Original Research Article

A Study on Change Detection of Vegetative Covers in KalaraNala Watershed of Damoh District Using Remote Sensing and GIS Technique

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ABSTRACT

Soil and water resources are currently under enormous strain as a result of the highly competing and frequently contradictory demands of an ever-expanding population. The optimum management of these two resources with the least amount of negative environmental impact is critical not only for long-term development but also for human survival. The evaluation and monitoring of watershed development programme is of prime importance to assess the conservation of natural resources and the efficiency of their utilization. The present investigation aims to detect change in vegetative cover due to water harvesting and recharging structures of study watershed situated in Patharia block of Damoh district, Madhya Pradesh. The watershed development programme was executed during the period 2018-2022. All the studies related to the evaluation of watershed development activities were performed using remote sensing and GIS tools. The developed watershed was evaluated with accessible remotely sensed pre- and post-development data in GIS environment. The change detection in vegetative cover was done based on Land Use Land cover pattern. Remote sensing and GIS technologies have proven to be an effective tool to analyze LULC changes on watershed basis. By adopting unsupervised classification approach high-resolution satellite data of Sentinel-2B for the year 2018 to 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 total watershed area however after the implementation of watershed development programme total vegetative cover increased to 60% of total watershed area in the year 2022. From the study it can be concluded that remote sensing and GIS can prove to be a viable tool for evaluation of watershed development programme.

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 the single or common outlet. The watershed is the effective hydrological unit for scientific efforts to manage soil and water resources for production and conservation. Appropriate management of land and water resource at a watershed level are highly advantageous in achieving long-term goals for sustainable development[1][2]. The watershed approach allows the planners and policy makers to maximize the productivity of soil, water, and vegetation while maximizing resource efficiency[3].The improvement of natural resource base of watershed 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. It's primarily objective is to conserve the soil and water in the watershed, which entails using the land properly and guarding it against all kind of deterioration. Additionally, it implies the preservation of soil fertility, the preservation of water for agricultural use, and an increase in resource productivity[6].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. Similarly, improving the socio-economic status of the watershed inhabitants is also important.

Evaluation of any watershed development programme with the aid of RS and GIS techniques 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 watershed level [7],[8], [9]. Land use and land cover classification using remotely sensed data really does have the ability to provide a macroscopic, quick, and real-time final result. Such data can provide more effective and accurate information[10],[11]. The accuracy and timely update of Land use Land cover is great consequence of worldwide change, environmental monitoring, yield approximation and cropping pattern[7],[12].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],[6].The land use land cover is highly dynamic, undergoing numerous changes as a result of changing socioeconomic habits and ecosystems [13],[14]. 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. Different conservation measures in a watershed can be implemented to protect soil and water resources [15].

2. MATERIAL AND METHODS /

2.1 Study Area

The watershed under consideration for the study includes the Bansakalan and Nandraipanchayat 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 of Damoh district of Madhya Pradesh, India. The district is part of the Sagar Division. It is situated in the north-eastern 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 Vindhyan Plateau. The climate in the study area is generally dry. Maximum temperatures range from 46°C to 36°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 between1% to12%.

2.2 Base map preparation

In the present study georeferencing was done to obtain the geographic coordinates from the top sheet map of the study area. The provided map was georeferenced using the ArcGIS 10.8 software, and the generated coordinates were used to the digitization process for additional maps. For the present study, watershed delineation process was performed by using the toposheet based on contours and runoff outlet. Topographic features e.g. contour lines, 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 (top sheet) is 1:50,000.

2.3 Land Use Land Cover (LULC) map preparation

Sentinel 2B image (with multi spectral image of 10 m spatial resolution) were collected for 2 years (2018 and 2022). The metadata of the satellite data are given in Table 1.Sentinel 2B data are pre-georeferenced with the projection of UTM zone 44 N using WGS-84 datum. Data were acquired with special focus on visible spectrum bands and near-infrared band 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.

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

2.4 Classification Approach

The method of unsupervised K means classification approach along with 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], [6].ERDAS IMAGINE 2020 was employed with the (ISODATA) clustering technique for unsupervised classification and training sample which uses the statistical data to analyze the differences or similarities of the pixel values and then collected the pixels into different classes [16]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.

2.5 Land Use Land Cover (LULC) classes

By using Raster -> Thematic -> Recode, the final unsupervised layer was precisely recoded into the six land use land cover classes. Finally, the appropriate colors were assigned to these classes.

Table-2: Colour represents Land Use Land Cover (LULC) classes

S.N.	Class Name	Color
1	Vegetation	Yellow

2	Built- up	Red
3	Forest	Dark Green
4	Open/ Fallow land	Light Gray
5	Wasteland	Sienna
6	Water bodies	Blue

2.6 Accuracy assessment

In the present study, 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 formulas.

