

# SPATIAL AND TEMPORAL VARIATIONS OF LAND USE AND LAND COVER IN KADIRI WATERSHED USING RS & GIS TECHNIQUES

## ABSTRACT:

The change detection and land use and land cover (LULC) maps are more important powerful forces behind numerous ecological systems and fallow land. It is widely known that land use/land cover (LULC) changes significantly alter watershed hydrology and sediment yields. The impact, especially on erosion and sedimentation, is likely to be exacerbated in regions dominated by high rainfall patterns such as monsoons. RS & GIS technologies are very useful to determine the LULC changes. Present research area Kadiri Watershed of Anantapur district of Andhra Pradesh, India, drains an area about 240 km<sup>2</sup> including 15 villages. The average annual rainfall in this area varies between 600mm to 700mm in which 60%, 35% and 5% of total rainfall occurs in South-West (S-W), North-East (N-E) and in Summer seasons respectively. The current research focuses on demarcating the spatiotemporal LULC changes. These effects directly affect the ecosystem, land resources, cropping pattern and agriculture. LULC assessment and surveillance are essential for long-term planning and sustainable use of natural resources. The LULC maps were prepared for the study area using Landsat-5, Senthinel 2 images pertaining to pre-monsoon and post-monsoon seasons of 2013, 2017 and 2021. Variations in the extents of agriculture, plantations, scrubs, water bodies, open lands, and built-up areas were noted during these years in the pre-monsoon season, and they ranged from 22 to 35 and 43%, 2 to 3 and 5%, 22 to 28%, 1 to 4%, 52 to 29 and 15%, as well as 1 to 5%, respectively. Similar fluctuations were seen in the post-monsoon season, where they ranged from 29 to 40 and 47%, 3 to 7%, 33 to 30%, 2 to 4%, 32 to 20 and 7%, as well as 1 to 5%. Kadiri watershed, an agriculturally dominant area, has seen an increase in cultivated land due to the conversion of fallow land and open scrub into cropland as a result of good rainfall received during the south-west monsoon during in assessment years and implementation of watershed development activities. These findings highlight the potential impacts of LULC changes in a monsoon-dominated watershed and may contribute to the development of successful LULC-based watershed management strategies for prevention of flooding and sediment loss.

(Keywords: Land Use Land Cover, RS & GIS, Pre-Monsoon, Post-monsoon etc.)

## 1.INTRODUCTION

“Land use land cover change is one of the stressors that significantly affect hydrological balance and then aggravate water quantity issues” (Fu *et al.*, 2009). “Hydrological processes such as infiltration, groundwater recharge, base flow and surface runoff are influenced by land use changes in a catchment”. [28]

“LULC modification such as changes in vegetation cover alter surface roughness and leaf area index (LAI) that can lead to disturbance in surface energy balance and evapotranspiration (ET)” (Pielke and Avissar, 1990). “The changes in energy balance and ET may significantly affect the timing and magnitude of evaporative losses to the atmosphere and the amount of water yield that governs soil moisture content, runoff and base flow patterns of regional hydrologic responses. Hence these

disturbance in hydrological balance lead to increase in runoff rate, volume and more intense and frequent floods” (Brath *et al.*, 2006).

“LULC changes are important drivers of water, soil, and pollution. The land cover gets affected due to clearance of land for agriculture. Vegetation clearance exposes (Najjar *et al.*, 2021, Mahammad *et al.*, 2020, Olokeogun and Kumar. 2020) soils to a greater risk of being eaten away by wind and water, especially on steep terrain, and once among the clouds, releases toxins into the atmosphere”. “Land use/cover changes must be detected in order to have a better knowledge of landscape dynamics during the property management period. It has already been widely accepted that the LULC play a very important role at local to global scales on ecosystem functioning, ecosystem services, and biophysical and human variables such as climate and government policies” (Meyer *et al.*, 1984). Hence, land-cover classification and change detection analysis have become one of the most important and typical applications of remote sensing data.

“Satellite based data as a basis for generating valuable information for LULC is now widely recognized, although initial efforts was made since mid seventies for application of different interpretation techniques in LULC mapping. Rapid replacements of land cover by various land use categories are observed globally” (Geist, 2001). “LULC changes on the surface of the earth are generally divided into land use and land cover which are two concepts and are often used interchangeably. The importance of investigating LULC and their impacts as a baseline requirement for planning and sustainable management of natural resources” (Lambin *et al.*, 2000; Petit *et al.*, 2001). These researchers have argued that land use has significant impacts on the functioning of socio-economic and environmental systems with important tradeoffs for sustainability, food security, biodiversity and socio-economic vulnerability of people and ecosystems.

