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Research Article

Remote Sensing and GIS Technique for Mapping Land Use/Land Cover of Kiknari Watershed

J Himanshu Rao*, Deepak Patle and Shailesh Kumar Sharma

Department of Soil and Water Engineering, College of Agricultural Engineering, Jawaharlal Nehru Krishi
Vishwa Vidyalaya, Jabalpur, 482004, Madhya Pradesh, India
*Corresponding Author E-mail: j.himanshurao@gmail.com

ABSTRACT

Classifying land use/land cover with its consequential analysis has gained due importance in the recent time for land resource management. The main purpose of this research was to create a land use/land cover map of Kiknari nala watershed a tributary of Burner river basin using remote sensing and GIS techniques. The fundamental prerequisite in mapping land use/land cover is a high spatial resolution satellite image. Sentinel – 2B image was utilized for such purposes. The investigation took unsupervised K means classification approach as a means to obtain broad categories of LU/LC in ERDAS IMAGINE® 2011 environment. Additionally, the system of on-screen visual interpretation method aided in diluting the aforementioned categories to forests, agriculture, fallow land, waste land, habitation and water body. The LU/LC analysis portrayed that majority of watershed area is covered under agriculture (i.e. 33.85%) followed by fallow land (27.07%) and forests (22.53%). However, fallow land is having a considerable spatial extent over the watershed, such land can be undoubtedly converted into agriculture and other plantation purposes if water and human resources are easily available in adequacy.

Keywords: *LU/LC, Satellite Imagery, Remote Sensing, GIS, Watershed.*

INTRODUCTION

Securing available food resources for fulfilling basic need is a prime prerequisite of human survival. In the recent development scenarios, land resources has proved itself to be a significant player in production development equally for country and region (Meshram et al., 2017). Degradation of land and water resources due to population explosion, lack of awareness is putting serious pressure on the available resources to remain clean and sustainable for the future generations (Rao et al., 2019; & Sharma et al., 2011a). Scanty available land resources and poor on-farm management practices is somehow putting a severe menace in managing food security (Sharma et al., 2008; Meshram & Sharma, 2018; & Sharma et al., 2018).

Effective land resource management at a watershed level is highly advantageous in achieving long-term sustainable development goals (Gajbhiye et al., 2015).

The sensible development and protection of land resources has become a key issue for mankind to explore (Liu et al., 2012; & Sharma et al., 2012).

The land use/land cover is highly dynamic that experiences numerous change patterns solely according to changing socio-economic practices and natural ecosystem (Patil et al., 2017). Database on land use is highly crucial in analyzing the environmental processes and complications that must be taken into consideration so as to make living standards to be imperishable (Sharma & Seth, 2010; & Sharma et al., 2015).

This change in any class of land use/land cover prominently relies on numerous atmospheric externalities such as climatic variability, soil type, rainfall (Rao et al., 2020; & Patle et al., 2020). Such emerging conditions necessitates in acquiring information regarding land use/land cover for planning, management and development strategies that plays a significant role in observing the earth systems. The accuracy and timely update of LU/LC is of great consequence to worldwide change, environmental monitoring, yield approximation and cropping pattern (Dubey et al., 2020; & Patle & Awasthi, 2019a). Classifying land use/land cover with subsequent monitoring via remotely sensed data has the potential of providing macroscopic, fast, and real time end product especially for large areas (Awasthi & Patle, 2019; & Awasthi & Patle, 2020). Information acquired from such data can be more effective and accurate. Recent development in the areas of remote sensing techniques with numerous sources of freely available data has made land resource investigation comparatively easier from the earlier available manual methods (Patle & Awasthi, 2019b).

The term land use refers to associated human activity or economic purpose related with a definite piece of land, whereas the term land cover relates to the kind of feature existing on the surface of earth (Pathak et al., 2018). Space borne remote sensing aids in gathering information concerning land use/land cover of an area that changes over temporal scales (Nema et al., 2017). Furthermore, the technique of remote sensing is highly advantageous in land cover mapping of areas like hilly regions, wetlands, dense conserved forests with limited and no grazing permissions. Analysing LU/LC at watershed level aids in resource management. A watershed is a type of landform that primarily contains confluence slopes which directs runoff to a single downward point referred as its outlet when rainfall commences on it.

