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Land Use Land Cover Change Detection in Churia of Bara District, Nepal by Using GIS and Remote Sensing

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KEYWORDS

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ABSTRACT

Land use land cover (LULC) is a dynamic process. It is derived by forces responsible for these changes. LULC changes has become a central component of current strategies in managing natural resources and monitoring environmental changes. Among them, Forest cover have been changes due to different activities like deforestation, encroachment infrastructure development etc. so, the study was carried out with integrated approach using Remote sensing and GIS techniques together with socio-economic data to examine the LULC change and its driving forces. Image processing was done through supervised classification in order to prepare LULC maps using Maximum Likelihood algorithm. Result showed that the forest cover as well as Rivers & Riverine area are decreasing by 0.39% and 1.06% per year respectively, contributing to increase Agricultural land and built-up area at the rate of 1.13% and 4.18% per year respectively in churia range of Bara, Nepal. Mostly, forest area has been converted to Built-up area between 1991 to 2018. Similarly, drivers found associated with forest cover decrease were illegal settlement & encroachment, high dependency on forest product, grazing & forest Fires, infrastructure development & urbanization, natural drivers, land fragmentation, environmental consequences and political instabilities.

1. INTRODUCTION

Land use land cover (LULC) change is a major issue of concern with rapid population growth and expansion of urban centers, scarcity of land needed for more production (Cheruto et.al., 2016). LULC change analysis is the basic method to understand the dynamics of the LULC status (Habte, et.al, 2021). LULC may be grouped on two categories: conversion and modification. Conversion refers to changes from one cover or use type to another while modification involve maintenance of the broad cover or use type in the face of changes in its attribute (Baulies and Szejwach, 1998). Driving forces of land degradation processes on hill slopes in the tropics are often directly related to

conversion in land cover. Annual population growth rate 1.40% is the most important factor behind decreasing forest cover in Nepal. The number of people dependent on agriculture is rising; and as a result, agricultural land has increased, mostly by encroaching upon forest areas (CBS, 2012, Chaudhary and Subedi, 2019). Conversion from forest to agricultural land affects on physical properties of soil structure, and decrease of organic carbon content (Matson, et.al. 1997; Shrestha, 2014). It has important consequences on natural resources through their impacts on soil and water quality, biodiversity, and global climatic systems (Awasthi et al., 2002).

There are various methods used in the collection, analysis and presentation of the resources data but the use of Remote Sensing and Geographic Information System technologies can greatly facilitate the process. Remote sensing along with GIS and Global positioning system (GPS) helps in maintaining up-to-date land use dynamics information for a sound planning and a cost-effective decision (Rickets, 1992, Yesuph and Dagnew, 2019). One of the widely used methods to determine the temporal dynamics of land use is the analysis of satellite image covering the same area acquired on different dates (Mulders, 2001). In Nepal, Satellite remote sensing data has been used in specific areas and its importance is still increasing (Sharma, 2002) since past four decades.

Churia is characterized by course-textured shallow soil and steep slope (Manjan, 2009). It comprises 37 districts of Nepal is regarded as home to about 14% of the total population (Chaudhary and Subedi, 2019) and covering 12.78% of the total area of the country (Uprety et.al., 2023). The Churia hills are the most recent mountain system of the Himalayan orogeny and the slopes are dry with poor slope development (Ghimire, 2011). Churia hills characterize steep and dissected topography, which is underlain by highly deformed and complicated structure of sedimentary rocks (Ghimire, 2014). The Churia range receives a greater amount and higher intensities of rainfall (Ghimire, 2011). The slopes are more susceptible to debris flow, landslide, bank cutting, soil erosion, soil degradation along with different kind of flood problems (Neupane and Dhakal, 2017). LULC changes are widespread, accelerating, and significant processes driven by human actions. The development activities like migration, deforestation, infrastructure development, urbanization and so on are the main reason for land use land cover change (Guangzhi et.al. 2020). The increasing human pressure in the Churia range of Nepal cause drastic change in land cover than any other region. This area is considered as one of the most vulnerable regions than any other regions (Pokhrel, 2012).

Over the period, the human pressure on Churia range (Subedi et.al., 2021) of Bara district has increased and cause drastic change in land cover than any other region. These has a great effect in the livelihood of upstream and downstream people and there are many factors which are responsible for these changes but still it is unclear that at what extend LULC changes have occurred in the Churia range of Bara district over the last 27 years, and how these changes are driven by the local people. Therefore, this paper focus to assess and document the changes taken place in the past 27 years using remote sensing and GIS technique to understand the landscape dynamics along with the driving forces of these changes. The understanding of land cover changes process and driving forces will help to ensure the changes that will occur in future and are useful for policy makers and developers.