“Collection of remotely sensed data facilitates the synoptic analysis of earth system function, pattern, and change at local, regional and global scales over time. As such, utilization of multispectral-multitemporal remotely sensed data has been widely used to generate thematic LULC inventories for a range of applications including urban planning, agricultural extension and forest ecosystem classification. Since 1972, the Landsat satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imagery. The most popular instrument in the early days of Landsat was the Multi-Spectral Scanner (MSS) and later the Thematic Mapper (TM) and the latest satellite in the series is Enhanced Thematic Mapper (ETM+). With repetitive satellite coverage, the rapid evolution of computer technology, and the integration of satellite and spatial data with geographic information systems (GIS), and development of environmental monitoring applications, change-detection analysis over time have become ubiquitous” (Jensen JR.1995). “The remote sensing and Geographical Information System (GIS) (Rahini and Breuste. 2021, Patas *et al.*, Matin and Hasan. 2021) technology is very useful tool for betterment of the selection of regions planned for Agricultural, Urban, Industrial purpose”.

“Several procedures have been developed and applied for monitoring the changes in LULC by making the use of remotely sensed data, for instance, image differencing, pixel- and object-based

classification in land cover change mapping (King, 2011), cross-correlation analysis (Jones, et al., 2009), comparison of spectral indices and principal component analysis (Yanan, et al., 2011), post-classification comparison (Hassan Z, et al., 2016) and image fusion-based land cover change detection” (Wang, et al., 2012). “Change detection analysis is widely used for demarcation of LULC changes based on multi-temporal remotely sensed data. There are a number of software extensions that can be added to ArcGIS that provide additional functionality, including 3D Analyst, Spatial Analyst, Network Analyst, Survey Analyst, Tracking Analyst, and Geostatistical Analyst” (Mhaweji et al., 2021, Raji et al. and Julian et al., 2021).

Research work has been carried out in Kadiri watershed to assess the changes in Hydrogeomorphologic parameters like runoff, water table, stream flows and sediment yield etc., with respect to land use dynamics due to implementation of watershed development program in 2012-13 onwards under Integrated Watershed Development program (IWDP) along with variations in LULC and rainfall using RS and GIS techniques. Hence, there is a need of knowledge about LULC prior to the implementation of soil conservation activities as well as post implementation too; also it is one of the important factors affecting the hydrogeomorphological parameters considerably.

## 2.1 STUDY AREA

Present study area of Kadiri watershed is located in between 78° 9' 32" N, and 14° 6' 49" E, having an extent of 239 km<sup>2</sup> which includes 15 villages. The extent of villages varies from 1.22 km<sup>2</sup> to 86.96 km<sup>2</sup>. The average elevation of study area was 620 m above the Mean Sea Level (MSL) with highest value of 830 m and lowest value of 409 m (Detailed Project Report of IWMP Cluster, 2012). The average annual rainfall in this area varies between 600 mm to 700 mm in which 60%, 35% and 5% of total rainfall occurs in S-W, N-E and in Summer seasons respectively (Based on rainfall analysis from 1982 to 2021). Major crops grown in this area were Bengal gram, ground nut, maize, mango and paddy. Watershed program was initiated from the year 2012-13 and completed in 2019-2020 during in this period different soil conservation measures as well as structures were carried out, these tends to observable changes land use land cover. The location map of study area shown in Fig.1

