Volume 64, Issue 2, 2020
Journal of Scientific Research
Institute of Science,
Banaras Hindu University, Varanasi, India.

Changes in Vegetation Cover Using GIS and Remote Sensing: A Case Study of South Campus BHU, Mirzapur, India

Rajani Srivastava[1], Sunita Singh[*2] and Abhimanu Oran[1]

[1]Environmental Science (Environmental Technology), IESD, RGSC, Banaras Hindu University, Mirzapur, 231001, India.
srivastava_252003@yahoo.com, rajani.srivastava25@gmail.com

[2]Department of Geography, Institute of Science, Banaras Hindu University, Varanasi-221002, India.
sunbhu11@rediffmail.com*

Abstract: **Exponential increase in the human population, economic upliftment and urbanization has prompted noticeable variations in land use and land cover (LULC) in tropical ecosystems. Such changes are negatively affecting the potential of these native ecological systems to provide economic and ecological services to the society, and thus needs policy formulation. This study aims to assess vegetation cover and vegetation types under different LULC in Barkachha, Mirzapur India for 10 years (from 2008 and 2018) using remote sensing and field study data. This investigation applied a supervised classification-maximum likelihood algorithm (ERDAS Imagine-14) to analyze LULC variations using multispectral satellite data of very fine resolution (1m) collected from the Google Earth image. In the present study, the LULC area was grouped into ten main classes. A remarkable shift in vegetation cover was noted through LULC use and overlap maps created in Arc GIS 10. In the last 1o years, there was shrank in natural vegetation by 11 % to 2.6%, whereas, the agricultural field increased by 5% to 6%. In 2008, an area under dense vegetation was 118.4 hectares (approx. 12% of total vegetation) whereas in 2018 it reduced to 29 hectares (about 3% of total vegetation). Dense vegetation cover has drastically decreased whereas thorny bushes and fallow land increased. Further, the new constructed area increased suddenly due to the construction of new structures in cultivated and natural lands for the development of the campus. Expansion of built area and concurrent enhancement in anthropogenic activities to develop the campus facilities linked to change in vegetation cover and vegetation types over ten years. The result of this study will help in-depth understanding of reasons for alteration and for formulating actual plans and strategies to reverse vegetation and land degradation in Barkachha, Mirzapur.**

Index Terms: **Change detection, Land use and Land cover, Remote sensing, Satellite image, Vegetation cover.**

I. Introduction

Land use and land cover (LULC) are two separate phrasings that are regularly utilized reciprocally (Dimyati et al. 1996). LC denotes to the physical attributes of the land's surface, including the spreading of flora, soil, aquatic body and other Physical qualities of the land, and those made exclusively by human exercises e.g., settlements. While LU discusses how the land has been utilized by people and their living space, for the most part with the emphasis on the functional job of land for human needs and wellbeing. The LULC extent of an area is a result of natural and socio-economic variables and their usage by the man in existence. For satisfying the need for the quickly developing populace, financial upliftment, and urbanization, LULC is evolving. Examination of the effect of LULC changes is significant for the determination, arranging, and usage of land use plans to satisfy the expanding needs for fundamental human needs and government assistance. Understanding the land outlines, variations and communications between human actions and natural phenomena are important for appropriate land use and choice development. Today, earth resource satellite data is truly pertinent and accommodating for the examination of LULC change (Yuan et al. 2005; Brondizio et al. 1994). In the course of the most recent couple of decades different procedures of LULC mapping and change recognition have been created and applied everywhere throughout the globe (Jin et al. 2013; Phiri and Morgenroth, 2017; Jin et al. 2017; Sekertekin et al. 2017).

In India, recently, analysis of LULC of Mirzapur region, have been studied by Srivastava et al. (2020). Whereas, many other researchers (Rai et al. 2015; Mishra et al. 2016; Singh and Rai 2018) analyzed changes in soil and vegetation cover using remote sensing and related methods and considered it as a valued method for assessment of soil natural resources. Just as importantly, timely and accurate information about the LULC's spatial change

[*] Corresponding Author

DOI: 10.37398/JSR.2020.640219

findings is critical to understanding the associations and interactions between human resources and the environment to make improved decisions. (Vishwakarma et al. 2016).

