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# Change Detection of Vegetative Covers in Kalara Nala Watershed of Damoh District Using Remote Sensing and GIS

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***Authors' contributions***

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

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## ABSTRACT

Remote sensing and GIS technologies have proven to be effective tools to analyse land use land cover (LULC) changes on watershed basis. The evaluation and monitoring of watershed development programmes are of prime importance to assess the conservation of natural resources and the efficiency of their utilization. The investigation aims to detect changes in vegetative cover due to water harvesting and recharging structures of the study watershed situated in Patharia block of Damoh district, Madhya Pradesh. The watershed development programme was executed during the period 2018-2022. All the processes related to the evaluation of watershed development activities were performed using remote sensing and GIS tools through pre and post development data in the GIS environment. The change detection in vegetative cover was done based on land use land cover patterns. By adopting unsupervised classification approach, high-resolution satellite data of Sentinel-2B for the years 2018 and 2022 were used for land use land cover (LULC) mapping and further analysis. During the year 2018, it was observed that the vegetative cover in the watershed was 37% of the watershed area however after the implementation of the watershed

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development programme total vegetative cover increased to 60% of the total watershed area in the year 2022. From the study, it can be concluded that remote sensing and GIS can prove to be viable tool for the evaluation of watershed development programmes.

*Keywords: Watershed; Land use Land cover (LULC) map; change detection; unsupervised classification.*

## 1. INTRODUCTION

A watershed is an area of land where all of the water that falls on it and drains off of it goes into a single or common outlet. The watershed is an effective hydrological unit for scientific efforts to manage soil and water resources for production and conservation. Appropriate management of land and water resources at a watershed level is highly advantageous in achieving long-term goals for sustainable development [1,2]. The watershed approach allows planners and policymakers to maximize the productivity of soil, water, and vegetation while maximizing resource efficiency [3]. The improvement of the natural resource base of watersheds is the main goal of a watershed development programme in order to increase the productivity of its forest, grazing land, and agricultural lands and to increase the economic condition of its nearby residents [4,5].

Watershed management entails the sensible use of land and water resources with the least amount of risk to the environment. Its primary objective is to conserve the soil and water in the watershed, which entails using the land properly and guarding it against all kinds of deterioration [6,7]. Additionally, it implies the preservation of soil fertility, the preservation of water for agricultural use, and an increase in resource productivity [8]. Monitoring and evaluation of how effectively natural resources are being used and how well they are being conserved are highly essential for the watershed development programme.

Evaluation of any watershed development programme with the aid of Remote Sensing and GIS technique is very helpful. It provides a set of tools through which large-scale regions can be monitored with ease as compared to conventional ground-based surveys. The technique of remote sensing and GIS is highly advantageous for mapping and analysing land cover and change detection at the watershed level [9,10,11]. Land use and land cover classification using remotely sensed data really do have the ability to provide a macroscopic, quick, and real-time final result. Such data can provide more effective and accurate information [12,13]. The accuracy and timely update of Land use Land cover is the great consequence of worldwide change, environmental monitoring, yield approximation and cropping pattern [9,14]. Mapping LULC and detecting changes using remote sensing and GIS techniques is a cost-effective method of gaining a clear understanding of the land cover phase of the analysis and the consequences caused by land-use change [2,8]. The land use land cover is highly dynamic, undergoing numerous changes as a result of changing socioeconomic habits and ecosystems [15,16]. The watershed-based technique for the planning of conservation measures is found to be very effective because excess rainfall or runoff from the watershed is drained to a common outlet controlled by various morphological features related to the shape, size, and relief of the watershed [17,7]. Different conservation measures in a watershed can be implemented to protect soil and water resources [18]. By considering all such observations, this current piece of research employs remotely sensed data of high spatial resolution for mapping land use land cover in order to detect changes in the vegetative cover of the study area named Kalara nala watershed of Damoh district in Madhya Pradesh.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The watershed under consideration includes the Bansakalan and Nandrai panchayat of Patharia block. It is located between 23°52'40"N and 79°07'45"E to 23°52'22"N and 79°13'08"E in the Damoh district of Madhya Pradesh, India. The district is part of the Sagar Division. It is situated in the northeastern part of the State. The watershed has a total geographical area of 4327.25 ha. The overall population of the study area is 20700 (as per the 2011 census). It lies in the agro-climatic zone of the Vindhyan Plateau. The climate in the study area is generally dry. Maximum temperatures range from 36°C to 46°C, while minimum temperatures range from 28°C to 8°C. The highest and lowest elevation of the watershed is 493 m and 161 m respectively. The average annual rainfall is 1173 mm and the slope ranges between 1% to 12%.

