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ASSESSMENT OF THE LAND USE LAND COVER CHANGE AND ENCROACHMENT OF NATIONAL FOREST IN LAMAHI MUNICIPALITY, DANG DISTRICT, NEPA

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ABSTRACT: *Land-use Land-cover change is the change in the biophysical cover and use of land for different purposes. Urbanization can be considered as the observable transformation of the spatial pattern of LULC, such as the transformation of agricultural land into built-up area or the gradual transformation of rural landscape into urban forms. The transformation of rural landscape to urban landscape has caused various impacts on ecosystem structure, function, and dynamics. Knowledge about LULC has become increasingly important since it the driver of local, regional and global environmental change. Encroachment is the illegal conversion area of the forest land into other land. Use is another major cause of disturbance to forests and other wooded lands in Nepal. Satellite remote sensing has been widely used to detect forest change, assess rates of reforestation or deforestation, and update existing forest maps. This study was carried out using Remote Sensing and GIS techniques and was aimed at identifying the forest cover change, causes, rate and trend of encroachment from 2000 to 2019 by classifying and analyzing Landsat ETM+ image of 2000, 2010 and Landsat OLI_TIRS image of 2019. Key informant interview, GPS, Google Earth, direct field observation and various literatures were used to collect spatial and socio-economic data. Supervised classification was performed using maximum likelihood classifier with the help of direct field observation, Google earth and topographic maps. The study area was categorized into 5 LULC classes i.e. Forest, Water, Agriculture, Settlement and Bareland. The area converted from Forest to Agriculture and Settlement was considered as the encroachment. The result shows that the forest area (major land cover) was converted to the four land use classes. Most of the forest was converted into Bareland followed by Agriculture and Settlement. According to the KII encroachment of forest was 1000 ha up to 2000 and in my study the encroachment was 751 ha from 2000-2010 and 380 ha from 2010 – 2019. The trend of encroachment was decreasing from past to present. According to the study causes of encroachment were construction of East-West highway, inappropriate forest policy, Flood in the Rapti River, Population pressure, Political decisions and Migrations.***

KEY WORDS: LULC, remote sensing, national forest, encroachment

INTRODUCTION

Land-use/land-cover change is the change in the biophysical cover and use of land for different purposes. The terrestrial or land covers of the earth and changes therein are central to a large number of the biophysical processes of global environmental change (Turner *et al.*, 1995). Land uses and land covers change over time in response to evolving economic, social, and biophysical conditions (Lebow *et al.*, 2012). Land use affects land cover with various implications. The present understanding of land cover and land use relationships, however, is inadequate, impeding progress towards certain objectives of the global change community, such as the ability to clearly

project LULC changes and to improve this understanding, land use and cover must be linked to human actions. These actions are the product of individual and group behaviours within specific socio-economic and environmental settings. These behaviours and settings are extremely complex, but can be grouped into common or typical patterns in broadly similar environments and political economies (Turner *et al.*, 1995). The growth of population and the rapid expansion of built-up area in recent decades have caused a substantial LULC change in Kathmandu valley (Thapa and Murayama, 2009; Ishtiaque *et al.*, 2017). With 3.94% urban growth rate between 2010 and 2014, the Kathmandu Valley is going through significant transformation of its landscapes in recent years making it important to understand the dynamics of LULC change processes, including their interactions with local and regional environmental change (UNDESA, 2014 as cited in Ishtiaque *et al.*, 2017).

