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Research Article

Monitoring of Land use/ land cover changes of Daying Ering Wildlife Sanctuary, Arunachal Pradesh, India, using Remote Sensing and Geographic Information System

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Abstract
The advent of geospatial technology plays a vital role in identifying environmental problems and provides solutions to good decision-making. In India, much of wildlife research and management occurs in protected areas. Therefore, it is imperative to study the landscape dynamics of such areas. The present study aimed to investigate the spatio-temporal of land use/land cover (LULC) changes that occurred in Daying Ering wildlife sanctuary, East Siang District, Arunachal Pradesh, for 10 years (2012-2022). The LULC were categorized into vegetation, water body, marsh, riverbed, and grassland. Supervised classification was used with the maximum likelihood algorithm in ERDAS 15.0 software. Post-assessment of the study area images revealed that there had been some major land changes whereby grassland has decreased by 25.10 %, an increase in the river bed (16.73%), and an increase in the water body (16.16%). The findings of the present study call for attention from researchers, environmentalists, policymakers, government officials and local villagers to study the consequences of LULC changes on vulnerable species and form mitigation/management measures accordingly.

Keywords: Daying Ering Wildlife Sanctuary , Eastern Himalayas , Land use/cover, Protected area, Remote sensing

INTRODUCTION

Globally, researchers have extensively studied the changes in Land use/ Land cover (LULC) using Remote Sensing (RS) and Geographical Information System (GIS) and have concluded that LULC must be conducted regularly (Annayat *et al*. 2022; Lodhi *et al*. 2014). Understanding LULC of a particular area, more unfortunately so, if a protected area, is an important question for holistic management and the locals living in proximity (Mutanga *et al*. 2015; Bilyaminu *et al*. 2021). With the application of remote sensing, it has been made possible to study the patterns of changes in land use/land cover at low cost, less time and high accuracy (Kachhwaha 1985). Advanced image processing and high spatial resolution have shifted to a more systematic, uniform, consistent monitoring and modelling of LULC patterns (Lo and Choi, 2004). LULC are two separate terms which can frequently be used interchangeably. However, on a specific note, land cover refers to the physical characteristics of the land, such chandraas mountainous, plains, sandy, etc., whereas land use refers to the land modified through human interventions. Land use/land cover detection is vital for a good understanding of landscape dynamics which can facilitate sustainable management of the area. The forest is a good example of an area with constant dynamic changes due to both natural and human-induced forces (Giri *et al*., 2007). The changes in LULC are pervasive, rapid and greatly contribute to forest fragmentation, which in turn impacts the habitats of species causing isolated and local extinctions (Aditya *et al*. 2016).

These impacts are the subject of concern on both local and global fronts since they hamper the ecological balance (Yuan *et al*., 2013; Behera *et al*., 2012). The common trajectory globally on changes in LULC is a rapid agricultural expansion and massive reduction in forest areas (Houghton, 2003; Yin *et al*., 2011). The main drivers of global LULC changes are natural factors such as steep slopes, drought and climate change and anthropogenic activities such as agricultural expansion and intensification (Pielke *et al*. 2011; Shiferaw & Singh, 2011). Protected areas, in particular, pay one of the heaviest costs since they play actual roles in ecosystem services, biodiversity services and ecological balance.

Several studies on LULC using remote sensing in northeast India (Balasubramanian *et al*., 2016) studied the anthropogenic LULC change in Bura Chapori Wildlife Sanctuary, Assam and their results revealed that the increased human-induced pressures could potentially threaten the wildlife population. Shimrah *et al*. (2022) monitored LULC and forest fragmentation in Ukhrul District of Manipur, while Ritse *et al*. (2020) worked on LULC patterns of Dimapur and Kohima. In present study area, Arunachal Pradesh Deka *et al*. (2019) revealed that there has been a rapid in three districts, viz. lower Dibang valley, Lohit and Changlang, increase of other land use categories at the cost of forest land. Posti and Baruah (2020) studied the fishery resources in West Kameng Arunachal Pradesh using geospatial technology and identified three suitable zones for aquatic resources: most suitable moderate and least suitable. Another study worked on Analytic Hierarchy Process and delineation of the groundwater potential of Papum Pare District Mahato *et al*. (2022). Another LULC study in Poba reserve forest, Assam and Arunachal Pradesh revealed that the open evergreen forests have increased on account of anthropogenic agricultural activities (Kumari *et al*. 2014). In the study of land Cover mapping of Namdapha National Park, AP, the authors (Lodhi *et al*. 2014) concluded that mapping protected areas may be less relevant from a developmental perspective. However, they are equally important, if not more, for biodiversity conservation.

