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*Full Length Research Paper*

# Land use land cover change detection of Patani micro-watershed of Madhya Pradesh using remote sensing data

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**This study investigates Patani micro-watershed situated in Majhagawan block of Satna District (M.P.). The watershed characterization was carried out using RS and GIS techniques. The major aim of this study is to prepare land use land cover and their change detections. In this study IRS-P6 Sensor, LISS-III satellite images of the dates 19th October, 2008 and 5th January, 2008 were used to detect the seasonal (*Kharif* and *Rabi*) changes in land use land cover of the Patani Micro-watershed. First the images were geo-referenced and land use land cover maps were prepared by image processing techniques. To differentiate the changes in land covers, and vigour of the vegetation, Normalized Difference Vegetation Index (NDVI) was used as an important indicator, NDVI maps were generated for both images of the dates 19th October, 2008 (*Rabi*) and 5th January, 2008 (*Kharif*), values of NDVI in the watershed varies from -0.42 to 0.15 for 19th October, 2008 and 0.99 to 0.24 for 5th January, 2008 respectively. The land use land cover classes identified in the watershed were forest, wasteland, agricultural land, open (Currently fallow), and water body. Maximum area (69%) of the watershed was under forest, 2% under wasteland, most of which was at hill top; there were no seasonal changes exhibited in forest and wasteland. Changes were detected in water body, agricultural and open land. Agricultural land was decreased by 2.87% from *Kharif* to *Rabi* season and open land was increased by 3.28% respectively. Most of the agricultural land is under rainfed and land with higher slopes and poor soil depth is kept fallow during the *Rabi* season. Reduction was also observed in the water body by 0.41% in *Rabi* season; this is due to use of water from water harvesting ponds for irrigation and losses as evaporation and seepage.**

**Key words:** RS, GIS, land use land cover, NDVI, Change detection.

## INTRODUCTION

Digital change detection is the process that helps in determining the changes associated with land use and land cover properties with reference to geo-registered multi-temporal remote sensing data. It is a measure of the distinct data framework; thematic change information can help to provide more tangible insights into underlying process involving land use land cover changes than the information obtained from continuous change. It helps in identifying change between two or more dates that is uncharacterized of normal variation. Land use land cover arrangement makes landscape patterns and better understanding of landscape dynamic during a known

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period of time having sustainable management. Land use land cover changes is a dynamic, widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drives changes that would impact natural ecosystem. Nowaday's, Earth resources satellites data are very applicable and useful for land use land cover change detection studies.

Widespread study on land use land cover changes have been carried out by many researchers. Prenzel and Treitz (2004) concluded that change detection in watersheds helped in enhancing the capacity of local governments to implement sound environmental management. Chonzguica (1989) studied the use of a SPOT FCC image of Swaziland prepare a land-use pattern. The major categories were agricultural land, forest, grassland, water bodies, settlements and rocky surfaces. RS data in the form of false colour composite (FCC) and digital data can be used to study and monitor land features, natural and dynamic aspects of anthropogenic activities towards preparation of thematic maps, depicting various status of land and soils (Korolyuk and Scherbenko, 1994). Maji et al. (1998) reported that the land information generated through soil resources mapping can be used to prepare thematic maps suggesting suitable land use plans at various level. In a case of land use study, the soils of Maharashtra's were mapped with GIS technique and were found suitable for growing most annual crops in shallow soils. Perennials may be grown in the deeper soils. Chowdary et al. (2001) studied the IRS LISS-III images of 1988 and 1996, pertaining to the pre and post treatment periods of each watershed. Classified and NDVI outputs of two years were compared to derive information, on changes that occurred over a period of time in watershed. The study revealed an increase in the area under cultivation, water bodies, plantations and tree cover as result of watershed management.

