INDONESIAN JOURNAL OF SOCIAL AND ENVIRONMENTAL ISSUES (IJSEI)
Journal Homepage: https://ojs.literacyinstitute.org/index.php/ijsei
ISSN: 2722-1369 (Online)
Research Article

Volume 5	Issue 2	August (2024)	DOI: 10.47540/ijsei.v5i2.1567	Page: 202 – 215

Land Use and Land Cover Change in Chure Conservation Area: A Study of Mithila Municipality, Dhanusha District, Nepal

Krishna Dev Joshi[1], Deepa Kumari Poudel[2]
[1]Disaster Risk Reduction, World Vision International Nepal, Nepal
[2]Disaster Risk Reduction, People in Need Nepal, Nepal
Corresponding Author: Krishna Dev Joshi; Email: kdjoshi.91@gmail.com

ARTICLE INFO

Keywords: Geographical Information System (GIS); Land Cover Classes; Land Use Land Cover; Landsat 7&8; Satellite Images.

Received : 21 July 2024
Revised : 22 August 2024
Accepted : 30 August 2024

ABSTRACT

Chure Hills is considered as youngest Himalaya in the Himalayan chain. These hills are also considered vulnerable due to its fragile nature and unpredictable natural and human intervention. On this ground, this study attempts to explore the land use and land cover change pattern and its driving forces in the Chure-Terai hills of Mithila Municipality. This study involved the analysis of freely available satellite images of the study area which was downloaded from USGS. The Landsat 7 and Land sat 8 satellite images from 2000 to 2020 have been extracted for the land use/land cover mapping. Supervised classification has been carried out through Remote Sensing and GIS software. With reference of the Land Use Act, 2019 seven major classes have been classified in the study area which includes Forest area, Agriculture area, Settlement area, Grassland, Water body, Sediment Area, and Landslide Area. Based on observation throughout the research, despite the dominancy of forest and agriculture, both were declining continuously by -3.66% from 2000 to 2010 & -3.77% from 2010-2020 and agriculture area by -4.86% from 2000 to 2010 and -4.03% from 2010-2020. Similarly, increment of grassland or say barren land by (+7.26%) and (+4.02%) has been observed. This observation concluded that this change was due to human encroachment, and haphazard settlement. Side-by-side disaster events have also increased whereas the water body has been degrading due to the illegal extraction of construction materials from the Chure region and braided characteristics of the river.

INTRODUCTION

Land cover is generally considered a geographically explicit feature that includes the coverage on the ground surface like forests, agriculture, settlements, urban infrastructures, water, grass, bare soils, rocks, snow, or others (FAO, 2016). Land covers on earth are continuously being changed by natural and anthropogenic activities (Li & Shao, 2014). Land basically plays a strategic role that determines the economic, social, and cultural development of human beings (Vink, 1975).

Land Use and Land Cover (LULC) change is defined as the change in quality and extent of the area of existing land use or cover (Moïse et al., 2022; Subedi et al., 2022). LULC change is the result of a natural process such as climatic variation, river channel shifting, and other environmental factors (Briassoulis, 2000). But considering the present situation, the change that occurred in LULC is mostly due to human intervention such as the use of land in production and settlement (Briassoulis, 2000). LULC change is also driven by human activities which is the major reason behind the environmental change, ecosystem modification, biodiversity loss, and expansion in agriculture and urbanization (Turner et al., 2007). Considering the land cover change in Nepal, factors like grazing, shifting cultivation, deforestation, urbanization, and land degradation have been revealed as the major actors in the past (Paudel et al., 2016) while on the other hand, some evolving socio-economic factors are also responsible for the land cover change.

Chure is the Sub-Himalayan Zone also called Siwaliks the youngest Himalaya of the Himalayan chain. This zone is located between the Lesser

Himalaya in the north and the Indo-Gangetic Plain in the South. The range covers about 12.8 percent of Nepal's total land area (18,860 sq. km) and touches 36 districts whose elevation varies from 200 m to 2,000 m (Bhandari & Dhakal, 2018). Chure region basically distinguished into 3 major zones i.e. Highly sensitive zone, sensitive zone, and normal zone) (Thing et al., 2015). About 19% population from the eastern part of Nepal has been totally dependent on the Chure region. And 13.16% of the Chure region has been used for agricultural purposes, 83.47% is covered with forest and bushes while 3.36% has been fully covered by a river beds (Singh, 2017). The climate of the Chure region ranges from subtropical to warm temperate and is characterized by hot and sub-humid summers, intense monsoon rain, and cold dry winters. The average annual minimum temperature ranges from 12 to 19 degrees Celsius, with the average annual maximum temperature ranging from 22 to 30 degrees Celsius. The precipitation pattern in the Chure is variable, with the highest annual rainfall in the Eastern and Central development regions. The total annual rainfall varies from a minimum of 1,138 mm to a maximum of 2,671 mm.

The Chure region is the origin of the third-grade rivers of Nepal i.e. Bakra, Balan, Khutti, Patharaiya, Tinua, Baikaiya, Ratu, Kamala, Sirsia, Manusmara, Banganga, Sunsari, etc. are the major rivers that originate in the Chure (Chure Forest of Nepal, 2014). Geologically, it consists of detritus rock such as coarsely embedded, rounded conglomerates, coarse sands, and other soil particles. Steep land slopes, hillocks, pillar-like mounds, gorges, large-span Rivers, and temporary streams are other additional geographical features (Pokhrel et al., 2002). It includes seasonal rivers, ravines, gorges, small valleys, and steep hills (RECOS, 1997; Pokhrel et al., 2002; BPP, 1995). The Chure region of Nepal only comprises 14% of the country's population (i.e., around 5 million people) therefore it has geo-political importance in Nepal (Bhattarai & Bishwokarma, 2018). According to DFRS (2015), the Chure region of Dhanusa district covers about 22% of the forest area. Similarly, Chure Hills touches four VDCs of Mithila Municipality (Ghimire, 2015). Bhabar zone is rolling plain ground starting from the Chure foothill to the point where groundwater emerges itself in winter and dry season in rivers (BPP, 1995).

Remote Sensing (RS) and Geographical Information Systems (GIS) are the types of tools that derive accurate and timely information on the spatial distribution of LULC changes over a specific area (Carlson, 1999). Advances in remote sensing enable the identification of ongoing land cover change processes and their locations. Remote sensing is one most used methods commonly used for collecting physical data to be integrated into GIS. Remote sensors collect data from objects on the earth without any direct contact. This process involves an interaction between incident radiation and the targets of interest. GIS provides a flexible environment for collecting storing, displaying, and analyzing digital data for necessary change detection (Demers, 2005). Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. It is also a procedure of observing the difference in a body or phenomena by visualizing at different times (Patidar & Sankhla 2015).

