International Journal of Environment and Climate Change

Volume 14, Issue 12, Page 536-548, 2024; Article no.IJECC.127165
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Geospatial Analysis of Land Use and Land Cover Dynamics Using Landsat Data: A Case Study of Ferozpore Nallah Watershed in Kashmir Valley

Deepasri Mohan [a*], Farooq Ahmad Lone [a], Javeed Iqbal Ahmad Bhat [b], Shabir Ahmad Bangroo [c], Imtiyaz Murtaza [b], Sethupathi Nedumaran [d], Areeba Aijaz [a] and Helen Mary Rose [d]

[a] Division of Environmental Sciences, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Srinagar, Jammu & Kashmir, India.
[b] Division of Basic Sciences & Humanities, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Srinagar, Jammu & Kashmir, India.
[c] Division of Soil Science, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Srinagar, Jammu & Kashmir, India.
[d] Department of Science & Technology, Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijecc/2024/v14i124643

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/127165

Original Research Article

Received: 22/09/2024
Accepted: 30/11/2024
Published: 26/12/2024

**Corresponding author: E-mail: deepasrimohan@gmail.com;*

Cite as: *Mohan, Deepasri, Farooq Ahmad Lone, Javeed Iqbal Ahmad Bhat, Shabir Ahmad Bangroo, Imtiyaz Murtaza, Sethupathi Nedumaran, Areeba Aijaz, and Helen Mary Rose. 2024. "Geospatial Analysis of Land Use and Land Cover Dynamics Using Landsat Data: A Case Study of Ferozpore Nallah Watershed in Kashmir Valley". International Journal of Environment and Climate Change 14 (12):536-48. https://doi.org/10.9734/ijecc/2024/v14i124643.*

ABSTRACT

Findings of LULC change detection are important for understanding the influence and impacts of natural and anthropogenic activities on the watershed resource management. The present study utilizes the Remote Sensing (RS) & Geographic Information System (GIS) technology to categorize and identify changes in the Ferozpore nallah watershed in district Baramulla of Kashmir valley in India from 2001 to 2021. Supervised classification with maximum likelihood approach was employed to classify and generate the LULC maps. High-resolution Google Earth Pro historical images were used to evaluate the accuracy of the classified maps and were validated using overall accuracy and Kappa statistics. Nine LULC classes (agriculture, horticulture, forest, built-up, barren land, marshes, waterbodies, pastures and scrubs) were mapped from the Landsat imagery obtained for the period 2001 and 2021. The findings of change detection analysis shows that the area under agriculture, forest and marshes decreased by 18.77%, 1.79% and 5.48%, respectively from 2001 to 2021. Whereas, area under horticulture, built-up, barren land, waterbodies, pastures and scrubs increased by 19%, 4.22%, 1.24%, 0.60%, 0.31% and 0.67%, respectively at the same time. The overall accuracy of the classified maps was 88.89% for 2001 and 94.44% for 2021 while the kappa co-efficient was 0.87 and 0.94 for 2001 and 2021, respectively. The results of this study provide data to the planners and policy makers in understanding the Land Use and Land cover scenario and insights towards formulating policies for an effective and eco-friendly natural resource management and sustainable land use in the watershed region.

Keywords: Kappa co-efficient; watershed ecosystem; land transformation; remote sensing; landsat imagery; image digitization; accuracy assessment; India.

1. INTRODUCTION

Land use and land cover are two distinct interchangeably used terminologies where land cover represents bio-physical state of Earth's surface such as topography, soil, artificial infrastructures etc. while land use describes how humans use the land cover to obtain benefits and support themselves. The Land Use Land Cover (LULC) pattern of any geographical area is the interplay of environmental, socio-economic and institutional factors along with their anthropogenic exploitation over time and space (Dimyati et al., 1996; Jamal and Ahmad 2020). The LULC changes refers to changes in a specific type of land use or land cover's areal extent, either increase or decrease. The extensive LULC changes have been identified as one of important factors accountable for environmental modifications globally (Ahmed et al., 2022).

The LULC dynamics over the past few years has become a serious concern for the scientific community worldwide because the rate and dimensions of LULC changes altered by the human interference are so encroaching and unprecedented having eminent influences on Earth's Landscape modifications and impacts climate of the earth as well (Lambin et al., 2001; Foley et al., 2005; Bae and Ryu 2015). The changes in LULC have a significant impact on the physical environment of a place and also in transforming the social and economic conditions of people inhabiting that place (Zubair, 2006). The assessment of LULC change has become important to diverse aspects of natural environment and human population, and an intricate interplay among them (Ji et al., 2006; Liu and Yang 2015).

Change detection analysis involves the process of utilizing multi-temporal remote sensing information in identification and quantification of the historical changes of objects/ any phenomena under investigation by observing it at different time periods and thereby quantify the associated LULC changes (Zoran and Anderson 2006; Othman et al., 2014). Remote sensing and Geographic Information System has proved to be cost effective and valuable tools for assessing the spatio-temporal LULC dynamics providing large scale data on LULC changes along with their geographical distribution (Serra et al., 2008; Yuan et al., 2005; Lambin et al., 2003).

RS & GIS offers an opportunity to explore the LULC changes over the complex mountainous terrains by overcoming the constraints of inaccessibility. The Land Use Land Cover changes in the mountainous environments has widespread consequences owing to their fragile ecosystem and vulnerability towards the negative impacts of the change. Kashmir valley known for snow clad mountains, picturesque landscapes, with ample water resources such as lakes, springs, streams, swamps, rivers and glaciers, etc. have been witnessing drastic LULC changes in the past decades with an accelerating rate triggering multiple environmental issues in the area (Shafiq et al., 2017; Singh and Andrabi 2014). The land transformations are driven by various causes such as population increase, increasing urbanization, changes in agricultural practices, deforestation, economic development, etc. in the last decades (Jamal and Ahmad 2020). Numerous studies pertaining to LULC change detection have been carried out in various parts of Kashmir valley (Rasool et al., 2021; Alam et al., 2020) viz. north Kashmir Himalaya (Fayaz et al., 2020), district Srinagar (Saini et al., 2019), Anantnag (Lone and Mayer 2019), Baramulla (Malik et al., 2017).