Use of remotely sensed information made conceivable to examine the variations in land cover in less time, requiring little to no effort and with better exactness in relationship with GIS that gives a reasonable stage to information investigation, update and recovery (Llena et al. 2019). The approach of high spatial resolution satellite imagery and more sophisticated image processing and GIS technology, switching to monitoring and modeling to the more regular and frequent use of LULC models. As a result of higher spatial resolution, remote-sensing has been extensively used in updating LULC maps and this mapping has become one of the most significant uses of remote sensing (Lo and Choi 2004). Pooja et al. (2012) have measured land use and the cover of Ganges watershed, area Almora utilizing a review of India topographic sheet of the year 1965 and LISS III satellite information for the year 2008 over a time of 43 years. Rawat et al. (2013, 2014) have done an investigation of Kumaun Himalaya of five significant towns (i.e., Ramnagar, Nainital, Bhimtal, Almora and Haldwani) in Uttarakhand, India. In light of 20 years of satellite information from 1990 to 2010 of land use and land cover change, they found that constructed building region has strongly expanded because of development of new structures in cultivated land and natural vegetated lands. LULC mapping of Srinagar city in Kashmir was analyzed by Amin et al. (2012). They saw that the Srinagar city has encountered huge changes from 1990 to 2007. The investigation likewise demonstrated that adjustments in land use design have brought about the loss of woodland territory, open spaces, and so on. Mehta et al. (2012) introduced an incorporated methodology of remote sensing and GIS for land-use changes in the years 1999 and 2009 of the dry condition of Kutch located in Gujarat. Tremendous endeavors have been made to portray LULC on a local, narrow scale and worldwide broad scale by applying diverse multi-temporal and multi-source remotely detected information from both aerial and spaceborne sensors. There is scarce information about the impact of LULC changes on the Vindhyan region of India especially in fast built-up areas like Rajiv Gandhi South Campus (RGSC), BHU, Barkachha on vegetation dynamic, using Arc GIS and field survey both as a tool.

Objectives:

The main aim of this work was to assess the nature, significance, and degree of alteration in vegetation cover from 2008 to 2018. Besides, it also expected to analyze the zones of quick change, the extent of variations and examine the previous and current conditions of Land Cover to understand the dynamics and trend of change.

The objectives of this study were:

1. To assess change detection in the spatial distribution of vegetation cover due to the LULC period of 2008 and 2018.
2. To analyze the effect of land-use changes on land cover and diversity of vegetation over ten years. Also, maintain a database of the RGSC BHU.

II. Materials and Methods

A. Study Area

The study area is RGSC, Barkachcha of Banaras Hindu University (BHU) located (~80 km road distance) in the south-west of Varanasi city and (about 10 km) in the south of Mirzapur Town, UP, India (Figure 1). The campus area lies at the southern margin of the Vindhyan plateau. The general elevation of the area ranged from 90-174m amsl. The elevation of the campus surface is within the range of 170-100m amsl. On the south and eastern side, the campus area is bound by the Khajuri River. The Vindhyan plateau here is formed from cross-bedded and and comparatively hard sandstone rocks extending through up to about 120 m. The campus and its surroundings enjoy a dry climate with an average annual rainfall of about 100 cm mostly falling during July- October. The mean annual temperature is around 27 ºC with a maximum at around 42-45 ºC and a minimum at around 3-6 ºC.

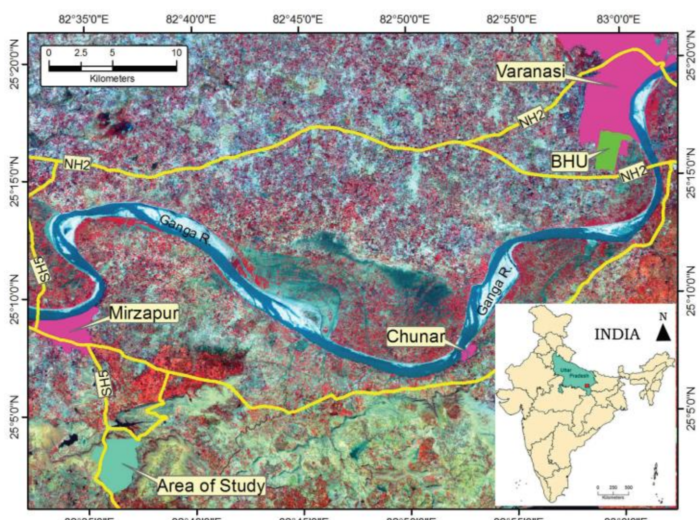


Fig. 1. Location of Study Area.