Reddy (2001) reported that the scientific approach through the GIS and NDVI was adopted for overall evaluation of watershed. Appropriate agricultural system as an expert system has been developed which assesses the suitability of specific soil and climatic conditions to support proper agriculture system (Amien, 1999). Boakye et al. (2008) described assessment of the land use and land cover changes in the Barekese catchment of Ghana using RS and GIS. The results of the analysis showed that between 1973 and 2000, forest decreased by about 43%, open forest decreased by about 32%, while grassland and open areas/towns increased by about 700 and 1000%, respectively (Boakye, 2008). The study identified population growth, timber logging and lack of proper education as causes of the changes in land use and land cover in the catchment area. Desai et al. (2009) state that technologies of Remote Sensing (RS) and Geographic Information System (GIS) can play an imperative role to explores the study of Urbanization growth of Pune city using RS data and GIS. Prakasam (2010) studied the changes in land use and land cover in Kodaikanal Taluk over 40 years period (1969 to 2008) through remote sensing approach. Forest area that occupied about 70% of the Taluk 's area in 1969 has decreased to 33% in 2008. Agricultural land, built up area, harvested land and waste land also have experienced change. Kodaikanal area is identified as one of the biodiversity area in India. Proper land use planning is essential for a sustainable development of Kodaikanal Taluk.

Mohammad and Adam (2010) investigated the effects of different vegetation types on runoff generation and soil erosion. The results indicated that there are significant and important differences in runoff generation and sediment production with respect to the different types of vegetative cover. They also concluded that the forests and natural vegetation dominated by *S. spinosum* prevent or decrease the risk of runoff and soil erosion.

On the basis of the above review of literature, problem statement and importance of land use and land cover change detection study, the Patani Nala micro watershed has been taken to study the changing pattern of seasonal land use and land cover by using RS, GIS, as a tool. The present study will be useful for further planning and management of the selected watershed and also will be very effective to enhance the agricultural production.

## MATERIALS AND METHODS

### Study area

The study area is situated in Satna district, Madhya Pradesh (Figure 1). The Patani Nala micro-watershed is a part of Chakra Nala milli-watershed and encompasses an area of 731 ha. The Patani micro-watershed lies between 24°53'30" to 24°53'45" N latitude and 80°46'15" to 80°45' 45" E longitude and covered in the Survey of India toposheets Number 63 D/9 and 63 D/ 13. The average annual rainfall of the study area is 944 mm. Rainfall through South West monsoon starts from middle of June and ends in third week of September. South West monsoon contributes about 90% of total rainfall whereas the rest is received from the North-East monsoon in winter. The area experiences extreme cold and hot air during winter and summer respectively. Temperature in the district varies from 5 to 45°C. The study area falls in Vindhyan Hills, categorized under agro climatic zone 4th, known as Kymore Plateau and Satpura Hills. Geologically the study area comprises sandstone, shale, gneiss, quartz and carboniferous rocks.

### Data used

Remote sensing data (IRS-P6 LISS-III) of date 19th October, 2008 and 5th January, 2008 and Survey of India (SOI), toposheets (1:50000 scale) were used for delineation of the watershed boundary, geo-referencing and salient features of the area.

### Preparation of thematic maps

Initially, base map was prepared from the SOI (Survey of India) toposheets on 1:50000 scale. The topographic maps were