1.1 STUDY AREA DESCRIPTION

The Study was conducted in Churia range Bara district of Nepal. It lies between 27.22630 to 27.30770 North latitude and 84.95850 to 85.27080 East longitude covering an area of about 195.608 Km2 i.e. 17.24 % of total area of Bara district with altitudinal variation from 161m to 903m. It consists Amlekhganj, Ratanpuri, Bharatganj sigaul and Nijgard Municipality as well as a small portion of Parsa national park. The average temperatures of the area varies

from 400C during summer to 180C during winter, having average annual rainfall is about 1664mm.

2. DATA COLLECTION

2.1 ACQUISITION AND ANALYSIS OF SPATIAL DATA

2.1.1 SATELLITE IMAGE

Landsat images were downloaded from the Earth Resource Observation System Data Center of the United States Geological Survey. Those Landsat satellite images were Landsat Thematic Mapper (TM) and Landsat 8 OLI/TIR. Satellite image of 1991 and 2018 were selected because these images have minimum only 3% cloud cover besides this 1991 is insurgency period, impacting land tenure system. The downloaded satellite images were imported in ERDAS Imagine 15 for Layer stack, Image sub-setting and Arc GIS 10.2 for preparation of thematic map, Image classification and accuracy assessment.

2.1.2 IMAGE ENHANCEMENT

Image enhancement is generally done in order to improve the visibility interpretability of an image by increasing the apparent distinction between the features in the scene, digital enhancement such as edge enhancement, resolution merging, pan sharpening etc. In this study, Pan sharpening i.e. satellite image was merged with panchromatic image (Band 8) of 15m spatial resolution for image enhancement.

2.1.3 LAND USE LAND COVER CLASSIFICATION

Supervised classification was performed to classify the image into different land use change (Otieno and Anyah, 2012; Ghimire, 2017). Maximum likelihood classifier was used of the supervised classification (Lillesand et al., 2004). In this, an unknown pixel 'x' with multispectral value ('n' bands) was classified into class K that has been the maximum likelihood {Mak lk(x)}. The likelihood (lk) was define as the posterior probability of a pixel belonging to class K (Japan association of Remote Sensing, 1996). Four different types of LULC like Forest, Agriculture land, Built-up area as well as Rivers and Riverine were selected for research. Training steps, classification stage and output stage were used. NDVI a remote sensing index is the common and useful index that helps to find plant health. It was used to measure the water molecule of the vegetation through the NIR bands. The index value higher than zero is considered to be water surface and lower than zero is non-water surface (McFeeters, 2013). The different thresholds value is used for extracting the respective water bodies. The threshold value is 0.2 in NDVI for distinguishing vegetation area from non-vegetation area (Taufik, Syed Ahmad, & Azmi, 2019). NDVI helps to determine the condition of the plant of different areas whether it is deteriorated, unchanged or improved (Wijitdechakul, Sasaki, Kiyoki, & Koopipat, 2017). The range of index value NDVI lies between −1 to1 (Raut et.al., 2020).

2.1.4 FIELD VERIFICATION AND DATA COLLECTION

Direct observation was carried out to observe encroachment area, forest area, agricultural area and other activities related with forest and other land use change. During field verification informal meeting was conducted with the key persons associated with NGOs and local key person to collect ground truth information and real condition of Churia range related to LULC. Group discussion was also conducted, participatory mapping method was used to know the LULC change drivers and trend of population pressure on Churia.

2.1.5 ACCURACY ASSESSMENT

The accuracy of the image classification is very crucial part. The limitations of utilizing remote sensing data in mountainous area are well known: Topographic shadow, Steep slope, cloud cover etc (Shrestha and Zinck, 2001). These factors reduce the accuracy of the image classification. It is important to determine the accuracy of the classified image, especially if the data is going to be used in

decision making process (Congalton and Green, 1999). The Error matrix can be used for this purpose, which is a comparison between the information from the reference sites and classified image (Lillesand et al., 2008; Congalton, 2010). So, accuracy assessment of classified image was checked. The error matrix constitutes N*N (total number of classes) elements based on ground truth data against classified image. Data of the different LULC obtained from the field survey (GPS location) was used as training samples accuracy assessment of satellite image 2018. The GPS points for training sample collection were carried out by Stratified random sampling technique and was proportional to each LULC class area. LULC was classified are Forest, Agricultural land, Rivers & Riverine and Built-up Area. Accuracy assessment of the classified images were calculated as producer accuracy, user accuracy, overall accuracy and overall kappa coefficient.