B. Vegetation

The campus has typical terrain representing the Vindhyan range and is a treasure of plant biodiversity especially medicinal plants which are characteristic of this range. The common, vegetation of the study area

(1) Dry deciduous shrub and (2) Dry deciduous mixed forest

The dominating deciduous shrub in the wastes lands is plums, in the dry deciduous tree types like Palash, Neem, Chilbil, Mahua, Reva, Tamrind, Mango, Eucalyptus, Shiv Babool, Karanj etc. Some are naturally grown trees and some trees are planted by BHU authorities.

C. Data Used and Methodology

The current investigation incorporates both primary and secondary data. The primary data was collected through the survey technique, with key observer, direct field recognition and communication with the common people of the experimental area. Then again, the secondary data for this investigation was gathered from the satellite.

I) Primary data collection

a) Reconnaissance survey: Reconnaissance survey was done at the beginning of the investigation. First, the limit was portrayed by existing map resources to comprehend the degree of the investigation. A detailed field perception, field presentation, objectives formulation, past study investigation evidence, scope recognizable proof was initiated.

b) Field survey: Although the entire study was based on available secondary information, a small field survey was conducted to ensure proper validation of the available data. The quadrat method was used for field study. Diversity of different plant species in the study area were calculated by Shannon-Weaver index, H' = −Σ pi log pi (Shannon & Weaver 1963), where, pi is the proportion of all individuals that belong to species *I* (the number of individuals of each species *i*/*N*) (Srivastava & Singh 2014). The field survey not only comprehends the natural verification of the study area but also to the local population's understanding of the study.

II) Secondary data collection

Remote sensing data of very fine resolution (1m resolution) of the years 2008 and 2018 have been taken from Google Earth. Image processing and geometric rectification techniques were undertaken for processing the digital data, a subset of each digital image. The digital images were geometrically and radiometrically calibrated to each other to facilitate their comparison. Geometric rectification is critical for giving spatially corrected maps through time. Digital images are geometrically and radiometrically adjusted to enable their comparison. Geometric correction is important for giving timely maps. It is necessary to identify the exact per-pixel registration change of the multi-temporal remote sensing data since the potential errors can be explained as land-cover and land-use changes, which can lead to a real change.

The satellite image is used to prepare the LULC map as well as the vegetation map. Information from satellite data is extracted through a supervised classification technique of Digital Image Processing using the Maximum Likelihood classifier as an algorithm. Before classification, the dataset was masked to the study area. Supervised classification results in spectral confusion resulting in unsatisfactory classification. The spectral resemblance of several substances causes such misunderstanding. Examples are unproductive land and agronomic fallow land; residential, and open forest land each are often classified into other classes by mistake. To avoid such problems, the processing of post-classification classified maps was applied in the present work. The post taxonomic processing involved in this study is a recalibration of misclasses, classified for appropriate misclasses based on LULC digitized polygons obtained from Google earth image and satellite imagery. All Digital Image Processing work as well as data preparation has been done in Erdas Imagine-14 software. The vegetation cover of both the datasets has been mapped by on-screen digitization in ArcMap 2010.

III. Results and Discussion

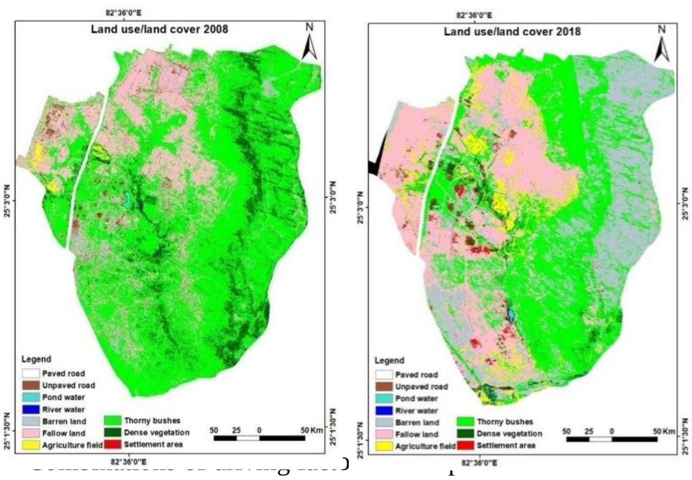
LULC changes have substantial environmental influence at local, regional, and global scales. At the regional and global scales, these variations have a strong impact on global biodiversity loss, disruptions in hydrological cycles, rapid soil loss, and sediment heaps. Locally, it affects watershed runoff development, changes in microclimatic resources, soil erosion and biodiversity loss at landscape-level, land degradation, and sediment loads (Sultan, 2016). All these are directly affecting the livelihoods of local communities. This study also highlights the influence of LULC changes on vegetation dynamics and related outcomes.