Watersheds are the hydrological units playing an important role in providing socio-ecological services to the population around (Fernald et al., 2012). Land use/land cover in the watershed is mostly determined by, elevations, gradients, biological conditions and in addition the LULC shift is also expected to be influenced by technological, social, and institutional structure in the region Hua, 2017; (Shekar and Mathew 2023). The LULC changes in the watershed area will directly impact water quality and indirectly affect watershed ecosystem and hence it has become vital to have an inventory of the land resources in a watershed due to the growing possibility of anthropogenic changes and its environmental impacts (Hua, 2017). Understanding spatial and temporal variations in the watershed over time along with the hydrological component interaction will lead towards better planning and formulation of water conservation strategies (Ashraf, 2013). Focusing the LULC changes in watershed of Kashmir valley, several studies were carried out in various locations like Sind watershed Nisar and Lone 2013), Dudhganga watershed (Iqbal and Sajjad 2014), Lidder catchment (Rafiq et al., 2018), Lolab watershed Shafiq et al., 2017) and (Wular catchment of Jhelum basin (Ganaie et al., 2021). The main objective of the current study was to utilize RS & GIS applications to detect the extent of land use/ land cover (LULC) changes in the Ferozpore nallah watershed in district Baramulla of Kashmir valley from 2001 to 2021 using multi temporal Landsat imagery.

2. MATERIALS AND METHODS

2.1 Study Area

The current investigation was carried out in Ferozpore Nallah watershed which is one of the major left bank watersheds of river Jhelum in district Baramulla of Jammu and Kashmir UT, India (Fig. 1). At latitudes 33º55′ and 34º18′ N and longitudes 74º17′ and 74º43′ E the watershed covers over 540.35 km^2 with elevation ranging from 1558 to 3562 m above sea level. From a topographic standpoint, the lower portion of this watershed is characterized by plains, while the upper reaches feature precipitous slopes and mountain ridges. The study area falls under sub-temperate climate zone with distinct severe winter and pleasant summers. Geology of the area is dominated by the quaternary group of Karewa deposits, alluvium, Triassic limestone formation, basic volcanic rocks of Panjal traps (Rashid et al., 2016).

2.2 Data Acquisition

Multispectral satellite images/data are the primary source of information for LULC change detection for any geographical area over a time period. Availability and compatibility of appropriate information with 30 m spatial resolution with wider range of applications (Rogan and Chen 2004) have been the motivation behind selection of Landsat imagery for the present study. The multispectral data collected by the Landsat satellite were made available by the USGS (United States Geological Survey) Earth Explorer (https://www.earthexplorer.usgs.gov). Images with cloud cover less than 10 percentage were selected to minimize their interference during the categorization. Also to minimize the impacts of changing seasons, images from autumn season were chosen uniformly for both the years. Specifications of the satellite data acquired for the analysis of LULC dynamics are given in Table 1.

2.3 Study Protocol

ArcGIS 10.7 software was used to view and edit geospatial data, delineate boundaries, and create thematic maps. Supervised classification method was employed for grouping the LULC sensed from the satellite imageries. For image classification, widely used Maximum likelihood algorithm approach was adopted (Jensen, 2005). A total of nine LULC classes were identified

(Table 2) in the study area. Delimiting polygons around different sites allowed selection of training sites representing samples of identified land use and land cover types. The pixels in the polygons provide the information regarding spectral signature for the various land cover categories in the satellite imagery. After the spectral signatures were found to be satisfactory, the classification system is created. Then the LULC classes were mapped using the Maximum Likelihood method. The LULC mapping process is depicted in Fig. 2.