Land cover is the observed (bio) physical cover on the earth's surface. Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment (Jansen *et al.*, 2000)."National Forest" means all Forest excluding Private Forest within the Nepal , whether marked or unmarked with Forest Boundary and the term shall also include waste or uncultivated land or unregistered lands surrounded by the Forest or situated near the adjoining Forest as well as path, pond, lake, river or stream and riverside land within the Forest (GON ,2049).In the Nepalese context, forest encroachment is the illegal conversion of forested land to other land uses, such as agriculture and settlement. It is one of the major drivers of deforestation and forest degradation in Nepal (Acharya *et al.*, 2011). In tropical regions, deforestation and forest degradation are progressive processes that are advancing at an alarming rate resulting in the conversion of forest area into a mosaic of mature forest fragments, pasture, degraded habitat, agriculture land and settlement. Deforestation is the conversion of forest to another land use type. In both processes human encroachment on forest land is a driver where forest land is cleared and opened for cultivation, settlement or other development activities. Encroachment i.e. illegal conversion area of the forest land into other land, use is another major cause of disturbance to forests and other wooded lands in Nepal (FAO, 2010).

Human encroachment on forest land gives rise to the change in another type of land use. Further, Land use change by human activities i.e. encroachment has become a proximate factor that catalyses deforestation and forest degradation (Tole, 1998). Hence, detecting the change in land use of the forest at different spatial and temporal scales could provide useful information for planning and sustainable management of forests. Satellite remote sensing has been widely used to detect forest change, assess rates of reforestation or deforestation, and update existing forest maps (Myers, 1980). Forest occupies a total of 5.96 million ha which is 40.36% of the total area of the country while Other Wooded Land (OWL) covers 0.65 million ha (4.38%) which together represent 44.74% of the total area of the country (DFRS, 2015). The country witnesses the variety of forest because of high elevation variation that ranges from 60 m to 8848 m from mean water level however due to the rise in human population encroachment of forests within the Terai region may be a long existing drawback since the last many decades in Nepal. The construction of Mahendra highway Nepal has lost important space of forest to

encroachment within the Terai region over the decades. Though encroachment is sitting serious threat to forest, there's lack of concrete policy and attempt to handle this drawback. Therefore, forest encroachment has become a chronic drawback in natural resources management regime in Nepal's Terai within the past, non-legal forest squatters were managed in associate ad-hoc basis. The matter of encroachment keeps on escalating throughout the amount of Political unrest and political liquidness within the country.

Therefore, in this study we used ancillary data sources to analyze the relationship between socioeconomic factors and change detection of forest land due to human encroachment process of National forest.

Specific Objectives:

Specific objective of the study are given below:

- To identify the types of landcover change of forest.
- To map the encroched forest area and explore the trend of forest encroachment.
- To identify causes of forest encroachment.

MATERIALS AND METHODS

Study Area

The study was conducted in National forest of the Lamahi Municipality, Dang which lies in the province no. 5 of Nepal. The total area of Dang district is 2955 sq km in which 2007 sq km area is covered by forest area. The total area of Lamahi municipality is 327 sq km consisting the population of 48012 (CBS, 2011). It lies in latitude form 27°83'60" N to 27°92'50" N and longitude 82°19'20" E to 82°62'40" E.