Research on LULC change has been scattered and scarce in the state. Therefore, the present study attempted to understand the land use land cover of the Daying Ering Wildlife Sanctuary (WLS) between 2012 and 2022 to detect the changes that have taken place in the protected area using GIS and Remote Sensing. This is the first attempt to illustrate the use of remote sensing and GIS, which are important technologies for temporal analysis and quantification of spatial phenomena in Daying Ering WLS.

MATERIALS AND METHODS

Study area

Daying Ering WLS comprises river islands in East Siang district, Arunachal Pradesh (Fig. 1) . The islands are surrounded by the Siang River (Tsangpo in Tibet and Brahmaputra in Assam, India) and its tributary,

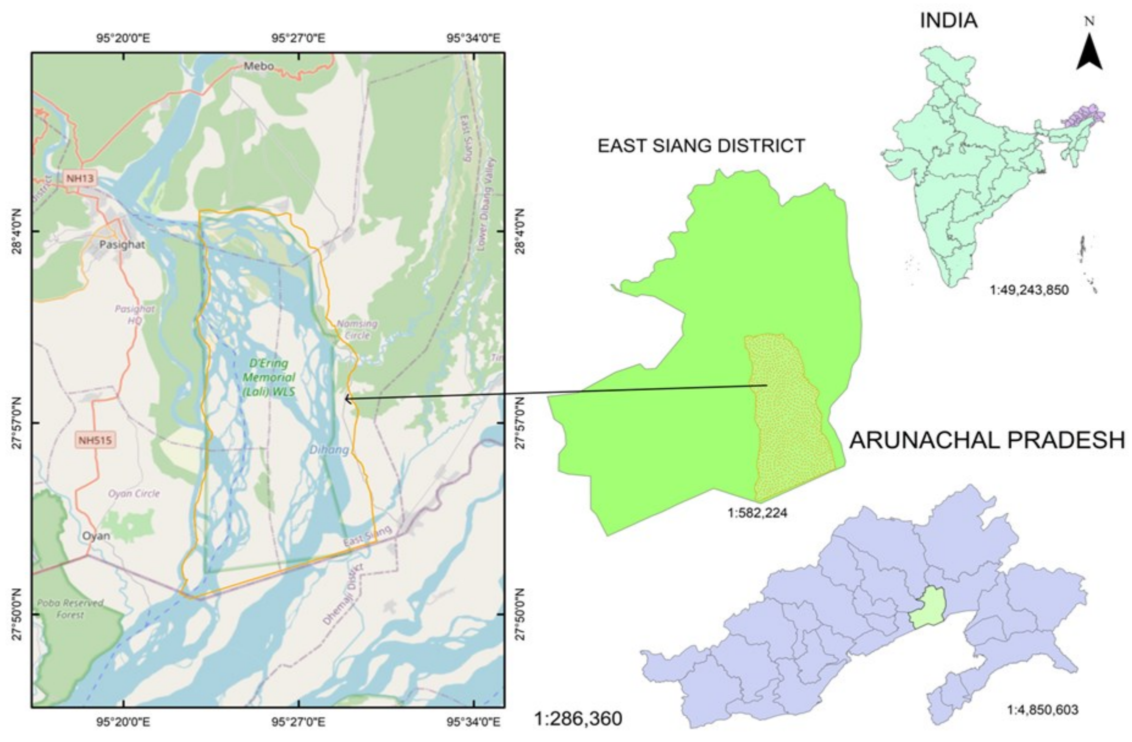

Fig. 1. *Study area map showing Daying Ering Wildife Sanctuary (DWS), situated in East Siang District, Arunachal Pradesh*

Sibia. The total area of the Sanctuary is 190 sq. km, between 95°22'E- 95°29'E and 27°51'N-28°05'N. The sanctuary is naturally separated from Dibru-Saikhowa National Park Assam and is known to house endangered species like the Bengal florican, Asiatic Elephant, Indian hog deer and wild water buffalo (Dodum, 2020). The main vegetation type of the region is evergreen forest and montane wet temperate forest; the local population belongs to the tribal community, Adi (Champion and Seth, 1968; Census, 2011). This community has a traditional natural inclination to depend on forest resources, including wildlife, and is not fully aware of nature conservation (Jyrwa *et al*., 2020). In fact, the study by Kumari *et al*. (2014) confirmed this by attributing the LULC changes in a nearby resource forest to careless anthropogenic activities. However, the sanctuary faces perhaps a more pressing threat by seasonal floods and major floods upstream from China (Chakraborty, 2014; The Wire, 2018)