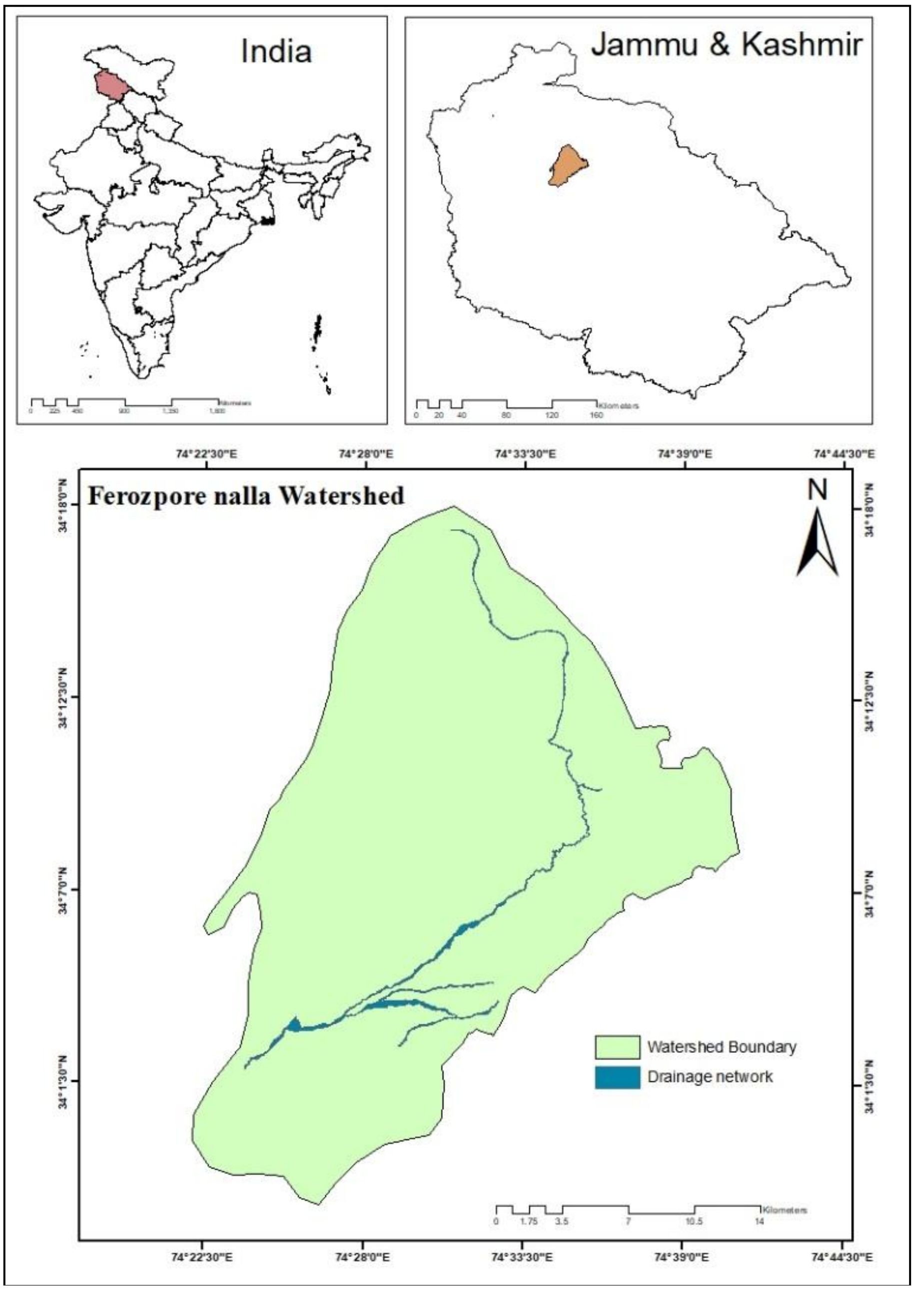

Fig. 1. Location map of the Study area - Ferozpore nallah watershed

Table 1. Information on satellite data used for the present study

Sensor/Satellite	Row & path	Date of acquisition	Spatial resolution	Source
LANDSAT 5 TM	149/36	21-October-2001	30 m	USGS
LANDSAT 8 OLI	149/36	25-October-2021	30 m	USGS

Table 2. Types of Land cover observed in Ferozpore nallah watershed

LULC category	Description
Agriculture	Crop fields (paddy, maize, pulses, vegetables, etc.), fallow land
Horticulture	Horticultural plantations (apple, pear, peach, almond, walnuts, etc.), tree covers with recognizable dispersed/ contiguous pattern
Forest	Dense tree covers with evergreen trees (pine, spruce, deodar, cedar, etc. in mountainous areas), mixed forests.
Built-up	Settlements, artificial infrastructure, roads, etc.
Barren land	Unforested areas, exposed rocks, open scrub land, etc.
Marshes	Wetlands/ water saturated areas, natural & manmade waterlogged areas.
Waterbodies	Surface waters in the form of rivers, stream, ponds, canals, etc.
Pastures	Grasslands
Scrubs	Scrub forests (includes less dense open forest with bushy vegetation mostly along the margins of the forests)

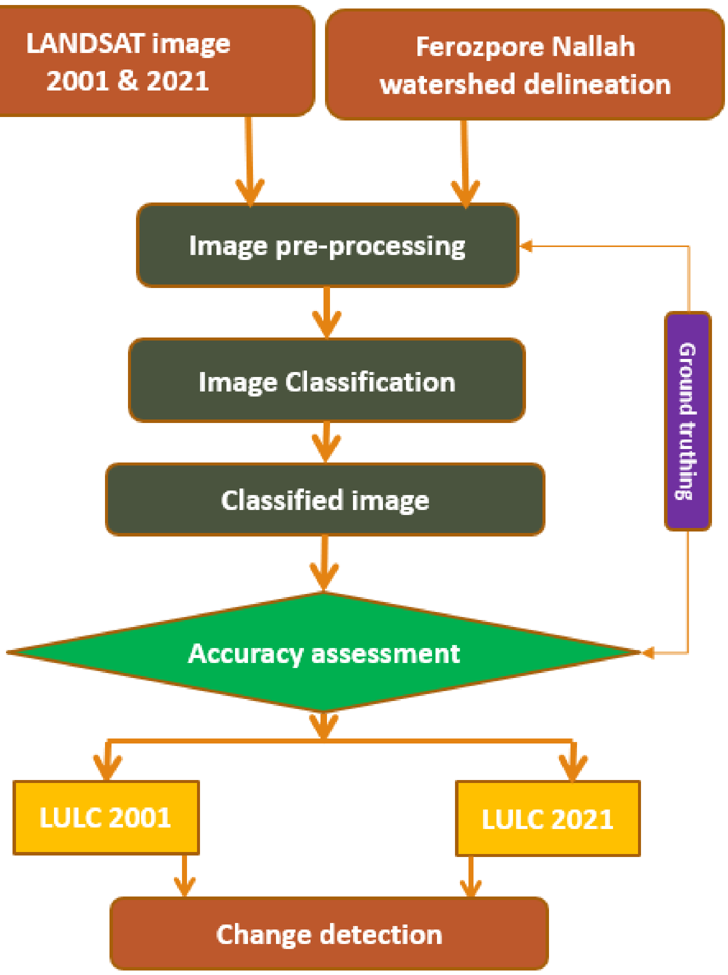

Fig. 2. Methodology flowchart for LULC change detection of Ferozpore nallah watershed