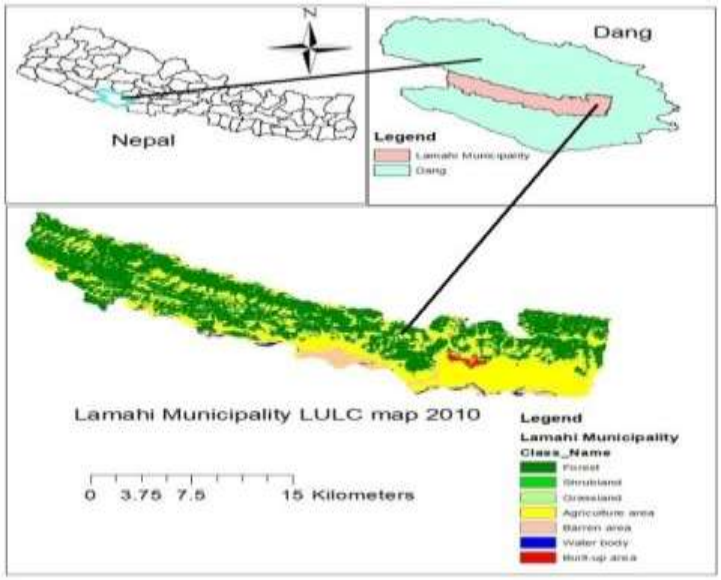
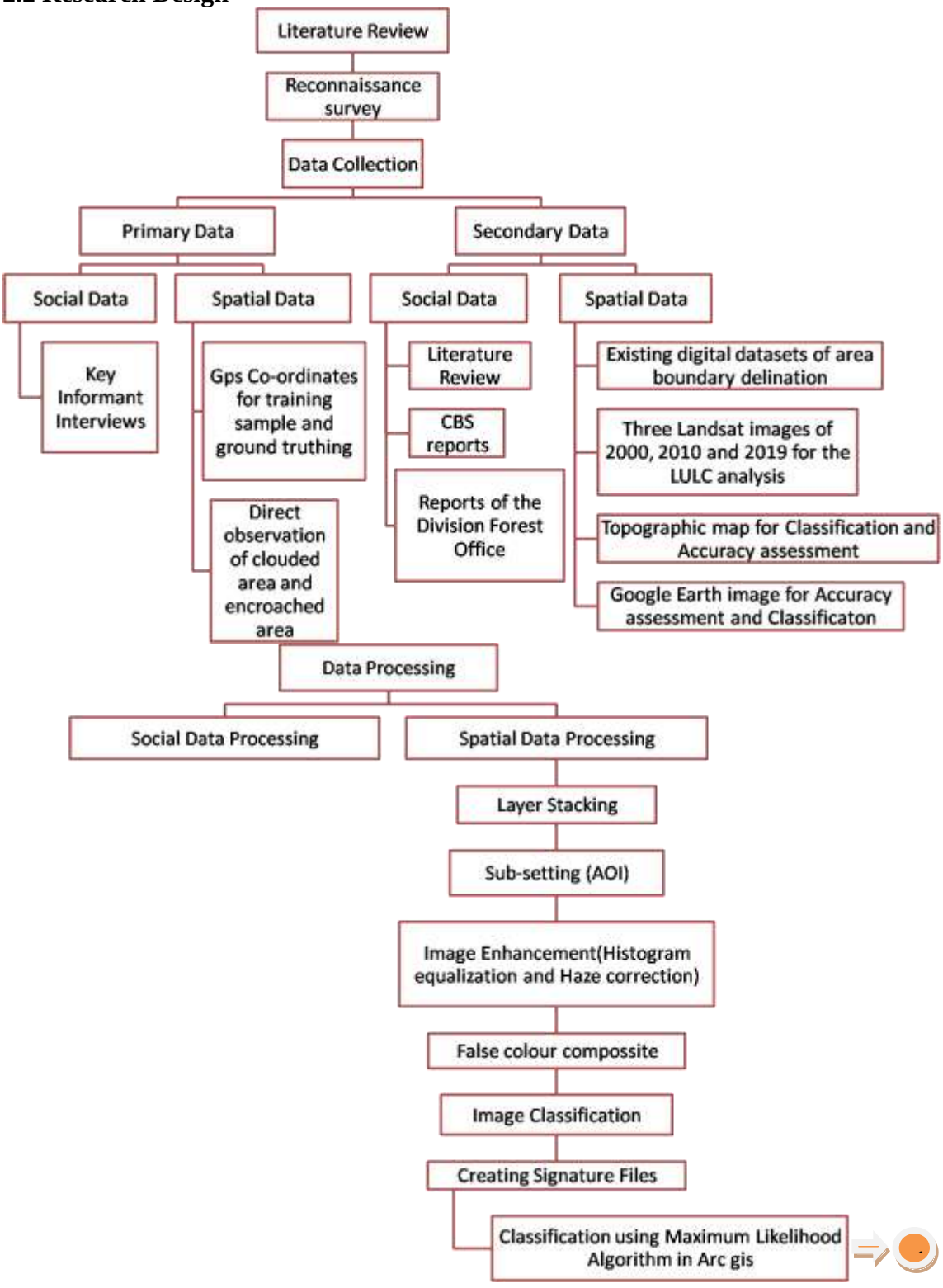
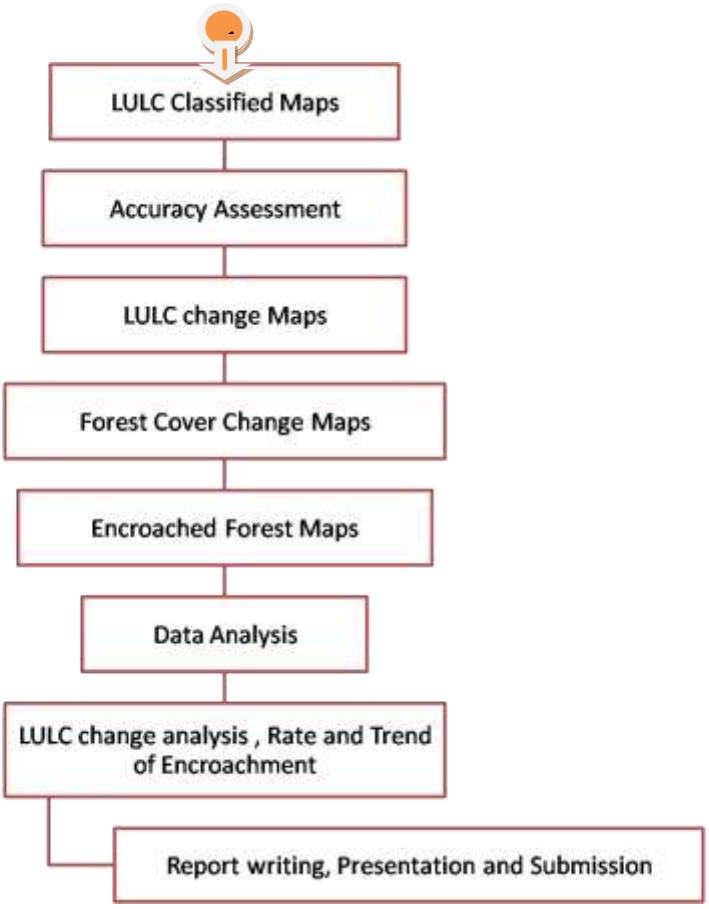


