising the LULC practices which might be fruitful in achieving the sustainable management goals.

Keywords: Geospatial, LULC, RS, GIS, Kashmir

INTRODUCTION

Land use Land cover (LULC) are two distinct terms but are sometimes used synonymously. The social, economic and environmental factors of a place along with the human based activities over space and time play a critical role in shaping the LULC pattern of a region or place (Jamal and Ahmad, 2020). All the human related activities which take place on earth's surface is termed as Land use while as the natural or human developed features on earth's surface is referred to as Land cover (Tiwari and Kanduri, 2011). In order to put forth the management strategies to mitigate the deleterious effects of climate change, developmental activities, unprecedented and exhaustive use of natural resources on ecosystem. The periodic assessment of spatio-temporal changes in LULC classes must be incorporated as an essential tool in management plans. This will be helpful in using the various natural and man-made resources judiciously and in perpetuity along with conserving them for future generations (Maarez *et al*., 2022; Basheer *et al*., 2022). Thus, LULC mapping is essential for comprehending the different facets of the natural surroundings of humans, their activities and the sophisticated association between the two (Singh *et al*., 2021). It finds wide applicability in disaster management, urban and conservation planning etc (Jamal and Ahmad 2020).

Over time advancement in RS and GIS or geospatial techniques like improvement in data acquisition methods, increase in spatial, temporal and spectral resolutions have increased the utility of these techniques in analysing and monitoring LULC dynamics. Some of the fundamental areas of advancements include precise mapping, modernized and diversified information or data sources, progression in algorithms used for classification, presence of diverse open access data sources and availability of techniques for integrating data from multiple sources etc (Mashala *et al*., 2023)

Geospatial techniques due to their extensive pertinence are being recommended as the efficient tools for LULC mapping. These techniques provide a great opportunity for studying the earth as an integrated system by providing a comprehensive view of the planet (Darem *et al*., 2023). Numerous studies have been conducted by researchers on international, national and regional level on LULC mapping, type and rates of change in LULC and its impact on social, economic and ecological aspects of the human beings and earth by obtaining data from different satellites (Ghayour *et al*., 2021; Bhattacharya *et al*., 2021; Sang *et al*., 2021; Mehraj *et al*., 2021; Dibs *et al*., 2020; Kaya and Görgün, 2020; Saddique *et al*., 2020). European Space Agency (ESA) based Sentinel-2 data has been found to be reliable and exceedingly valuable source of data for developing LULC maps due to its vast spatial resolution and temporal precision (Abbas and Jabir, 2024).

Being the summer capital of Jammu and Kashmir and trading center of the Kashmir valley, the ecological situation within Srinagar city has greatly altered (Dar, 2014). Anthropogenic activities, population growth and urbanization have immensely disrupted the fundamental ecological services. The negligence in using the natural land use capabilities and managing the same have drastically affected the ecological well-being of the city (Ahmad *et al*., 2024). Therefore, the resources assessment on spatio-temporal basis that could make data accessible on kind, position, geographical coverage, extent and form of alteration in each LULC class is need of the hour (Murtaza *et al*., 2015). Hence, the current research on LULC mapping was carried in district Srinagar of Jammu and Kashmir using Sentinel-2 as data source.

2. MATERIALS AND METHODS

2.1 Study Area

Srinagar district situated in the heart of Kashmir valley is located at an altitude of 1580 m above mean sea level and between geographical coordinates of 33°58'0"N and 34°13'0"N latitude and 74°40'0" E and 75°9'0"E longitude (Fayaz, 2023). It is bordered by district Ganderbal in north, district Pulwama in south, Budgam in south-west and Bandipora in north east. The district is surrounded by a chain of Zanskar mountains and Pir Panjal Ranges. The latitudinal variation leads to wide variation in climatic conditions due to which areas of the district at high altitude witness a typical temperate climate thereby experiencing severe cold and snowfall during winter while as places at lower altitudes experience mild summers designating tropical climate.