2.4 Accuracy Assessment

The accuracy of the classification is determined by comparing the classification with actual data and it is a vital step to examine the quality of information produced from the data. Accuracy assessment aims to measure the precision of the pixel sampling in a LULC classified map which is then quantified by error matrix (Foody, 2002; Shooshtari and Gholamalifard 2015). Using a stratified random sampling approach with 180 points, user's accuracy, producer's accuracy, overall accuracy, and kappa co-efficient were assessed. User's accuracy measures errors of commission, which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location. Producer's accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. The classification accuracy in the error matrix form depicts the accuracies of each category with errors of commission and omission in the present classification. Kappa Co-efficient is a robust multivariate statistical method used to assess inter-rater arrangement between categorical variables (Cohen, 1960) considering all elements of the error matrix. The kappa co-efficient with value >0.85 is excellent, 0.70-0.85 is very good, 0.55-0.70 is good, 0.4-0.55 is fair and <0.4 is poor (Tewabe and Fentahun 2020). Higher the accuracy values, higher the quality and precision of data generated. Accuracy assessment of the LULC maps generated for 2001 and 2021 were carried out using the error matrix. The Overall accuracy and Kappa co-efficient were determined by using the equations (1) and (2).

$$Overall\ accuracy\ = \frac{Total\ number\ of\ correctly\ classified\ pixels}{Total\ number\ of\ Reference\ pixels} x\ 100 \quad (1)$$

$$Kappa\ Co-efficient\ = \frac{(TS\ x\ TCS) - \sum (Column\ total\ x\ Row\ total)}{(TS)^2 - \sum (Column\ total\ x\ Row\ total)} x\ 100 \quad (2)$$

where, TS is the Total Samples and TCS is the Total Correctly Classified Samples.

3. RESULTS AND DISCUSSION

Ferozpore nallah watershed had significant LULC changes over time. The resulting LULC from the supervised classification is listed in Table 3 indicating nine classes: agriculture, horticulture, forest, built-up, barren land, marshes, water bodies and pastures for 2001 and 2011, respectively.

In 2001, two classes dominating the watershed were agriculture (40.29%) and horticulture (29.60%) followed by forest area covering 14.37%. The marshes occupied 7.54 % of the area followed by built-up (4.13%), waterbodies (1.80%), pastures (1.14%), scrubs (0.93%) and barren land (0.21%). The two major classes: agriculture and horticulture alone cover about 70% of the total watershed area indicating that farming was the dominant occupation in the study area. Forest represents the dense tree covers while scrubs and pasture lands are typically used for grazing livestock. The spatial coverage of land use land cover of study area during 2001 is presented in Fig. 3.

During the year 2021, horticulture dominated with 48.60% area followed by agriculture (21.53%). The forest occupied 12.58% followed by built-up (8.34%), waterbodies (2.40%), marshes (2.06%), scrubs (1.59%), pastures (1.45%) and barren land (1.45%). The horticulture and agriculture were the main classes covering almost 70% of the total area. The spatial coverage of land use land cover of study area during 2021 is presented in Fig. 4.

3.1 Change Detection in LULC Patterns over the Period of 2001-2021

The changes in the land use land cover of the study area obtained using the Landsat imagery from the present study is mentioned in the Table 4. Analyzing the data, the Ferozpore nallah watershed had experienced a significant LULC change over the years from 2001 to 2021. Quantification of the LULC change depicted that area under agriculture, forest and marshes decreased while horticulture, built-up, barren land, waterbodies, pastures, and scrubs increased. Agriculture, one of the main land cover classes in this study area has significantly decreased during the past decades by 101.4 km^2. Horticulture became the most significant land cover class with a significant increase of 102.69 km^2 area in the past decades (Fig. 5). Overall, area under agriculture decreased by 18.77% from 2001 to 2021. Similarly, forest area decreased from 14.27% (2001) to 12.58% (2021) and the marsh land decreased from 2001 (7.54 %) to 2021 (2.06%). On the other hand, area under horticulture increased by 19% from 2001 to 2021. The proportion of built-up land increased form 4.13% in 2001 to 8.34% in 2021. Likewise, from 2001 to 2021 overall area under barren land, waterbodies, pastures and scrubs increased by 1.24%, 0.60%, 0.31% and 0.67%, respectively.

Table 3. Distribution of LULC classes in Ferozpore nallah watershed

LULC Class	2001		2021	
	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)
Agriculture	217.72	40.29	116.32	21.53
Horticulture	159.93	29.60	262.62	48.60
Forest	77.63	14.37	67.95	12.58
Built-up	22.29	4.13	45.08	8.34
Barren land	1.14	0.21	7.82	1.45
Marshes	40.73	7.54	11.12	2.06
Waterbodies	9.75	1.80	12.97	2.40
Pastures	6.16	1.14	7.86	1.45
Scrubs	5	0.93	8.61	1.59
Total	**540.35**	**100**	**540.35**	**100**