Figure 1: Map of Study Area

Figure 2: Google earth image of Lamahi

2.2 Research Design





Data Collection

Spatial Data

Satellite Images: Three Landsat images were used for LULC classification of the study. Landsat OLI_TIRS image and Landsat ETM+ image was obtained from USGS GloVis (http://www.glovis.usgs.gov) free of cost. The table showing landsat image detail is below (Table 1)

Table 1: Landsat Image Detail

WRS (Path or Row)	Scene ID	Sensor	No. of Bands	Spatial Resolution	Acquired Date
Path = 143 Row = 41	LC81430412019033LGN00	Operational Land Imager and Thermal Infrared Sensor	11	30 * 30 m	2019-02-02
Path = 144 Row = 44	LE71440402010343ASN00	Enhanced Thematic Mapper Plus	8	30 * 30 m	2010-12-09
Path = 143 Row= 41	LE71430412000325SGS01	Enhanced Thematic Mapper Plus	8	30 * 30 m	2000-11-20

Topographic Maps: Topographic maps were purchased from Department of survey, Minbhawan, Kathmandu. These maps were provided to us in digital format. These maps were used in assisting image classification and accuracy assessment of the 2000 Landsat image.

GPS Coordinates: Sufficient numbers of GPS coordinates using spatial reference system of WGS 84/UTM Zone 44N were collected in the field to train the maximum likelihood algorithm for proper supervised classification of 2019 Landsat image. Some of the collected GPS coordinates were also used for the ground trothing during accuracy assessment.