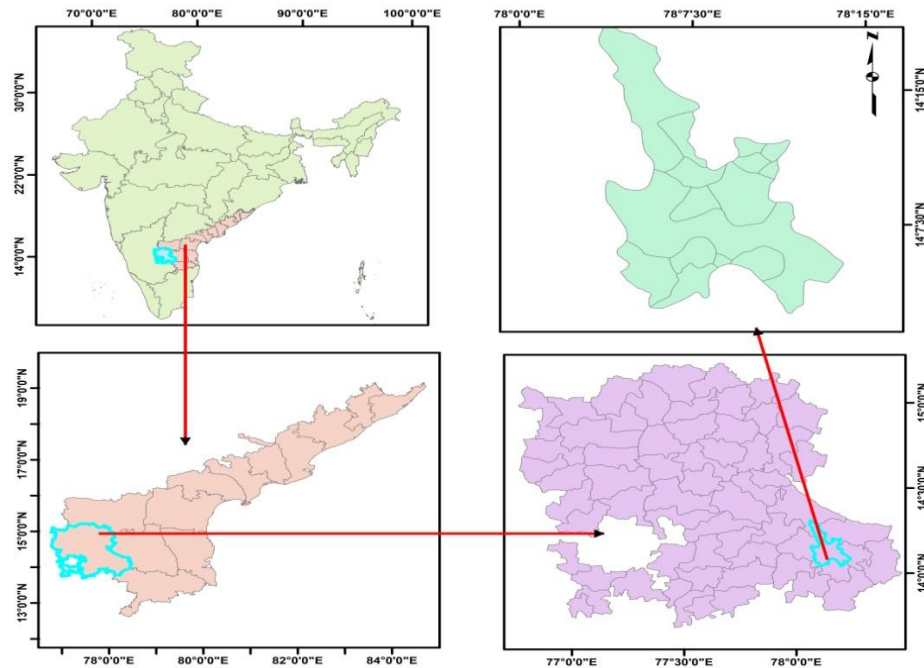


FIG. 1 Location map of Kadiri watershed of Anantapur District.

### Methodology:

The LULC maps were prepared for the study area using Landsat-5, Sentinel 2 images pertaining to pre-monsoon and post-monsoon of 13<sup>th</sup> April and 7<sup>th</sup> November of 2013, 24<sup>th</sup> April and 21<sup>st</sup> October of 2017 as well as 12<sup>th</sup> February and 25<sup>th</sup> September and respectively. For the classification of land cover and creation of training sets, data from photos and toposheets were used. Ground truth survey was carried out by walking around the field boundaries for two times (pre-monsoon and post-monsoon) during 2013, 2017 & 2021 using GPS. Unsupervised classification was used for the present study area.

Unsupervised Classification is the process of Classifying or Separating the Satellite Reflectance Numbers OR Digital Numbers into Meaningful Information into Several numbers of Classes Such as Agriculture- Different Crops, Forestry, Urban Settlements, Water Bodies., etc with the Inbuilt Classifiers in the Software using Mathematical Algorithms Such as K Means or ISODATA without any TRAINING DATA or GROUND FIELD POINTS. Fig.2 provides the flow chart of crop mapping and acreage estimation using RS and GIS technique. Accuracy of LULC variations obtained through RS and GIS compared with feedback from the farmers, Agricultural officials and Watershed Development Team (WDT) members.

**FLOW CHART OF  
CROP MAPPING AND ACREAGE  
ESTIMATION USING RS AND GIS  
TECHNIQUE**

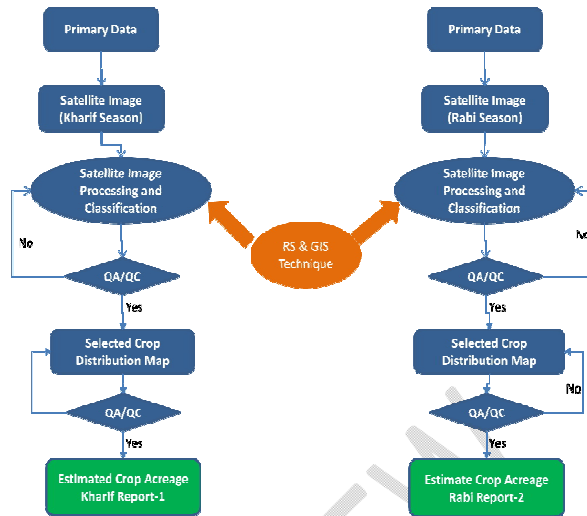


Fig. 2 Flow chart for preparation of LULC.

**3. Results and discussions:**

The land use land cover maps were prepared for the present watershed as described above for both Pre-Monsoon and Post Monsoon LULC estimation was done from three years i.e. 2013, 2017 and 2021 (pre-implementation of watershed programe, during the programe and post-implementation) respectively.

The investigated area has observable changes during this period. LULC maps of watershed are represented in Figs. 3.(a), (b), 4 (a), (b) and 5 (a), (b). The year wise detail of different LULC's were represented in the Table 1.