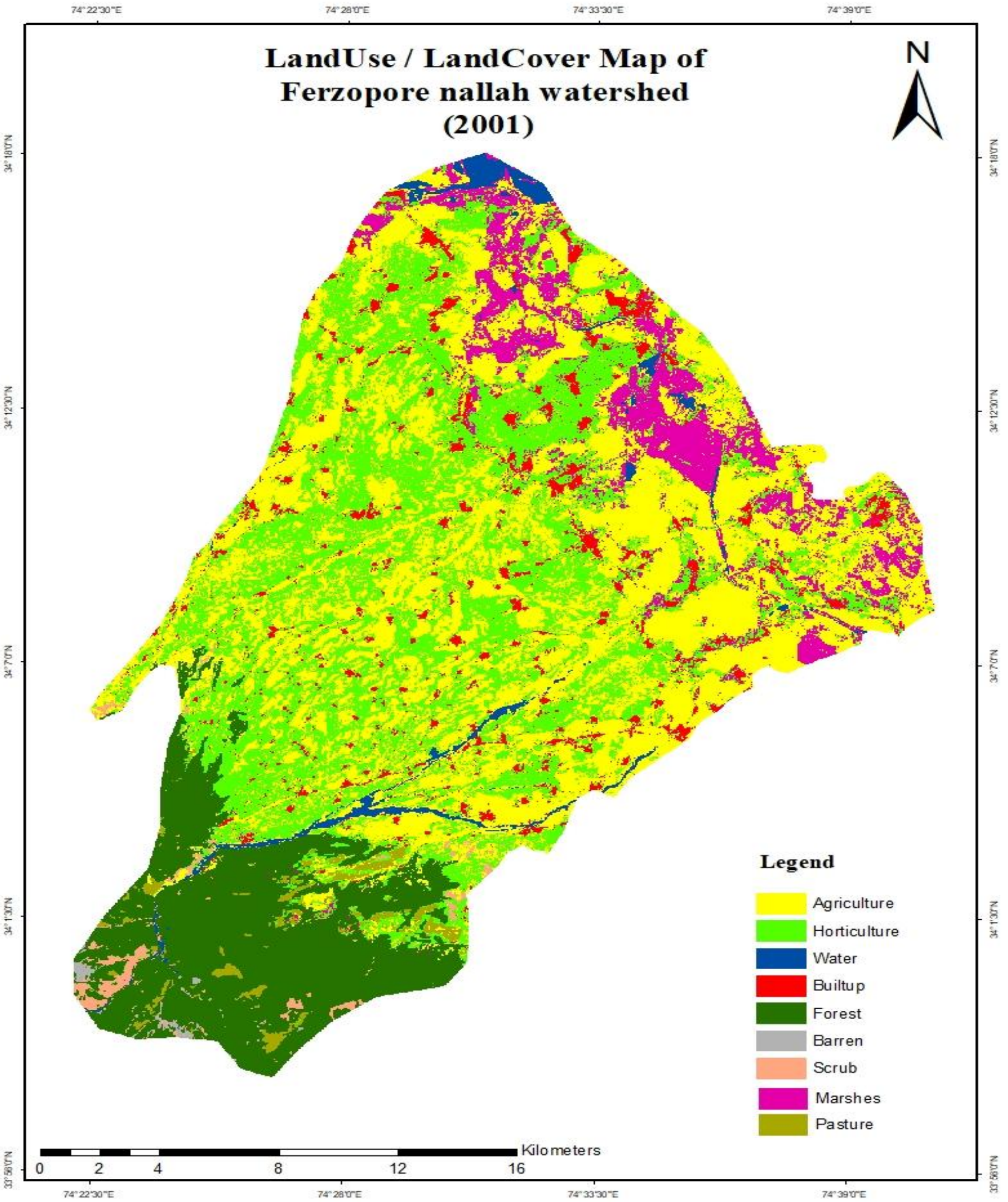

Fig. 3. LULC map showing the Ferozpore nallah watershed in 2001

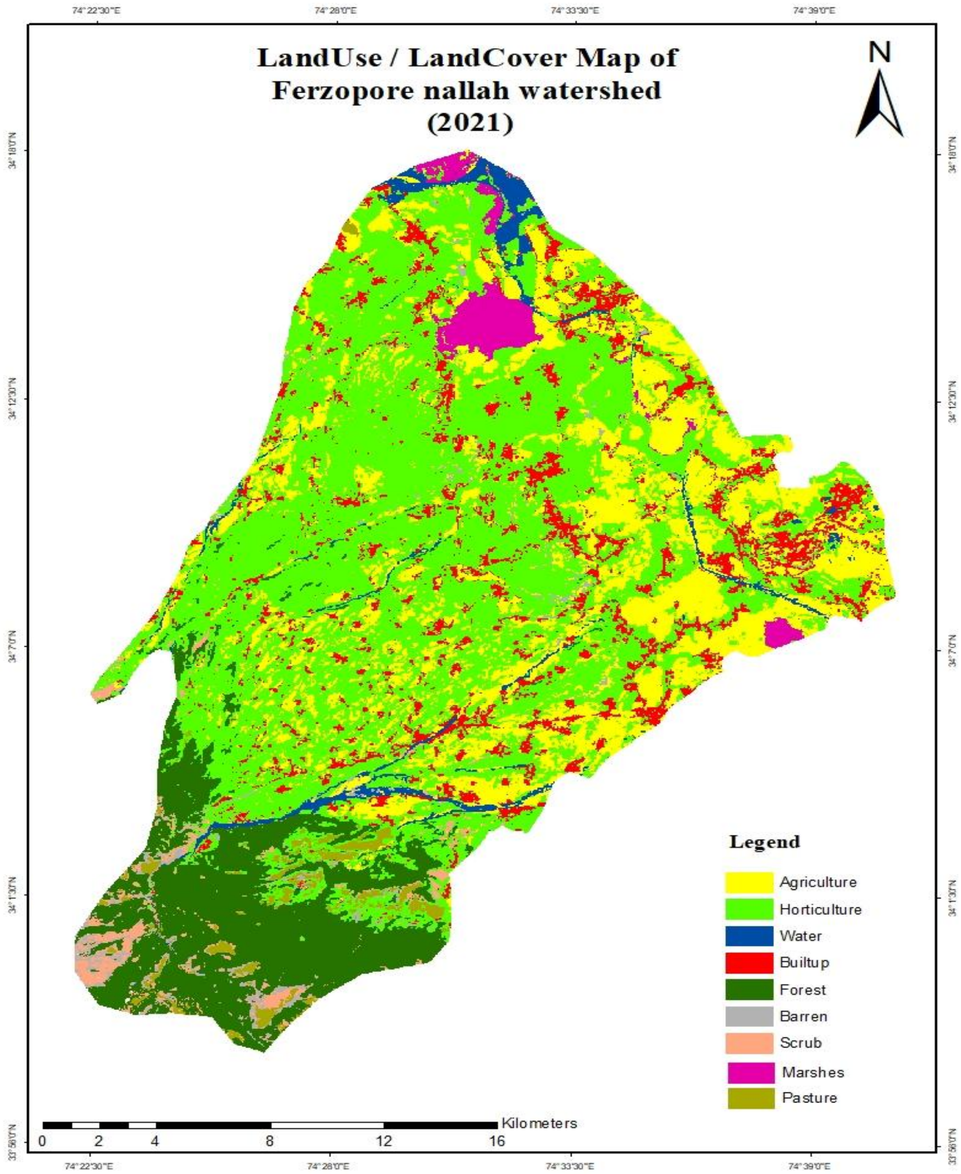

Fig. 4. LULC map showing the Ferozpore nallah watershed in 2021

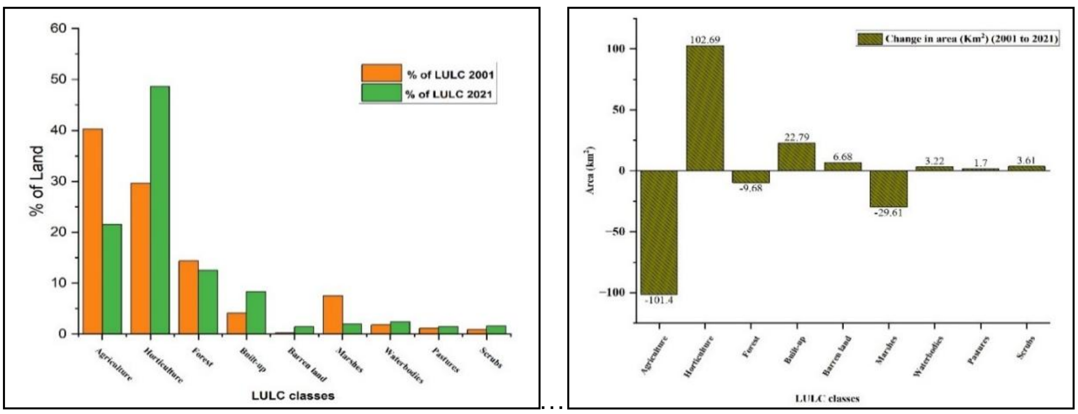

Fig. 5. Temporal patterns in the LULC of the Ferozpore nalla watershed (a) & (b)

Table 4. Decadal LULC change detection in Ferozpore nallah watershed under different classes

LULC Classes	Overall changes in 2001-2021	
	Area (Km^2)	Area (%)
Agriculture	-101.4	-18.77
Horticulture	102.69	19.00
Forest	-9.68	-1.79
Built-up	22.79	4.22
Barren land	6.68	1.24
Marshes	-29.61	-5.48
Waterbodies	3.22	0.60
Pastures	1.7	0.31
Scrubs	3.61	0.67

Table 5. Accuracy assessment of LULC maps of Ferozpore nallah watershed (a)2001 and (b)2021

					2001						
LULC Class	**A**	**H**	**F**	**Bu**	**Ba**	**M**	**W**	**P**	**S**	**RT**	**UA (%)**
A	**37**	4	0	0	0	1	0	0	0	42	88.10
H	2	**28**	0	0	0	0	0	0	0	30	93.33
F	0	0	**21**	0	0	0	0	0	1	22	95.45
Bu	0	0	0	**16**	1	0	0	0	0	17	94.12
Ba	0	0	0	1	**4**	0	0	0	0	5	80.00
M	0	0	0	0	0	**20**	4	0	0	24	83.33
W	0	0	0	0	0	3	**17**	0	0	20	85.00
P	1	0	1	0	0	0	0	**10**	0	12	83.33
S	0	0	0	0	0	0	0	1	**7**	8	87.50
CT	40	32	22	17	5	24	21	11	8	**180**	
PA (%)	92.50	87.50	95.45	94.12	80.00	83.33	80.95	90.91	87.50		
					2021						
A	**27**	1	0	0	0	1	0	0	0	29	93.10
H	1	**38**	0	0	0	0	0	0	0	39	97.44
F	0	0	**21**	0	0	0	0	0	1	22	95.45
Bu	0	0	0	**22**	1	0	0	0	0	23	95.65
Ba	1	0	0	0	**12**	0	0	0	0	13	92.31
M	0	0	0	0	0	**15**	1	0	0	16	93.75