Figure 3: GPS coordinates taken in the field for training sample and accuracy assessment

Google Earth: Google earth including its "show historical imagery" function was also used in assisting classification and accuracy assessment of Landsat images. It was also used to download images of study area and extract different features on the ground.
Direct Field Observation: Direct Field Observation was carried out during the reconnaissance survey to get information about possible LULC classes in which the study area can be classified into. It was also done to see the encroached forest area and verify the data obtained through the change detection.

Social Data
Key Informant Interview: Key-Informant Interview (KII) was conducted. The Key Informants were present and former AFO and rangers from the Division Forest Office, Sub Division Forest Office and individuals who have been living in the area for an extensive period of time. KIIs were exclusively unstructured and all the questions were exclusively open ended. This nature of conversation allows for spontaneity and for questions to develop during the course of the interview, which are based on the interviewees' responses. The chief feature of the unstructured interview is the idea of probe questions that are designed to be as open as possible (Bailey and kenneth, 2008). KII was mainly done to know about the causes of encroachment, by whom it is done and from when.

Other Socioeconomic Data: Demographic data was collected from the CBS website and Annual Progress Report published by DFO and Municipality, Lamahi. Also, other socioeconomic data was collected from various literatures.

Data Analysis
1. Computer Software used for Data Processing and Analysis: The processing and analysis of Landsat images and all the other GIS Data was done using ERDAS Imagine 2015 and ArcGIS 10.5, also all the numerical data was analyzed using MS Excel. MS Excel was also used to interpret the numerical results into bar-graphs, charts and tables.
2. Landsat Image Processing:
i) Layer Stacking: At first the bands of Landsat images were stacked in one with the layer stack tool in ERDAS Imagine 2015. For the Landsat 8 only 7 bands out of 11 bands were used and for Landsat 7 all the 8 bands were used in layer stacking.
ii) Image Sub-setting: After the formation of the layer stacked image, study area was prepared from the three Landsat images using the Area of Interest (AOI) file having the delineated study area; by the application of subset tool in ERDAS Imagine 2015.
iii) Image Enhancement: Image enhancement was done to improve the visual interpretability of different objects or features in the scene. Image enhancement tools in ERDAS Imagine 2015 such as Histogram Equalization, General Contrast, Haze Correction and Brightness were used.
iv) Band Combinations and Indices: Landsat images were converted to false color composites using bands 5, 4, 3 (for Landsat OLI_TIRS image) and bands 4, 3, 2 (for Landsat ETM+ image) to assist the image classification process.
v) Image Classification: First of all, Image enhanced layer stacked image was imported to ArcGIS 10.5 and signature files were created from the training samples for all the classes and Supervised Classification was performed using maximum likelihood algorithm in ArcGIS 10.5.

The maximum likelihood algorithm is one of the most popular methods of classification in remote sensing, in which a pixel with the maximum likelihood is classified into the corresponding class (Japan Association of Remote Sensing, 1996). The study area was classified into following 5 LULC classes:

Table 2: Definitions of classified LULC classes

S.N	Classes	Definitions
1	Forest	Lands dominated by woody vegetation with a percent cover 50% and height exceeding 2 meters.
2	Water	All areas within the landmass periodically water covered.
3	Bareland	Lands exposed soil, sand, or rocks and has less than 10% vegetated cover during any time of the year.
4	Agriculture	Lands covered with temporary broadleaf or grass-type crops that are harvested at the completion of the growing season then remain idle until replanted. Neither the broadleaf or grass-type crops represent more than 60% of the cropland. At least 60% of the landscape must be covered with cropland. 4
5	Settlement	Land covered by buildings and other man-made structures and activities.