Table 1: Land use and Land cover (LULC) changes of study area over ten years (google earth data set used; date of acquisition 28 January 2008 to 30 January 2018). Values are in parenthesis show percent contribution of that land-use type in total.

S. No.	LULC Class	Area cover under different land use (hectare)			
		2008	(%)	2018	(%)
1	Settlement area	1.78	(0.17)	11.02	(1.03)
2	Agriculture field	5.30	(0.49)	62.96	(5.92)
3	Barren land	55.49	(5.22)	291.6	(27.44)
4	Fallow land	225.05	(21.2)	275.8	(25.95)
5	Paved road	0.53	(0.04)	0.04	(0.003)
6	Unpaved road	22.52	(2.11)	6.42	(0.60)
7	Dense vegetation	118.38	(11.14)	28.58	(2.68)
8	River water	1.17	(0.11)	1.52	(0.14)
9	Pond water	0.89	(0.08)	0.91	(0.08)
10	Thorny bushes	631.41	(59.42)	380.06	(35.75)

The total study area has been grouped into ten LULC classes (overall accuracy 81% and 89% in 2008 and 2018, respectively). LULC maps prepared at the decadal interval and there has been a positive variation in some class, whereas, some show negative variation. There has been a drastic decrease in dense vegetation and thorny bushes classes in the last ten years (Table 1). An area under dense vegetation has reduced up to four times; it was 118.4 hectares (approx. 12% of total vegetation) in 2008, whereas in 2018 it was reduced up to 29 hectares (approx. 3% of total vegetation). On the contrary, settlement area, agriculture field and barren land have increased. The area under agricultural land use and barren lands were only 0.5% and 5% respectively, in total land use in 2008 whereas, in 2018 after ten years these contributed up to 6% and 28% in total land area. There was a gradual increase in fallow land also. Most of the natural dense vegetation was cut down and converted into barren land and fallow land. A comparative LULC change of the years 2008 and 2018 can be seen in maps presented in Figure 2. In the year 2018, settlement areas increased six times and agricultural land increased 12 times compared to the year 2008. About 5-6 times increase in barren land was also noted in 2018. There were no significant changes noted in the case of paved roads whereas, unpaved roads decreased up to four times. River water and pond water during the study period remained the same. Figure 3 emphasizes only on the change in vegetation of two multi-temporal data. According to satellite data, there was a drastic reduction in dense natural vegetation (about five times) and thorny bushes (about two times) in 2018 compared to vegetation present in 2008, whereas fallow land has increased. During the survey, drastic reductions in natural tree species were noted. However, there was little increase in planted species on the campus. Thorny bushes were spread in the entire campus area.

Fig. 2 LULC (Land use land cover) map of RGSC campus during the years 2008 and 2018. The map clearly shows the difference in changes in land cover between two years.