In the preceding years, numerous studies have been executed by using remotely sensed data not only for individual land use/land cover mapping but also for various scientific studies (Gajbhiye & Sharma, 2015). Sharma et al. (2011b) performed LU/LC analysis of classified satellite imagery of Gusuru river watershed in parts of Panna and Satna districts, Madhya Pradesh whose findings concluded that 88.03 percent of area is covered by forests. Six different classes of LU/LC was prepared by Palanichamy (2018) for Tiruchirappalli district of Tamil Nadu whose findings expressed that 39 percent of area was under cultivation. By considering all such observations, this current piece of research employs remotely sensed data of high spatial resolution in a study area named Kiknari nala watershed of Mandla district in Madhya Pradesh for mapping LU/LC.

MATERIALS AND METHODS
2.1 Study area:
Kiknari Nala watershed is located in Mandla, Madhya Pradesh that contributes its discharge to Burhner river near Mohgaon town area of the district. Geographical location of watershed varies from 80°50'42" E to 80°56'57" E longitude and 22°33'59" N to 22°37'42"N latitude with elevation ranging from 910 m to 540 m above mean sea level (MSL). The shape of the watershed is almost triangular having an area of 3894.32 ha. The watershed involves a tropical climate with daily minimum and maximum temperature of 7.6°C and 41.50°C. Annual precipitation in watershed is pivotally received by south-west

monsoon from the mid of June to mid of September. Soil texture in watershed is broadly classified into clay and loam soils. The

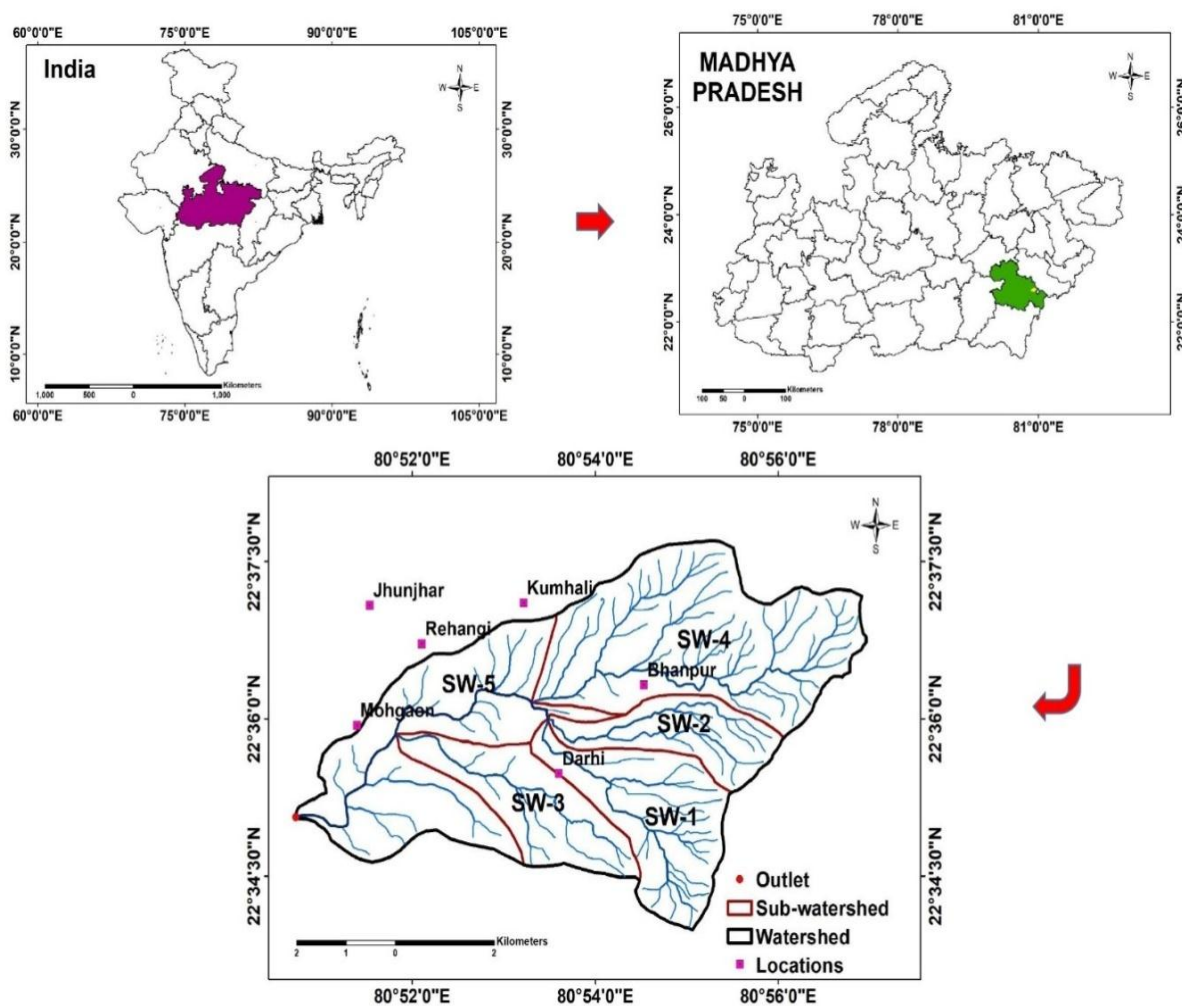location map of watershed is depicted in Figure 1.