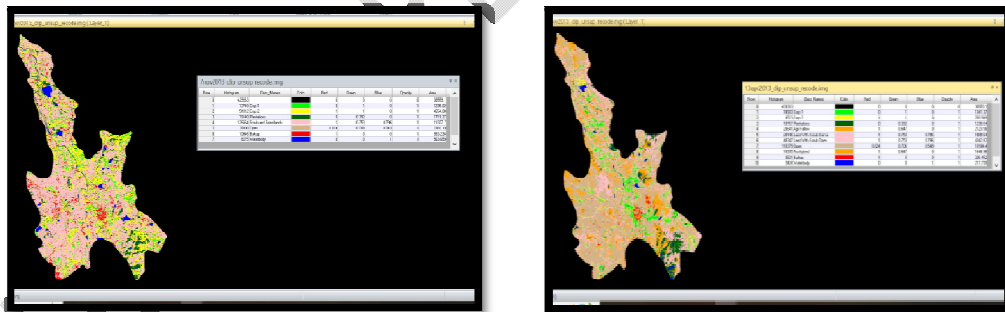


Fig. 3 (a), (b) Pre-monsoon and Post-monsoon LULC images of 2013

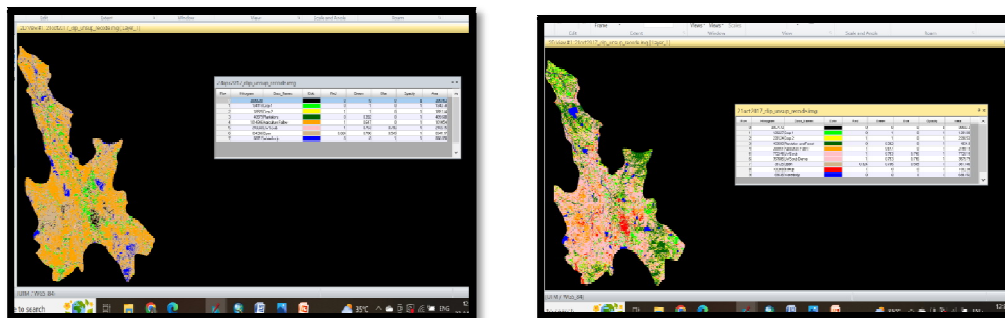


Fig. 4 (a), (b) Pre-monsoon and Post-monsoon LULC images of 2017

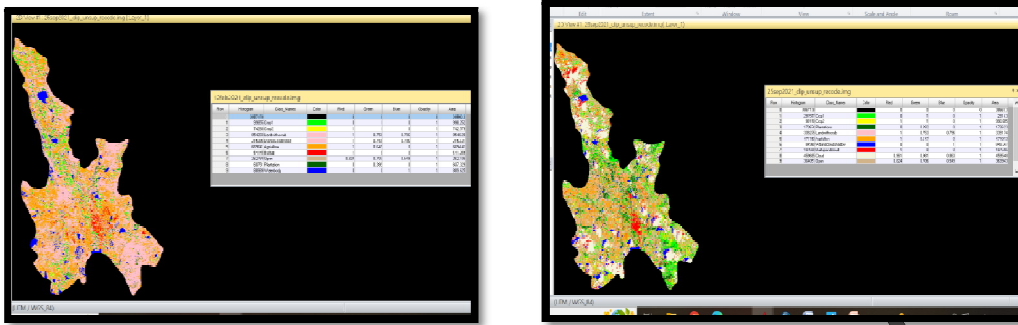


Fig. 5 (a), (b) Pre-monsoon and Post-monsoon LULC images of 2021

TABLE 1. LULC Comparison (ha)

LULC	Pre-Monsoon			Post-Monsoon		
	2013	2017	2021	2013	2017	2021
Agril.	5280	8435	10175	6900	9680	11145
Plantation.	410	608	1237	619	750	1545
Scrubs	5166	6552	6700	7864	7365	7150
Waterbodies	285	587	890	564	688	1025
Open lands	12355	6977	3627	7550	4760	1745
Builtup	340	625	1250	340	630	1270
<b>Total</b>	<b>23836</b>	<b>23784</b>	<b>23879</b>	<b>23837</b>	<b>23873</b>	<b>23880</b>

From the above table it is clearly identified that the LULC extent in the present area was considerably changed during the years 2017 and 2021 respectively. In pre-monsoon season percent change in Agriculture, plantation, Scrubs and Water bodies, Open lands and Builtup were shown in Fig's. 6 (a - c). During these years variations of extent in agriculture, plantations, scrubs, water bodies, open lands as well as built up were from 22 to 35 and 43%, 22 to 28%, 2 to 3 and 5%, 1 to 4%, 52 to 29 and 15% as well as 1 to 5% respectively.