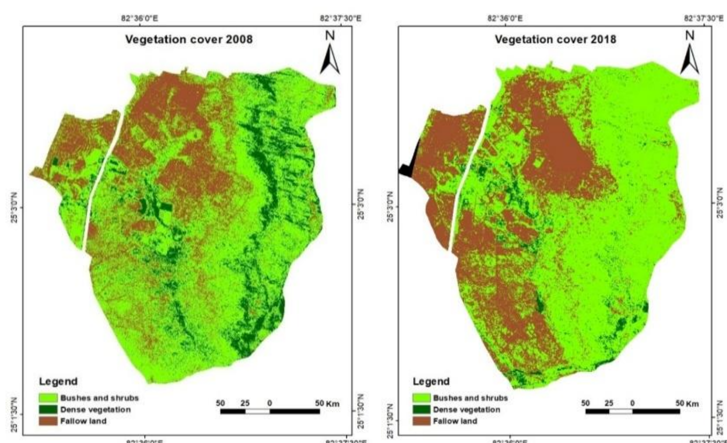


reduction of dense forest in RGSC between 2008 and 2018. Among various factors, random forest cutting, illegal poaching and stone quarrying by villagers are the important driving forces of LULC changes in RGSC that have increased in the past 10 years. Field observation confirmed the intense land degradation and soil erosion problems in all surveyed study areas of the RGSC campus. Jha et al. (2005) used remotely sensed data in their study to analyze changes in vegetation cover due to fragmentation over 10 years and its impact on biodiversity. They concluded that changes in habitat loss result in loss of biodiversity. The effect of declining forest size is responsible for the reduction in the diversity of tropical dry deciduous forests in the highlands of Vindhyan dry tropical forests in India. Forest fragmentation accelerated due to rapid industrial development and urbanization. Mekonnen et al. (2018) in Ethiopia (2018) establishes the extent of LUCL change and generalized differential vegetation index with land degradation. They highlighted the causes of LULC change and the implications for climate change adaptation. According to them, different factors play a role in the dynamics of the LULC and the vegetation dynamics vary both spatially and temporally against both rainfall and temperature. This study also shows spatial and temporal differences in vegetation dynamics and is associated with land degradation.

On this campus, many different trees species recorded which were larger in number on this campus. Mostly trees species were identified in this campus are medicinal in uses. With these some nitrogenous shrubs/trees like *Leucaena leucocephala*, *Bambusa vulgaris, Acacia catechu* etc. were also abundant (Table 2). The field survey was conducted from RGSC Guesthouse to Vetenary faculty and seed godown to water tank for all planted trees present mostly inside of constructed roads. Some planted trees were also present in settlement buildings inside the campus that were also counted. On the campus, there were more than 4000 planted trees, but due to lack of fencing and also lack irrigation facility many plants died. There were also wild animals such as *Boselaphus tragocamelus* (Nilgai) and *Sus scrofa* (wild boar) which destruct the newly planted trees or agricultural fields also. There was no ban on cattle grazing. Uncontrolled cattle grazing to pastures land was also one of the reasons for the destruction of newly planted trees. At present campus authorities' priority has shifted towards plantation at the side of new roads and new building campuses and also for better facilities of irrigation.

The number of trees planted on campus increased compared to previous years. The disappearance of multipurpose indigenous tree species such as *Madhuca longifolia* (Mahua) and *Terminalia arjuna* (Arjuna) decreased pastureland and reduced abundance of the medicinal plant were other consequences of LULC revealed by the local people. The respondents also mentioned the reduction of wildlife as other effects of LULC changes in the study area. Zhang and Sun (2019) have established relationships among subpixel land cover, surface temperature and population size. According to them, the urban heat island effect intensified due to urbanized land growth. The surface fabric of urban areas (ie it's land and land use) plays an important role in the production of urban/rural temperature differences.

Fig.3 Vegetation cover map of RGSC campus, in the map using satellite imagery during the years 2008 and 2018.



With many planted trees, many natural grown tree species, herbs and shrubs were also present in good numbers (approx.1640).

Table 2: Spatial variation in tree and shrub/herb number and their diversity in RGSC campus, values are in parenthesis in no. column show number of natural grown species.