With this changing pattern of LULC Nepal can't remain an exception as a result Nepal has also faced a constant change in LULC over the past few decades as the result of anthropogenic and natural factors and their impacts (Paudel et al., 2016). Chure hills of Nepal are facing LULC change due to their fragile nature. It is more exploited due to its inclined slope, and loose lithology of conglomerates and sandstones. In addition to this, the Chure range of Nepal is experiencing the highest precipitation rate in Nepal and become more vulnerable due to unpredictable rainfall and devasting flash floods caused by climate change (Bhandari & Dhakal, 2018). With this, Pokharel (2013) adds that human activities such as deforestation, unplanned road construction, and cultivation on steep slopes have further made the Chure region more fragile. According to the latest IOF (2019) report, 40% of its region is susceptible to landslides. Ecologically, the Chure to Tarai Madhesh landscape region is diverse and it provides good ecosystem services downstream. Due to several natural and man-made activities such as deforestation, forest land management, encroachment, rural road construction, cultivation, etc. resulted in land degradation in upstream as well as siltation and sedimentation in the fertile land downstream

(Rayamajhi et al., 2019). Due to the growing demand for sand, gravel, and boulders, many mining industries excavated the Chure region and as a consequence, it has faced the burden of environmental degradation. Thus, more dependency on the growing population for livelihood and uncertain change in climate impact in the Chure region is recognized as the major reason behind the change in land cover and land use.

To more extent, human activities have altered the surface environment of Chure hills and adjoining Indo-Gangetic parts of Nepal. Nepal has witnessed multiple events and developments events such as migration, deforestation, growth of infrastructures and settlements, and urbanization, etc in Chure Hills (Gansser, 1964). Not only is this but global warming is also considered one of the aspects which may affect the natural environment. Massive diversion of the vegetated surface into a settlement, bare land, and agricultural land has increased LST (Kayet et al., 2016).

LULC changing pattern shows the serious implication of hazards and land degradation of Chure hills and the adjoining Terai region. Against this backdrop, LULC change of Chure hills in Mithila Municipality will play a vital role in the sustainability of livelihood and future development (Ghimire, 2015).

At the cross roads of the twenty first century, threats of climate change, increasing frequency of disasters and other human induced activities have been proven to be responsible for the changes resulting in modified landscapes that negatively impact ecosystem services and human wellbeing surrounding Chure region. In order to know and compute the trend of LULC change, increasing issues on Chure mining, and Chure destruction due to hydrological disasters the present study is necessary. Unless land for settlement and to manage the farmland properly this study would contribute to decision makers to identify the LULC changes and classes. There have been several studies related on land cover changes previously; however, but due lack of proper study on LULC at local level some loopholes have been created on sustainable developmental activities at the Chure region. So, it is crucial to understand the major LULC class and spatiotemporal patterns of LULC changes of the study area. The increasing trend in the rise of temperature, short duration intense precipitation due to the effect of climate change with a combined effect of faulty land use practice of people, consequences of flood on life and material of people will increase in coming days (Shrestha et al., 2014).

Rawat & Kumar (2015) defined LULC as two separate terminologies that are often used interchangeably i.e. Land cover refers to the biophysical characteristics of the earth's surface including vegetation distribution, water soil, and other physical features of land while in the same hand, land use illustrates the use of land by humans and their habitat. Land use can be measured as one important factor that significantly influences the hazard condition in an area (Pathak, 2014). LULC change is an increasing concern with regard to national and global policies promoting sustainable mountain development (Kohler et al., 2012). LULC change detection is essential for land use planning, management and in some case, it helps to reduce vulnerability and natural hazards and disaster risks (UN/ISDR, 2004). Land cover are the most required component to understand the interaction between human activities and the environment. Land use and land cover are distinct yet closely linked with each other. A better understanding of the process of land use change and their influence on the landscape is essential for the rational management of land resources and the environment (Gurung & Khanal, 1986-88). Land use is the exploitation/utilization of the land by human activities for the purpose of settlements, agriculture, forestry, and by pasture-altering land surface processes including biogeochemistry, hydrology, and biodiversity (Di Gregorio & Jansen 2000). As per FAO (1999), land-use arrangements, activities, and inputs from people are undertaken in a certain land cover type to produce change or to maintain it. According to Lambin & Meyfroidt (2010), transition in LU/LC can be caused by negative socio-ecological feedback that comes from a rigorous degradation in ecosystem services.

According to Schreier (1994), the land cover change can be unidirectional or may be multi-directional. Basically, Change detection is the process of identifying differences of an object by observing it on different time series (Singh, 1989). Classification or quantification of spatial and temporal dynamics of LULC changes has been accomplished by using satellite images, classifying them through supervised classification, and post-classification change detection in GIS.

LULC classification plays vital role in several aspects including national development. In fact, accurate and appropriate information of LULC is enormously significant for analyzing various socio-ecological developmental concerns such as urban planning, land planning, agriculture, rural management and sustainable development and disaster risk management (Sharma et al., 2018). According to the Land Use Policy (2019), LULC has been categorized into 9 classes which include Agriculture, Residential, Commercial, Industrial, Mines Construction and extraction, Cultural, River and watershed area, Forest, Public use zone, and land under government. With this, forest area covers 6.54 million ha i.e., 44.47%, other land occupies 4.22 million ha i.e., 26.68% of the total area, Crop land occupies 3.22 million ha i.e., 21.88% to total area. Similarly, Settlement and wetlands cover only 0.17 and 0.18 million ha i.e., 1.15% and 1.22% of the total area whereas Grassland only covers 0.38 million ha equivalent to 2.60% of the total area (MoFE, 2019). Land use Land Cover change is an important component in understanding the interactions of human activities with the environment and thus it is necessary to monitor and detect changes to maintain a sustainable environment (Sreenivasulu et al., 2014).

Research based on Rayamajhi et al. (2019), Chure-Terai landscape region is ecologically diverse and important region for biodiversity. With this, it also provides several ecosystem services to the downstream as well as it influences the environmental quality. Tectonically, the Chure zone is bounded by MFT in the south and MBT in the north. Chure Hills comprises of mainly fluvial sediments, which were deposited because of Neogene tectonics of the Himalaya (Bhandari & Dhakal, 2018). Basically, it is Steep slope with dissected topography underlain by an extremely deformed and complicated structure of sedimentary rocks (sandstone, mudstone, and conglomerates) (DMG, 2007; Ghimire, 2015). Though it is only 16 km wide in places, the range has an average elevation of 900 to 1,200 m. The chure range is mostly a long single file of a low hill that runs continuously from Indus River in Pakistan in the west throughout the length of Nepal until it reaches Bramhaputra River in India in the east (Bhandari & Dhakal, 2018). It's mountain is made up of geologically young sedimentary rocks such as mudstones, shale, sandstones, siltstones and conglomerates (Paudel, 2011; Bhandari, 2018). Chure region is structurally weak and fragile due to deforestation, forestland fragmentation, encroachment, rural road construction forest fire, steep slope cultivation, and soil erosion (Rayamajhi et al., 2019). IOF (2019) also explored that more than one-third of Chure region is highly susceptible to the landslide.

Chure hills are basically rugged and also deeply separated by gullies and streams. Chure hills comprises 36.6% of total area including river valleys (Ghimire, 2015). The Chure Rivers drain an area of about 18,860 km² in both the Chure range and Nepal's Tarai though the catchment of an individual river may be generally less than 350 km². The discharge of the rivers in Chure basins is not measured systematically and indirect estimates suggest a combined annual run-off of 456 m3 /s (Shrestha & Silwal, 2017). The proportionate area of the plain is higher in eastern chure than in western chure. It is a depositional land form composed of boulder, gravel, silt, clay basically 400 to 600 m thick. On the basis of the depositional landform Terai is classified into Bhabar, Middle terai and Lower Terai. Bhabar zone is identified as piedmont zone consist of active and inactive fans at topographic breaks comprises 14.9% of the total area. Proportionately, hills area is highest in western chure region to eastern chure region. The average relief of hill slopes are 196 to 530 masl. About 15% of hill slopes lies in West Chure, 3.9% in Central Chure and 1.7% in East Chure. And, Chure hill slopes are very dry and have poor soil development (Ghimire, 2015). There are 2,837 (60%) community forests in Chure, through which 490,547 households are directly engaged in forest management (DoF, 2013).

