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FATE OF AGRICULTURAL LAND OF TRIYUGA MUNICIPALITY OF NEPAL: LULC STUDY USING LANDSAT IMAGERY ON ERDAS 2014

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ABSTRACT

Rapid expansion in urbanization due to migration of people from the hill to the city area is becoming a big problem for underdeveloped country like Nepal. For employment most of the youth are in foreign country. Young manpower problem is becoming as a challenging issue for nation. Its main impact is felt on the agricultural productivity. The dependency on the foreign import is rising up tremendously. On the other hand the human activities are becoming the reason of decreased in agricultural products. The changing environment and climate is also affecting to the land conditions. So the assessment of real situation of the land cover and land use pattern felt an important task within the country .For the purpose this study is carried out to identify the real status of the land cover and land use condition of the agricultural area Triyuga River Basin of Udayapur Nepal in regional basis**.** For the study Landsat images are used to detect land use and land cover change. The spectral Indices NDVI, NDBI, SAVI, RVI, MSI and NDWI were investigated for the water body, dense vegetation, light vegetation, bare land, agricultural land, urban area and sandy area using Landsat 8 ETM+ data downloaded from USGS Earth Explorer of the area. From supervised image processing the change scenario of the land area for the year 2010 and 2019 were studied as a time series of 9 years gap. From supervised image processing analysis the most affected area found is the agricultural land which is decreased from 34.3649 square miles (16.26%) in the year 2010 to 10.6392 square miles (5.02%) in the year 2019.The urbanization trend found increased from NDBI index. The bare land is in increasing mode. While the vegetation cover are found in good conditions but the

indices showed large trees area are reduced during the time period selected. The NDWI index obtained by model maker at the year 2019 was found 0.98 and for the year 2010 was 0.94 as its maximum values which showed water body is increased during the time period. From the accuracy assessment the results of land use and land cover in Triyuga municipality area for period 2010 and 2019 showed as over all classification accuracy 80.33% and 83% .The overall Kappa Statistics were as 0.81 and 0.83 respectively which showed the reliability of the results obtained in acceptable range.

Keywords: Landsat, Spectral Index, LULC

1. Introduction

Land is in two conditions in nature. Some area are occupied by the population for their specific purposes such as agriculture, inhabitation, cattle farming are called land use and some area are covered by natural vegetation are called land cover. Land cover includes the biophysical condition of the earth surface. It includes the features like grass land, forest, concrete etc. whereas land use includes intention related with the land cover like agriculture use, cattle, urban development. Land use is closely related with the land cover in many forms such as forests are used for both agriculture and animal farming as timber works.

The major issue is the sustainable development on agriculture land and urbanization. Rapid expansion on urbanization and human activities are becoming serious issues and challenges for land cover conditions. Its direct impact is felt on the environmental and ecological system of the nature. So the study of the change scenario on land use and land cover is important work. It is not possible in a short year. Study on the basis of decadal time series gives realistic information on the change conditions in a large area rather than a small land use and land cover. For the study an accurate method is always important.

In recent year the application of the remote sensing and arc GIS has been increasing greatly for the earth surface analysis. The data captured by the sensor set up at the satellite has high capacity to capture in high resolutions so that the image obtained can give lots of information of the earth surface which are far from us and out of reach. Not only of the earth surface even within the earth can the information be extracted from the image analysis and interpretation. From a small scale to regional scale the application of remotes sensing data are widely used these days. From the mining study to the land cover land use pattern (LULC) study the remote sensing and GIS are used extensively whose results are seemed more reliable. The water bodies, vegetation, soil surfaces, structures, urban area can be easily studied from the remotely sensed image data of the remote sensing satellite. The study of earth surface in high Himalayan area, deep valley is difficult .But remote sensing has become a very accurate and precise instrument for the study and information acquisition.

Real time information about the change in land cover and land use earth surface gives a well knowledge about the relationships between land, Natural activities and human activities. This helps for the planning and policy making for the development work in regional scale.

Determining the effects of land use change on the Earth system especially depends on the understanding of past land use practices, present land use patterns, and prediction of future land use, as affected by human institutions, population size and distribution, economic development, technology, and other factors. Viewing the Earth from space is crucial to the understanding of the influence of human activities and human impacts on land use changes over time period. Information on Land Use/Land Cover (LULC) at regional scales derived with observations of the earth from space provides objective information of human utilization of the landscape. Such information is required to support environmental policy, physical planning purposes and sustainable land use and land development.

The change scenario of water bodies in a region has become a great problem for human, plant and animals to survive. The depletion of the water resources has become a serious issue and its understanding is equally important[1]. The remote sensing data has become useful for the study of ground and surface water sources too. The agricultural conditions and environmental conditions have become easy for the study using remote sensing and GIS. All these indicates the usefulness and significance of remote sensing and GIS for the study[2].

1.2 Objective of the Study

The following will be pursued to achieve the aim of the study.

(1) To interpret the image in both true color and false color combination and making a comparison with the real situation by field observation.
(2) To map the land cover and land use change pattern of the area on the basis of the indices NDVI, NDWI, SAVI, NDBI, MSI and RVI over the time period selected.
(3) To find nature of the LULC and the applicability of the Landsat 8 image for the areas under urbanization mode.

2 Materials and Method

2.1 Study Area

Triyuga river basin is one of the largest river basin of Udaypur /District of Nepal. Its map coordinate is latitude 26^{o} 48’0’ and longitude 86^{0} 42’ 0’ after its name Triyuga municipality is the third largest municipality of Nepal. The rising urban municipality is surrounded by Mahabharat hills in north and churiya hill in south. The total area of the municipality is 211.36 square miles. The valley shaped basin has most popular agricultural land for paddy

crop of the Udaipur District of Nepal is large affected by urbanization so its destiny is considered important for the study on land cover and land use patterns of the years using satellite imagery in ERDAS 2014.Figures are the shape and the area divided shown in figure 1 and figure 2.