Figure 1: Location map of Kiknari nala watershed

2.2 Georeferencing and preparation of base map:

Kiknari nala watershed principally lies in Survey of India Toposheet No. F44/14 of 1:50000 scale. The georeferencing of Toposheet was initially performed by importing the toposheet in ERDAS IMAGINE® 2011 environment with WGS 1984 as Geographic Co-ordinate System. Additional preparation of base map primarily comprising stream network, contours and watershed boundary was delineated in ArcGIS® 9.3. The sub-watersheds of Kiknari nala were identified by considering third and fourth order streams as outlets of sub-watersheds (Figure 1).

2.3 Classification approach:

The flowchart of classification approach taken into consideration for mapping LU/LC of Kiknari nala watershed is clearly depicted in Figure 2. Sentinel 2B image with multi spectral image of 10 m spatial resolution acquired in May 2020 was adopted for such purpose 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). These were initially imported in ERDAS IMAGINE® 2011 environment so as to convert it to imagine compatible file in which further image pre-processing technique such as atmospheric correction was performed. The bands were subsequently layer stacked to get a composite band image of the study area
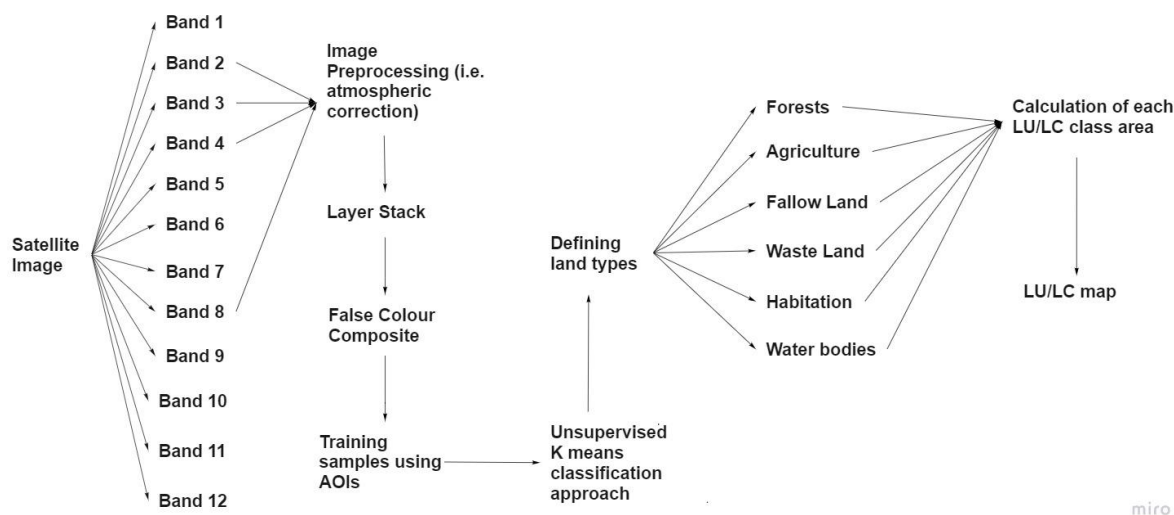
Figure 2: Flowchart depicting classification approach for attaining LU/LC of Kiknari nala watershed

2.4 False Color Composite (FCC):
Preparation of False Colour Composite prerequisites in LU/LC analysis. Layer stacked image was utilized at the initial level, whose further change in band combination yielded FCC. The Figure 3 depicts FCC of Kiknari nala watershed.