Chure hills extended over 36 districts named as Ilam, Jhapa, Morang, Sunsari, Dhankuta, Bhojpur, Siraha, Udaypur, Sindhuli, Dhnausha, Mahttari, Sarlahi, Rautahat, Bara, Para, Mkawanpur, Kavrepalachwok, Lalitpur, Chitwan, Nawalaparasi, Plapa, Tanahun, Argakhanchhi, Pyuthan, Salyan, Dang, Banke, Surkhet, Bardia, Kailali, Knachanpur, Doti and Dadeldhura whereas Dang, Sindhuli, Kailai, and Surkhet occupies more than 6% and Nawalparasi, Banke, Chitwan, Bardiya, Argakhanchhi, Dadeldhura, Ilam, Salyan, Dhanusha and Parsa shared 2-6% of Chure hills. The estimated population of Chure is 3.6 million covering 14% of total population (CBS 2011). As per the CBS (2011) population density is comparatively lower in Chure hills than in Terai plains. Chure is considered as hotspot of biological diversity. Approximately, 666 different species of flora including 240 trees, 144 shrubs, 187 herbs, 70 climbers,22 ferns and 3 epiphytes are available, and 305 species of medicinal herbs are available in Chure region (FRA/DFRS, 2014). Though, terai has only 14% suitable land for cultivation agriculture is main occupation and source of income of people living in terai (Paudel, 2011; Ghimire, 2016).

LULC changes are widely spread throughout the world driven by human action which also impacting the human. Since, last 5 decades Chure hills and adjoining Indo-Gangetic plains has witnessed multiple events such as migration deforestation, urbanization, the progress of infrastructures and so on. All these activities altered the existing environment of Chure hills and adjoining Indo-Gangetic plains (Ghimire, 2015).

A dramatic land use and land cover change in Terai happens with the eradication of malaria in 1950s when a government allows for deforestation in Terai and Duns and raised the land revenue and later on government launched the resettlement program for disaster affected communities (Ghimire, 2015; Joshi et al., 2000).

At this backdrop, the utilization patterns of land resources in Chure hills and adjoining terai implicates the serious hazards such as land degradation and resource inaccessibility which somehow directly or indirectly affect the livelihood of the people living in that region. So, LULC in Chure-Terai region plays the major reason behind the sustainability in livelihood and future development (Ghimire, 2015). Mostly, inner river valleys of Chure hills forest land was converted into cultivated land and distributed to natural disaster victims migrated from hilly districts. Such as in Ratu river valley of Mahottari and Dhanusha districts, settlements came into existence after 1965 (Ghimire, 2015) that becomes the reason behind land use conversion and high dependency on fire wood for energy in both domestic and commercial purposes, squatter settlements nearly river banks, over grazing in flood plain areas and in old river bed, subsequently growth of urban centers and road networks expansion along with Mahendra Highway (Ghimire, 2015).

Increasing landslides and flooding; and human intervention makes Chure more fragile and weakest zone where lack of/inadequate livelihood assets and food insecurity are noted (Pokhrel, 2013). Chure region is also recognized for best construction materials. This region particularly supplies sand, gravel and stones legally at the rate of 6.5 million m3/yr and illegally extraction was estimated to be twice at mentioned amount (Ghimire 2016). This region continuously experienced heavy environmental degradation due to illegal extraction of sand, gravel, and boulders, unsustainable land use, uncontrolled quarrying sand gravel and boulders (Bishwokarma et al., 2016). Particularly, in eastern part of Chure the major serious problem is continuous encroachment, the occurrence of flood, landslide, mud flow and river cutting including Koshi and Madhesh Province whereas forest fires, inadequate knowledge and awareness are the major concern in western Chure hills (Rayamajhi et al., 2019).

Chure hills of Dhanusa districts comprises 25.5 % of total area which includes VDCs named as Bengadawar, Bharatpur, Godar, Nakatajhijh, Puspalpur, Tulsichauda, Yagyabhumi, Hahriharpur, Umaprempur (Ghimire, 2015). Dhanusha district comprises 119,633 ha, out of which 72% is Terai and 28% Chure hills. There are altogether 9 seasonal rivers in Dhanusha which includes Chure hills and some lower part of plain area that has been used for conservation and management purpose. Mostly rivers of Dhanusha districts originated from southern slope of the Chure hills and flow from north to south (Dhanusha District Profile 2074). There is also one Collaborative Forest in Dhanusha district, which has 2,190 hectares of forest. In 1995, forest area of Chure region at Dhanusha has been estimated 24% while in 2010, Chure region covers about 22% of forest area (Shrestha & Silwal, 2017). Kamala river basin is one of the river basin which originates in Sindhuli and lies mostly in Udaypur, Dhanusha and Siraha dističts. The Kamala River basin is heavily dependent on monsoon rainfall but water availability varies substantially across the season. As per present scenario, river basin is deteriorating due to waste dumping along the river, river bed extraction, vehicle river crossing and water diversion (Shah et al., 2019). Kamala basin self covers 271.9 sq.km within Dhanusha district and covers about 21 VDCs.

According to CBS (2011), the total population of Kamala basin is 74,336 lies in Dhanusha district. Kamala basin touches Puspalpur, Tulasichauda and Natkajhijh VDCs which almost covers 1 sq.km of Mithila Municipality (NDRI & CSIRO, 2017). The total forest area of Mithila Municipality covers 10095 ha i.e. 53.95% among total area (DFRS, 2018).

With the aim to overcome environmental challenges of Chure ecological crisis and urgency to protect the geological fragile landscape different policies, institutional arrangements has been initiated by government. Chure region is highly vulnerable to landslides and soil erosion therefore Nepal Government has making high effort on Chure conservation and Terai-Madhesh protection from negative consequences of Chure degradation. For this, Nepal Government has launched the PCTMDP (Rayamajhi et al., 2019). In this development program Nepal government has invested about NRs.6.15 billion to achieve the target (ATLAS Booklet, 2017). Considering the increasing incident of natural disaster such as drought, devasting flood and gradual desertification of low land areas in Chure region the GoN has launched "Rastrapati Chure Terai-Madhesh Conservation program" in from 2010 (Ghimire, 2016). The policies and strategies mostly related to establishment of Chure as a rich bio-diversity zone, with hazardless and improved livelihoods (Pokhrel, 2013). In the context of heavy exploitation of stones, sand and gravels from the Chure region, the Ministry of Commerce and Supply banned the excavation and export of such resources from the Chure region resulted some positive impact towards Chure conservation. The Protocols published by PCTMCDB (2015), distinguish the Chure region as either 'highly sensitive', 'sensitive' or 'normal' zones. Highly sensitive zone consists of naked areas, landslide and multiple gully areas, and >31-degree slope areas, which have to be completely protected (except collection of fallen trees) and trees, poles, regenerations and seedlings have to be maintained. Sensitive zone lies between 21-31-degree slopes, where trees having more than 60 cm diameter could be removed but equal distribution of trees in each 0.5-hectare area and sufficient density of vegetation should be maintained. In the normal zone, which lies below 21-degree slope. Similarly, the Chure Conservation Programme has launched several construction programmes, including check dams, water conservation ponds and other soil conservation structures in the prioritized upstream rivers and embankments in the downstream rivers to save land from erosion. For instance, the width of Ratu river of Mahottari, and Jaladh river of Dhanusha have been drastically reduced and hundreds of hectares of lands have been recovered by conservation plantation and construction of check dams and conservation ponds in many creeks in the upstream, and by the construction of embankments and a ban on the collection of river products (Singh, 2017). According to Nepal data (2022-23), Nepal government has allocated 2 Arba 17 crore for Chure Conservation Area program.