## 2.2 Remote Sensing Data Used

In the study, georeferencing was done to obtain the geographic coordinates from the toposheet map of the study area. The provided map was georeferenced using the ArcGIS 10.8 software, and the generated coordinates were used in the digitization process for additional maps. The watershed delineation process was performed by using the toposheet based on contours and runoff outlet. Topographic features e.g. contour lines, and other natural and man-made features including water bodies, drainage lines, benchmarks etc. are well represented in the Survey of India (SOI) Topographic sheets/ maps. The scale of the map (toposheet) is 1:50,000.

Sentinel 2B images (with multi-spectral images of 10 m spatial resolution) were collected for 2 years (2018 and 2022). The metadata of the satellite data is given in Table 1. Sentinel 2B data are georeferenced with the projection of UTM zone 44 N using WGS-84 datum. Data were acquired with a special focus on visible spectrum bands and near-infrared bands such as band 2 (blue), band 3 (green), band 4 (red) and band 8 (near-infrared). The necessary pre-processing methods such as calibration, atmospheric correction and removal of data dropouts were carried out using ERDAS IMAGINE® 2011.

## 2.3 Classification Approach

The method of unsupervised K means classification approach along with a combination of onscreen visual interpretation gave rise to different Land use Land cover classes such as forest, agriculture wasteland, fallow land habitation water bodies etc [2,8]. ERDAS IMAGINE 2020 was employed with the (ISODATA) clustering technique for unsupervised classification and training sample which uses the statistical data to analyse the differences or similarities of the pixel values and then collected the pixels into different classes [19] This procedure requires multiple passes or repetitions before reaching a convergence threshold. A signature file was then used to create a new raster layer with specific class values.

## 2.4 Land Use Land Cover (LULC) classes

By using the process Raster -> Thematic -> Recode, the final unsupervised layer was precisely recoded into the six land use land cover classes. Finally, the appropriate colours were assigned to these classes. These land use land cover categories were further diluted to match specific classes based on tone, texture, colour, shape, association, and pattern, as well as Google Earth imagery of forest, vegetation, fallow land, wasteland, habitation, and water bodies. The area covered in each class was calculated based on the spatial extent of pixels.

## 2.5 Accuracy Assessment

The acquired LULC map was then added to the ArcGIS 10.8 software to assess its accuracy. The assessment was carried out by randomly generated accuracy assessment points throughout the raster file of the LULC classification. This method primarily aids in evaluating randomly distributed points across various LULC classes. The confusion matrix that produces the Kappa coefficients of the LULC mapping was obtained with the help of further verifying points using Google Earth Pro 7.3. The kappa coefficient, overall accuracy, producer accuracy and user accuracy of LULC classification were based on standard formulae.

## 2.6 GIS Based Location Map Preparation

GIS based location map was prepared by adding the location of water harvesting and recharging structures on the generated stream lines of the watershed. Coordinates (latitude and longitude) of water harvesting and recharging structure were overlaid on the map in the form of point shapefile. A total of 189 structures of different categories were located and legends were assigned according to the categories. All these steps were followed to better understand the location of structures. The location map of different water harvesting and recharge structures is shown in Fig. 3.

**Table 1. Information about the satellite datasets**

| Procured Date | Attribute Name | UTM zone |
|---|---|---|
| 16/02/2018 | L1C_T44QLM_A004950_20180216T052514 | 44N |
| 25/02/2022 | L1C_T44QLM_A025971_20220225T052828 | 44N |