Similarly, in post-monsoon season percent change in Agriculture, plantation, Scrubs and Water bodies, Open lands and Builtup were shown in Fig's. 7(a - c). During these years variations of extent in agriculture, plantations, scrubs, water bodies, open lands as well as built up were from 29 to 40 and 47%, 3 to 7%, 33 to 30%, 2 to 4%, 32 to 20 and 7% as well as 1 to 5% respectively.

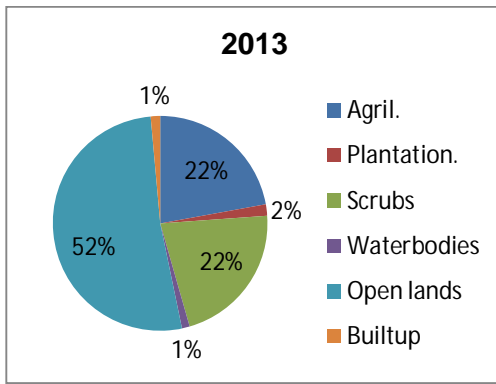


Fig. 6(a)

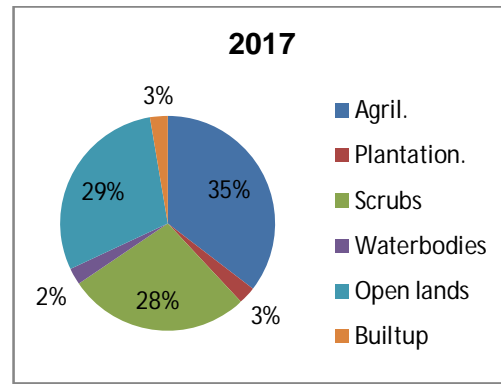


Fig. 6 (b)

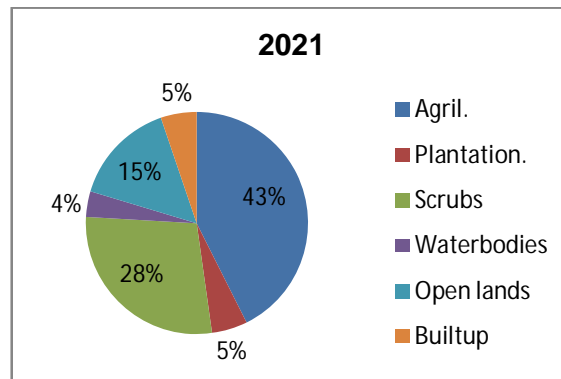


Fig. 6(c)

Fig's. 6 (a-c) Variations in LULC during pre-monsoon seasons in 2013, 2017 and 2021 at study area.

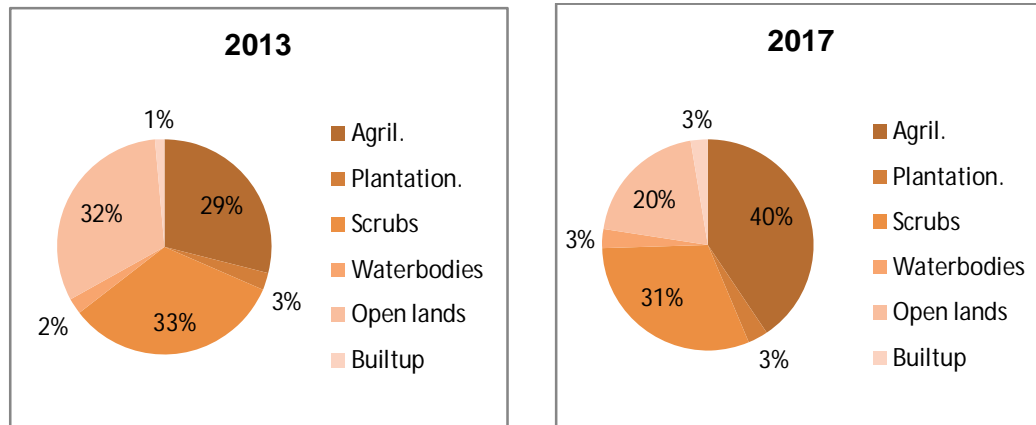


Fig. 7 (a)