Various techniques of LULC change detection were discovered among which RS and GIS are most suitable tools to obtain more precise and timely spatial data of land use and land cover as well as analyzing and evaluating the changes in a study area (Reis, 2008). It can effectively record the land use existing condition and extract, analyze and stimulate changes efficiently. The satellite based remote sensing also provides valuable information that can be used in the assessment of the various aspect of atmospheric environment, climatology, meteorology, ecology, agronomy and environmental protection (Kern, 2011). That's why RS has been widely used to detect and monitor the land use at different scales (Pradhan, 2008; Mishra, 2016). This technique enables us to investigate and know the tendency of LULC change in period of certain time. In spite of huge benefits, the main challenges of this technology are to ensure that that change is not short-term variations (Chaudhary, 2016). Similarly, GIS is a tool that provides a flexible environment for collecting, storing, displaying and analyzing the digital data for required change detection. According to Burrough (1990), data in GIS is composed of three dimensions that mean spatial (geographic), time and attribute. GIS not only store spatial objectives (areas, points and lines) but also capable of spatial analysis based on the relation between these objects, including the relationship between objects defined by their location and geometry.RS is becoming most useful technique as it provides synoptic view and multi-temporal LULC data and serves as tool for environment resources assessment and monitoring (Abbas 2008). With the availability of historical remote sensing data, the reduction in data cost and increased resolution from satellite platforms, remote sensing technology appears ready to make an even greater impact on monitoring land-cover change (Gumindoga, 2010). According to Macleod & Congation (1998), there are four LULC change detection (aspects of change detection), which are important when monitoring natural resources, distinguishing change, detection/finding of the changes that have occurred, measuring the area extent of the change, assessing and investigating spatial pattern of the change and so on.

Considering the fact this study was conducted to gather information about the trend of LULC class and changes of the area, provide input for government policymakers and other concerned bodies for their decision-making processes related to how LULC changes through time and provide opportunity to understand the trends of changes and its driving factors.

MATERIALS AND METHODS

Study Area

Mithila Municipality is lies south-eastern of Dhanusha District, Madhesh Pradesh. It stands as a municipality after 2014 by merging six existing VDCs (Bengadwar, Natkajhijh, Puspalpur, Hariharpur, Dhalkebar and Tuslipur). Municipality includes total 11 wards merging 6 existing VDCs. Its total area is 187.93 sq. km with a population density 240 sq. km (MoFAGA, 2074). According to CBS (2021) the total population of Mithila Municipality is 48,676. Its geographical location is 26.570N and 86.570E. Its elevation is of 222 masl. Almost 53.95% of the municipality has been occupied by forest area (DoF, 2013) where most of them are community forest and leasehold forest.

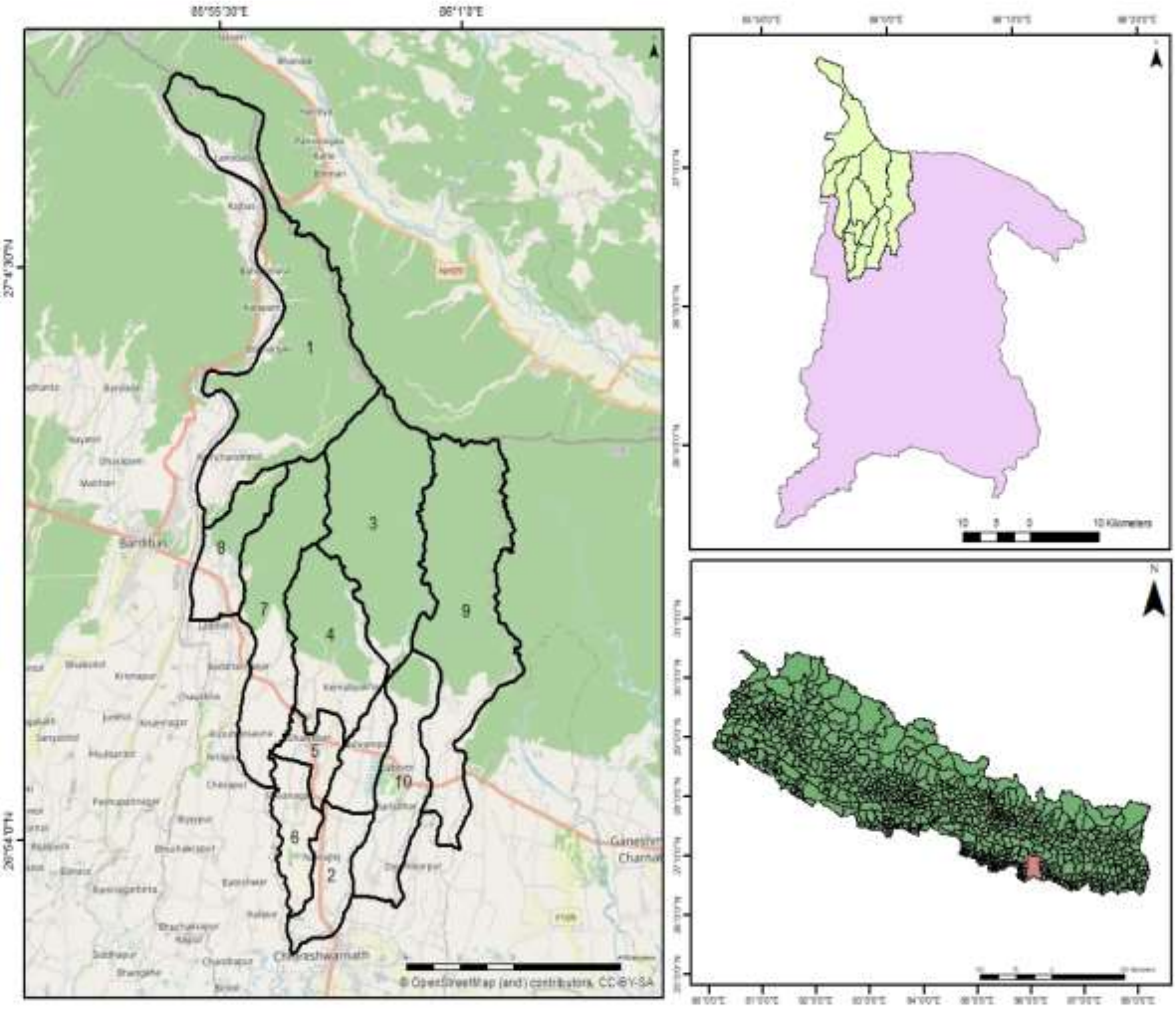


Figure 1. Study Area Map (Mithila Municipality, Dhanusha District)

Data Collection

Spatial data and socioeconomic data were collected to evaluate the LULC change process. Landsat satellite image corresponding to the study area of the year 2000, 2010, and 2020 was downloaded from USGS Earth Explorer. These data imported in (tar.) form in GIS. After which satellite image processing software has been used to create false color composite. The band composite has been changed according to land classification. BGR-652 for Agriculture, BGR-562 for healthy vegetation, BGR-564 for Land/Water, BGR-764 for Urban. The images were obtained with multiple bands. So, to combine different bands in a single composite band layer stacking process was performed. Layer stacking is the process of combining various colored multiple bands into a single image. The temporal image was then extracted by a sub-setting shape file of Mithila Municipality with the same datum and transformation i.e., UTM45N, WGS 1984).