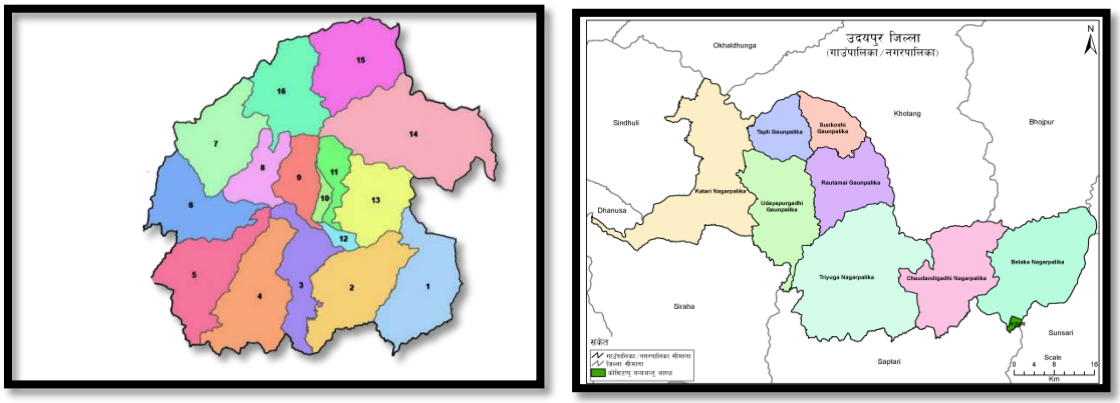


Figure1: Location map of Triyuga municipality of Udayapur, Nepal

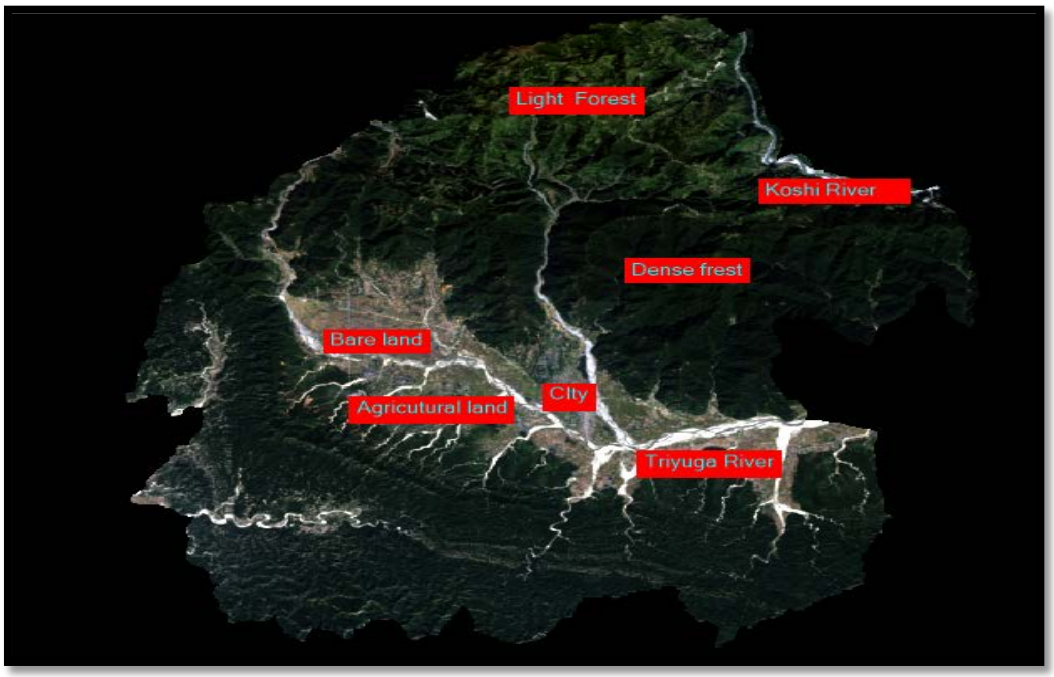


Figure 2: Udayapur District and shape file of Triyuga Municipality in multispectral band

2.2 Data Used

The primary data used for LULC mapping and its analysis is satellite imagery. The study used Landsat 7 and Landsat 8 satellite imagery. The satellite imagery Landsat 5TM Landsat 8 OLI and sentinel-2 MSS of the study area were downloaded from the US geological survey

image database site (http.//earthexplorer.usgs.gov) and image are projected in spatial reference system WGS 1084UTM Zone 45N.

2.3 Methodology

Landsat TM and Landsat 8 OLI-TIRS data were used in this study. Normalized Difference Vegetation Index (NDVI) Normalized Differences water index(NDWI),Soil Vegetation Index(SVI),Normalized difference built up index(NBDI),Soil moisture stress index(SMSI),Ratio vegetation Index(RVI) and Soil Adjusted Vegetation Index(SAVI) Land use change assessment of the study area were performed from the satellite imageries using ERDAS Imagine 14. ERDAS Imagine 14 was used for image processing, classification, its final analysis. NDVI, NDBI, NDWI, SVI, SAVI RVI and Land use map generation respectively to achieve the objectives of the study. ERDAS Imagine was used to generate the false color composite, by combining near infrared, red and green which were bands 4,3,2 and 5,4,3together for the two (2) imageries of 2010,and2019. This false color composite was used for vegetation recognition; its range wise index classification, because chlorophyll in plants reflects very well in the near infrared rather than visible band. The NDWI index was observed for the change in water body of the study area. The urbanization trend was observed by the index NDBI.Indices RVI,SAVI,SMSI were observed for the land cover change with the change in vegetation cover during the time series gap of 2010 to 2019 .The Equations for each index are mentioned below.[4]