Database preparation

LISS III thematic Mapper at resolution of 30m in 2012, 2017 and 2022 was used for land use/cover classification. The satellite data covering the study area were obtained from Bhuwan National Remote Sensing Centre (NRSC) (https://bhuvan.nrsc.gov.in/home/indes.php) for the month of December for all the three years. These datasets were imported in ERDAS Imagine 2015 Version 15.0 (Leica. Geosystems, Atlanta, USA). Satellite image processing software and false color composite (FCC) were created. The sub-setting of satellite images was performed to extract the study area from the images by taking the geo-references line boundary of the Daying Ering WLS map as AOI (Area of Interest). For better classification results, some indices, such as normalized difference vegetation index (NDVI) and normalized difference water index (NDWI) were also created to classify the images (Rawat and Kumar, 2015).

Land use/cover detection and analysis

A Supervised classification method with maximum likelihood algorithm was incorporated in ERDAS Imagine 15.0 to work out land use/cover classification. The error matrix and Kappa Khat were used to compute the accuracy of the maps. Five land use/cover types were observed and identified in the study area viz., i) Vegetation ii) Grassland iii) Marsh iv) Water body and v) Riverbed (Rawat and Kumar, 2015).

Land use/ land cover change detection and analysis

The post-classification detection method was incorporated for LULC detection, where in this method, a comparison between classified image pairs of two different years of data was worked out. The qualitative aspect of the changes from 2012 to 2017, 2017 to 2022 and from 2012 to 2022 were determined using ERDAS Imagine 15.0 software, change matrix (Weng, 2001; Rawat and Kumar, 2015) was produced. These quantitative areal data of LULC changes in each category for the three years intervals were compiled and imported into ArcMap10.8.2. Each of the detected change categories was colour-coded, and the map layouts were subsequently exported.

RESULTS AND DISCUSSION

Land use/ land cover status

Accuracy assessment of the land use/cover classification results obtained showed an overall accuracy of 85.94% for 2012 and 90.13% for 2022. The Kappa coefficients for the 2012 and 2022 maps were 0.82 and 0.912, respectively. According to the latest LULC map, Daying Ering WLS comprised mostly water bodies (36.70%) and riverbed (27.88%), followed by marsh (12.85%), grassland (12.23%) and a very small percentage of vegetation (10.33%) (Fig. 2 and Table 1).

Land use/ land cover change

The decadal analysis of land use/cover change revealed that there had been some positive and negative changes from 2012 to 2022. Grassland had decreased considerably by 25.10% (84.50 km^2 to 28.60 km^2) from 2012 to 2022. On the other hand, dry barren riverbed increased by 16.73% (25.25 km^2 to 65.19 km^2), followed by an increase in water body and vegetation by 16.16 % and 1.35%, respectively. Marshy land decreased by 9.14 % from 2012-2022 (Table 1 and Figure 4). The massive decrease in grassland raises a concern for grassland specialist species like Asiatic elephants, Bengal florican, Hog deer and Water buffaloes, which are endangered and present in the study area (NMHS report, 2020) and on the other hand the increase in dry barren areas and water body indicated that the area was vulnerable to disasters such as flood.

The land use land cover matrix for the different land categories reveals that there have been dramatic changes from one category to another in the last decade. The following points sums up the change matrix in decreasing order:

A staggering proportion of 52.95 % of grassland had changed into marshy region, 37.69% into vegetation, 29.25% into river bed, and 23.78 % into water body.

About 26.68% of the water body had been converted into river bed, 9.89 % to marsh, 3.55% to grassland and 3.21% to vegetation.

About 24.78% of the marshy region had been converted to river bed, 23.78% into water body, 14.89 % to grassland and 10.98% to vegetation.

About 17.30 % of river bed had been converted to water body, 8.66% to marsh, 0.65% to vegetation and

Table 1. Area and amount of change in different land use/cover categories in Daying Ering Wildlife Sanctuary from 2012 to 2022

Land Cover/ Cover Change	2012		2017		2022		Change 2012-2022	
	Sq.kms	%	Sq.kms	%	Sq.kms	%	Sq.kms	%
Water Body	46.48	20.53	70.57	31.21	85.80	36.70	39.32	16.16
Vegetation	20.33	8.98	40.00	17.69	24.15	10.33	3.82	1.35
Marsh	49.79	22.00	31.86	14.09	30.07	12.86	-19.73	-9.14
River Bed	25.26	11.16	51.76	22.89	65.19	27.88	39.94	16.73
Grassland	84.50	37.33	31.91	14.11	28.59	12.23	-55.91	-25.10
Total	226.36		226.10		233.81		7.45	