Data Analysis

Image Processing

As the images were taken from different months of the year based on availability of cloud free data, they might be influenced by seasonal disturbances and atmospheric effects like aerosols, dust particles, cloud, varying sun angle etc. Besides, noises in data are also results from limitations in sensing by the sensor, signal digitization, or data recording process. After then radiometric and geo-metric correction was achieved by pan-sharpening the obtained images. Remote sensing software was used to remove periodic line dropouts and to fill the gap which prevailed in land sat image of 2010.

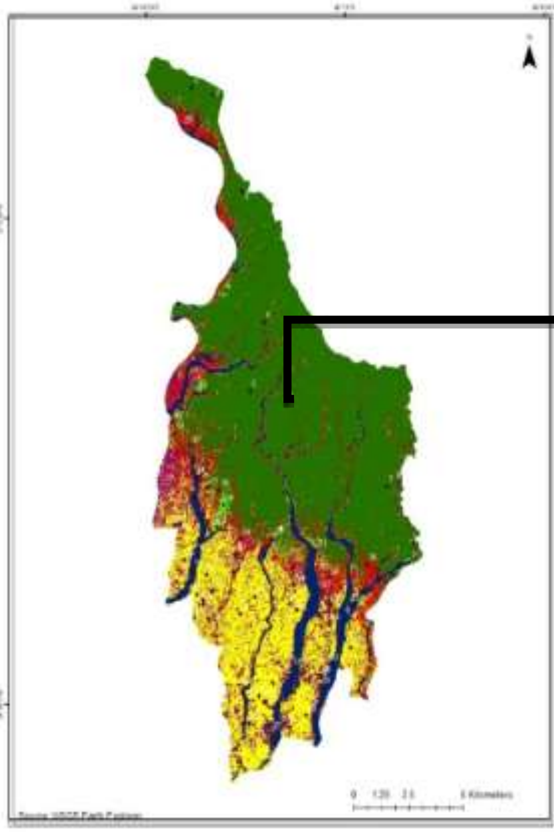
Land Cover Classification

Maximum likelihood algorithm has been used for land cover classification based on accuracy and kappa coefficient value. The following steps were performed to execute the classification:

1. Creation of training set and develop the signature file: 7 training samples were created for the development of the signature file of each class.
2. Classified them by using the maximum likelihood classification tool.
3. Accuracy and assessment were done by taking random samples and comparing to the ground truth by using Google Earth Pro.

Field Verification

Field verification has been done through ground truthing approach. Basically, ground truthing is the collection ground data of the location that interpret the unknown materials in multispectral and hyperspectral remote sensing data. Around 50-70 training sample were collected from supervised classified randomly from dense forest area, 10 from water body, 10 from agriculture and so on. And those training sample has been converted to (kml.or kmz.) file so that we can easily extract the training sample into google earth image. Each training sample were carefully assessed with Google Earth image. If the predicted and truth image are same, then it is counted as correct classification. But, if the prediction and truthing are not same then classified point was incorrect. Often incorrect points occurred when one feature stops and other begins.



Id	User	Producer
1	2	2
2	2	2
3	2	2
4	2	2
5	2	2
6	2	2
7	2	2
8	2	2
2=Forest Area		

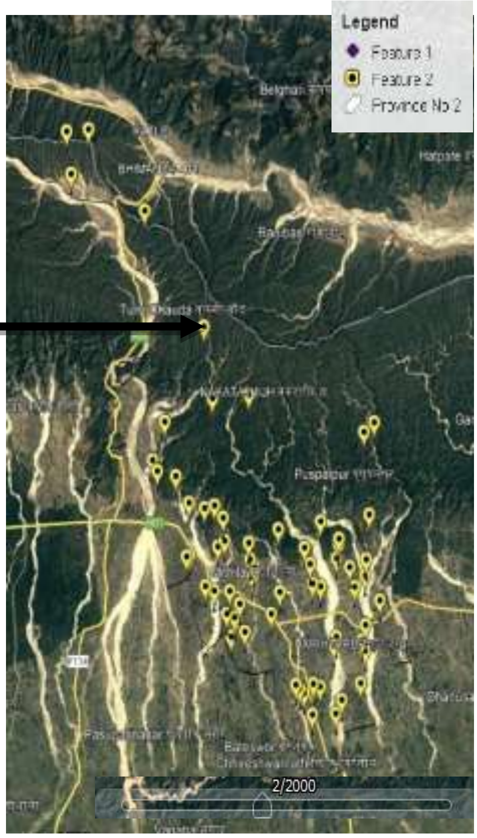


Figure 2. Process of Ground Truthing through Kappa Statistics

Accuracy Statement

Kappa statistics is suitable method for the accuracy assessment. Therefore, during this study kappa statistics has been used for accuracy assessment. kappa statistics helped to measure the difference between true data and reference data by indicating the extent to which the percentage correct values of an error matrix that occurred due to true data versus reference data.

Kappa statistics (¯K¯) = $N(\sum_{f=1}^{r} Xii) - (\sum_{f=1}^{r}(Xi * X + i)$/N2-$\sum_{f=1}^{r}(Xi * X + i)$

Where,

r = number of rows in the error matrix

Xii = number of rows in row i and column i (on the major diagonal)

Xi = total observation in row I (shown as marginal total to the right of the matrix

N =total number of observations included in matrix

Preparation of land cover maps

Initiating from data acquisition up to accuracy assessment final LULC map of three different periods 2000, 2010, and 2020 were prepared. The map had range of scale 1:1, 25,000 for proper and interpretation grid scale for more clearance.

Change detection

Land use change detection has been done by overlaying the output feature of different time periods i.e., 2000, 2010, and 2020 by using GIS software. Land cover change has been detected by analyzing and evaluating change sin excel sheet.

Results and Discussion

Within the period of 10 years from 2000 to 2010 AD, forest area has been declined by 3.66 %. With this water covered area has also been slightly decreased by 1.11%. Positively, disaster like landslide has also been decreased 4.04%. But unfortunately, the population status of municipality has been increased by. And grassland area and sediment area has been expanded by 7.26% and 2.12% respectively. The largest expansion of settlement or urbanization i.e. 4.28% and sharpest decline of agriculture by 4.86% were observed in the period 2000-2010.

During the period of 2010 to 2020 forest and agriculture both were dominant land use type and not so drastic eradication on forest and agriculture land were observed on that period. But still both were on declining state from 28.60 sq.km (15.27%) to 21.08 sq.km (11.24%) on agriculture land and 91.18 sq.km (48.68%) to 84.22 sq.km (44.91%). Despite many Chure conservation activities forest area has been declining continuously. Though in comparison to 2000 to 2010 period areas of grassland has somehow converted into forest but still that's no enough to recovers as it is. Similarly, disastrous incident like landslide and sediment area has been increased by 4.52% to 5.10% in case of landslide and 5.36% to 8.38% on case of sediment area.