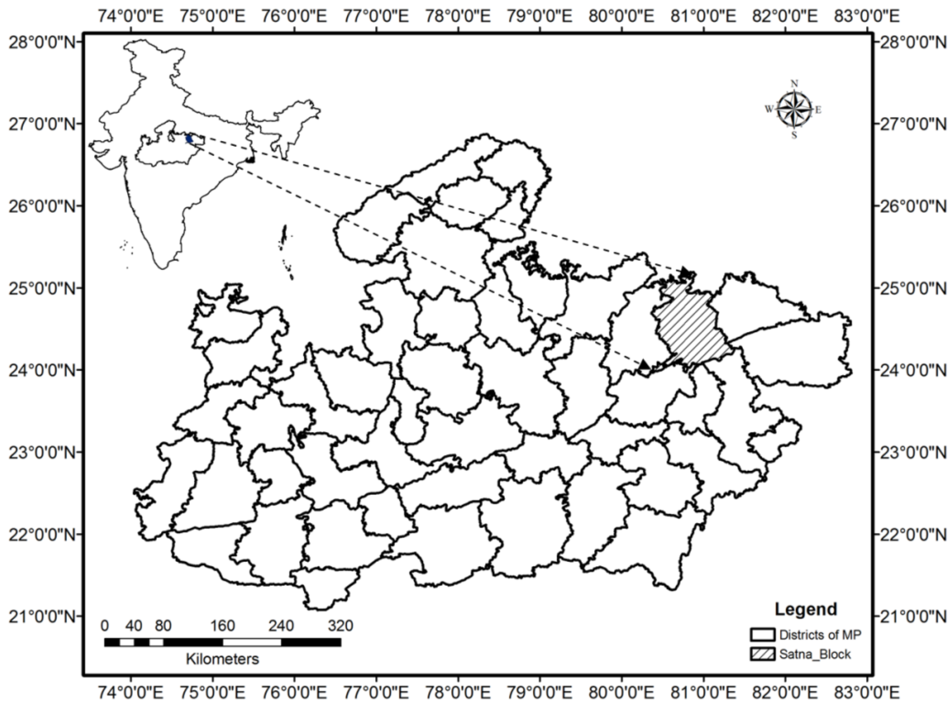


**Figure 1.** Location map of the study area (Patani micro-watershed).

geometrically corrected having specifications of coordinate- Lat/long, projection- Polyconic, datum- Indian 1975 and spheroid Name- Everest. The geometric precision was tested by comparing the Root Mean Square Error (RMSE) with their theoretical coordinates kept within one pixel. The land use land cover map of the study area was prepared using remotely sensed data obtained from IRS-P6 Sensor LISS-III for 19th October, 2008 and 5th January, 2008. Figures 2 and 3 present the false colour composite (FCC) of band infra-red, red and green (band 3, 2 and 1) assigned red, green and blue colour respectively. Unsupervised classification of the satellite data was carried out. The success of the unsupervised methods is based on the premise that the input raster dataset includes natural statistical group of spectral patterns that represent particular types of physical features. Visual interpretation have been carried out which was not only useful in increasing the classification accuracy of the Landsat images, but it was also helpful in identifying areas with the effective use of water for irrigation and areas of private land reclamation (Abd El-Kawy et al., 2011). Ground truth has been done to verify the unsupervised classification with the help of field visit using Global Positioning System. About 10% of the various features of land use land cover maps were physically verified on spot and with personal information regarding crops taken on particular piece of land gathered from the farmers.

#### Normalized difference vegetation index (NDVI) map

It was used to describe the dynamics of vegetation and seasonal growth of vegetative cover. The formula used to calculate NDVI is given below.

$$NDVI = \frac{NIR - R}{NIR + R}$$

Where,
NIR = near infrared reflectance.
R = red reflectance.

## RESULTS AND DISCUSSION

### Land use land cover

The land use land cover map of the study area has been prepared through the remotely sensed data obtained from IRS-P6 Sensor LISS-III for dates 5th January, 2008 and 19th October, 2008. These images have been classified for land use land cover representing *Rabi* and *Kharif* seasons and depicted in Figures 4 and 5, respectively. The land use land cover classes identified in the watershed were forest, wasteland, agricultural land, open (Currently fallow), and water body. Area covered under the different classes can be seen in Table 1.

### Seasonal change detected in two different satellite images

A change between two different images has been depicted in Figure 6. Maximum area (69%) of the watershed was found under forest, 15 ha under wasteland, most of which was at hill top. There were no seasonal changes observed in forest and wasteland. There was change experienced in the agricultural, open