The methodology adopted for conducting the research is discussed below:

Procurement of satellite data: The data was sourced from European Space Agency (ESA)

Preprocessing of satellite data: With the aid of image processing software and by using ideal band combinations False Color Composite (FCC) was made by preprocessing the acquired satellite data. Moreover, for the better interpretation of LULC classes in the study area various image enhancement techniques were used.

Preliminary survey of the study area: For obtaining the pioneer information about study area regarding land use, topographical features etc and the number of LULC classes to be delineated, preliminary survey of the district Srinagar was carried.

LULC map generation: ArcGIS at a mapping scale of 1:30,000 was used for mapping purpose. The LULC classes in which satellite data was demarcated were:

1.Forest scrub 2. Forest 3. Agriculture 4. Horticulture 5. Trees outside forest 6. Wetland 7. Wasteland 8. Grassland 9. Waterbody 10. Snow 11. Built-up

Accuracy assessment of LULC map: The accuracy assessment of generated LULC map was carried by using ground truth points collected during field trips and from google earth in case of in accessible areas.

Validation of LULC map: The user's accuracy, producer's accuracy, overall accuracy and finally KAPPA (khat coefficient) were calculated for validating the map. This was done by generating the error matrix (Congalton *et al*., 1983).

$$\textbf{Producer's Accuracy} = \frac{Number\ of\ correctly\ classified\ pixels\ in\ each\ category}{Total\ number\ of\ validation\ points\ used\ for\ that\ category\ (column\ total)}$$

$$\textbf{User's Accuracy} = \frac{Number\ of\ correctly\ classified\ pixels\ in\ each\ category}{Total\ number\ of\ validation\ points\ used\ for\ that\ category\ (row\ total)}$$

$$\textbf{Overall Accuracy} = \frac{Number\ of\ correctly\ classified\ pixels}{Total\ number\ of\ validation\ points}$$

$$k = \frac{N\sum_{i=1}^{r} x_{ij} - \sum_{i=1}^{r}(x_i + x_{ij})}{N^2 - \sum_{i=1}^{r}(x_i + x_{x+i})}$$

Where k = Kappa coefficient

r = number of rows in the error matrix

x_{ij} = the number of observations in row *i* and column *j* (on the major diagonal)

x_{ij}= total number of observations in row *i* (shown as marginal total to right of the matrix)

x_{ij}= total number of observations in column *i (*shown as marginal total at bottom of the matrix)

N = no. of observations

3. RESULTS

3.1 Land use Land cover (LULC) of district Srinagar

The study area wad delineated into 11 LULC classes among which the highest area was occupied by forest (19.61%) followed by (16.85%) by built -up, (11.33%) by agriculture, (10.04%) by forest scrub, (8.44) by wasteland, (8.25%) by grassland, (6.52%) by TOF, (6.37%) by horticulture, (6.26%) by snow, (4.16%) by waterbody and (2.17%) by wetland as shown in Table 1.The Landuse/Landcover map of district Srinagar is presented in Fig 1. Different color code schemes were used to designate the demarcated LULC classes.

3.2 Accuracy assessment and Validation of LULC map

For accuracy assessment total of 110 ground truth points were collected across the study area.

The error matrix generated for the developed map of district Srinagar (2022) is shown in Table-2. This was employed for calculating producer' s accuracy, user's accuracy of each

LULC class. The results obtained are presented in Table- 3. The values for overall accuracy and kappa statistics obtained were 89.09% and 0.88 respectively.