Table 1. Comparative analysis of LULC class from 2000-2010 A.D. in Mithila Municipality, Dhanusha

Year	2000		2010		Change % (2000-2010)
Land Cover Class	Area (Sq.km)	Area %	Area (Sq.km)	Area %	
Agriculture	37.7	20.13	28.6	15.27	-4.86
Settlement	10.39	5.55	18.41	9.83	4.28
Grassland	3.54	1.89	17.14	9.15	7.26
Sediment Area	6.06	3.24	10.04	5.36	2.12
Landslide	16.03	8.56	8.47	4.52	-4.04
Forest	98.01	52.34	91.18	48.68	-3.66
Waterbody	15.54	8.3	13.47	7.19	-1.11

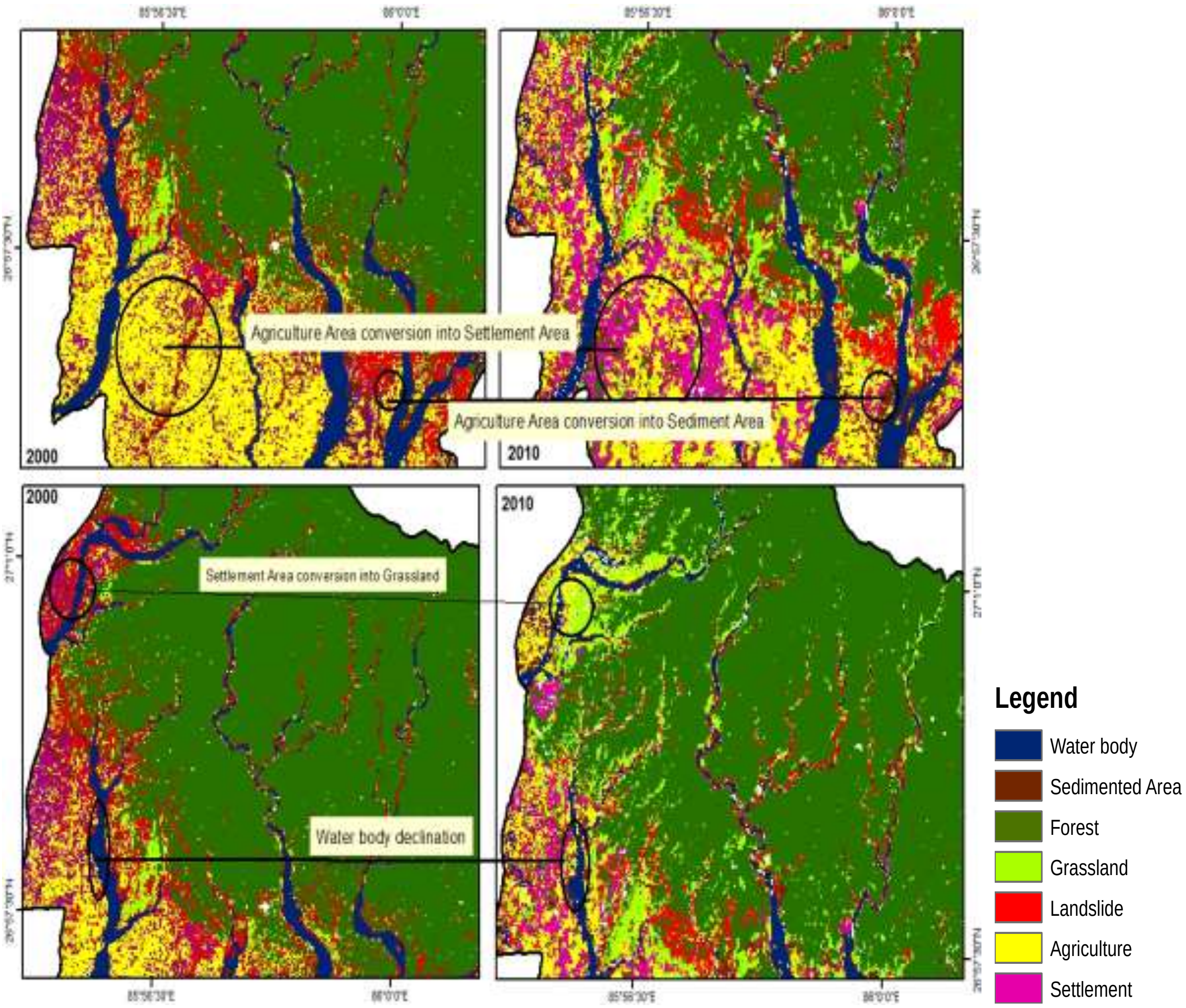


Figure 3. Land class conversion in a particular area from 2000-2010

Table 2. Comparative analysis of LULC class from 2000-2020 A.D. in Mithila Municipality, Dhanushas

Year	2010		2020		Change %	Overall Change %
Land Cover Class	Area (Sq.km)	Area %	Area (sq.km)	Area%	(2010-2020)	(2000-2020)
Agriculture	28.6	15.27	21.08	11.24	-4.03	-8.89
Settlement	18.41	9.83	19.1	10.19	0.36	4.64
Grassland	17.14	9.15	24.69	13.17	4.02	11.28
Sediment Area	10.04	5.36	15.71	8.38	3.02	5.14
Landslide	8.47	4.52	9.56	5.1	0.58	-3.46
Forest	91.18	48.68	84.22	44.91	-3.77	-7.43
Waterbody	13.47	7.19	13.16	7.02	-0.17	-1.28