2.7 Change analysis of vegetative cover.

Change detection analysis describes and quantifies the difference between images of the same area at different periods[17]. 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[18]. GIS based location map was prepared by adding point shape file of 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) map

For the preparation of land use land cover map of the study and analysed in the ERDAS Imagine 2020 software. The satellite data for the month of February for the year 2018 and 2022 were used and analysis was 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 gradual increase in vegetation area. The prepared land use land cover map of the study area for different years is shown in Figure 1 and 2. The area covered by different land use land cover classes for different years is shown from Table 3 and 4.

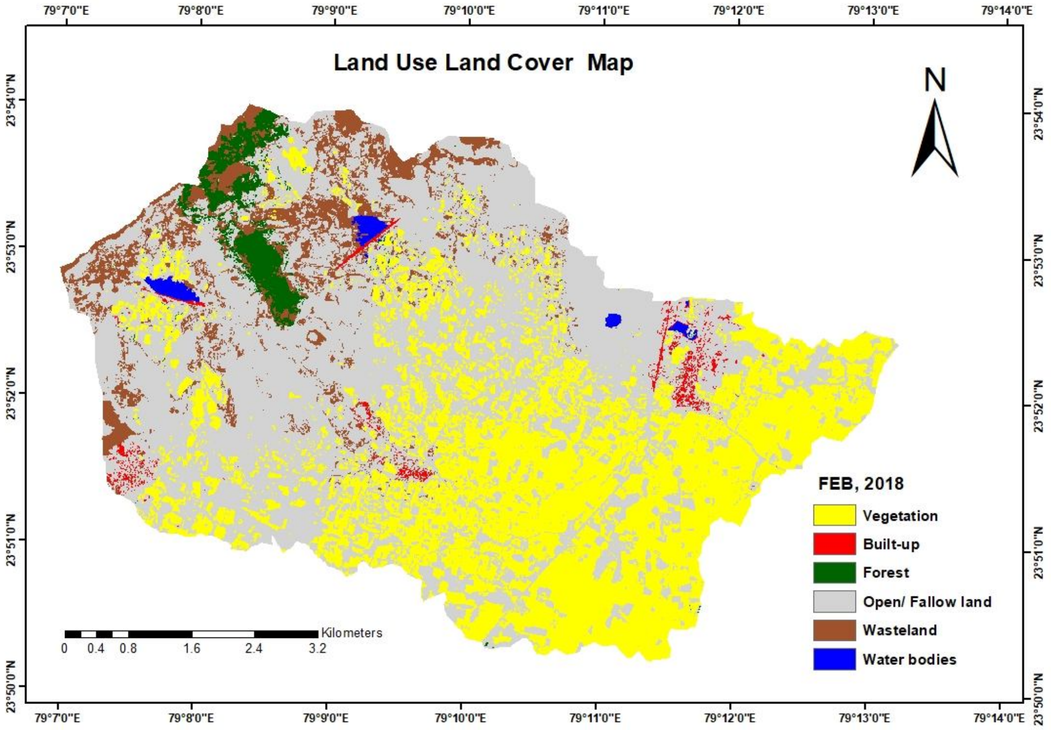

Fig 1: Land Use Land Cover Map for February, 2018

Table -3: 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