2.1.6 CHANGE DETECTION AND ANALYSIS

Change detection is the process of identifying the differences in the state of an object or phenomenon by observing it at different time (Anderson, 1977). Change detection in LULC can be performed on temporal scale to assess the landscape changes cause due to different anthropogenic activities on land (Yadav et al., 2012). The change detection of land cover change over time from digital data involves a comparison of two or more images in raster, vector, or other data format, even though all techniques of change detection in remotely sensed images are a comparison in raster format. So, the classified images prepared in ArcGIS 10.2 of two different dates were processed through raster calculator to produce LULC change map showing "From to" change in LULC cover between 1991 and 2018. The numerical analysis of LULC dynamics was conducted using Microsoft Excel.

Formula used to estimate the rate of LULC changes in percent is:

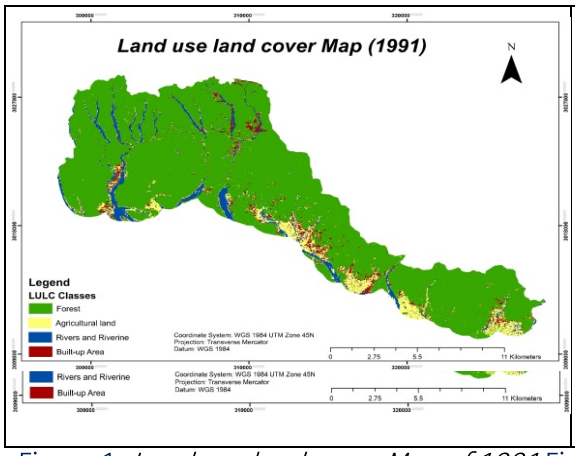
$$\text{Rate of changes (\%)} = \left[\left(\frac{a_2}{a_1}\right)^{\frac{1}{n}} - 1\right] \times 100$$

Where,a1 is base year data of 1991 LULC for different classes, a2 is end year data of 2018 LULC for different classes and n= number of years (i.e. 27 years)

3. RESULTS

3.1 LAND USE LAND COVER IN 1991 AND 2018

Four LULC classes were classified for the period of 1991 and 2018 are Forest, Agricultural land, Rivers & Riverine and Built-up area as in figure 1 and 2. Out of the 19557.15ha forest land had covered 16435.55 ha and 14776.80 ha which was 84.04% and 75.56% respectively of the total area, followed by Agricultural land cover 1388.93 ha and 1881.73 ha which was 7.10% and 9.62% of the total area. Rivers & Riverine had covered 1053.89 ha and 847.63 ha which was 5.39% and 4.33% of the total area. Similarly, Built-up area had covered 678.78 ha and 2050.99 ha which was 3.47 % and 10.49 % of the total area in the year 1991 and 2018 respectively as shown in LULC map of the years.



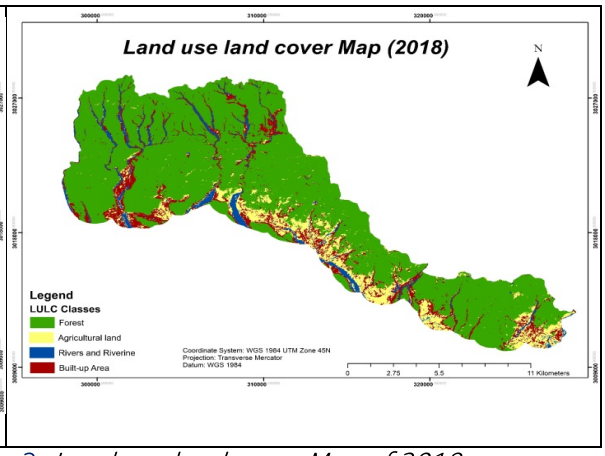


Figure 1: *Land use land cover Map of 1991* Fig 2: *Land use land cover Map of 2018*

3.2 ACCURACY ASSESSMENT OF THE IMAGE CLASSIFICATION

The supervised image classification shows a greater extent of accuracy. The user's knowledge, skills aid in properly classification from the supervised way. All the features were classified properly and accurately. The accuracy assessment of the classified image of 1991 was assessed after computing the error matrix, total 120 points was taken for the year from google earth based of stratified sampling method. Users accuracy and producer's accuracy for forest was 94.44%, Agricultural land was 83.87% found, whereas for Rivers and Riverine was 90.48% and 82.61% as well as Built-up area was 81% and 86.67% found respectively. The image was classified with overall accuracy 87.50% and Kappa coefficient 0.832.