(FAO, 2010)

vi) Change Analysis and Quantification: The classified images or the LULC map were obtained for the three Landsat image after the image classification in ArcGIS and area of each class was computed using "Zonal geometry as Table" tool in Spatial Analyst Extension. LULC conversion map was created using "Raster calculator" employing the following expression:
(LULC map of 2000 * 10) + LULC map of 2010 for the change map of 2000 to 2010.
(LULC map of 2010 *10) + LULC map of 2019 for the change map of 2010 to 2019.
Finally, Numerical analysis was performed in MS Excel to compute the LULC change and to interpret them in suitable form such as graphs, charts, tables.

vii) Rate of change of LULC: The following formula was used to compute rate of change of land cover and land use in the study area

$$\text{Rate of change (\%)} = \left[\left(\frac{a2}{a1}\right)^{1/n} - 1\right] * 100 \text{ (FAO, 1995)}$$

Where, a1 = base year data (old)
a2 = End year data (new)
n = no. of years

Rate of change of encroachment was also calculated through this formula.
Where, a1 = Encroachment in ha (old)
a2 = End year Data (new)
n = no. of years

viii) Encroached Map: After the change detection or analysis in Arc Map the area that were converted from Forest to Agriculture and Forest to Settlement were highlighted through "Select by Attribute" tool in Attribute table. For the change map or the encroached map "Extract by

Attribute" tool was used to extract the area covered by the Forest to Agriculture and Forest to Settlement. The extracted area was then shown in the vector shape file of Lamahi Municipality and was exported to JPEG as the encroached map.

RESULT AND DISCUSSION

Results

Land use and Land cover Change

Image Classification: Landsat ETM+ and Landsat OLI_TIRS images were used for the LULC classification. The result shows that forest is the major land cover and agriculture is the major land use in the area followed by bareland, settlement and water. The LULC status of the area in 2000, 2010 and 2019, as well as the LULC changes and conversions in the area from 2000 to 2019 is given below in figures, tables and graphs. The image classification of 2000 revealed that 68.36 percent of total land was covered by forest which was the major land cover type in the study area, where as agriculture occupying 17.29 percent was the major land use 2000. Bareland and settlement occupied 10.44 percent and 2.18 percent respectively and the rest 1.73 percent of the area was water. Similarly, the image classification of 2010 showed that forest still remains the major land cover type covering 65.82 percent of total land. Similarly, agriculture is still the major land use occupying 14.61 percent. There is huge increase in the settlement covering 6.55 percent of total land. Forest still remain the major cover type covering 64.29 percent of total land as well as agriculture remains the major land use covering 14.26 percent of the total land. The status of different LULC classes is given in Table:

Table 3: Status of different LULC classes

	Area in ha			**Area Change**		**Area in Percent**			**Change (%)**	
Name	**2000**	**2010**	**2019**	**2000 to 2010**	**2010 to 2019**	**2000**	**2010**	**2019**	**2000 to 2010**	**2010 to 2019**
Forest	22320	21490	20992	-830	-498	68.36	65.82	64.29	-2.54	-1.53
Water	564	482	337	-82	-145	1.73	1.48	1.03	-0.25	-0.44
Bareland	3410	3769	4373	359	604	10.44	11.54	13.39	1.10	1.85
Agriculture	5645	4771	4655	-874	-116	17.29	14.61	14.26	-2.68	-0.36
Settlement	712	2138	2297	1426	159	2.18	6.55	7.03	4.37	0.49