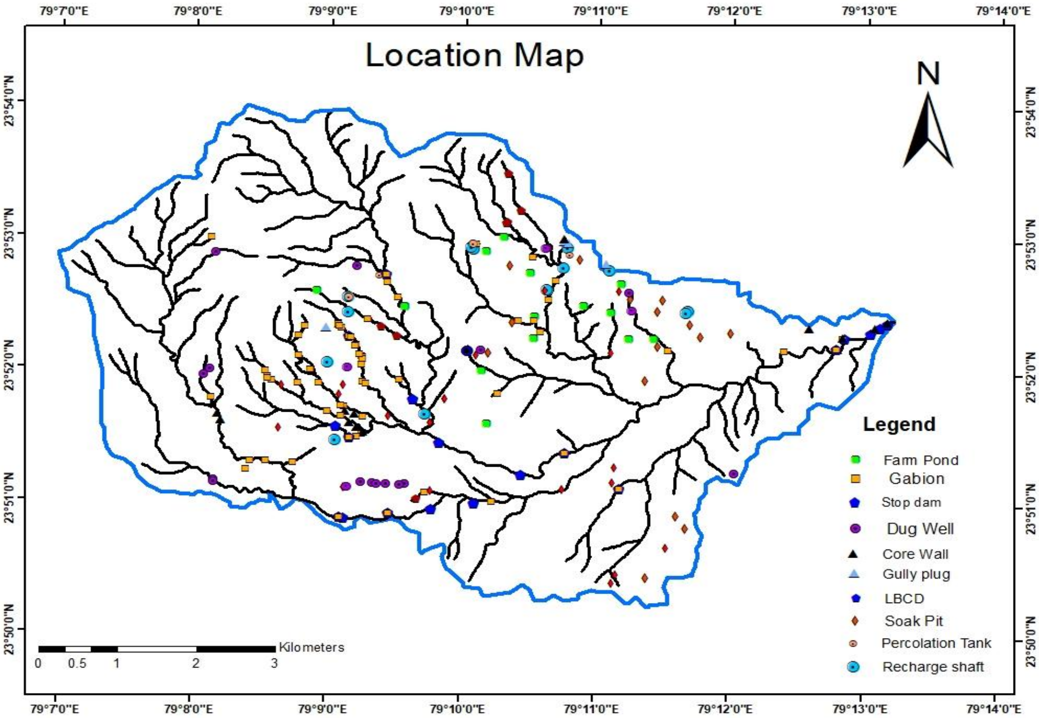


**Fig. 1. Structure location and stream order map**

## 2.7 Change Analysis of Vegetative Cover

Change detection analysis describes and quantifies the difference between images of the same area at different periods [20]. This type of analysis is very much helpful to identify the various changes in land use/land cover, such as an increase in built-up land and a decrease in agricultural land [21]. The GIS based location map was prepared by adding a point shapefile of the location of water harvesting and recharging structures on the generated stream lines of the watershed. The various locations and attribute data of geographic features were stored in the shapefile.

For the analysis of change in vegetative cover buffer analysis method was adopted. Buffer analysis is the spatial analysis in which a buffer zone was created around a geographic feature that contains places that are within a particular distance of it.

## 3. RESULTS AND DISCUSSION

## 3.1 Land Use Land Cover (LULC)

For the preparation of the land use land cover map of the study area, sentinel 2B data was used. Data was downloaded from USGS earth explorer and analysed in the ERDAS Imagine 2020 software. The satellite data for the month of February for the years 2018 and 2022 were used and analyses were further classified into six major classes. The obtained classes were Vegetation, Built-up, Forest, Open/ Fallow land, Wasteland and Water bodies. In the watershed dominating classes were vegetation and open/ fallow land. Over the period of 2018 to 2022, it was observed that there is a gradual increase in vegetation area. The prepared land use land cover map of the study area for different years is shown in Figs. 1 and 2. The area covered by different land use land cover classes for different years is shown in Tables 3 and 4.

### 3.1.1 Accuracy assessment

The accuracy assessment of the classified land use land cover maps for the two years (i.e. 2018 and 2022) was performed in order to obtain the level of reliability. The accuracy assessment points as verified from google earth pro were used as input for generating the confusion matrix. The confusion matrix is also called as error matrix on the Contingucy table [22].