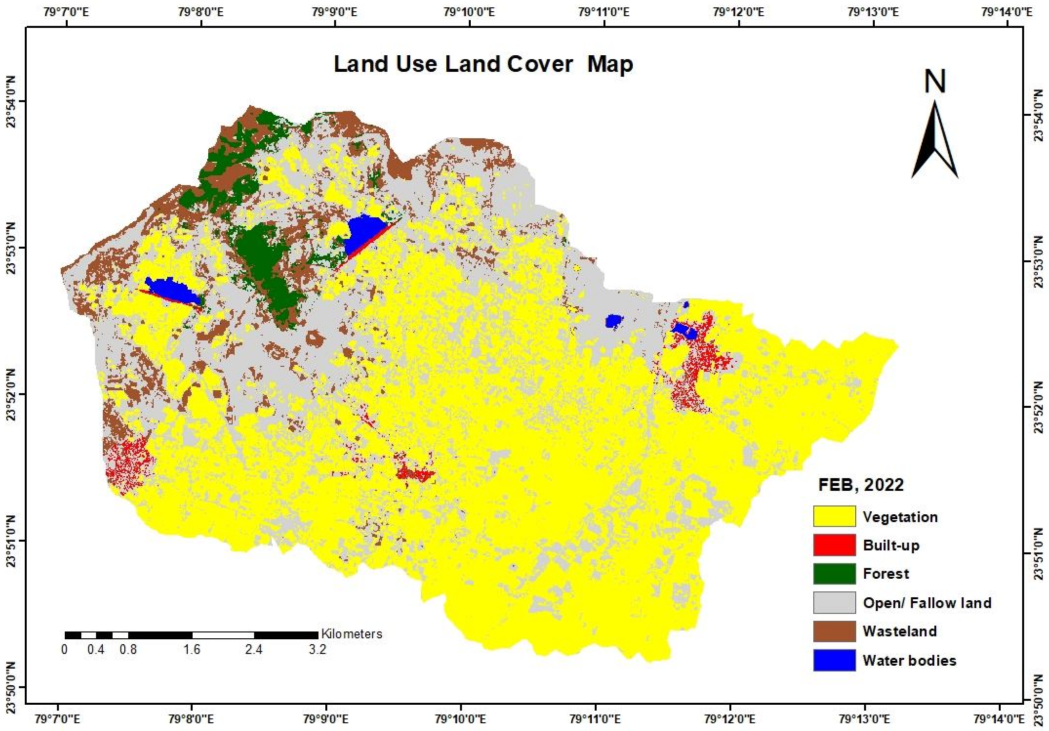

Fig 2: Land Use Land Cover Map for February,2022

Table-4 Area covered by LULC Classes in February,2022

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

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 contingency table [19].

Table-5 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 -6 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
	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 GIS based location map preparation

In the next step 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 of the location of structures. The location map of different water harvesting and recharge structures is shown in Figure 3.

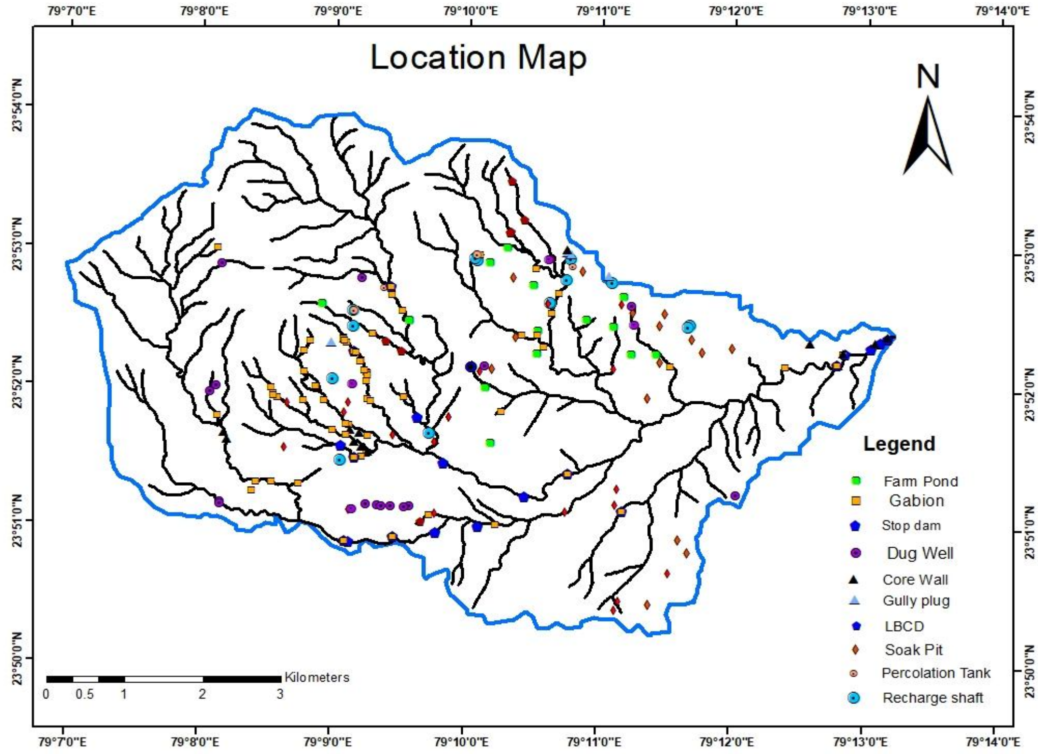

Fig. 3: Structure location and Stream order map

3.3 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 buffer tool in ArcGIS software. Point shapefile of located structure was used as input feature. Buffer areas were clipped from the LULC map of year 2018 and 2022 for calculation purposes.