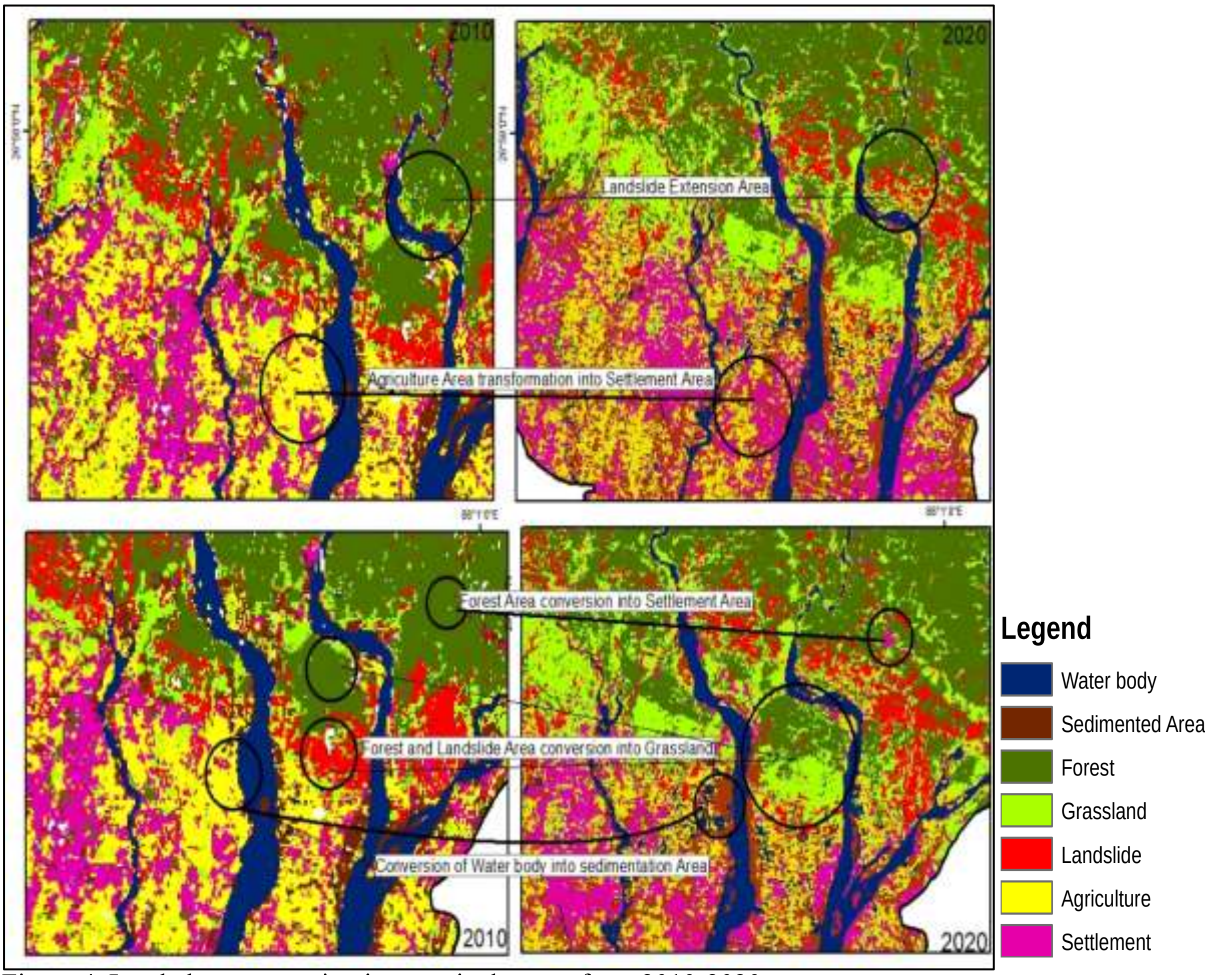


Figure 4. Land class conversion in a particular area from 2010-2020

This observation agrees with the terms that urbanization is the direct and indirect reason behind the continuous loss of agricultural land globally (Beckers et al., 2020). This is due to the availability and accessibility of better public services in well infrastructure area, higher return in land values. Not only this the consolidation and multiplication of satellite settlements, largely along with East-West Highway symbolizes the urban expansion process (Rimal et al., 2019). Similarly, one of the reasons for the decline of agricultural land due to lack of stringent government policies on land use to protect the conversion of agricultural land to other forms (Khanal et al., 2019; Paudel et al., 2016). The malaria eradication program of malaria (1958) and the initiation on the resettlement program in the 1960s resulted the large portion of forest areas has been destructed and converted to open grassland area and settlement area. This encroachment on forest leads towards the disaster such as landslide which gradually in recovering while coming towards 2010. In addition, positive aspect of expansion of grassland ecosystems provides important ecological and social services especially for livestock grazing, which is an important livelihood activity. The eradication of malaria, the construction of the East-West highway that passes from the foothills of the Chure throughout the country, and the other local roads have made it easy to migrate to and to access lands in the Chure. Such factors have been pulling factors in increasing the settlements and population (including towns and urban centers) in the Chure region. Consequently, the population and the value of land in Chure have rapidly increased, and thereby land tenure in the region has been affected.

According to the IRA report (2017), 2017 flood destroyed about 1791 houses of Dhanusha districts where as many VDCs were waterlogged due to thick mud and flood where settlements nearby riverine areas has been shifted towards other places and considered as sukumbasi basti. This is reason behind increment of settlement area by 0.35%. According to Shah (2019), Kamala River cannot contain extreme flood discharge in definite banks and over bank flow as well as branching is common in kamala river basin. As a result, the inundation in Dhanusa districts by the flood of 2017 reduced the cultivation area by 4.03% and forest area by 3.77% and sediment and grassland area increased by 3.02% and 4.02% respectively. Since, river meandering starts from terai region and especially from Bhabar Zone River braided river starts due to lose of lithological structure of Chure Bhabar Zone. So, due to braiding character as well as human encroachment, sand mining of riverbed the water covered has been slightly decreased by 0.17%.

Conclusion

LULC practices in the study area have changed dramatically over the past 20 years based on the data acquired through the use of GIS and RS technologies to meet the specific research objectives. In addition, ground truth data were collected based on google earth images. As per the observation, the dominant features were forest and agriculture followed by settlement, water body, and grassland. Similarly, a major disaster is considered as landslide and the deposition of sand and gravels is recognized as a sediment area. In spite the dominancy of forest and agriculture, agriculture area has been reduced by 4.86% and forest area has been reduced by 3.66% followed by water body with 1.11% by 2010. Similarly, grassland and sediment area has been expanded by 7.26% and 4.28% respectively by 2010. Similarly, in between 2010 to 2020 agricultural area has been reduced by 4.03% and forest area has been reduced by 3.77% followed by water body declination of 0.17%. And the remaining settlement area and grass land has been expanded by 0.35% and 4.02%. And alarming increment in landslide by 2020 with 0.57%. Considering the observed major driving forces that changed LULC OF 2 decades were the availability and accessibility of better public services in the Chure Terai Bhabar zone as compared to other regions, high land tenure values, forest encroachment and abandoned of agriculture areas as open grazing area, riverbank cutting, sand mining and climatic events and lack of stringent government policies on land use various landforms.

References

Abbas, I. I. (2008). Building Remote Sensing Capabilities in Africa: The Nigerian Example. *Proceedings of Map Africa 2008 Conference, Johannesburg, South Africa*, 21-22.

Aryal, K. R. (2012). The history of disaster incidents and impacts in Nepal 1900–2005. *International Journal of Disaster Risk Science*, 3(3), 147-154.

Bhandari, B. P., & Dhakal, S. (2018). Lithological Control on Landslide in the Babai Khola Watershed, Siwaliks Zone of Nepal, 5, 54-64.

Bhattarai, B., Bishwokarma, D., & Legras, M. (2018). Breaking the Bottleneck: Conflicts Metamorphosis of Chure Landscape Management in Federal Nepal. 16(1), 71-86.

Bishwokarma, D., Thing, S. J., & Paudel, N. S. (2016). *Political ecology of the Chure region in Nepal*, 14(1), 84-96.

Briassoulis, H. (2000). Analysis of land use change- Theoretical and modelling approaches. Regional Research Institute, West Virginia University.

Burrough, P. A. (1990). *Principles of Geographic Information Systems*. Oxford University Press, UK, 333.

Carlson, T. N., & Sanchez-Azofeifa, G. A. (1999). Satellite remote sensing of land use changes in and around San Jose, *Costa Rica*. 70(3), 247-256.

Congalton, R. G. (1991). A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. *Remote Sensing of Environment*, 37, 35-46.

Demers, M. N. (2005). Fundamentals of Geographic Information Systems. John Wiley & Sons, Inc, New York, USA.

Ghimire, M., & Basnet, L. (2015). Land use and Land cover change in the Tarai Region, Nepal. *Journal of Ministry of Forests and Soil Conservation*.

Ghimire, P. (2016). Chure Conservation Area: Lessons for the Management and Use of Natural and Biological Resources in Nepal. Case Study Report, Kathmandu, South Asia Watch on Trade, Economics & Environment (SAWTEE).