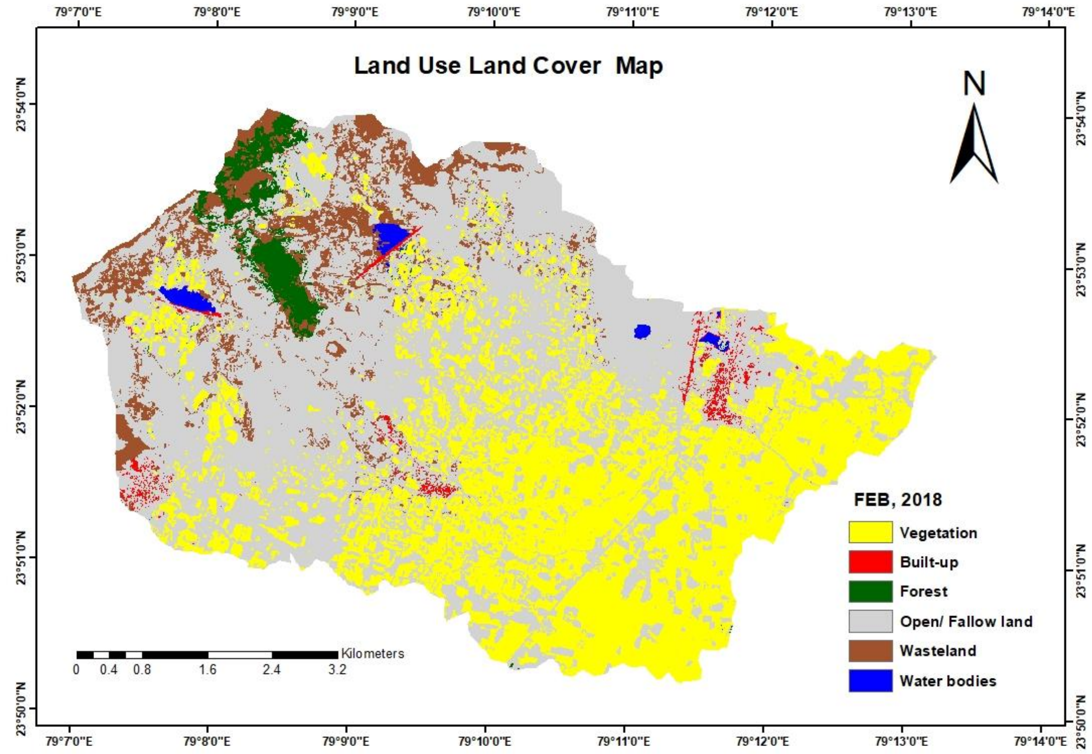


**Fig. 2. Land use land cover for February 2018**

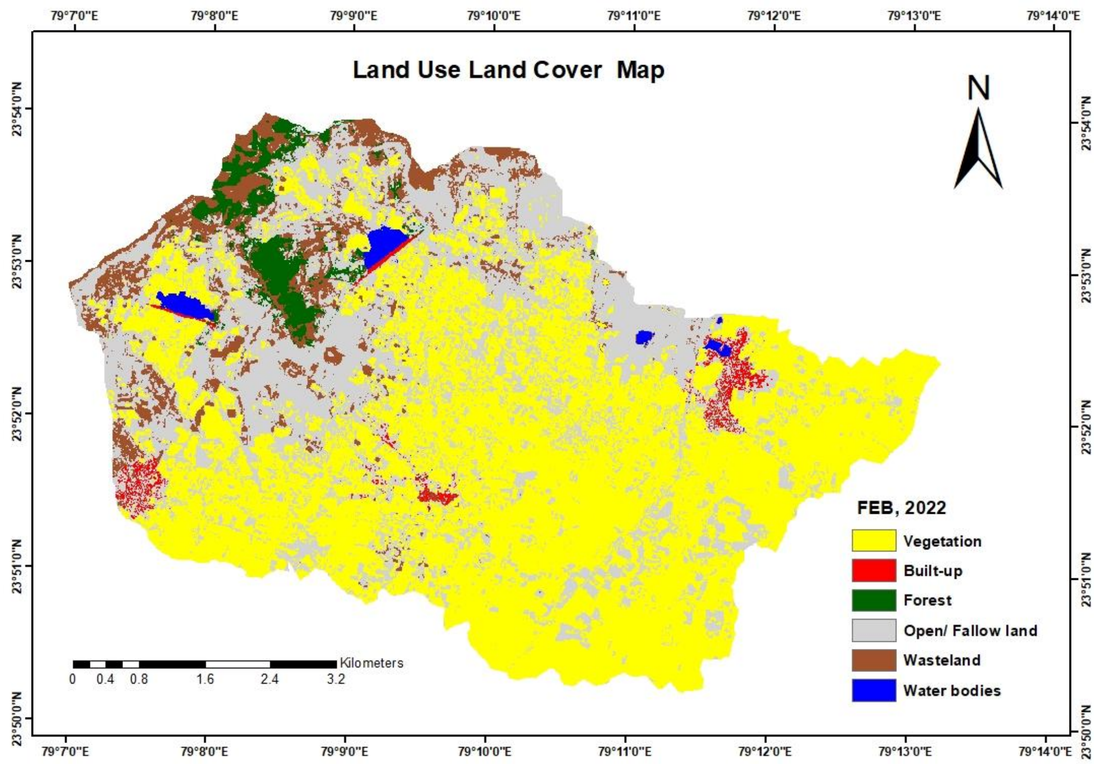


**Fig. 3. Land use land cover for February 2022**

**Table 2. Area covered by LULC classes in February 2018**

| SN | Class | Area (ha) |
|---|---|---|
| 1 | Vegetation | 1480.55 |
| 2 | Built-up | 37.86 |
| 3 | Forest | 110.76 |
| 4 | Open/ Fallow land | 2333.16 |
| 5 | Wasteland | 337.86 |
| 6 | Water bodies | 27.06 |