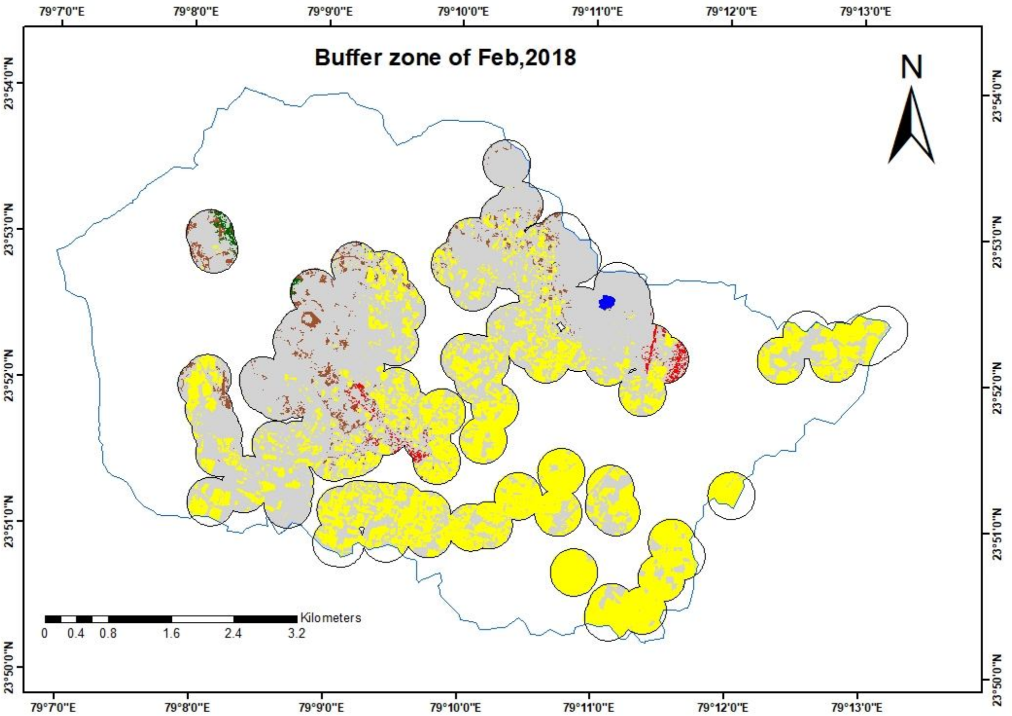

Fig 4: Buffer zone for February, 2018

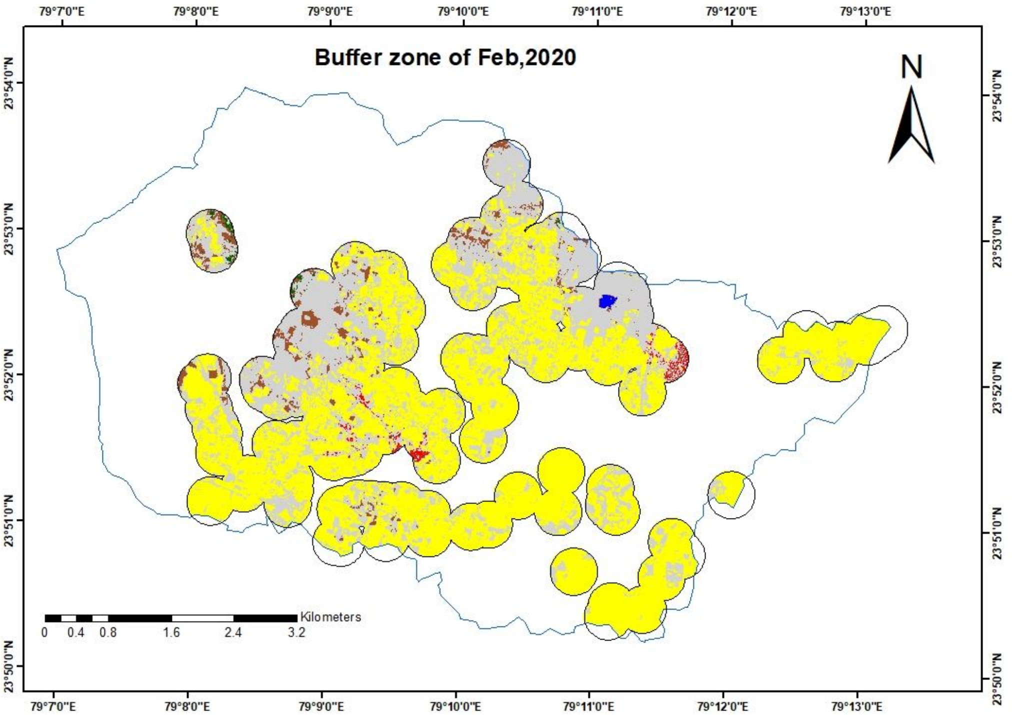

Fig 5: Buffer zone for February, 2022

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

Table 5: Vegetative cover in 2018 and 2022

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

From the Table 5, it is clear that vegetation cover in the watershed 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 area covered by other classes is 40%.The increase in vegetative cover as observed is467.53ha. Hence, it can be observed that the increase in vegetation area is 23%.

4. CONCLUSION

The present 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 positive impact with the increase in vegetative cover.

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