S.N.	Trees (Common name)	Total No
1	*Abrus precatory* L.(Gumachi)	uncoun
2	*Acacia catechu* L.f.(Khair)	uncoun
3	*Acacia nelotica* (Linn)(Babool)	uncoun
4	*Aegle marmelos* L.(Bael)	26
5	*Albizia lebbeck* (L.) Benth.(Siris)	310
6	*Annona reticulata* L.(Custard apple)	185
7	*Artocarpus heterophyllus Lam.*(Jackfruit)	31
8	*Azadirachta indica* A.Juss.(Neem)	157 (646)
9	*Bambusa vulgaris* L.(Bamboo)	293(38)
10	*Bauhinia variegate* L.(Kachnar)	5
11	*Vernonia cinerea* Less (Sahdevi)	Uncoun
12	*Bombax ceiba* L.Green (semal)	17
13	*Bombax malabaricum* L.(Semal)	5
14	*Butea monosperma* (Lam)kuntze(Palash)	211
15	*Carica papaya* L.(Papaya)	4
16	*Carissa carandas* L.(Karonda)	520 (uncoun)
17	*Cassia fistula* L.(Amaltas)	50
18	*Citrus limon* L.(Lemon)	19
19	*Cocculus hirsutus* (L.)(Jamiti ki bel)	Uncoun
20	*Dalbergia sissoo* Roxb.(Shisham)	245
21	*Delonix regia* (Hook.)(Gulmohar)	25
22	*Eucalyptus globulus* Labill.(Eucalyptus)	17
23	*Ficus benghalensis* L.(Banyan)	44
24	*Ficus racemosa* L.(Gular)	22 (38)
25	*Ficus religiosa* L.(Peepal)	38
26	*Holoptelea integrifolia* (Roxb.)(Chilbil)	184
27	*Jatropha curcas* L.(Jatropha)	17
28	*Leucaena leucocephala* (Lam.)(Subabul)	410
29	*Madhuca longifolia* L.(Mahua)	41 (37)
30	*Mangifera indica L.*(Mango)	88
31	*Melia azedarach* L.(Chinaberry)	17
32	*Millettia pinnata* (L.)(Karanj)	344
33	*Moringa oleifera* Lam.(Sahjan)	13
34	*Morus nigra* L.(Mulberry)	2
35	*Murraya koenigii* (L.)(Curry tree)	1
36	*Musa acuminate* (Banana)	13
37	*Nyctanthes arbor tristis* Linn.(Parijat)	uncoun
38	*Alstonia scholaris* (L.) R.Br.(Pakadi)	1
39	*Peltophorum pterocarpum*(DC.)	263
40	*Phyllanthus emblica* L.(Amla)	30
41	*Pithecellobium dulce*(Roxb.)Benth	6
42	*Psidium guajava* L.(Guava)	199
43	*Plumeria obtuse* L.(Gulchin)	3
44	*Punica granatum* L.(Pomegranate)	3
45	*Saraca asoca* (Roxb.)Willd.(Ashoka)	74
46	Unknown Show tree	62
47	*Sida cordifolia* L.(Bariyarai)	uncoun
48	*Syzygium cumini* (L.)(Jamun)	175(165)
49	*Tamarindus indica* L. (Tamarind)	7
50	*Tectona grandis* L.f. (Teak)	360
51	*Terminalia arjuna* (Roxb.) (Arjuna)	135(207)
52	*Ziziphus mauritiana* Lam. (Ber)	uncoun
53	*Ziziphus jujube* Mill. (Jangali ber)	uncoun
Diversity of tree species		
I	Around administrative building	1.29
II	Near check Dam	1.75
III	Area near river	1.86
IV	Near vetenary faculty	1.59
Diversity of herb/shrub species		
I	Croplands near employee house	2.02
II	Near riverside forest area	1.47

About 1949 trees/shrubs in 20 different quadrats were recorded on the entire campus. Quadrats were used for the study of density and diversity of natural and planted tree species of campus. The dominant planted trees/shrubs of this RGSC campus were: *Azardichata indica* (Neem: 646 trees), *Carissa carandas* (Karonda: 520 trees), *Butea monosperma* (Palash), *Tectona grandis* (Sagon: 360 trees), *Millettia pinnata* (Karanj: 344), *Peltophorum pterocarpum* (Copper pod: 263), *Dalbergia sissoo* (Shisham: 245), *Psidium guajava* (Guava: 199), *Madhuca longifolia* (Mahua), *Acaiakatechu* (Khair), *Acaia nilotica* (Babool), *Ziziphus glaberrima* (Ghut) and *Terminalia arjuna* (Arjuna). Besides these, there were many shrubs and tree saplings of different species present at different location. These are species of *Acacia catechu* (Khair), *Acacia nilotica* (Babool), *Ziziphus jujube* (Ber, edible), *Ziziphus mauritina* (Ber, non-edible) etc. The detailed information and list have been prepared for individual tree species of the area. Lambin et al. (2003) emphasize the need for a combination of agent-based systems and understanding approaches to comprehensive, location-based research on LULC alteration. According to him, land-use change is driven by a combination of factors like, resource shortages, production pressure on resources, changes in market-generated opportunities, policy interventions, loss of adaptive capacity, and other factors that lead to changes in social organization and attitudes. Changes in ecosystem goods and services cause land-use change responses on drivers of land-use change.