**Table 3. Area covered by LULC classes in February 2022**

| SN | Class | Area (ha) |
|---|---|---|
| 1 | Vegetation | 2323.54 |
| 2 | Built-up | 46.31 |
| 3 | Forest | 107.88 |
| 4 | Open/ Fallow land | 1499.26 |
| 5 | Wasteland | 316.02 |
| 6 | Water bodies | 34.78 |

**Table 4. Confusion matrix for LULC map 2018**

| | | Ground Truth (Reference) data | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Vegeta -tion** | **Built up** | **Forest** | **Open land** | **Waste land** | **Water bodies** | **Total (user)** | **User Accuracy (%)** |
| **Classified data** | Vegetation | 40 | 0 | 1 | 2 | 1 | 1 | 45 | 88.88 |
| | Built up | 1 | 29 | 0 | 2 | 0 | 0 | 32 | 90.62 |
| | forest | 0 | 3 | 19 | 0 | 0 | 0 | 22 | 86.36 |
| | open land | 0 | 0 | 2 | 23 | 2 | 0 | 27 | 85.19 |
| | waste land | 0 | 0 | 0 | 1 | 17 | 0 | 18 | 94.44 |
| | water bodies | 0 | 0 | 1 | 0 | 0 | 15 | 16 | 93.75 |
| | Total (producer) | 41 | 32 | 23 | 28 | 20 | 16 | 160 | |
| | producer accuracy (%) | 97.56 | 90.62 | 82.6 | 82.14 | 85 | 93.75 | | |

| | |
|---|---|
| Over all accuracy | 89.37 % |
| Kappa coefficient | 0.87 |

**Table 5. Confusion matrix for LULC map 2022**

| | | Ground Truth (Reference) data | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Vegeta -tion** | **Built up** | **Forest** | **Open land** | **Waste land** | **Water bodies** | **Total (user)** | **User Accuracy (%)** |
| **Classified data** | Vegetation | 37 | 1 | 2 | | 1 | | 41 | 90.24 |
| | Built up | 0 | 24 | 1 | 0 | 0 | 2 | 27 | 88.89 |
| | forest | 1 | 2 | 26 | 0 | 0 | 1 | 30 | 86.67 |
| | open land | 0 | 0 | 1 | 17 | 1 | 0 | 19 | 89.47 |
| | waste land | 0 | 1 | | 1 | 23 | 0 | 25 | 92.00 |
| | water bodies | 1 | 0 | 0 | 0 | 2 | 15 | 18 | 83.33 |

| Classifie | | Ground Truth (Reference) data | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Vegeta-tion** | **Built up** | **Forest** | **Open land** | **Waste land** | **Water bodies** | **Total (user)** | **User Accuracy (%)** |
| | Total (producer) | 39 | 28 | 30 | 18 | 27 | 18 | 160 | |
| | producer accuracy (%) | 94.87 | 85.71 | 86.67 | 94.44 | 85.19 | 83.33 | | |

| | |
|---|---|
| Over all accuracy | 88.75 % |
| Kappa coefficient | 0.86 |

### 3.2 Analysis of Change in Vegetative Cover Around the Structures

For the calculation of change in vegetative cover and impact analysis of different water harvesting and recharging structures of the watershed initially buffer area was created around the water harvesting and recharging structures using the buffer tool in ArcGIS software. Point shapefile of the located structure was used as input feature. Buffer areas were clipped from the LULC map for the years 2018 and 2022 for calculation purposes.

To compare vegetative cover scenarios of buffered areas for the years 2018 and 2022, an analysis tool (overlay and intersect) of ArcGIS 10.8 software was used. Further calculation for change in vegetative cover was done and analysed.

From Fig 6, it is clear that vegetation cover in the watershed for the year 2018 was 37% of the total buffered area of the watershed whereas the area covered by other classes was 63%. Whereas total vegetation cover is 60% of the total buffered area and the area covered by other classes is 40% in the year 2022. The increase in vegetative cover as observed is 467.53ha. Hence, it can be observed that the increase in vegetation area is 23%.