2.5 Classifying LU/LC:
The FCC of study area became the core pillar for obtaining training samples using AOIs (area of interests) (Figure 3). The samples were prepared on the basis of on-screen visual interpretation principles as tabulated in Table 1. Mapping of LU/LC in Kiknari nala watershed was strictly based on the guidelines

as proposed by NRSC (2019). Subsequently, unsupervised K means classification approach was performed to attain broad categories of LU/LC classes. These aforementioned categories of LU/LC were further diluted to match definite classes based on colour, texture, shape, tone, association and pattern along with Google Earth imageries such as forests, agriculture, fallow land, waste land, habitation and water bodies. The calculation of area covered in each class was based on the spatial extent of pixels which finally generated LU/LC map. The LU/LC map of study area is shown in Figure 4.
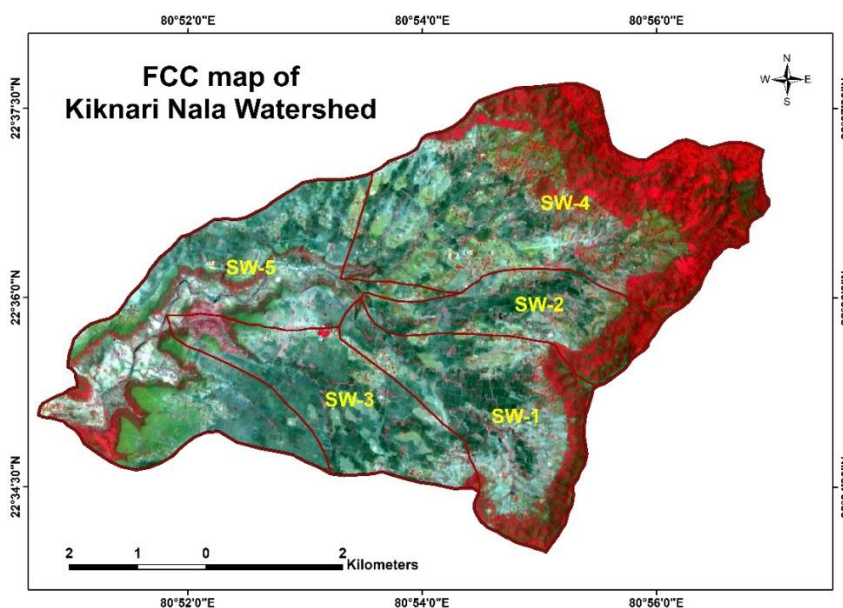

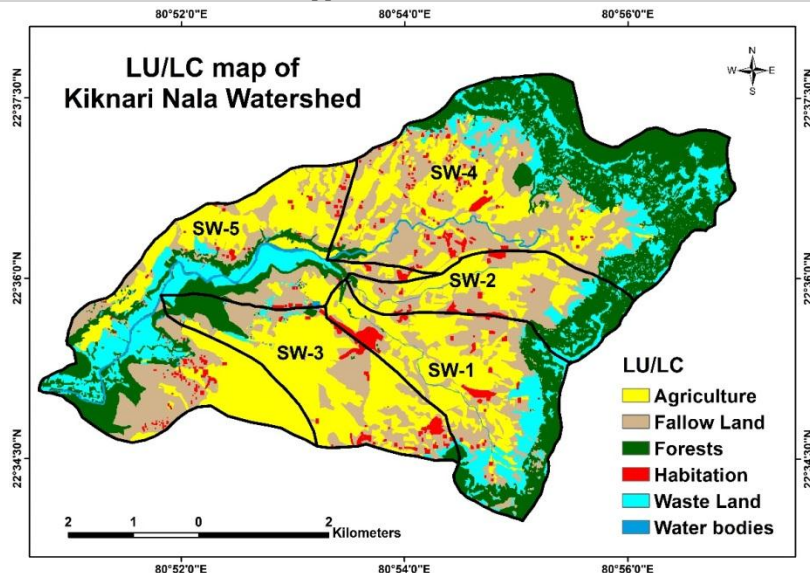**Figure 3: False Colour Composite of Kiknari nala watershed**