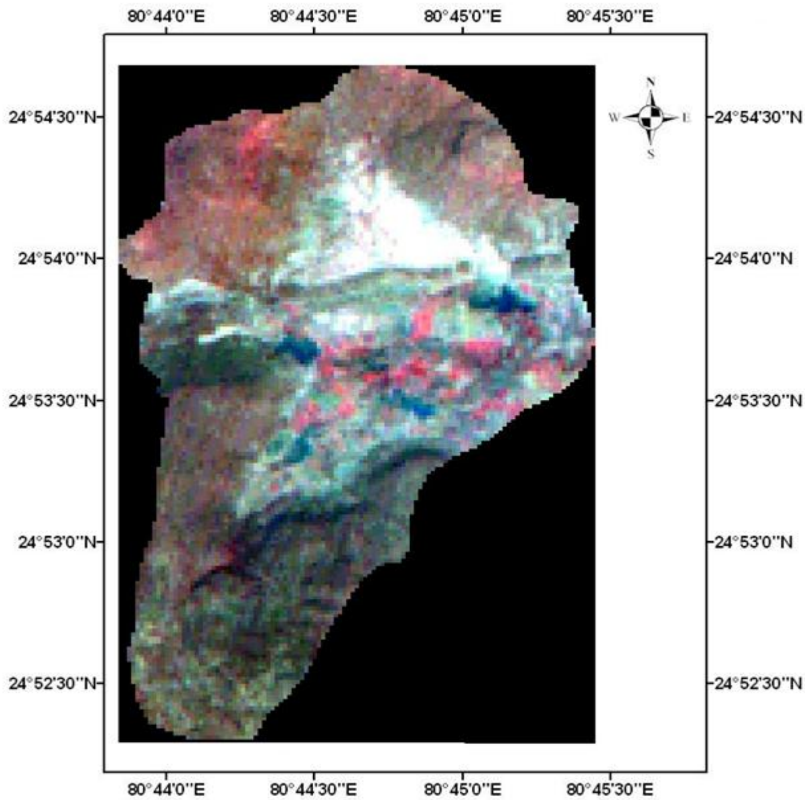


**Figure 2.** False Color Composite of 5th January, 2008, IRS- P6 LISS III Image.

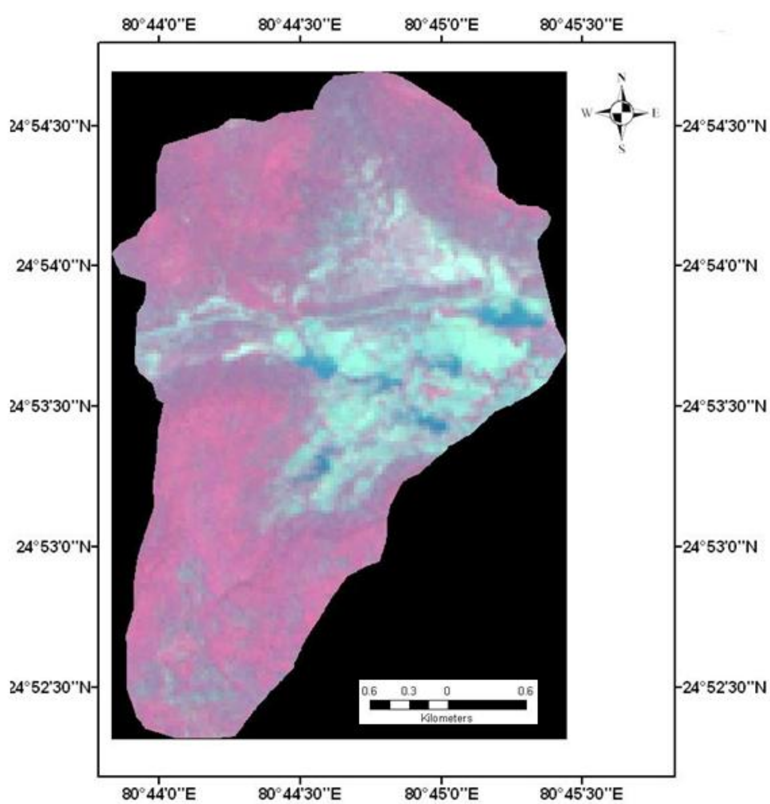


**Figure 3.** False Color composite of 19th October, 2008 IRS-P6 LISS III Image.

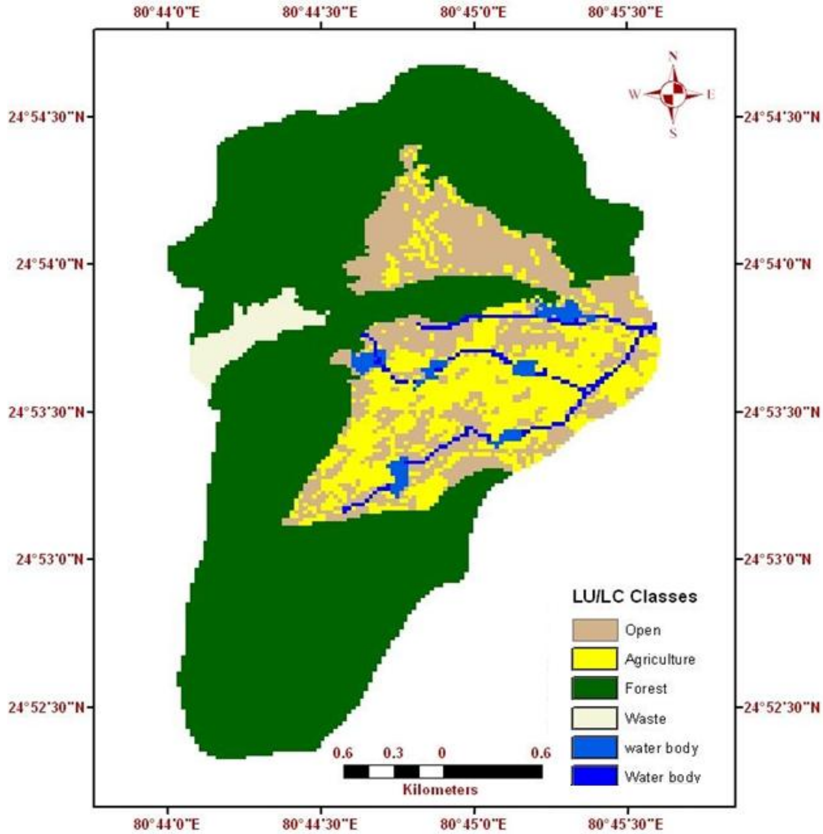


**Figure 4.** Land Use Land Cover map of 5th January, 2008 IRS-P6 LISS III Image.

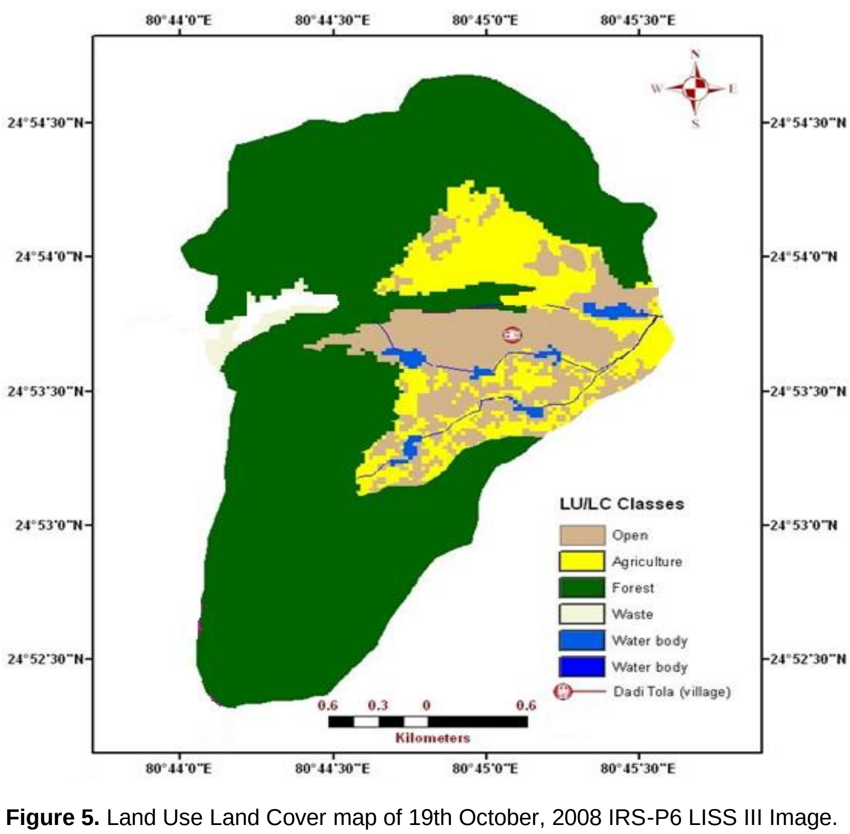


**Figure 5.** Land Use Land Cover map of 19th October, 2008 IRS-P6 LISS III Image.

**Table 1.** Percentage variation of land use land cover under *Kharif* and *Rabi* seasons.

| S. No. | Land use land cover class | Area in *Kharif* (hectare) | Area in *Rabi* (hectare) | Percentage changes |
|---|---|---|---|---|
| 1 | Forest | 507 | 507 | 0 |
| 2 | Wasteland | 15 | 15 | 0 |
| 3 | Agriculture | 131 | 110 | -2.87 |
| 4 | Open land | 68 | 92 | 3.28 |
| 5 | Water body | 10 | 7 | -0.41 |