Similarly, for classified image of 2018 total 139 point was checked on field for ground truth of different class, based on stratified random sampling. The error matrix of 4*4 size was generated. Users accuracy and producer's accuracy for Agricultural land was 88.89% found, whereas for forest was 94.87% and 97.37%, Rivers and Riverine was 88.46% and 85.19% as well as Built-up area was 89% and 89.47% found respectively. The image was classified with overall accuracy 90.65% and Kappa coefficient 0.874.

3.3 LAND USE LAND COVER CHANGE FROM 1991 TO 2018

The LULC change between 1991 and 2018 was compared. There was fluctuation between total areas of different LULC classes between 1991 and 2018. LULC change showed that built-up area played the major role mainly due to urbanization. During this period out of the total area 19557.15 ha, the built-up area and agricultural land has been increased by 1372.21 ha (7.02%) and 492.8 ha (2.52%) respectively. Meanwhile Forest and Rivers & Riverine has been decreased by 1658.75 ha (8.48%) and 206.26 ha (1.06%) respectively. Figure no. 3 and 4 shows the alteration in the major LULC types within the Churia range of Bara district. The result is similar as a study of change analysis done for the period of 1989-1999-2005 in Bara District reported forest area (5748 ha) has been decreased during 1989-2005 with an annual deforestation rate of about 0.72% (Kandel et al., 2010). The pattern of change is due to human activities. People of the area tremoundsly increasing settlement and physical construction haphazardly.

It is also found that from 1991 to 2018 forest area of 844.17 ha, 9.23 ha and 805.35ha changed into Agricultural land Rivers & Riverine and Built-up area respectively. Similarly, Agricultural area of 5.74 ha and 479.15 changed into Rivers & Riverine and Built-up area respectively. Likewise, Rivers & Riverine of 133.52 ha and 87.7 ha changed into Agricultural land and Built-up Area respectively.

Maps showing change of land use land cover from 1991 to 2018

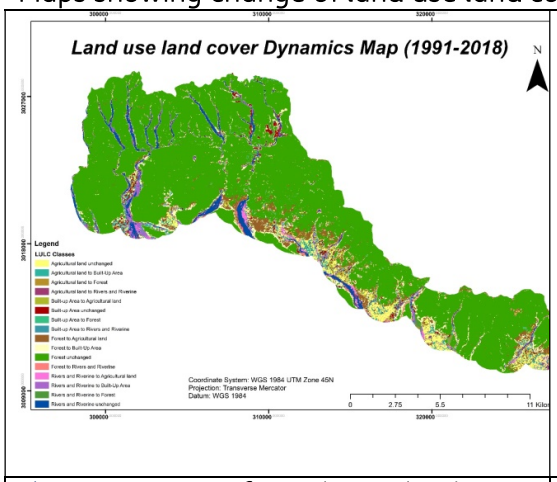


Figure 3: *Map of Land use land cover Change Map (1991-2018)*

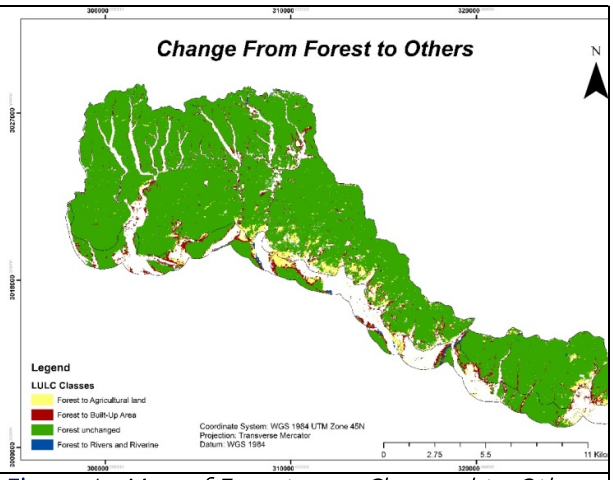


Figure 4: *Map of Forest area Changed to Others as Built-up, Rivers & Riverine and agricultural land*

3.4 RATE AND DRIVERS OF LAND USE LAND COVER CHANGES

The Result showed that the Built-up area and Agricultural land are increasing by the rate of 4.18% and 1.13% in the same time period forest area and Rivers & Riverine are decreasing by the rate of 0.39% and 0.8% per year respectively. It is less than the result of Kandel et al., 2010. As they found the annual rate of deforestation 0.66%, and 0.87% during 1989-99 and 1999- 2005. Though the performance of the classification results is satisfactory there are some limitations. The spatial resolution of Landsat image is low comparing to others. To conclude, there is higher rate of increasing the urban area and decreasing Forest and agricultural land.