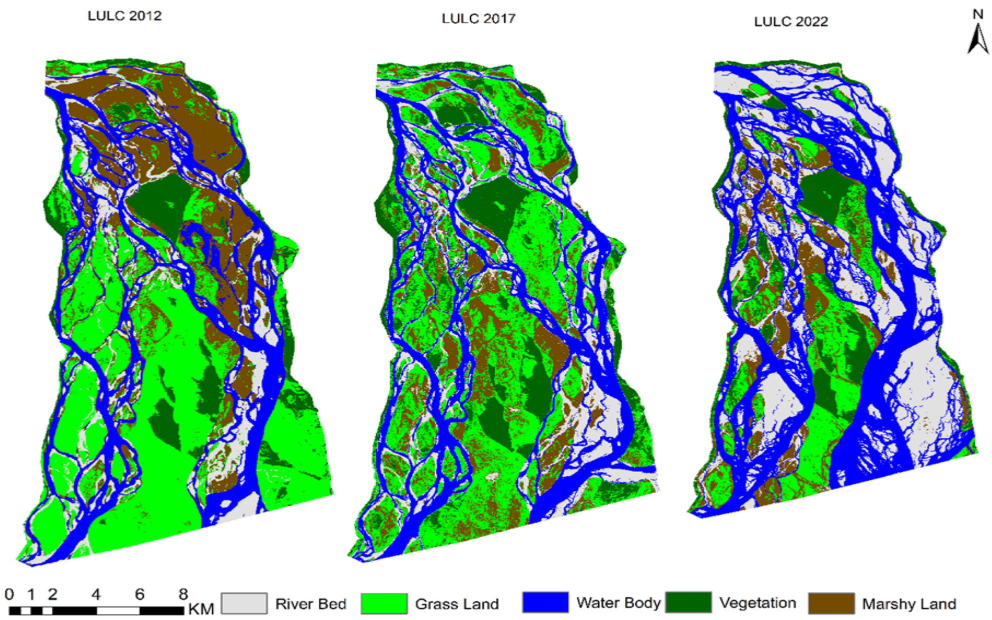

Fig. 2. *Land use/cover status of the Daying Ering Wildlife sanctuary; in 2012, 2017 and 2022*

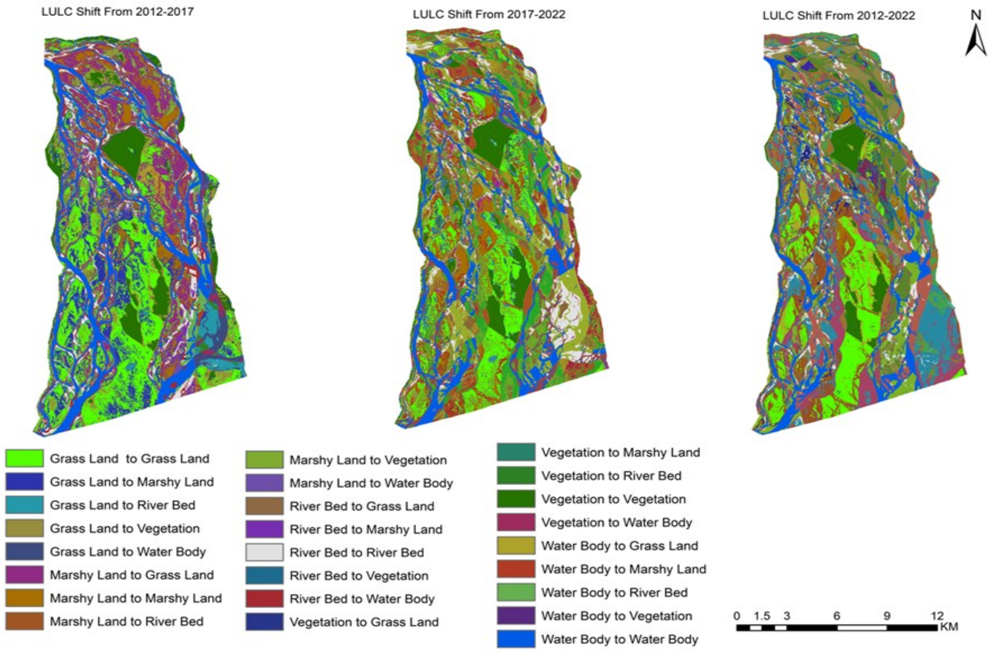

Fig. 3. *Land use/cover change in different categories during the last decade in the Daying Ering Wildlife Sanctuary (2012- 2022)*

Table 2. Land use/cover change matrix showing land changes (in %) of Daying Ering WLS for 2012-2022.