4. DISCUSSION

The current research which was undertaken in district Srinagar by using ESA based Sentinel-2 for the year 2022 as data source. For mapping purpose ArcGIS at a mapping scale of 1:30,000 was employed and the findings revealed that the maximum area was under Forest (19.61%) > Built-up (16.85%) > Agriculture (11.33%) > Forest scrub (10.04%) > Wasteland (8.44%) > Grassland (8.25%) > TOF (6.52) >Horticulture (6.37%) > Snow (6.26) >Water body (4.16) > Wetland (2.17). Using the data from wide variety of satellites various researchers have conducted LULC assessment like the studies conducted by Raza *et al*. (2024), Tempa *et al*. (2024), Mishra *et al*. (2020). Lohare *et al*. (2024) carried GIS based LULC mapping in Jabalpur district, Madhya Pradesh and found that maximum area 59.26% was occupied by agriculture followed by 18.28% by forest, 18.08% by open/barren/wasteland, 2.68% by waterbodies and 1.70% by built-up. Hedge *et al* (2023) conducted an investigation on LULC practices in district Kalaburgi, Karnataka by using geospatial techniques and reported that out of the 3 delineated LULC classes, area recorded under agriculture was 83% under waterbody was 11% and 6% of area was under built-up. In a RS and GIS based research conducted on LULC dynamics in Patna, Bihar by Ahmad *et al* (2023) for the time period 2007-2017. It was reported that in built-up an increase of 21.86% was witnessed and in cropland and vegetation a decline of 8.95% and 8.5% respectively was recorded. Zahoor *et al.* (2020) conducted LULC assessment in district Ganderbal of Kashmir region using Landsat (OLI) satellite data and concluded that out of the 10 delineated LULC classes namely, grassland, snow, forest scrub, forest, agriculture, waterbody, built-up wasteland, wetland and TOF maximum area (33.96%) was under forest while as minimum area (1.35%) was under wetland. Similarly, another study conducted on analysing resource potential and quality of soil under trees outside forests by Mehraj (2018) in district Ganderbal of Kahmir region revealed that out of the demarcated LULC classes, highest area (34.43%) was occupied by forests and lowest (1.21%) was under wetland.

In the current research, an overall classification accuracy and overall kappa statistics of 89.09 % and 0.88 respectively were obtained. During a study conducted by Seyam *et al*. 2023 on change in LULC in Mymensingh region of Bangladesh by using Remote sensing and GIS based techniques they documented an overall classification accuracy of 87.2% for 2002 and 89.6% for 2022 and kappa statistic value 0.84 and 0.87 for respective years. Rasool *et al*. (2021)

conducted an investigation to detect change in LULC in South region of Kashmir from 1990 to 2017 by using various geospatial techniques. There study concluded an overall classification accuracy of 89%, 84.56% and 92.83% respectively and the values obtained for kappa statistics were 0.89, 0.84 and 0.92. Rwanga and Ndambuki (2017) while studying LULC classification and accuracy assessment in Limpopo province in South Africa using RS and GIS based tools obtained an overall accuracy of 81.7 % and Kappa value of 0.722. Our findings are in agreement with Chakraborty *et al* (2016), Traore *et al* (2020) and Mehraj (2023).

Table 1: Areal distribution of LULC classes in district Srinagar (2022)

Class	Area(ha)	%
Agriculture (a)	5420.96635	11.33
Forest(f)	9388.4899	19.61
Forest Scrub (fs)	4804.6186	10.04
Built Up (btp)	8065.8844	16.85
Grassland (g)	3947.7492	8.25
Horticulture (h)	3047.1417	6.37
Snow (s)	2998.5004	6.26
TOF (t)	3120.7068	6.52
Waterbody (wb)	1993.15561	4.16
Wetland (wl)	1040.3288	2.17
Wasteland (wsl)	4038.81	8.44
Grand Total	**47866.3517**	**100**