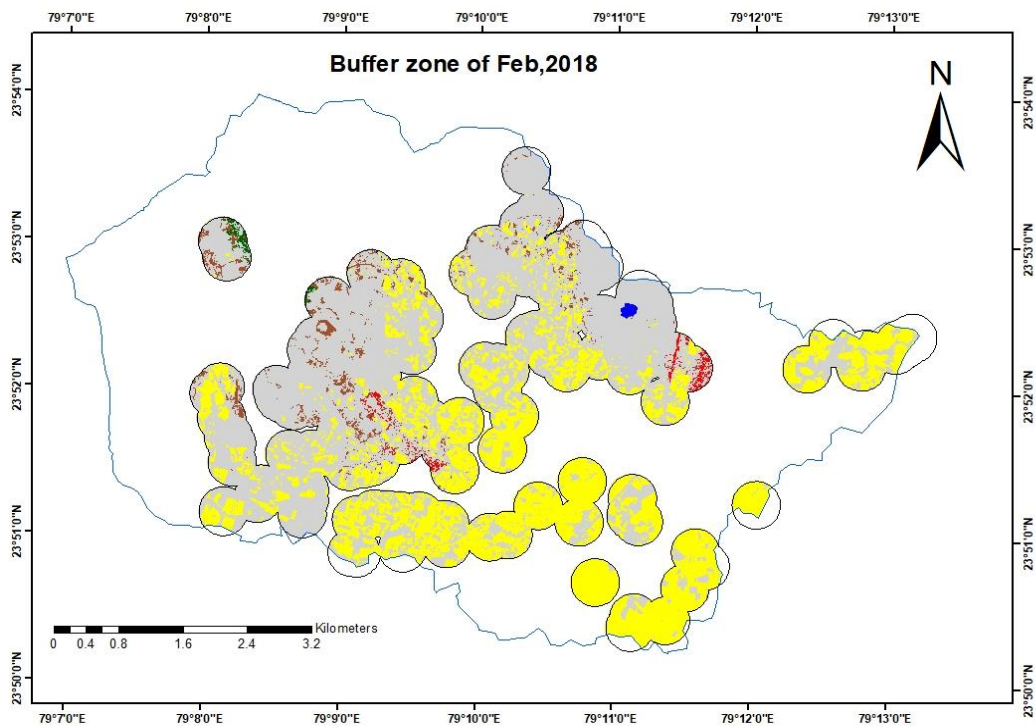


**Fig. 4. Buffer zone for February 2018**

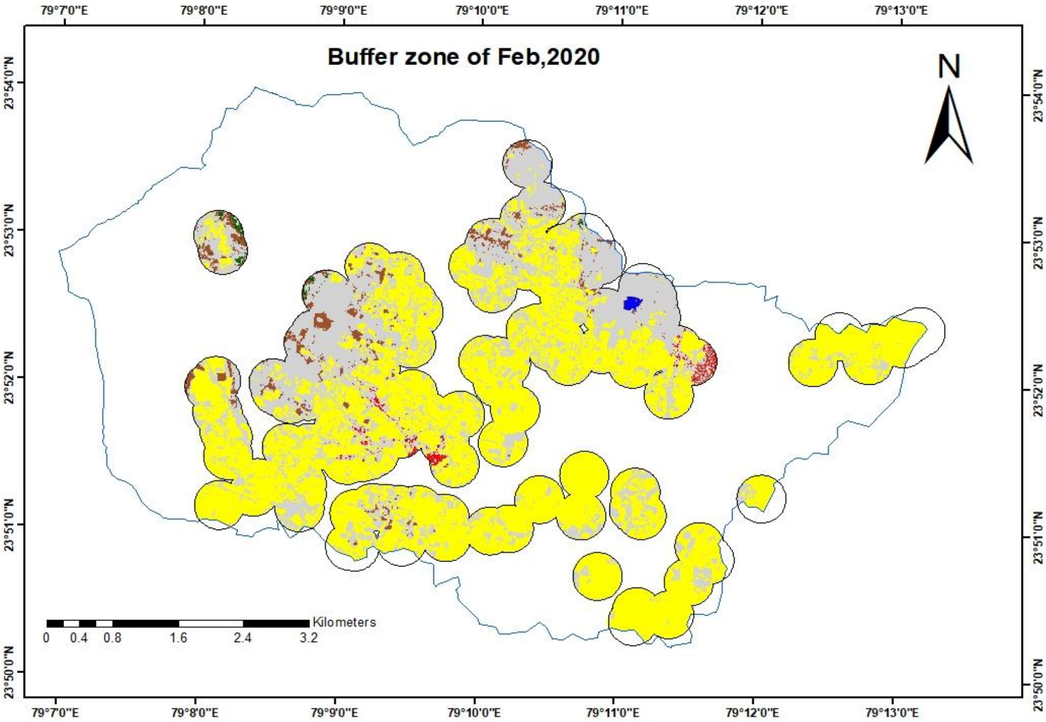


**Fig. 5. Buffer zone for February 2022**

**Table 6. Vegetative cover in 2018 and 2022**

| Year | Vegetation | Other areas |
|---|---|---|
| 2022 | 1188.35 ha | 779.61 ha |
| 2018 | 720.82 ha | 1246.75 ha |