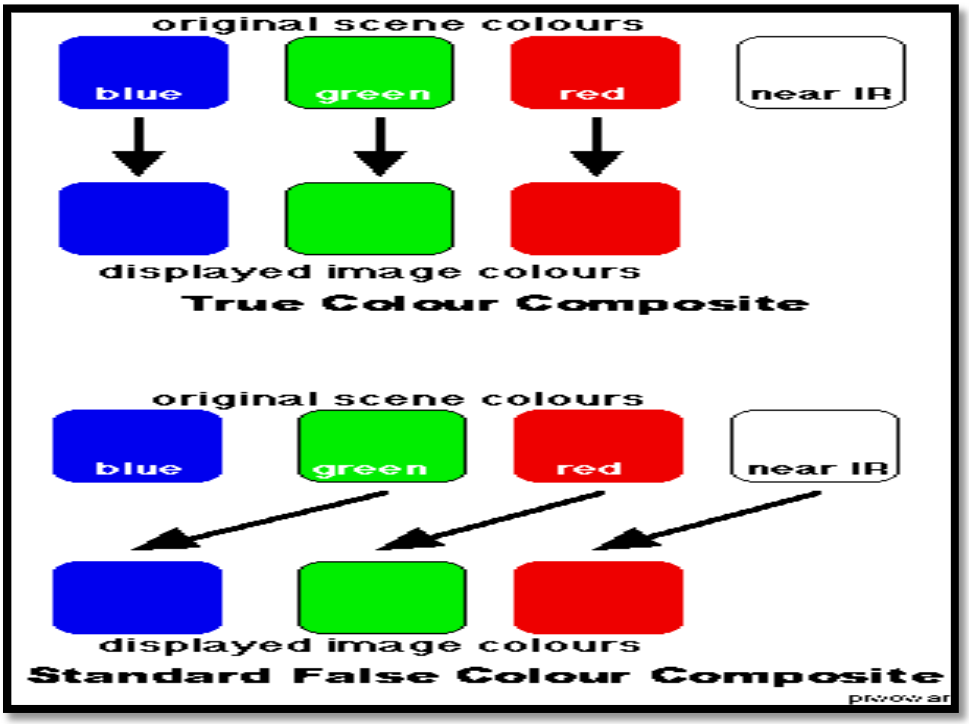


Figure 3: True and false color combination

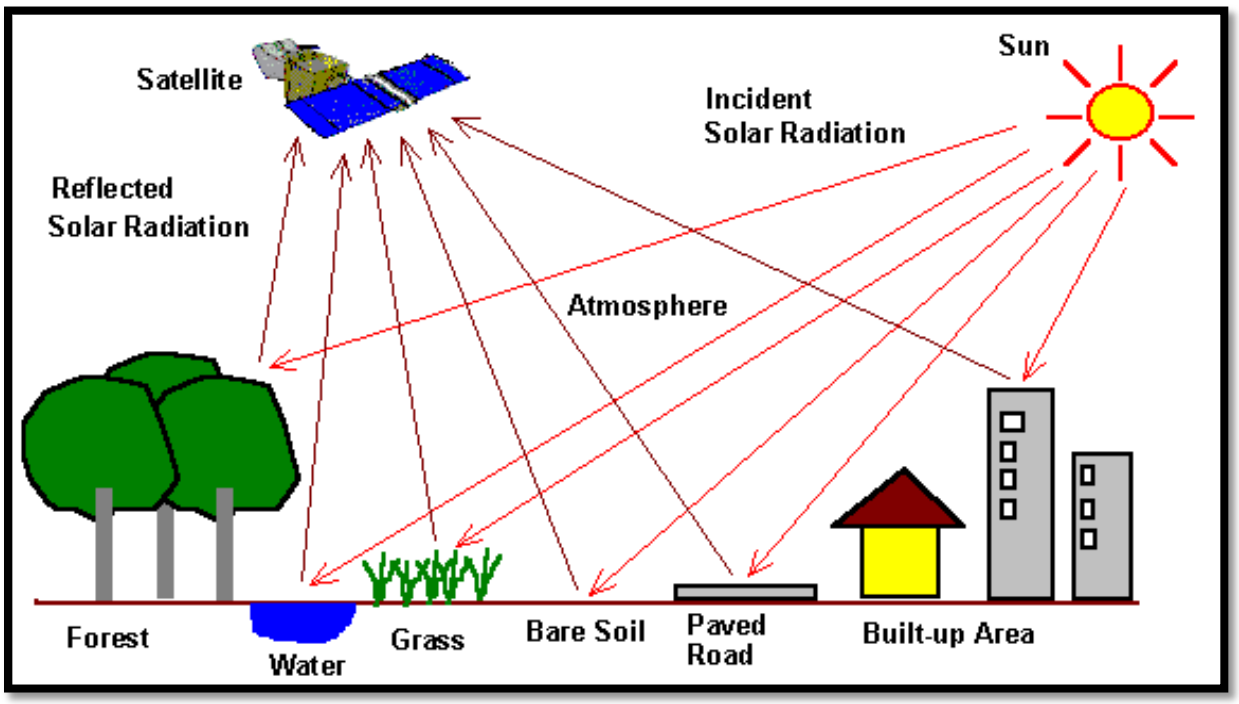


Figure 4: Earth features and satellite in remote sensing

Normalized Difference Vegetation Index (NDVI): The Normalized Difference Vegetation Index (NDVI) is the most commonly used vegetation index for observe greenery globally. Other commonly used vegetation indices Enhanced Vegetation Index (EVI), Perpendicular Vegetation Index (PVI), Ration Vegetation Index (RVI). In general, Healthy vegetation is good absorber of electromagnetic spectrum in visible reason. Chlorophyll contains in a greenie highly absorbs Blue (0.4 - 0.5 µm) and Red (0.6 - 0.7 µm) spectrum and reflects Green (0.5 – 0.6 µm) spectrum. Therefore, our eye perceives healthy vegetation as green. Healthy plants having high reflectance in Near Infrared (NIR) between 0.7 to 1.3 µm . This is primarily due to internal structure of plant leaves. High reflectance in NIR and high absorption in Red spectrum, these two bands are used to calculate NDVI. So, following formula gives Normalized Difference Vegetation Index (NDVI)

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)} \quad (1)$$

The NDVI value varies from -1 to 1. Higher the value of NDVI reflects high Near Infrared (NIR), means dense greenery. Generally NDVI = -1 to 0 represent Water bodies ,NDVI = -0.1 to 0.1 represent Barren rocks, sand, or snow ,NDVI = 0.2 to 0.5 represent Shrubs and grasslands or senescing crops , NDVI = 0.6 to 1.0 represent dense vegetation or tropical rainforest The NDVI rate can be calculated using raster calculator in ArcGIS.[5]

Normalized Difference Built-up Index (NDBI): There are lots of indexes for the analysis of built-up area. Normalized Difference Built-up Index (NDBI), Built-up Index (BU), Urban

Index (UI), Index based Built-up Index (IBI), Enhanced Built-up and Bareness Index (EBBI) are most common indexes for analysis the built-up areas. These different indexes having their own formula, own calculation method. The build-up areas and bare soil reflects more SWIR than NIR. Water body doesn't reflect on Infrared spectrum. In case of greenie surface, reflection of NIR is higher than SWIR spectrum. For better result, you can use Built-up Index (BU). Build-up Index is the index for analysis of urban pattern using NDBI and NDVI. Built-up index is the binary image with only higher positive value indicates built-up and barren thus, allows BU to map the built-up area automatically,

$$BU = (NDBI - NDVI) \quad (2)$$

Image classification technique (supervised classification and unsupervised classification) is lengthy and complex process. It requires composite band & apply numbers of operation for the final result. The accuracy derived from image classification technique depends on the image analyst & method followed by analyst. However, NDBI calculation is simple and easy to derive. NDVI can be calculated by following formula.

$$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)} \quad (3)$$

Also, the Normalize Difference Build-up Index value lies between -1 to +1. Negative value of NDBI represents water bodies whereas higher value represents build-up areas. NDBI value for vegetation is low.