W	0	0	0	0	0	1	**20**	0	0	21	95.24
P	0	0	0	0	0	0	0	**8**	1	9	88.89
S	0	0	0	0	0	0	0	1	**7**	8	87.50
CT	29	39	21	22	13	17	21	9	9	**180**	
PA (%)	93.10	97.44	100.00	100.00	92.31	88.24	95.24	88.89	77.78		

***A**: Agriculture, **H**: Horticulture, **F**: Forest, **Bu**: Built-up, **Ba**: Barren land,*
***M**: Marshes, **W**: water bodies, **P**: Pastures, **S**: scrubs*
CT: Column total, RT: Row total, PA: Producer's accuracy, UA: User's accuracy
(a) Sum of diagonals=160; Total =180; Overall accuracy: 88.89%; Kappa coefficient:0.87
(b) Sum of diagonals=170; Total =180; Overall accuracy: 94.44%; Kappa coefficient:0.94

The significant decrease in agriculture land can be attributed to shifting of land to other uses because of lower income opportunities. However, horticulture has gained a significant portion of its land from agricultural field conversions due to farmers' preference for high-yielding cash crops with higher economic returns, mainly apple production (Jamal and Ahmad 2020). With growing population and rapid urbanization, the built-up area comprising settlements, industrial infrastructure, roads, etc. also increased significantly (Rafiq et al., 2018). The marshes are disappearing due to various encroachments and conversion into agriculture/horticulture land. Conversion of forest land to scrubs/pastures because of forest degradation, deforestation, expansion of agriculture/horticulture land and other anthropogenic pressures are the reasons for decline in forest area (Shafiq et al., 2017).