Gregorio, A., & Jansen, L. J. (2000). Land-cover classification-classification concepts and user manual. Food and Agriculture Organization (FAO) of the United Nations, Rome.

Gumindoga, W. (2010). Hydrologic Impact of Land-Use Change in The Upper Gilgel Abay River Basin, Ethiopia: TOPMODEL Application. ITC Netherlands.

Gurung, H. B., & Khanal, N. R. (1986-88). Landscape process in the Chure Range. *The Himalayan Review*, 17, 2–43.

International Journal of Remote Sensing (1989). Digital change detection techniques using remotely sensed data. 10(6), 989-1003.

IOF (2019). Preliminary Evaluation of the President Chure-Tarai Madhesh Conservation Development Program. President Chure-Tarai Madhesh Conservation Development Board, Khumaltar, Kathmandu. Institute of Forestry, Pokhara, Nepal.

Joshi, A. L., Shrestha, K., & Sigdel, H. (2000). Deforestation and Participatory Forest Management Policy in Nepal: Underlying causes of deforestation and forest degradation. *Asia World Rainforest Movement*.

Kern, A. (2011). Deriving Normalized Difference Vegetation Index based on remotely sensed AVHRR and MODIS data. Eötvös Loránd University.

Khanal, N., Uddin, K., Matin, M. A., & Tenneson, K. (2019). Automatic detection of spatiotemporal urban expansion patterns by fusing OSM and Landsat data in Kathmandu. *Remote Sensing*, (19), 11.

Lambin, E. F., & Meyfroidt, P. (2010). Land-use transitions: Socio-ecological feedback versus socioeconomic change. *Land Use Policy*, 27, 108–118.

Land Use Act Policy (2076). *Ministry of Land Reform and Management* (MoLRM), Singhdurbar, Kathmandu.

Li, X., & Shao, G. (2014). Object-Based Land-Cover Mapping with High-Resolution Aerial Photography at a County Scale in Midwestern USA. *Remote Sensing*, 6, 11372-11390.

Macleod, R. D., & Congalton, R. G. (1998). A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data. *Photogrammetric Engineering and Remote Sensing*, 64(3), 207–216.

Maingi, J. K., & Marsh, S. E. (2002). An Accuracy Assessment of 1992 Landsat-MSS Derived Land Cover for the Upper San Pedro Watershed (U.S./Mexico). United States Environmental Protection Agency, Washington, DC, USA, 29.

Manonmani, R., & Suganya, G. M. D. (2010). Remote sensing and GIS application in change detection study in urban zone using multi-temporal satellite. *International Journal of Geomatics and Geosciences*, 1, 60–65.

Moïse, M. K., Ozer, P., Gloire, M. K., Jonathan, A. M., Isaac, U. D., Muyisa, M. K., Hintou, K. M., & Walere, M. S. (2022). Dynamics of Land Use and Land Cover Change in the South Talihya Watershed North Kivu, Eastern Democratic Republic of Congo. *Indonesian Journal of Social and Environmental Issues* (*IJSEI*), 3(2), 179-193.

Mishra, V. N., Rai, P. K., Kumar, P., & Prasad, R. (2016). Evaluation of land use/land cover classification accuracy using multi-resolution remote sensing images. Forum Geographic, *University of Craiova, Department of Geography*, 15(1), 45.

Paudel, B., Zhang, Y. L., Li, S. C., Liu, L. S., Wu, X., & Khanal, N. R. (2016). Review of studies on land use and land cover change in Nepal. *Journal of Mountain Science*, 13(4), 643-660.

Paul, B. K., & Rashid, H. (2017). *Climatic Hazards in Coastal Bangladesh*: Salinity Intrusion and Impacts.

Pokhrel, K. P. (2013). Chure forestry conservation and management plan: A case study of Arghakhanchi district, Nepal. *Journal of Geography and Regional Planning*, 6(5), 172.

Pradhan, B., Lee, S., Mansor, S., Buchroithner, M., Jamaluddin, N., et al. (2008). Utilization of optical remote sensing data and geographic information system tools for regional landslide hazard analysis by using binomial logistic regression model. *Journal of Applied Remote Sensing*, 2(1), 023542.

Rawat, J. S., & Kumar, M. (2015). Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, Almora, Uttarakhand, India. *Egyptian Journal of Remote Sensing and Space Science*, 18(1), 77-84.

Rayamajhi, S., Pokharel, R. K., Tiwari, K. R., Heyojoo, B. P., Chhetri, B. B. K., & Kandel, P. N. (2019). An Assessment of the President Chure-Tarai Madhesh Conservation Development Program. *Journal of Institute of Forestry*, Nepal, 16, 101-110.

Reis, S. (2008). Analyzing land use/land cover changes using remote sensing and GIS in Rize, North-East Turkey. *Sensors*, 8(10), 6188-6202.

Rimal, B., Keshtkar, H., Sharma, R., Stork, N., Rijal, S., & Kunwar, R. (2019). Simulating urban expansion in a rapidly changing landscape in eastern Tarai, Nepal. *Environmental Monitoring and Assessment*, 191(4).

Schreier, H. B. (1994). Gaining Forests but Losing Ground: A GIS Evaluation in a Himalayan Watershed. *Environmental Management*, 18, 139-150.

Sharma, B. (2006). The Role of Pasture and Fodder Development Program for Landless Farmer in Degraded Forest Land of Agri-Environment and Biodiversity Section. Ministry of Agriculture and Cooperatives: Kathmandu, Nepal, 89–99.

Sharma, J., Prasad, R., Mishra, V. N., Yadav, V. P., & Bala, M. (2016). Evaluating land use/land cover classification accuracy using multi-resolution remote sensing images. *Forum Geographic*, 15(1), 7-21.

Shrestha, R. K. (2008). *A Study of Remote Sensing and GIS for Land Use Change Detection and Urban Growth*. Kathmandu University, Nepal.

Singh, R. P., & Sinha, P. K. (2015). Land use/land cover change detection using remote sensing and GIS: A case study of Dehradun city, India. *Journal of Geographic Information System*, 7(6), 533-545.

Smith, M., & Sood, A. (2005). The accuracy of land use/cover classification using medium-resolution remote sensing data in tropical regions. *International Journal of Remote Sensing*, 26(18), 4017-4037.

Srinivasan, K., & Sabesan, S. (2005). Land use and land cover change detection in the Bangalore district of India using remote sensing and GIS. *Remote Sensing Reviews*, 24, 341-358.

Subedi, P. B., Ojha, P., Adhikari, A., Acharya, S., & Acharya, S. (2022). Mapping of Major Land Use Land Cover Dynamics and Its Driving Factors: A Case Study of Nepalgunj Sub-Metropolitan City, Banke, Nepal. *Indonesian Journal of Social and Environmental Issues* (*IJSEI*), 3(1), 67-80.

Tiwari, B. K. (2014). Effects of land cover change on the surface temperature in Nepal. *Advances in Remote Sensing*, 3(4), 155-163.

Yadav, R., & Singh, S. (2015). Comparative analysis of land cover classification accuracy of Landsat-8 and Landsat-7 ETM+ data. *ISPRS Journal of Photogrammetry and Remote Sensing*, 103, 66-78.

Yoshida, T., & Saito, T. (2010). Land use change and its effect on the environment in Nepal. *International Journal of Environmental Science and Technology*, 7(3), 563-572.