Table1 shows the band and wavelength of Landsat 8 imagery

Band Number	Description	Wave length	Resolution
Band 1	Coastal / Aerosol	0.433 to 0.453 µm	30meter
Band 2	Visible blue	0.450 to 0.515 µm	30meter
Band 3	Visible green	0.525 to 0.600 µm	30meter
Band 4	Visible red	0.630 to 0.680 µm	30meter
Band 5	Near-infrared	0.845 to 0.885 µm	30meter
Band 6	Short wavelength infrared	1.56 to 1.66 µm	30meter
Band 7	Short wavelength infrared	0.50 to 0.68 µm	60meter
Band 8	Panchromatic	0.50 to 0.68 µm	15meter
Band 9	Cirrus	1.36 to 1.39 µm	30meter
Band 10	Long wavelength	10.3 to 11.3 µm	100meter

	infrared		
Band 11	Long wavelength infrared	11.5 to 12.5 µm	30meter

Normalized Difference Water Index (NDWI): Normalize Difference Water Index (NDWI) is use for the water bodies' analysis. The index uses Green and near infra-red bands of remote sensing images. The NDWI can enhance water information efficiently in most cases. It is sensitive to build-up land and result in over-estimated water bodies. The NDWI products can be used in conjunction with NDVI change products to assess context of apparent change areas.

Water bodies having low reflectance. It only reflects within visible portion of the electromagnetic spectrum. Water bodies in their liquid state are generally high reflectance on Blue (0.4 - 0.5 µm) spectrum than Green (0.5 -0.6 µm) and Red (0.6 – 0.7 µm) spectrum. Clear water having greatest reflectance in the blue portion of the visible spectrum. So, water appears blue. Turbid water has higher reflectance in visible spectrum. There is no reflection in Near Infrared (NIR) and beyond. NDWI is developed by McFeeters (1996) to enhance the water related features of the landscapes. This index uses the near infrared (NIR) and the Short-Wave infrared (SWIR) bands. NDWI can be calculated by following formula:

$$NDWI = \frac{(GREEN - NIR)}{(GREEN + NIR)} \quad (4)$$

Normalize Difference Water Index (NDWI) value lies between -1 to 1. Generally, water bodies NDWI value is greater than 0.5. Vegetation has much smaller values which distinguishing vegetation from water bodies easily. Build-up features having positive values lies between 0 to 0.2.[6]. Similarly index RVI and SAVI equations are given below.

$$RVI = \frac{RED}{NIR} \quad (5)$$

$$SAVI = \frac{(NIR - NIR)}{(NIR + NIR)}(1 + l) \quad (6)$$

2.3.1 Image processing

The downloaded satellite data is pre-processed first before data analysis due to the occurrence of atmospheric effect, topographic effect and geometric effect in the satellite imagery. The topographic correction chosen is sun angle correction which minimizes the effects that occur due to different positions of the sun (i.e. in the morning, noon, evening).

Sun angle correction is termed as absolute radiometric correction obtained by dividing top of atmosphere (TOA) correction by solar elevation angle[7]

2.3.2 Image classification

Image Classification is the process of extracting different features class from the satellite imagery-based upon similar DN value (Janssen & Gorte, 2001). The supervised automatic classification method is used for selecting training samples and processing them automatically choosing a maximum likelihood algorithm of supervised classification to prepare the land use and land cover (LULC) map of different years.[8]

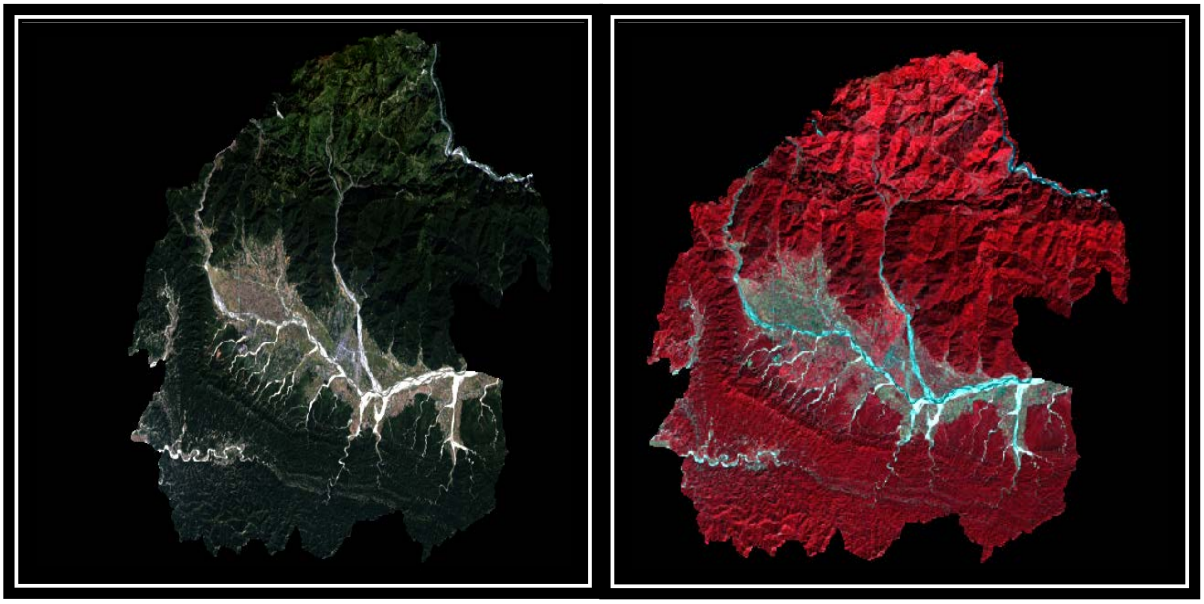
2.3.3 Accuracy measurement

Accuracy assessment plays an important role in any thematic mapping project. It relates the classified image to referenced data (i.e. Ground truth). Kappa statistics are calculated to understand how closely classified data matched the sample data as ground truth if results close to 1 show truly partial ground condition.[9]

3. Result and Discussion

3.1 Image interpretation

Image interpretation is the most important job in remote sensing which enable us to identify and differentiate the features and characteristics in images captured and stored in digital data. We interpret the various features such as land use forest cover, waterbodies, urban area (settlements), agricultural land, bare land etc. These features are identified on the basis of the radiation (reflectance) from the bodies and their associations and locations. The main interpretations keys used are shape, size, patterns, tone, texture ,shadows and associations[10].From the True color combination and false color combination the interpreted and real field observed features are shown in figure 5 and figure 6 below of the study area Triyuga municipality area of Udayapur,Nepal.