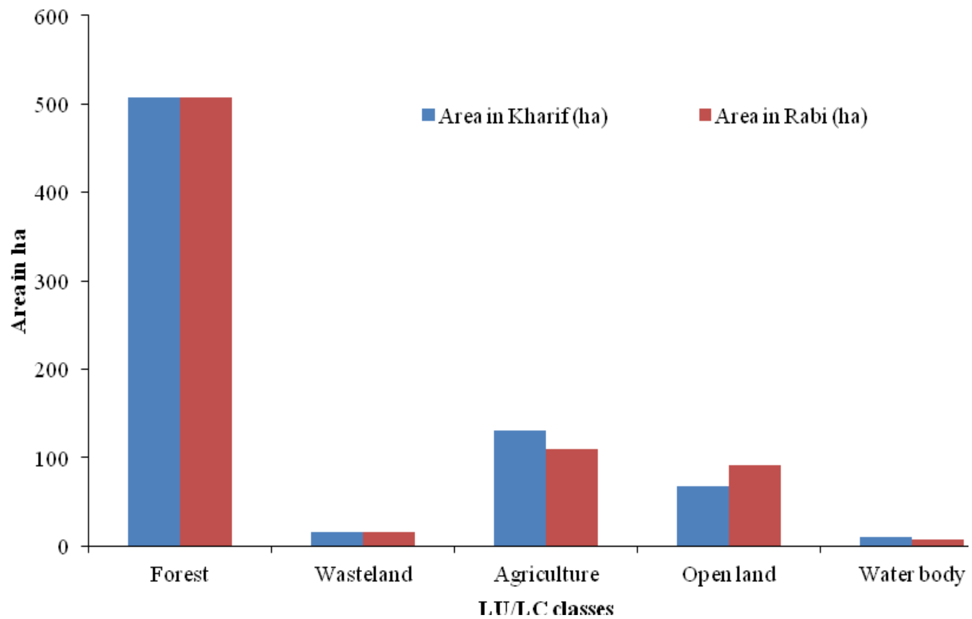


**Figure 6.** Seasonal LU LC changes.

land and water body during *Kharif* and *Rabi* seasons. A reduction of 3 ha has been observed in the water body during *Rabi* season, this is due to use of water from water harvesting ponds for irrigation and loss of water due evaporation and seepage. The area under agriculture was also reduced about 2.87% during *Rabi* season, while open land increased by 3.28%. Reduction in agricultural land during *Rabi* season revealed that most of the agricultural land is under Rainfed. Land with higher slopes, poor soil depth and due to shortage of irrigation water most of the land was kept fallow during the *Rabi*.

To differentiate different land covers, and vigour of the vegetation, Normalized Difference Vegetation Index (NDVI) is used as in important indicator. NDVI maps generated for dates 5th January, 2008 and 19th October, 2008 are presented in Figures 7 and 8 respectively. Values of NDVI in the watershed are in the range of -0.99 to 0.24 for 5th January, 2008 and -0.42 to 0.15 for 19th October, 2008 respectively. Negative value of NDVI reflects water body, zero reflects soil and positive value reflects vegetation, maximum positive value indicates good vegetation of the area. Higher value of NDVI has been observed on the image of 5th January, 2008 (*Rabi*) as compared to 19th October, 2008 (*Kharif*) due to the fact that during the *Kharif* maize, green gram and black gram crops are taken in the area. These crops are at maturity stage; therefore the vigour of the vegetation is poor and has resulted in lower value of NDVI.