	Land Use/ Cover Types	Year 2022 (in %)				
		Water body	Vegetation	Marsh	River bed	Grassland
Year 2012	Water Body	29.58	3.21	9.89	26.68	3.55
	Vegetation	5.57	47.47	2.83	6.86	1.20
	Marsh	23.78	10.98	25.68	24.78	14.89
	River Bed	17.30	0.65	8.66	12.44	0.59
	Grassland	23.78	37.69	52.95	29.25	79.77
	Class Total	100	100	100	100	100

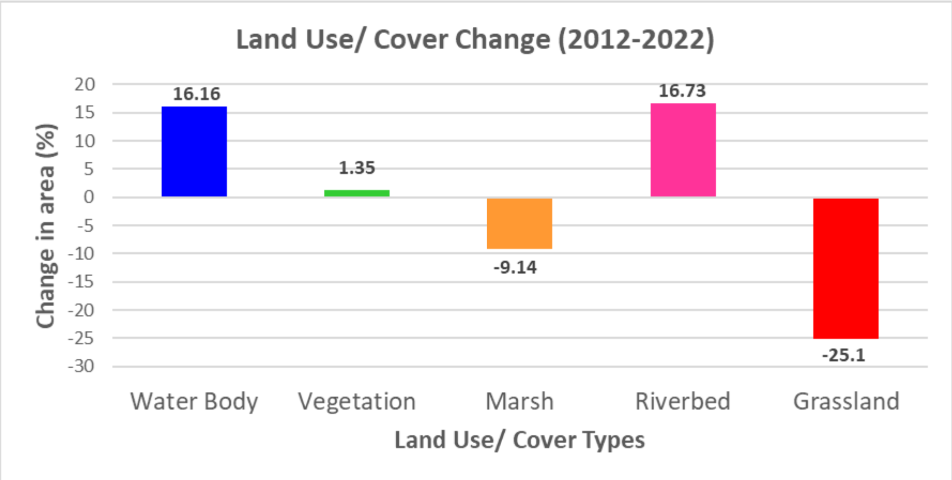

Fig. 4. *Diagrammatic illustration of land use/cover change in percent during 2012–2022 in Daying Ering Wildlife Sanctuary*

0.59% to grassland.

About 6.86 % of vegetation had been converted to river bed, 5.57% to water body, 2.83% to marsh and 1.20% to grassland.

Daying Ering WLS basically comprised inter-connected islands and was typically a grassland-dominated area, but over the last decade, it has faced tremendous changes. This study revealed that the major land use in the study area is grassland, marsh, and water body. The massive decrease in grassland raises a concern for grassland specialist species like Asiatic elephants, Bengal florican, Hog deer and Water buffaloes, which are endangered and present in the study area (NMHS report, 2020). Marshy areas have also decreased due to erosion and accretion, which houses water buffaloes, Asiatic Elephants, and other species for sunbathing. Water body and riverbed, on the other hand, collectively has increased by 32.89% while, positively, forest area seems to have increased by 1.35%. This could be a good sign for elusive species such as leopards, golden jackals and other carnivores.

China being on upstream of the Siang River shares an annual hydrological report with India every year (The Wire, 2018). There was evidently a lot of erosion and accretion because of the rapid changes in river ow and directions (Fig. 2 and 3; Table 1 and 2). This could also be attributed to the recent China flood, in which Indian government officials have warned about the "changing features" of the river and the danger it poses to humans and animals (The Wire, 2018).

Conclusion

The present study concluded that land use/ land cover is rapidly altering in the Daying Ering Wildlife Sanctuary mainly because of river movement, soil erosion and accretion. In one decade, i.e., between 2012-2022, grassland has declined by 25.1 % per cent at the cost of endangering grassland species like Hog deer, Asiatic elephants, etc., found in the sanctuary. Further, water body and riverbeds have collectively increased by 32.89 %, which may affect the movement of elusive species such as leopards and other carnivores. The land use/cover change indicates rapid erosion and silt accretion in the region, which is not a good sign ecologically for such a protected area. For the area's sustainability, certain restrictions and regulations in upstream developmental activities are highly necessary to prevent such diversion of water movement and high deposition of sand materials. Efforts must also be made to involve all the forest stakeholders in Daying Ering Wildlife Sanctuary management.

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Conflict of interest

The authors declare that they have no conflict of interest.

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