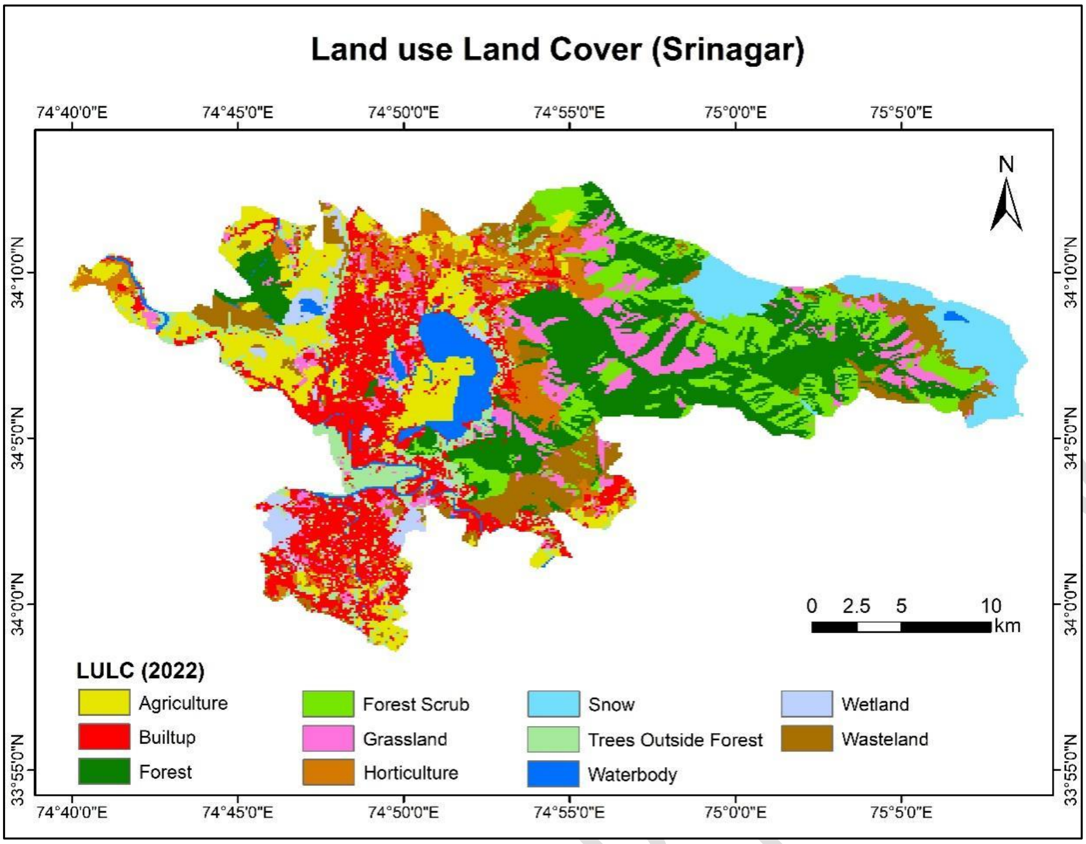

Fig.1: LULC map (2022) of district Srinagar

Table.2: Error matrix for LULC map (2022)

Class	**Forest**	**Agriculture**	**Forest scrub**	**Buit-up**	**Grassland**	**Trees outside forest**	**Wasteland**	**Wetland**	**Snow**	**Waterbody**	**Horticulture**	**Row total**
Forest	9	0	0	0	0	1	0	0	0	0	0	10
Agricuiture	0	8	0	0	0	0	0	0	0	0	2	10
Forest scrub	0	0	9	0	1	0	0	0	0	0	0	10
Built-up	0	0	0	9	0	0	0	0	1	0	0	10
Grassland	0	0	1	0	9	0	0	0	0	0	0	10
Trees outside forest	1	0	0	0	0	8	0	0	0	0	1	10
Wasteland	0	0	0	0	1	0	9	0	0	0	0	10
Wetland	0	0	0	0	0	0	0	10	0	0	0	10
Snow	0	0	0	0	0	0	0	0	10	0	0	10
Waterbody	0	0	0	0	0	0	0	1	0	9	0	10
Horticulture	0	1	0	0	0	1	0	0	0	0	8	10
Column Total	10	9	10	9	11	10	9	11	11	9	11	**110**

Overall Classification Accuracy = **89.09 %**

Kappa statistics = **0.88**

5. CONCLUSION

By using the Geospatial analysis and Sentinel 2 satellite as data source, the current study delineated the district Srinagar into 11 LULC classes out of which highest percentage of area was under forests followed by built-up and the lowest percentage of area was under wetland. The value obtained for overall classification accuracy was 89.09 % and Kappa statistics was 0.88. The findings of the current research might be helpful in identifying and evaluating environmentally sensitive zones or LULC classes which could eventually be helpful in prioritizing these zones or classes for conservation or rehabilitation. Moreover, the LULC mapping might be helpful in understanding the consequences of various developmental and economic activities like urbanization industrialization etc on ecological stability thereby providing an insight in choosing sustainable LULC patterns for the study area.

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