Figures5: True color (3, 2, 1) and false color (4, 3, 2) band combination of the year 2019

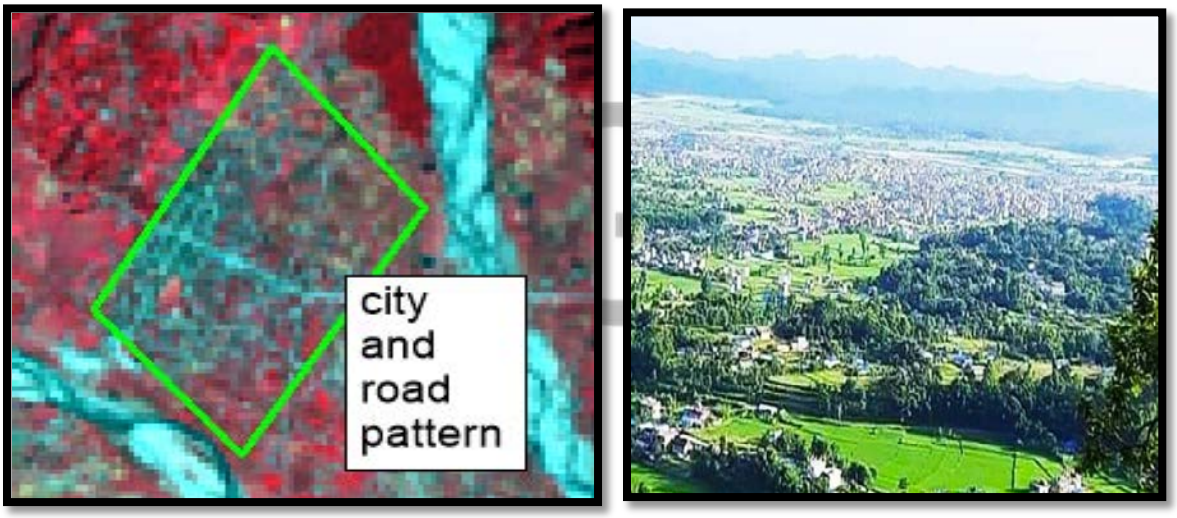


Figure 6: Interpreted and field observation image of Triyuga municipality Udaypapur, Nepal

3.2 Land use and Land cover mapping

The main objective of this study is to estimate the change in land use and land cover in the Triyuga municipality which is the most important agricultural area of the udayapur district of Nepal. Due to urbanization and plotting of land for settlements the fertile land for agriculture especially for rice and wheat crop are in mode of destiny which affects to the agriculture product in the country like Nepal which is agriculture based and its income is only agricultural product. Nepal a land locked and underdeveloped country must give priority to the agricultural product

but contrary fate of agricultural land is in increasing mode. The main cause of the decrease in agriculture product is the rise in settlement and unplanned policy of land plotting for housing in urbanized area. So the distribution of land cover and land use and its temporal variation seemed necessary for mapping so that the well information can be suggested to the policy maker and related department. In this study the total area is 211.36 square miles of the municipality. Out of this area from the image processing the information about the area in the year 2010 were as given in the table below. From which the area of settlement was 21.625 square miles (10.23%) of the total area where as in 2019 it is of 28.78(13.61%).The settlement increased by 3.38%. The reason of this increment in settlement area is due to migration of people from the hilly village area to the headquarter of the district seeking education and health facility instead of other employment opportunity. In the year 2010 the bare land is found 2.10 square miles (0.99%) where as it is 11.41 square miles (5.39%) in the year 2019 of the total area. Increase in bare land is high in this region which causes the decreases in productivity. The main reason of this is the manpower drain to the foreign country especially in Arabian country for the employment and it is a big problem of the country Nepal as youth are in aboard and manpower shortage is rising up unfortunately every year. The area is seemed rich in dense forest which is 129. 41Square miles (61.66%) in 2010 and increased to 130.72 square miles (62%) in 2019. It is due to the community based program to preserve the vegetation covers in the area launched. Whereas light vegetation cover found 19.15 square miles(9.06%) in 2010 and 26.94 square miles(12.74%) in the year 2019. The trend on light forest is found in increasing order during the time period. The main important area for the study agricultural land found as 34.3649 square miles (16.26%) in the year 2010 where as it is found 10.6392 square miles (5.02%) in the year .2019The image analysis showed very decreasing trend in agricultural land which is a big fate of the district and it indicates the trends over the country as the agricultural production is very low and dependent to the neighboring country India is increasing every year. In case of water body the area found

1.2673 square mile in 2010 where as in the year 2019 it is 1.97445 square miles. The analysis showed not so much change in water body during the time series in the basin. Figures7 and 8 shows the areas of the LULC of the municipality area for both year 2010 and 2019 of the time gap 9 years.

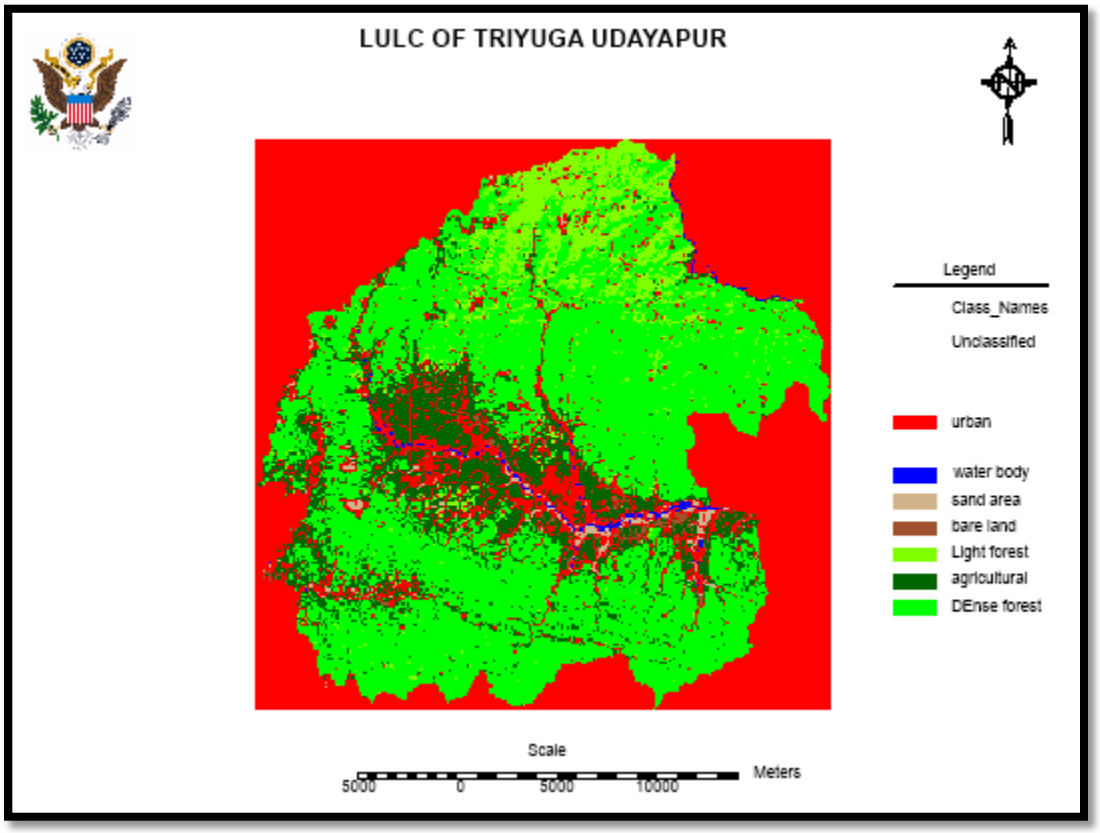


Figure 7: Supervised image classification of the study area for the time 2010 in ERDAS 2014