Figure 4: LU/LC of Kiknari nala watershed

Table 1: Adoption of various on-screen visual interpretation principles for identification of different LU/LC classes (Sharma et al., 2011b)

Classes	Tone	Texture	Shape	Association	Pattern
Forest	Dark red/reddish brown	Smooth	Regular	Everywhere	Contiguous
Open forests and scrubs	Bright red	Smooth to coarse	Fragmented	Open forest, forest gaps, degraded forest, scrubs	Scattered
Agriculture/ Other vegetation	Dark green	Smooth	Mixed		Contiguous
Open/Barren land	Grey to Green	Smooth			Contiguous
Habitation	Whitish tan/brown	Smooth	Regular		Scattered
Water body	Blue to Black	Smooth	Regular		Scattered
Wasteland	White to Whitish blue	Coarse	Uneven		Scattered

2.6 Accuracy Assessment:

The obtained LU/LC was further added in ArcGIS® 9.3 environment to perform its accuracy assessment. The assessment was executed by creating accuracy assessment points randomly distributed over raster file of LU/LC classification. This procedure primarily helps in assessing random spatially distributed points over diverse LU/LC classes. The further verification of these points using Google Earth imageries helped in obtaining confusion matrix that generates Kappa coefficients of LU/LC mapping. The kappa coefficient, overall accuracy, producer's accuracy, user's accuracy of LU/LC classification was based on standard formulas as indicated in eq. (i), (ii), (iii) and (iv). The confusion matrix prepared using assessment points data is an essential decisive aspect in LU/LC change detection and other LU/LC based analysis.

$$\text{Kappa coefficient} = \frac{(TP \times TCP) - \sum(\text{Column total of each class} \times \text{Row total of each class})}{TP^2 - \sum(\text{Column total of each class} \times \text{Row total of each class})} \times 100 \qquad \text{(i)}$$

where, TP = Total number of points taken in accuracy assessment

TCP = Total number of correct points obtained in accuracy assessment

$$\text{Overall accuracy} = \frac{\text{Total number of correctly classified pixels (Diagonal)/"Ground Truth Points"}}{\text{Total number of reference pixels/"Classified"}} \times 100 \quad \text{(ii)}$$

$$\text{Producer's accuracy} = \frac{\text{Number of correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (The column total)}} \times 100 \quad \text{(iii)}$$

$$\text{User's accuracy} = \frac{\text{Number of correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (The row total)}} \times 100 \qquad \text{(iv)}$$

RESULTS AND DISCUSSION

3.1 LU/LC mapping:

Six categories of LU/LC based on the guidelines of NRSC (2019) were classified in the study area. The Table 2 shows detailed LU/LC analysis of each class covered in different sub-watersheds of Kiknari nala watershed. The analysis indicated that watershed with higher altitudinal variations such as SW-4 was predominant in forests areas due to its topography. On the contrary, lower lying areas with flat topography such as SW-5 was principally covered with agriculture. In addition to higher agriculture areas in SW-5, it was also heavily covered with waste land due to land degradation. Habitations in almost every sub-watershed was highly fragmented and was only spatially congregated in SW-1 and SW-3.

The Figure 5 shows percentage distribution of different LU/LC classes of complete Kiknari nala watershed. The graph clearly reflects the prevalence of agriculture cover in the area followed by fallow land and forests in the area. Abundance of fallow lands in the study area clearly indicates unutilized potential of land resources in the area. This condition is highly correlated with lack of surface water resources such as lakes, ponds and reservoirs apart from streams. The fallow lands can only be converted into agriculture areas on the ground of proper water resources management with sufficient sort of available manpower in the watershed.