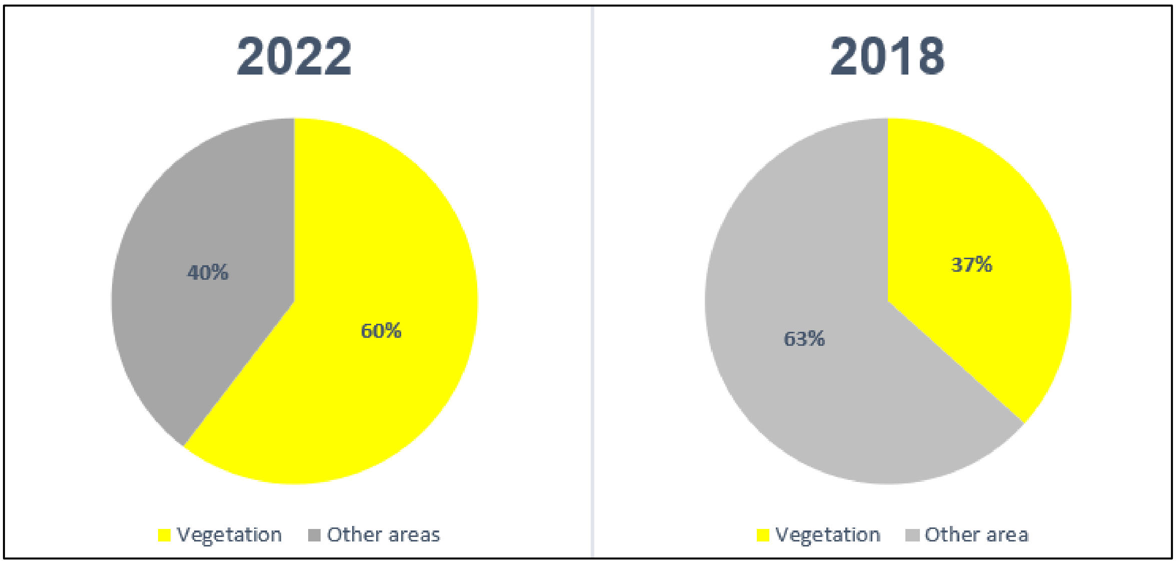


**Fig. 6. Vegetative cover in 2018 and 2022**

## 4. CONCLUSION

The study was undertaken with the purpose of emphasizing the merits of using remote sensing technology in the domain of LULC and its change detection. Classified maps prepared by unsupervised classification methods and comparison revealed changes in area coverage. The vegetation class expanded the most at the expense of the other categories. Thus, water harvesting and recharging structures showed a positive impact with the increase in vegetative cover.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Gajbhiye S, Sharma SK, Tignath S. Development of a geomorphological erosion index for Shakkar watershed. J Geol Soc India. 2015;86(3):361-70. DOI: 10.1007/s12594-015-0323-3
2. Rao JH, Patle D, Sharma SK. Remote sensing and gis technique for mapping land use/ land cover of Kiknari watershed. Ind J Pure App Biosci. 2020b;8(6): 455-63. DOI: 10.18782/2582-2845.8458.
3. Kutter A, Nachtergaele FO, Verheye WH. The new FAQ approach to land use planning and management, and its application in Sierra Leone. ITC J. 1997;1997-3(4):278-83.
4. Alka, Jha G, Kalra B. Mondal, Biswajit, Singh. Int J Agric Stat Sci. Socio-economic impact of watershed development programmes in Bundelkhand region of Madhya Pradesh, India. 2014;10:181-7.
5. Nema S, Awasthi MK, Nema RK. Trend analysis of annual and seasonal rainfall in Tawa command area. Int J Environ Agric Biotechnol. 2016;1(4):952-7. DOI: 10.22161/ijeab/1.4.46
6. Gul S, Bibi T, Rahim S, Gul Y, Niaz A, Mumtaz S et al. Monitoring of land use and land cover changes using remote sensing and geographic information system. Environ Sci Pollut Res. 2022. DOI: 10.21203/rs.3.rs-1721904/v1
7. Abebe G, Getachew D, Ewunetu A. Analysing land use/land cover changes and its dynamics using remote sensing and GIS in Gubalafito district, Northeastern Ethiopia. SN Appl Sci. 2022;4(1). DOI: 10.1007/s42452-021-04915-8
8. Patle D, Rao JH, Sharma SK. Land use / land cover mapping of Nahra nala watershed using SENTINEL-2B imagery. Int J Agric Environ Biotechnol. 2020b; 13(4):439-46. DOI: 10.30954/0974-1712.04.2020.8
9. Dubey S, Rao JH, Patle D. Morphometric analysis and prioritization of sub watersheds of Umar Nala watershed, Madhya Pradesh using geospatial technique. Int J Agric Environ Biotechnol. 2020;13(3):269-74. DOI: 10.30954/0974-1712.03.2020.2
10. Patle D, Rao JH, Dubey S. Morphometric analysis and prioritization of sub-watersheds in Nahra watershed of Balaghat District, Madhya Pradesh: A remote sensing and GIS perspective. J Exp Biol Agric Sci. 2020a;8(4):447-55. DOI: 10.18006/2020.8(4).447.455