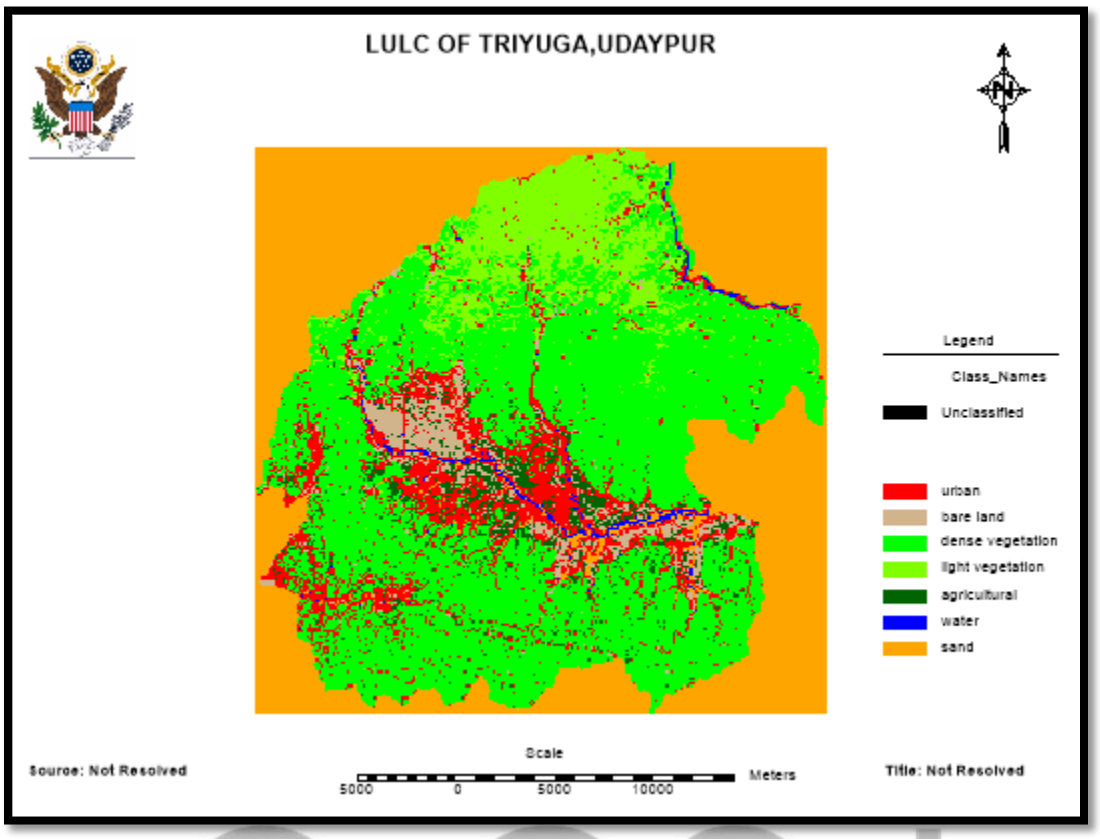


Figure 7: Supervised image classification of the study area for the time 2019 in ERDAS 2014

Table2 LULC Distribution of the Triyuga Basin area throughout the selected time period.

SN	LAND	AREA(2019)sqmiles	AREA(2010)sqmiles
1	Urban	28.7793	21.625
2	Bare land	11.4144	2.10267
3	Dense vegetation	130.728	129.413
4	Light vegetation	26.9407	19.1479
5	Agricultural	10.6392	34.3649
6	Water	1.97445	1.2673
7	Sand	1.10764	1.198348

3.2 Spectral Indices

The indices NDVI, NDWI, NDBI, SAVI, RVI and SMSI are calculated for the selected time period 2010 and 2019.These indices are very useful to observe the land cover and land use condition of any region in satellite images. [11] The NDWI index is obtained by model maker in this study. Comparative study results are as below.

3.2.1 NDVI INDEX

From the analysis the NDVI index of the study area Triyuga basin area as greater than 0.5 but less than 0.6 in the year 2019 where as its value is below 0.5 at the year 2010 time selected. From comparative study the greenery is found increased during the time period. Where as in case of water body the index shows decreased in water area and its intensity. The graph in figure 9 below shows very clear comparative results of the two time years.

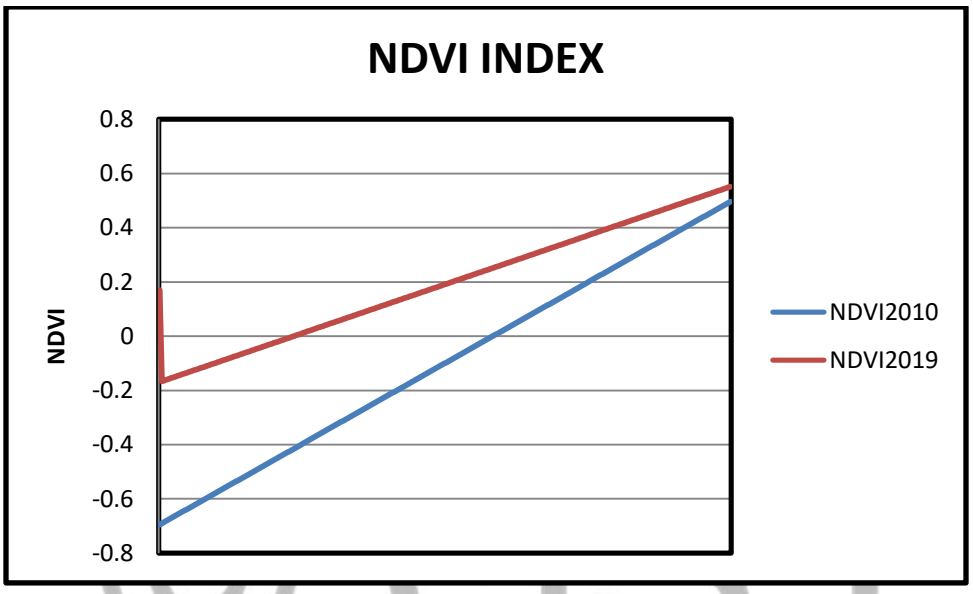


Figure 9: NDVI INDEX of the study area at 2010 and 2019 time series

3.2.2 RVI INDEX

The graph in figure 10 shows the comparative values of the RVI index of the study area. Higher Relative vegetation index indicates the healthy vegetation and lower value indicates soil, water and ice. From the comparative result graph healthy vegetation were more in the year 2010 than in the year 2019 in the river basin area whose maximum values are 1.29 and 1.78 respectively. But it indicates the bare land is larger in the year 2019 than in the year 2010 time series.