Figure 4, shows the changes in vegetation cover of major tree species of RGSC campus during the years 2008 and 2018. In 2008, the dominance of tree species like Arjun (*Terminalia arjuna*), Jamun (*Syzygium cumini*), Gullar (*Ficus racemosa*) was higher along the riverside and chack dam. But in 2018, there is a drastic reduction of these species. Some other important tree species like Bargad (*Ficus benghalensis*), Pipal (*Ficus religiosa*) and Neem (*Azadirachta indica*) have also reduced. Pakad (*Alstonia scholaris*) and Palash (*Butea monosperma*) have decreased but less as compared to other species on campus. Although many Neem trees have harvested or cut for other types of land use, some new trees have planted on campus. The location of different tree species and their spatial diversity in the RGSC campus are shown in Table 2. Species diversity of tree species was higher in the area near the river and check dam, as anthropogenic activities (like construction, settlement activities, agricultural activities) are least. Minimum natural tree species diversity was noted around the administrative building as lots of construction/developmental activities going on. Although plantation of trees started here. The diversity of herb/shrub species was calculated into two major areas of campus. In this case, the diversity of cropland was greater because of many cropland weeds. However, lower diversity is noted around river areas near the forest.

Primary biodiversity records are an important step in diverse areas of scientific investigation as they document the biodiversity temporally and spatially. LULC challenges are important for real information available from biodiversity datasets and therefore its possible uses. With the progression of time, one can anticipate a consistent increment in the accessibility and utilization of natural records yet not without them getting more established and liable to be out of date via land utilizes changes. In this way, it gets important to evaluate records' out of date quality, as it might imperil the information and impression of biodiversity designs (Escribano et al. 2003).

As LULC changes are linked to land degradation, precise information on such changes is important for understanding the reasons for change and evolving actual policies and strategies to either slow or reverse the land destruction at the local level like in presently studied campus. We can amplify this study at a regional and global level also for assessing intensify the impact. The present study highlighted the need to focus on halting deforestation and slow down the pace of land cover changes and the development of alternative strategies to conserve resources. It further assists with structuring future land management directions, landscape-based adjustment and restoration techniques to be considered by policymakers.

ACKNOWLEDGEMENT

The authors thank the Professor In Charge, RGSC and the Course Co-ordinator, Environmental Science (Environmental Tech.), Director, IESD, for permitting field study in the campus and providing laboratory and library facilities. Authors are also thankful to the Department of Geography (Remote Sensing & GIS Lab) for support in data analysis.

REFERENCES

Amin, A., Amin, A. & Singh, S.K. (2012). Study of urban land-use dynamics in Srinagar city using a geospatial approach. *Bulletin of Environmental and Scientific Research*, 1 (2),18-24.

Brondizio, E.S., Moran, E.F., & Wu. Y. (1994). Land-use change in the Amazon estuary: patterns of Caboclo settlement and landscape management. *Human Ecology*, 22 (3), 249-278.

Dimyati, M. Mizuno, K., & Kitamura, T. (1996). An analysis of land use/cover change using the combination of MSS Landsat and land use map: a case study in Yogyakarta. *Indonesia International Journal of Remote Sensing*, 17, 931-944.

Escribano, N., Ariño, A.H., & Galicia, D. (2016) Biodiversity data obsolescence and land uses changes. *PeerJ*, 4:e2743; DOI 10.7717/peerj.2743.

Jha, C.S., Goparaju, L., Tripathi, A., Gharai B., Raghubanshi, A. S., & Singh, J.S. (2005). Forest fragmentation and its impact on species diversity: an analysis using remote sensing and GIS. *Biodiversity and Conservation* 14, 1681–1698.

Jin, S., Yang, L., Zhu, Z., & Homer, C. (2017). A land cover change detection and classification protocol for updating Alaska NLCD 2001 to 2011 *Remote Sensing and Environmen*t, 195, 44-55

Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., & Xian, G. (2013). A comprehensive change detection method for updating the national land cover database to circa 2011 *Remote Sensing and Environment*, 132, 159-175

Lambin, E.F., Helmut J. G. & Erika L. (2003). Dynamics of land use and land cover change in tropical region. *Annual Review on Environmental Resource*, 28, 205–4.