Most of the forest area has been converted into agricultural land and Built-up area. The rapid conversion of forest area into agriculture were seen near the highways and residential areas due to proximity to east-west and north-south highways, access to market and larger number of migrants from the hilly area. Likewise, the Churia range of Bara district has also experienced the decrease in forest cover and increase in agricultural land and built-up area mainly due to rapid population growth, infrastructure development, encroachment, land fragmentation, high dependency on forest product and agricultural expansion.

Group discussion and key informant identified the drivers responsible for LULC changes in the area are:

i. Illegal settlement and encroachment: Many hill migrants settled spontaneously by encroaching the forest areas in the Churia range. Some cases of spontaneous settlements were found on environmentally unstable areas, for instance, river banks and foothills which were prone to floods and erosion.

ii. High dependency on forest product: Most of the people in the Churia range depends on forest resources for fuelwood, timber, grass and fodder for domesticated animals. Moreover, forest is the only source for timber used in the construction of houses and are also essential for non-timber forest products and herbal resources. This high dependency on forest causing forest deforestation and degradation. Many landless people are selling fuel wood in nearby market for their livelihood that influenced deforestation.

iii. Grazing: People of this area are grazing for a long time. An increase

in livestock numbers has encouraged the excessive and uncontrolled grazing as well as exploitation of forest resources for fodder and litter.

iv. Infrastructure development and urbanization: The migration of people from hills to the Tarai has become a major feature in the population distribution trend. Due to the various development activities like the extension of the road network and development of irrigation facilities, Churia-Tarai region has become a destination for migration, a frontier of settlement, and a locus of urbanization.

v. Political Instabilities: Political transformation, transition, and instability since the 1950s to present, remain one of the major drivers of deforestation. The lack of governance and very weak forest administration during political regime change accelerated deforestation in the Churia- Tarai Region

4. CONCLUSION

The study on LULC change in Chure area of Bara district, Nepal was conducted using Landsat TM and OLI/TIR images. The area was classified in four LULC classes as Forest, Agricultural land, Rivers & Riverine and Built-up area using supervised classification for the period of 1991 and 2018. The use of GIS and Remote Sensing is found effective tool to monitor LULC change for better result and frequent updates. Out of total area of the district 13557.15 ha of land in chure area was classified. Forest land covered more than 75% in the area, followed by Agricultural land cover 1388.93 ha and 1881.73 ha which was 7.10% and 9.62% of the total area. Rivers & Riverine had covered 1053.89 ha and 847.63 ha which was 5.39% and 4.33% of the total area. Similarly, Built-up area had covered 678.78 ha and 2050.99 ha which was 3.47 % and 10.49 % of the total area in the year 1991 and 2018 respectively as shown in LULC map of the years. Forest encroachment is found as main factor of deforestation and degradation as driven by high rate of population growth in the area.

The Churia range of Bara district is reported to be illegally settled and encroached by the people so the government should form a legislation to reduce the trend of illegal settlement and deforestation. Multi-disciplinary collaboration among the various governmental and non-governmental along with local community could improve the planning and implication of management strategies. Most of the People in Churia are unemployed and landless or with little land and also unaware of these factors so Job opportunities should be provided to reduce the dependency on forest resources and further encroachment along with the awareness program about the effect of their activities on the forest resources. It is experienced that rapid decrease in Forest and Rivers & Riverine around 8.48% and 1.06% whereas increase in agricultural land and Built-up area around 2.52% and 7.02% respectively during 1991-2018. Forest has showed major transformation to Built-up areas over 27 years. About 987.65 ha of forest has converted into Built-up area between 1991 and 2018. The different drivers identified for the LULC dynamics in the Churia range of Bara Districts are illegal settlement and encroachment, high dependency on forest product grazing and forest Fires, infrastructure development and urbanization, natural drivers, land fragmentation, environmental consequences and political instabilities.

The Result showed that the Agricultural land and Built-up area are increasing by the rate of 1.33% & 4.18% and meanwhile the Forest area and Rivers & Riverine are decreasing by the rate of 0.39% & 0.80% respectively. Thus, this study concludes the detailed studies of LULC patterns are essential for effective conservation of forest of Churia range in long term. Maps and result executed by this study could be useful for the governmental and non-governmental authorities for the conservation and sustainable management of the natural resources in Nepal. Such

coarser study might provide a baseline integrating measure to cope with the current extent of problems of particular district.

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