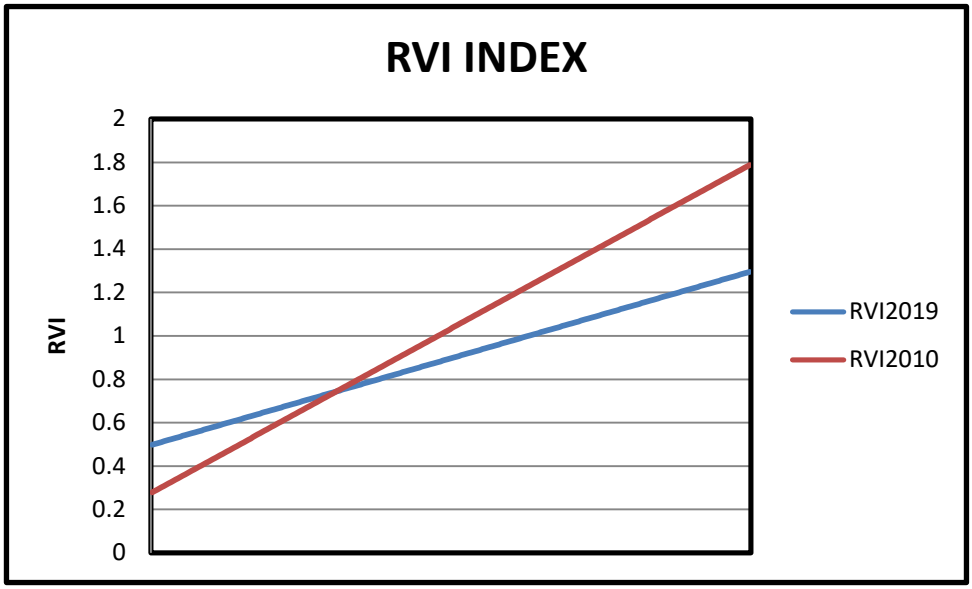


Figure 10: RVI INDEX of the study area at 2010 and 2019 time series

3.2.3 NDBI IDEX

From the result graph in figure 11 shows the trend of urbanization which is in increasing mode. The NDBI index is increased from 2010 to 2019.which caused decrease in agricultural land .The maximum index values are 0.28 and 0.55 in the time selected. Figure

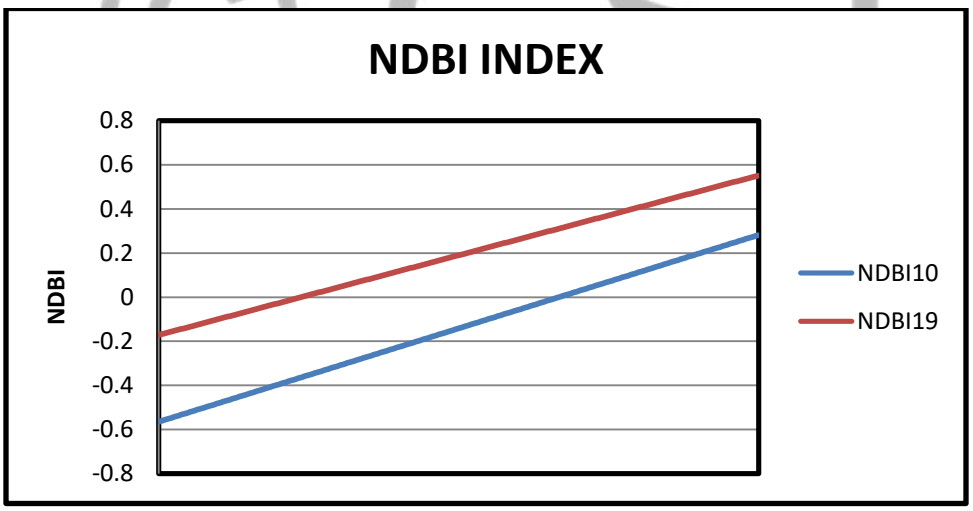


Figure 11: NDBI INDEX of the study area at 2010 and 2019 time series

3.2.4 MSI INDEX

Moisture stress index indicates the moisture available in the soil so that the drought or rainfall year could be found. From the index value obtained the year 2019 is more rainfall year than 2010 or the moisture available in the soil is increased in the time period. The figure 12 shows result obtained from the image analysis in ERDAS 2014 on Landsat 8 images.

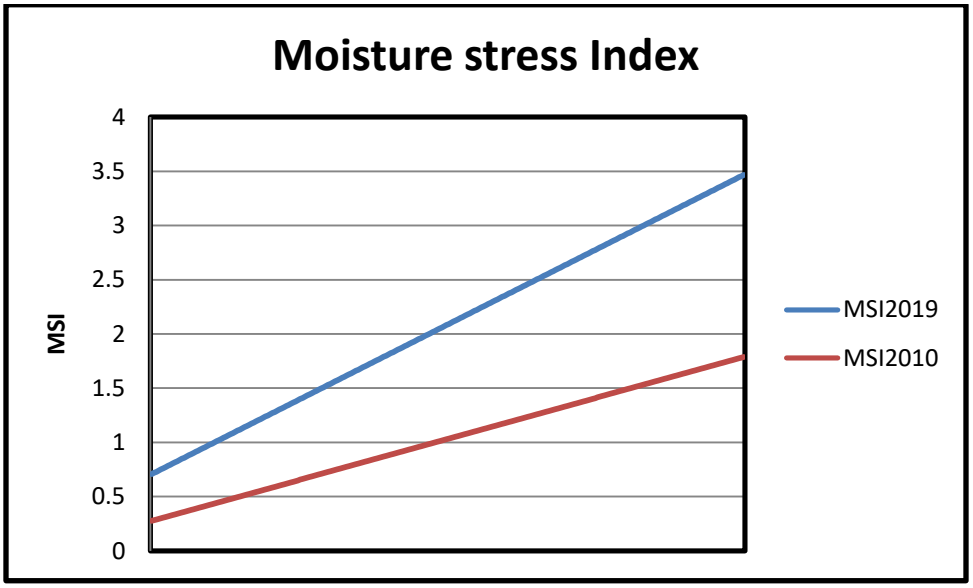


Figure 12: MSI INDEX of the study area at 2010 and 2019 time series

3.2.5 NDWI INDEX

The NDWI INDEX of the study area is obtained by Model Maker in ERDAS. The higher value above 0.5 indicates water body. In the year 2019 NDWI values are found 0.5 to 0.98 for water body. 0 to 0.2 for built up area. And 0.2 to 0.5 are vegetation area. Figure 13 and 14 are the model maker and its output in ERDAS14. In the year 2010 the maximum value of NDWI was found 0.94 where as it was found 0.98 in the year 2019. The index value above 0.5 showed the water body is increased during the time period which is good for vegetation covers and agriculture field.