Scrubs representing the intermediate zones between forest and non-forest land had gained area from the forests and productive lands as result of anthropogenic actions (Alam et al., 2020). Increase in pastures may be attributed to overgrazing while increase in barren land is attributed to natural disasters like landslides, etc. Increase in barren land poses a major threat to the ecosystem and sustainability of the study region (Meer and Mishra 2020).

3.2 Accuracy Assessment

Accuracy evaluation for the classified image with the actual information is significant to validate the LULC maps. The accuracy of the 2001 and 2021 classified maps were evaluated using the kappa co-efficient technique. The results obtained from the comparison of different reference points selected from the LULC maps of the study area during 2001 and 2021 with the Google Earth Historical imagery are presented in Table 5. The diagonal elements in the error matrix denotes accurate predictions of each class while elements off the diagonal represents misclassifications. The user accuracy is computed by dividing the diagonal value by the sum of the corresponding row. The producer accuracy is calculated by dividing the diagonal element by the column total. The overall accuracy for the year 2001 is 88.89% and 2021 is 94.44%. A higher Kappa co-efficient value signifies that the LULC classification has a great correlation. The Kappa co-efficient for 2001 and 2021 are 0.87 and 0.94, respectively indicating an excellent quality grade. Similar results were obtained by Kumari et al (2024) and Shekar & Mathew (2023).

4. CONCLUSION

The present study shows how LULC changes in the Ferozpore nallah watershed have altered significantly over the past decades. The findings of the change detection analysis shows that from 2001 to 2021, area under agriculture, forest and marshes decreased while horticulture, built-up, barren land, waterbodies, pastures, and scrubs has increased. The change in area under agriculture, forest and marshes decreased by 18.77%, 1.79% and 5.48% respectively. Also, the area under horticulture, built-up, barren land, waterbodies, pastures and scrubs increased by 19%, 4.22%, 1.24%, 0.60%, 0.31% and 0.67%, respectively. The validation of the LUC map was done using the kappa statistics. The overall accuracy for the classified image of 2001 and 2021 were 88.89% and 94.44%, respectively. The Kappa co-efficient was 0.87 for 2001 and 0.94 for 2021 indicating excellent accuracy grades. The findings of these land use land cover change detection are important for understanding the influence and impacts of both natural and anthropogenic activities on the watershed resource management. Therefore, this research anticipates that the findings might provide valuable information to the land planners and decision makers for environmental management and sustainable development in the Ferzopore nallah watershed and will also benefit the policy makers in planning towards future challenges.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Ahmed, R., Ahmad, S. T., Wani, G. F., Ahmed, P., Mir, A. A., & Singh, A. (2022). Analysis of landuse and landcover changes in Kashmir valley, India—a review. *GeoJournal, 87*(5), 4391-4403.

Alam, A., Bhat, M. S., & Maheen, M. (2020). Using Landsat satellite data for assessing the land use and land cover change in Kashmir valley. *GeoJournal, 85*(6), 1529-1543.

Alam, A., Bhat, M. S., & Maheen, M. (2020). Using Landsat satellite data for assessing the land use and land cover change in Kashmir valley. *GeoJournal, 85*, 1529-1543.

Ashraf, A. (2013). Changing hydrology of the Himalayan watershed. In *Current Perspectives in Contaminant Hydrology and Water Resources Sustainability* (Vol. 1, p. 13).

Bae, J., & Ryu, Y. (2015). Land use and land cover changes explain spatial and temporal variations of the soil organic carbon stocks in a constructed urban park. *Landscape and Urban Planning, 136*, 57-67.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20*(1), 37-46.

Dimyati, M. U., Mizuno, K., Kobayashi, S., & Kitamura, T. (1996). An analysis of land use/cover change in Indonesia. *International Journal of Remote Sensing, 17*(5), 931-944.

Fayaz, A., Shafiq, M. U., Singh, H., & Ahmed, P. (2020). Assessment of spatiotemporal changes in land use/land cover of North Kashmir Himalayas from 1992 to 2018. *Modeling Earth Systems and Environment, 6*, 1189-1200.

Fernald, A., Tidwell, V., Rivera, J., Rodríguez, S., Guldan, S., Steele, C., Ochoa, C., Hurd, B., Ortiz, M., Boykin, K., & Cibils, A. (2012). Modeling sustainability of water, environment, livelihood, and culture in traditional irrigation communities and their linked watersheds. *Sustainability, 4*(11), 2998-3022.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., & Helkowski, J. H. (2005). Global consequences of land use. *Science, 309*(5734), 570-574.

Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote Sensing of Environment, 80*(1), 185-201.

Ganaie, T. A., Jamal, S., & Ahmad, W. S. (2021). Changing land use/land cover patterns and growing human population in Wular catchment of Kashmir Valley, India. *GeoJournal, 86*, 1589-1606.

Hua, A. K. (2017). Land use land cover changes in detection of water quality: A study based on remote sensing and multivariate statistics. *Journal of Environmental and Public Health, 2017*, 7515130.