Fig. 7 (b)

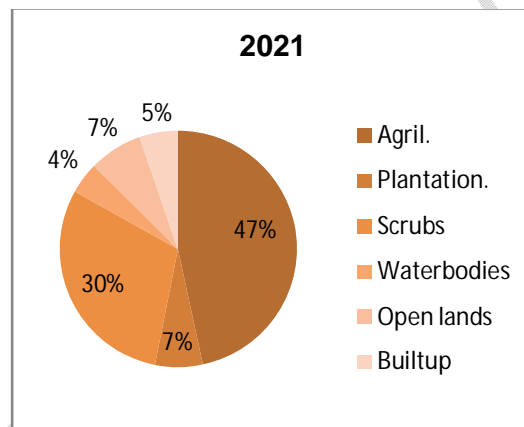


Fig. 7 (c)

Fig's. 7 (a-c) Variations in LULC during post-monsoon seasons in 2013, 2017 and 2021 at study area.

### Conclusions:

From the research it is concluded that in pre-monsoon season observed variations of extents in agriculture, plantations, scrubs, water bodies, open lands as well as built up were from 22 to 35 and 43%, 2 to 3 and 5%, 22 to 28%, 1 to 4%, 52 to 29 and 15% as well as 1 to 5% respectively. Similarly, in post-monsoon season variations observed as 29 to 40 and 47%, 3 to 7%, 33 to 30%, 2 to 4%, 32 to 20 and 7% as well as 1 to 5% respectively. Kadiri watershed, an agriculturally dominant area, has seen an increase in cultivated land due to the conversion of fallow land and open scrub into cropland as a result of good rainfall received during the south-west monsoon during in assessment years and implementation of watershed development activities. These findings highlight the potential impacts of LULC changes in a monsoon-dominated watershed and may contribute to the development of successful LULC-based watershed management strategies for prevention of flooding and sediment loss. The methodology adopted herein demonstrates the ability of remote sensing and GIS in the

change detection analysis of land use/land cover of a given area. The results of the study could be used for decision-makers in the administration and planning sectors for effective and sustainable management.

#### REFERENCES:

1. Al-Najjar H A H, Pradhan B, Kalantar B, Sameen M I, Santosh M and Alamri A 2021 Landslide susceptibility modeling: An integrated novel method based on machine learning feature transformation Remote Sens. 13
2. Arulbalaji, P., Gurugnanam, B., (2015). High resolution data for land use land cover assessment in Salem Taluk, Salem District, South India. *Elixir Soc Sci* 83:33104–33106.
3. Belal, A.A., Moghanm, F.S., (2011). Detecting urban growth using remote sensing and GIS techniques in Al Gharbiya governorate, Egypt. *Egypt J Remote Sens Sp Sci* 14:73–79. <https://doi.org/10.1016/j.ejrs.2011.09.001>
4. Brath, A., Montanari, A and Moretti, G. 2006. Assessing the effect on flood frequency of land use change via hydrological simulation. *Journal of Hydrology*. 324(1-4): 141-153.
5. Fu, B.J., Wang, Y.F., Lu, Y.H., He, C.S., Chen, L.D and Song, C.J. 2009. The effects of land-use combinations on soil erosion: a case study in the Loess Plateau of China. *Progress in physical geography*. 33(6):793-804.
6. Geist, H.J., Lambin E.F., (2001). What Drives Tropical Deforestation? A MetaAnalysis of Proximate and Underlying Causes of Deforestation Based on Sub-national Case Study Evidence. Louvain-la-Neuve (Belgium): LUCC International Project Office, LUCC Report Series no. 4.
7. Hassan, Z., Shabbir, R., Ahmad, S.S. *et al* (2016). Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *Springerplus* 5:812. <https://doi.org/10.1186/s40064-016-2414-z>
8. Hegazy, I.R., Kaloop, M.R., (2015). Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. *Int J Sustain Built Environ* 4:117– 124. <https://doi.org/10.1016/j.ijbsbe.2015.02.005>.
9. Jayakumar, S., Arockiasamy, D.I., (2003). Land use/land cover mapping and change detection in part of Eastern Ghats of Tamil Nadu using remote sensing and GIS. *J Indian Soc Remote Sens* 31:251–260. <https://doi.org/10.1007/BF03007345>
6. Schneider A (2012) *Remote sensing of environment*.
10. Jensen, J.R., *Introductory Digital Image Processing: A Remote Sensing Perspective*. 2<sup>nd</sup> Edn. Upper Saddle River: Prentice Hall;