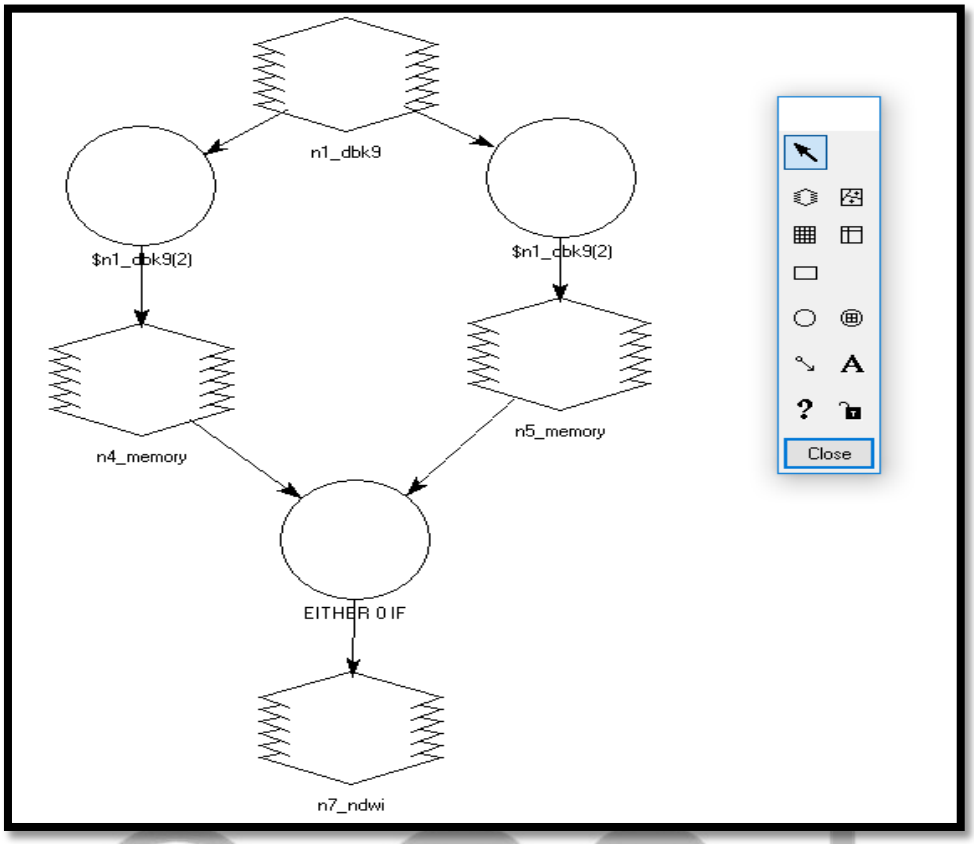


Figure 13: Model maker for finding NDWI INDEX in ERDAS 2014

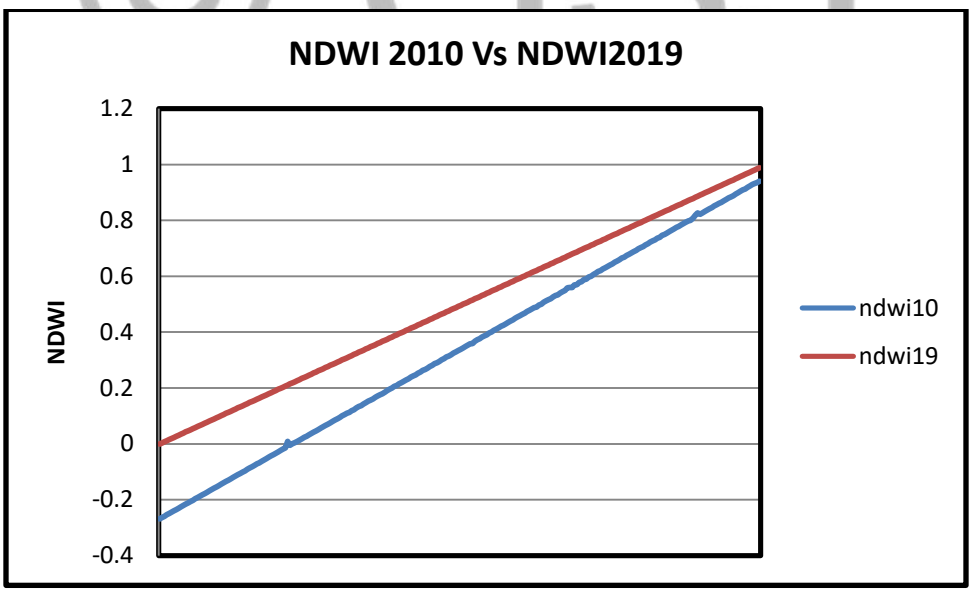


Figure 14: NDWI INDEX of the study area for 2010 and 2019 time series

4. Accuracy Measurement

For quantifying the level of accuracy of the classification product accuracy assessment is most important tool.[12] Image preprocessing including radiometric and geometric correction, and image enhancement were done. For the acceptance of the results obtained accuracy assessment in ERDAS2014 was used for supervised classification of land use land cover. Accuracy assessment was calculated based on confusion matrix and Kappa coefficient. The results of land use land cover in Triyuga municipality area for period 2010 and 2019 showed over all classification accuracy 80.33% and 83% and overall Kappa Statistics 0.81 and 0.83 respectively.

5 Conclusions

Land use and land cover information contributes significantly on the study of agricultural and urban planning .The acquisition of the information can be effectively done using remote sensing technique. In this study Landsat 8 multispectral image with spatial resolution of 30 meter were used of Triyuga municipality Udayapur, Nepal very agricultural area which is in mode of rising urbanization surrounding of a perennial. Triyuga River Basin. The supervised classifications of the image on ERAS 2014 were done. The accuracy assessment for overall efficiency and kappa values for the selected time period were found within the acceptable range of required rating value for the model.

In conclusion concerning the site and its study the satellite images of Landsat 8 and its analysis in ERDAS 2014 found easy and applicable tool for the interpretation , analysis of features and their real ground situations of any time period through supervised classification and unsupervised classification of area. And in this there are some most important recommendations based upon the results obtained of the research study for the better management, conservation and monitoring of land resources:

- Government organization should work though the collaboration and cooperation with non-government organization and stake holders of the area.

- The agricultural land management policy of the government should be effective for the protection of land and enhance the productivity making self-dependent on food product. The policy should minimize human induced hazard to the agricultural resources.
- The local people should be motivated for the protection of the resources by creating incentive based programs and opportunities so they look after the resources feeling their own properties.

Conflicts of Interest

The authors declare that they have no any conflicts of interest.

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