Llena, M., Vericat, D., Cavalli, M., Crema, S., & Smith, M.W. (2019). The effects of land use and topographic changes on sediment connectivity in mountain catchments *Science of the Total Environment* 660, 899–912

Lo, C.P. & Choi, J. (2004) A hybrid approach to urban land use/cover mapping using Landsat 7 enhanced thematic mapper plus (ETM+) images. *International Journal of Remote Sensing*, 25 (14) pp. 2687-2700

Mehta, A., Sinha, V.K., & Ayachit, G. (2012). Land-use/Land-cover study using Remote Sensing and GIS in an Arid Environment. *Bulletin of Environmental and Scientific Research*, 1(3-4), 4-8.

Mekonnen, Z., Berie, H.T., Woldeamanuel, T., Asfaw, Z., & Kassa, H. (2018). Land use and land cover changes and the link to land degradation in Arsi Negele district, Central Rift Valley, Ethiopia. *Remote Sensing Applications: Society and Environment* 12, 1-9

Mishra, V.N., Rai, P.K., & Mohan, K. (2016). Prediction of land use changes based on Land Change Modeler (LCM) using remote sensing: A case study of Muzaffarpur (Bihar), India. J. Geogr. Inst. Cvijic. 64(1) (111-127).

Phiri, D., & Morgenroth, J. (2017). Developments in landsat land cover classification methods: a review *Remote Sensing* 1-9

Pooja, K., M., & Rawat J.S. (2012). Application of Remote Sensing and GIS in Land Use and Land Cover Change Detection: A Case study of Gagas Watershed, Kumaun Lesser Himalaya, India. *Quest-The Journal of UGC-ASC Nainital*, 6(2), 342-345..

Rai, P.K., Singh, S. & Mohan, K. (2015). Land Use Change Detection Using Multi-Temporal Satellite Data: A Case Study of Haridwar District, Uttrakhand, *Journal of Scientific Research*, (Banaras Hindu University), 59 (1 & 2), 1-16.

Rawat, J.S., Kumar, M. & Biswas, V. (2014). Land use/cover dynamics using multi- temporal satellite imagery: a case study of Haldwani Town area, district Nainital, Uttarakhand, India Inter. *Journal of Geomtry and Geosciences*, 4 (3), 536-543.

Rawat, M. Kumar & V. Biswas (2013). An integrated approach of remote sensing and GIS for land use/cover change detection: a case study of Bhimtal Tourist Town (India). *Bulletin of Environmental Science and Research*, 2 (2–3), 1-6.

Sekertekin, A., Marangoz, A.M., & Akcin, H. (2017). Pixelbased classification analysis of land use land cover using sentinel-2 and landsat-8 data The International Archives of the Photogrammetry, *Remote Sensing and Spatial Info Sciences* (ISPRS Archives) XLII-4/W6, 91-93

Shannon, C.E., & Weaver, W. (1963). The Mathematical Theory of Communication. University of Illinois Press, Urbana, IL.

Singh, S. & Rai, P.K. (2018). Application of Earth Observation data for Estimation of Changes in Land Trajectories in Varanasi District, *Indian Journal of Landscape Ecology*, 11(1), 5-18.

Srivastava R, Mohapatra M, & Latare A (2020) Impact of land use changes on soil quality and species diversity in the Vindhyan dry tropical region of India. *Journal of Tropical Ecology* 36, 72–79.

Srivastava, R. & Singh K.P. 2014. Diversity in weed seed production and soil seed bank: Contrasting response between two agroecosystems. *Weed Biology and Management* 14: 21-30.

Sultan, R. M. (2016) The impacts of agricultural expansion and interest groups on deforestation: An optimal forest control model. *International Journal of Agricultural Resources, Governance and Ecology*.12(2): 137-154.

Vishwakarma, C.S., Thakur, S., Rai, P.K., Kamal, V. & Mukharjee, S. (2016). Changing Land Trajectories: A Case Study from India Using Remote Sensing, *European Journal of Geography*. 7 (2), 63-73

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

Zhang Y & Sun L. (2019). Spatial-temporal impacts of urban land use land cover on land surface temperature: Case studies of two Canadian urban areas. *International Journal of Applied Earth Observation and Geoinformation*, 75, 171–18.

***