11. Jones, D.A., Hansen, A.J., Bly., K *et al* (2009). Remote sensing of environment monitoring land use and cover around parks: a conceptual approach. *Remote Sens Environ* 113:1346–1356. <https://doi.org/10.1016/j.rse.2008.08.018>
12. Jullian C, Nahuelhual L and Lattera P 2021 The Ecosystem Service Provision Index as a generic indicator of ecosystem service supply for monitoring conservation targets *Ecol. Indic.* 129
13. Kachhwaha, T.S., (1985). Proceedings of the Sixth Asian Conference on Remote Sensing. Hyderabad, India.
14. King, D.J., (2011). Comparison of pixel- and object-based classification in land cover change mapping AU—Dingle Robertson, Laura. *Int J Remote Sens* 32:1505–1529. <https://doi.org/10.1080/01431160903571791>
15. Lambin, E.F., Rounsevell, M.D.A., Geist, H.J., (2000). Are agricultural land-use models able to predict changes in land-use intensity? *Agric. Ecosyst. Environ.* 82 (1–3), 321–331. [https://doi.org/10.1016/s0167-8809\(00\)00235-8](https://doi.org/10.1016/s0167-8809(00)00235-8).
16. Matin N and Hasan G M J 2021 A quantitative analysis of shoreline changes along the coast of Bangladesh using remote sensing and GIS techniques *Catena* 201
17. Meyer, W.B., Turner, B. L. II., (1994). Changes in Land Use and Land Cover: A Global Perspective. Cambridge University Press.
18. Mhaweji M, Nasrallah A, Abunnasr Y, Fadel A and Faour G 2021 Better irrigation management using the satellite-based adjusted single crop coefficient (aKc) for over sixty crop types in California, USA *Agric. Water Manag.* 256
19. Mohamed M A, Anders J and Schneider C 2020 Monitoring of changes in land use/land cover in Syria from 2010 to 2018 using multitemporal landsat imagery and GIS *Land* 9
20. Olokeogun O S and Kumar M 2020 An indicator based approach for assessing the vulnerability of riparian ecosystem under the influence of urbanization in the Indian Himalayan city, Dehradun *Ecol. Indic.* 119
21. Patas K W and Zawadzki J 2020 Sentinel-2 imagery processing for tree logging observations on the bialowieza forest world heritage site *Forests* 11
22. Petit, C., Scudder, T., Lambin, E., (2001). Quantifying processes of land-cover change by remote sensing: resettlement and rapid land-cover changes in south-eastern Zambia. *Int. J. Remote Sens.* 22 (17), 3435–3456. <https://doi.org/10.1080/01431160010006881>.
23. Rahimi A and Breuste J 2021 Why is Lake Urmia Drying up? Prognostic Modeling With LandUse Data and Artificial Neural Network *Front. Environ. Sci.* 9

24. Raji O, Ouabid M, Bodinier J-L, El Messbahi H, Malainine C E and Tabbakh Z 2021 An Integrated Approach for Rapid Delineation of K-Rich Syenites Suitable as Unconventional Potash Resources *Nat. Resour. Res.* 30 3219–39
25. Suribabu, C.R., Bhaskar, J., Neelakantan, T.R., (2012). Land use/cover change detection of Tiruchirapalli city, India, using integrated remote sensing and GIS tools. *J Indian Soc Remote Sens* 40:699– 708. <https://doi.org/10.1007/s12524-011-0196-x> 5.
26. Wang, D., Morton, D., Masek, J., *et al* (2012). Remote sensing of environment impact of sensor degradation on the MODIS NDVI time series. *Remote Sens Environ* 119:55–61. <https://doi.org/10.1016/j.rse.2011.12.001>.
27. Yanan, L., Yuliang, Q., Yue Z (2011). Dynamic monitoring and driving force analysis on rivers and lakes in Zhuhai City using remote sensing technologies. *Procedia Environ Sci* 10:2677–2683. <https://doi.org/10.1016/j.proenv.2011.09.416>.
28. Pielke RA, Avissar R. *Influence of landscape structure on local and regional climate. Landscape Ecology.* 1990 Jul;4:133-55.