11. Rao JH, Patle D, Dubey S. Implementation of Morphometric analysis in prioritizatizing sub-watersheds: A remote sensing and GIS aspect. Indian J Pure Appl Biosci. 2020a;8(4):318-29.
12. Awasthi MK, Patle D. Water harvesting in kharif fallow for augmenting ground water recharge. In: SCSI New Delhi NASC 4th International Conference on Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livestock Security. New Delhi, India: Page. 2019;94.
13. Awasthi MK, Patle D. Trend analysis of ground water recharge in Tikamgarh district of Bundelkhand using geospatial technology. Int J Chem Stud. 2020; 8(4):417-20. DOI: 10.22271/chemi.2020.v8.i4g.10181

14. Patle D, Awasthi MK, Sharma SK, Tiwari YK. Application of geoinformatics with frequency ratio (FR) model to delineate different groundwater potential zones in ken basin, India. Indian J Ecol. 2022; 49(2):313-23.
15. Bisen S, Choudhary P, Awasthi MK, Patle D. Kharif fallow utilization for groundwater recharge. Int J Curr Microbiol Appl Sci. 2019;8(12):284-90.
DOI: 10.20546/ijcmas.2019.812.039
16. Patil RJ, Sharma SK, Tignath S, Sharma APM. Use of remote sensing, GIS and C++ for soil erosion assessment in the Shakkar River basin, India. Hydrol Sci J. 2017;62(2):217-31.
DOI: 10.1080/02626667.2016.1217413
17. Anley MA, Minale AS, Haregeweyn N, Gashaw T. Assessing the impacts of land use/cover changes on ecosystem service values in Rib watershed, Upper Blue Nile Basin, Ethiopia. Trees Forests and People. 2022;7.
DOI: 10.1016/j.tfp.2022.100212
18. Saptarshi PG, Raghavendra RK. GIS-based evaluation of micro-watersheds to ascertain site suitability for water conservation structures. J Indian Soc Remote Sens. 2009;37(4):693-704.
DOI: 10.1007/s12524-009-0057-z
19. Mishra A, Ratnadeep RG, Deshmukh R. LULC analysis using unsupervised classification; 2020.
DOI: 10.18522/2311-3103-2020-3-184-192
20. Belal AA, Moghanm FS. Detecting urban growth using remote sensing and GIS techniques in Al Gharbiya governorate, Egypt. Egypt J Remote Sens SP Sci. 2011;14(2):73-9.
Available:https ://doi. doi: 10.1016/j.ejrs.2011.09.001
21. Hegazy IR, Kaloop MR. Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. Int J Sustain Built Environ. 2015;4(1):117-24.
Available:https :. doi: 10.1016/j.ijsbe
22. Congalton RG. A review of assessing the accuracy of classifications of remotely sensed data. Remote Sens Environ. 1991;37(1):35-46.
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