## Conclusion

Successful characterization of Patani Nala Micro watershed was completed using RS and GIS technique. Most land of the Patani micro watershed was found under forest cover and very small area comes under the agricultural land. No seasonal changes have been found in forest and waste land. Reduction in agricultural and water body was identified from *Kharif* to *Rabi* season. Agricultural production of this watershed highly depends on the rainfall, hence there is need to implement irrigation practices so that cultivable land can also be cultivated

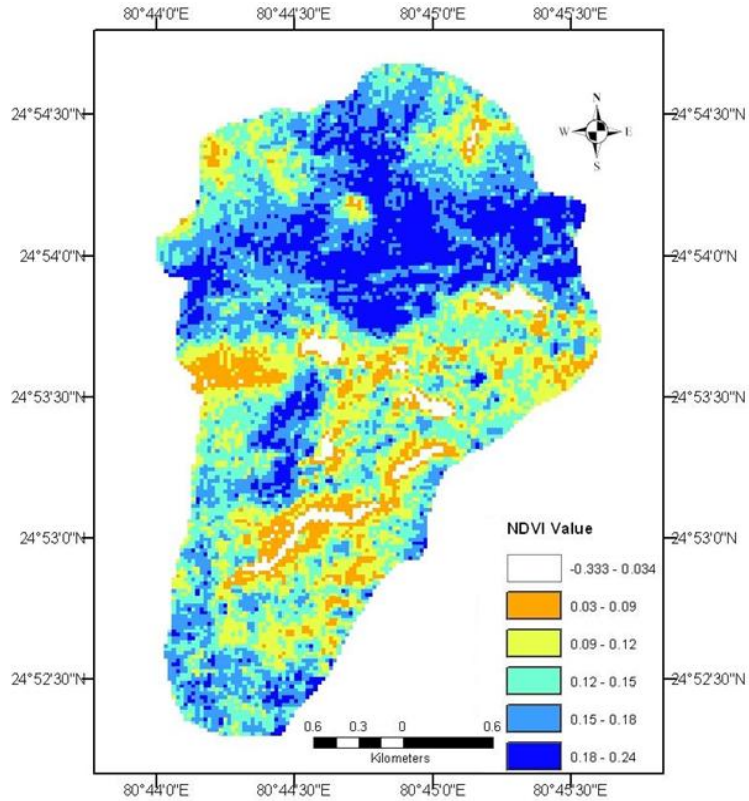


**Figure 7.** NDVI map for 5th January, 2008 image of study area.

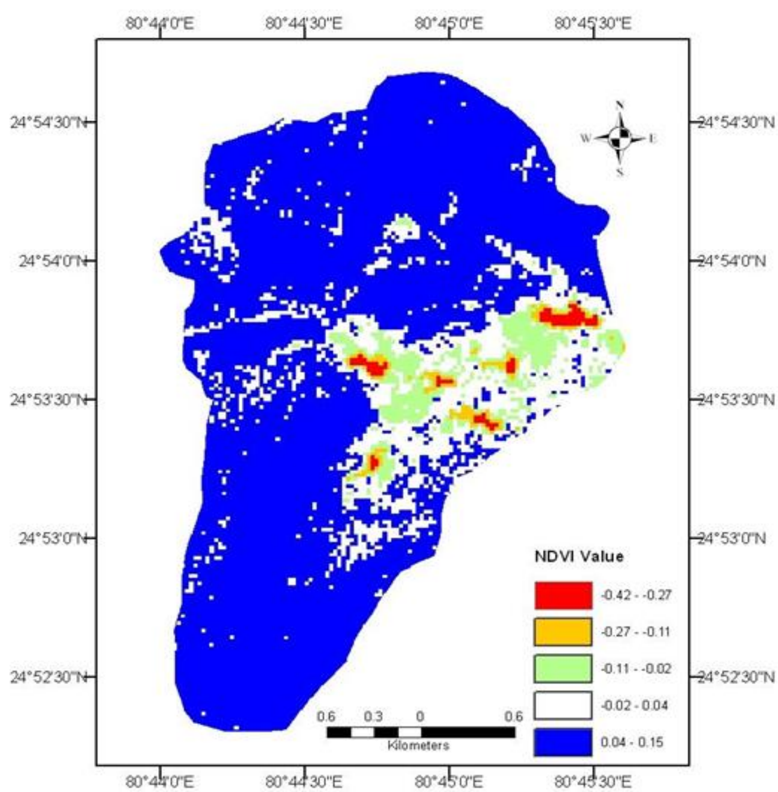


**Figure 8.** NDVI map for 19th October, 2008 image of the study area.

during the *Rabi* and *Kharif* seasons and can enhance the agricultural production.

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