Iqbal, M., & Sajjad, H. (2014). Watershed prioritization using morphometric and land use/land cover parameters of Dudhganga Catchment Kashmir Valley India using spatial technology. *Journal of Geophysics & Remote Sensing, 3*(115), 2169-0049.

Jamal, S., & Ahmad, W. S. (2020). Assessing land use land cover dynamics of wetland ecosystems using Landsat satellite data. *SN Applied Sciences, 2*(11), 1891.

Jensen, J. R. (2005). *Introductory digital image processing: A remote sensing perspective*. Pearson Prentice Hall.

Ji, W., Ma, J., Twibell, R. W., & Underhill, K. (2006). Characterizing urban sprawl using multi-stage remote sensing images and landscape metrics. *Computers, Environment and Urban Systems, 30*(6), 861-879.

Kumari, N., Ayare, B. L., Bhange, H. N., Ingle, P. M., & Kasture, M. C. (2024). Land use and land cover change detection using remote sensing in the Kal River Basin, Raigad District, Maharashtra, India. *International Journal of Environment and Climate Change, 14*(10), 58-69.

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources, 28*(1), 205-241.

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O. T., Dirzo, R., Fischer, G., Folke, C., & George, P. (2001). The causes of land-use and land-cover change: Moving beyond the myths. *Global Environmental Change, 11*(4), 261-269.

Liu, T., & Yang, X. (2015). Monitoring land changes in an urban area using satellite imagery, GIS and landscape metrics. *Applied Geography, 56*, 42-54.

Lone, S. A., & Mayer, I. A. (2019). Geo-spatial analysis of land use/land cover change and its impact on the food security in District Anantnag of Kashmir Valley. *GeoJournal, 84*, 785-794.

Malik, M. M., Tali, J. A., & Nusrath, A. (2017). Assessment of land use and land cover change in district Baramulla, Jammu and Kashmir. *Research & Reviews: Journal of Space Science & Technology, 6*(3), 1-4.

Meer, M. S., & Mishra, A. K. (2020). Remote sensing application for exploring changes in land-use and land-cover over a district in Northern India. *Journal of the Indian Society of Remote Sensing, 48*, 525-534.

Nisar, M., & Lone, F. A. (2013). Effect of landuse/landcover change on soils of a Kashmir Himalayan catchment-Sindh. *International Journal of Research in Earth & Environmental Sciences, 1*(1), 13-27.

Othman, A. A., Al-Saady, Y. I., Al-Khafaji, A. K., & Gloaguen, R. (2014). Environmental change detection in the central part of Iraq using remote sensing data and GIS. *Arabian Journal of Geosciences, 7*, 1017-1028.

Rafiq, M., Mishra, A. K., & Meer, M. S. (2018). On land-use and land-cover changes over Lidder Valley in changing environment. *Annals of GIS, 24*(4), 275-285.

Rashid, I., Romshoo, S. A., Hajam, J. A., & Abdullah, T. (2016). A semi-automated approach for mapping geomorphology in mountainous terrain, Ferozpora watershed (Kashmir Himalaya). *Journal of the Geological Society of India, 88*, 206-212.

Rasool, R., Fayaz, A., ul Shafiq, M., Singh, H., & Ahmed, P. (2021). Land use land cover change in Kashmir Himalaya: Linking remote sensing with an indicator based DPSIR approach. *Ecological Indicators, 125*, 107447.

Rogan, J., & Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning, 61*(4), 301-325.

Saini, R., Aswal, P., Tanzeem, M., & Saini, S. S. (2019). Land use land cover change detection using remote sensing and GIS in Srinagar, India. *International Journal of Computer Applications, 178*(46), 42-50.

Serra, P., Pons, X., & Saurí, D. (2008). Land-cover and land-use change in a Mediterranean landscape: A spatial analysis of driving forces integrating biophysical and human factors. *Applied Geography, 28*(3), 189-209.

Shafiq, M., Mir, A. A., Rasool, R., Singh, H., & Ahmed, P. (2017). A geographical analysis of land use/land cover dynamics in Lolab watershed of Kashmir Valley, Western Himalayas using remote sensing and GIS. *J. Remote Sens. GIS, 6*, 189.

Shekar, P. R., & Mathew, A. (2023). Detection of land use/land cover changes in a watershed: A case study of the Murredu watershed in Telangana state, India. *Watershed Ecology and the Environment, 5*, 46-55.

Shooshtari, S. J., & Gholamalifard, M. (2015). Scenario-based land cover change modeling and its implications for landscape pattern analysis in the Neka Watershed, Iran. *Remote Sensing Applications: Society and Environment, 1*, 1-9.

Singh, H., & Andrabi, R. H. (2014). Changing land use/land cover analysis in Pulwama district of Jammu & Kashmir. *International Journal of Scientific and Research Publication, 4*(8), 1-8.

Tewabe, D., & Fentahun, T. (2020). Assessing land use and land cover change detection using remote sensing in the Lake Tana Basin, Northwest Ethiopia. *Cogent Environmental Science, 6*(1), 1778998.

Yuan, F., Sawaya, K. E., Loeffelholz, B. C., & Bauer, M. E. (2005). Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing. *Remote Sensing of Environment, 98*(2-3), 317-328.

Zoran, M., & Anderson, E. (2006). The use of multi-temporal and multispectral satellite data for change detection analysis of the Romanian Black Sea coastal zone. *Journal of Optoelectronics and Advanced Materials, 8*(1), 252.

Zubair, A. O. (2006). Change detection in land use and land cover using remote sensing data and GIS (A case study of Ilorin and its environs in Kwara State). *Department of Geography, University of Ibadan*.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/127165