Table 2: Sub-watershed wise LU/LC distribution in Kiknari nala watershed

S.No.	Class	Area						
		SW-1	SW-2	SW-3	SW-4	SW-5	Kiknari Nala Watershed	
		(ha)					(ha)	%
1.	Forests	114.49	74.82	42.86	465.85	179.20	877.22	22.53
2.	Agriculture	227.70	136.31	275.51	278.42	400.12	1318.06	33.85
3.	Fallow Land	167.85	118.40	139.48	355.74	272.82	1054.29	27.07
4.	Waste Land	87.53	31.82	11.71	177.35	169.96	478.37	12.28
5.	Habitation	28.65	10.85	23.69	30.14	27.88	121.21	3.11
6.	Water bodies	3.51	2.39	1.31	12.16	25.80	45.17	1.16
	Total Class Area	**629.73**	**374.59**	**494.56**	**1319.66**	**1075.78**	**3894.32**	**100**
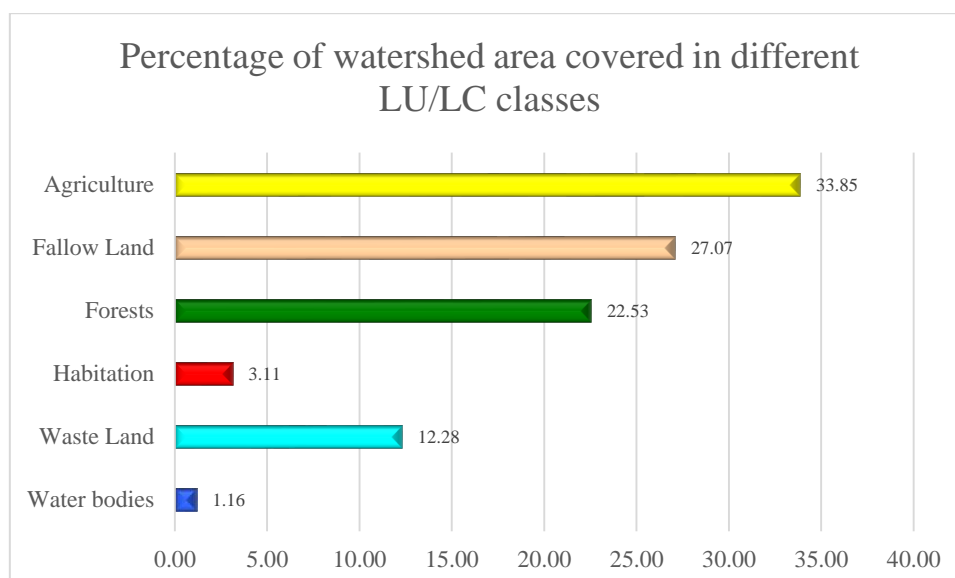
Figure 5: Percentage of watershed area covered in different LU/LC classes

3.2 Accuracy Assessment:

The accuracy assessment points generated in ArcGIS® 9.3 environment helped in identifying the accuracy of the classification. The assessment points generated primarily consists of two columns, in which the first column comprised details of LU/LC class represented as "classified" whereas second column represented "ground truth" details which were further verified using actual ground truth points data and Google Earth imageries. The confusion matrix (error matrix) of finally verified points as represented in tabular format (Table 3) was obtained by consuming the accuracy assessment points data of LU/LC classification.

The overall accuracy of the classification yielded good results with an accuracy of 85.02%, whereas the Kappa coefficient was 0.8036 signifying good accuracy of classification.

Table 3: Confusion matrix of accuracy assessment points for LU/LC of Kiknari nala watershed

Class Value	Forests	Agriculture	Fallow Land	Waste Land	Habitation	Water bodies	Total	User's Accuracy	Kappa Coefficient
Forests	63	1	3	5	0	0	72	0.88	0.00
Agriculture	1	91	13	2	0	0	107	0.85	0.00
Fallow Land	3	4	79	0	0	0	86	0.92	0.00
Waste Land	1	2	3	33	0	0	39	0.85	0.00
Habitation	0	3	2	0	5	0	10	0.50	0.00
Water bodies	0	0	2	5	0	13	20	0.65	0.00
Total	68	101	102	45	5	13	334	0.00	0.00
Producer's Accuracy	0.93	0.90	0.77	0.73	1.00	1.00	0.00	0.85	0.00
Kappa Coefficient	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.8036**

CONCLUSION

In the present study, earlier proven techniques of remote sensing and GIS was highly advantageous in studying the Land Use/Land Cover of Kiknari Nala watershed. The principles of digital image interpretation in combination with ground truth points were the core pillars in successful execution of the study. The method of unsupervised K means classification approach along with combination of on-screen visual interpretation gave rise to six different LU/LC classes such as forests, agriculture, waste land, fallow land, habitation and waterbody. Majority of area was covered under agriculture and forests. But on the contrary, a considerable portion of fallow land in watershed clearly illustrates its potential that can be utilized, if satisfactory water and human resources are available in order to obtain maximum output from the land resources in a sustainable manner.

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