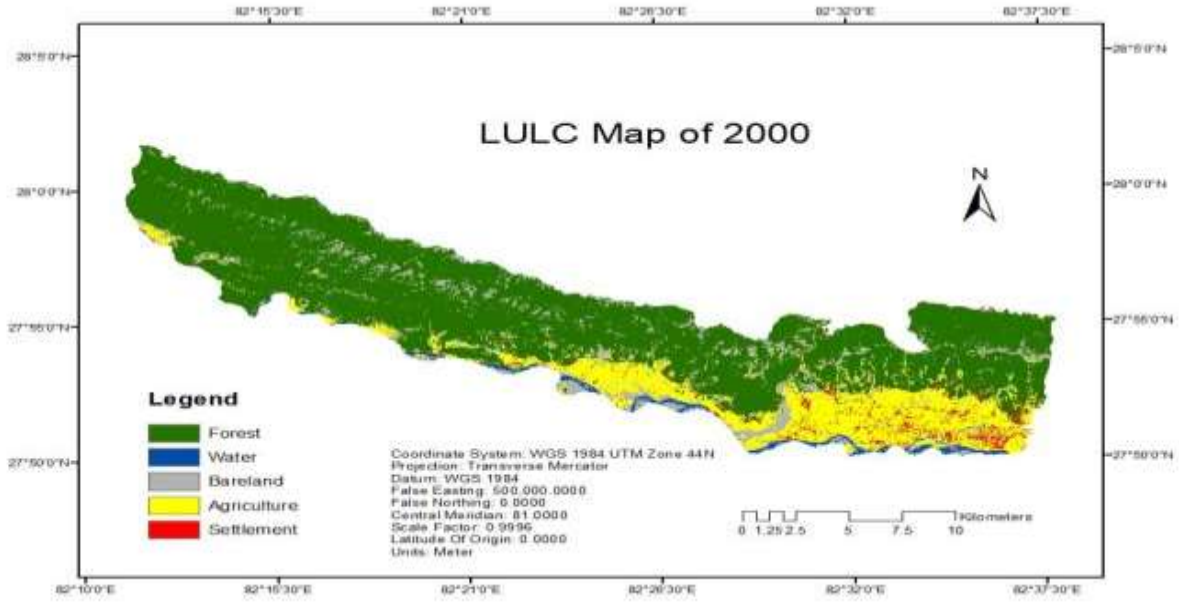


Figure 4: Land Use Land Cover Map 2000

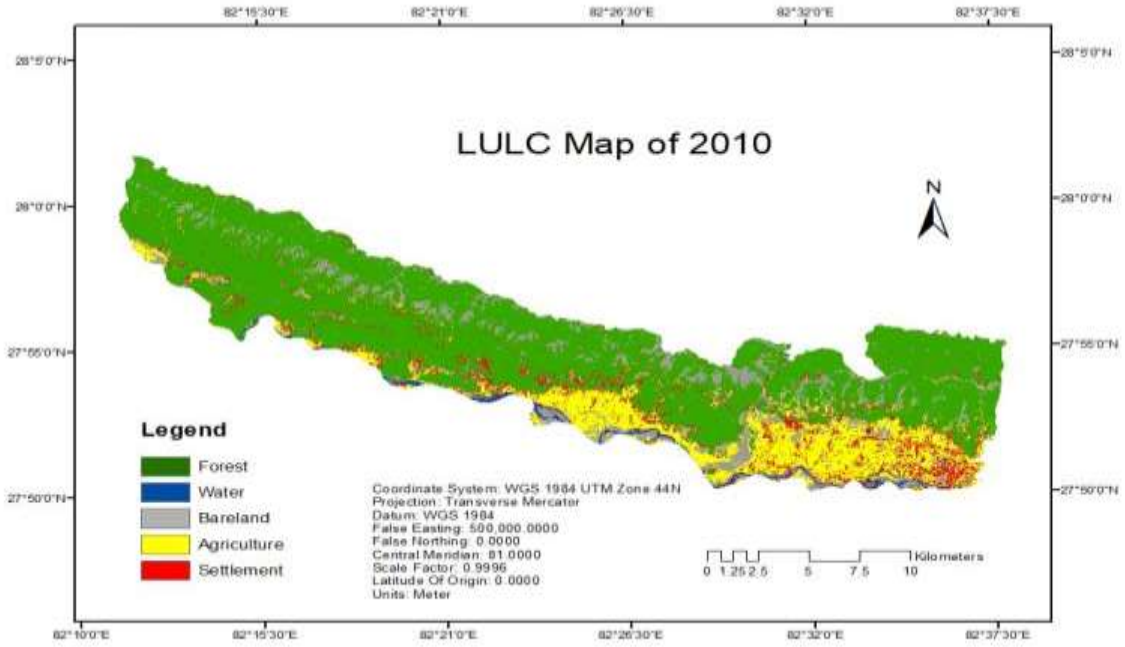


Figure 5: Land Use Land Cover Map 2010

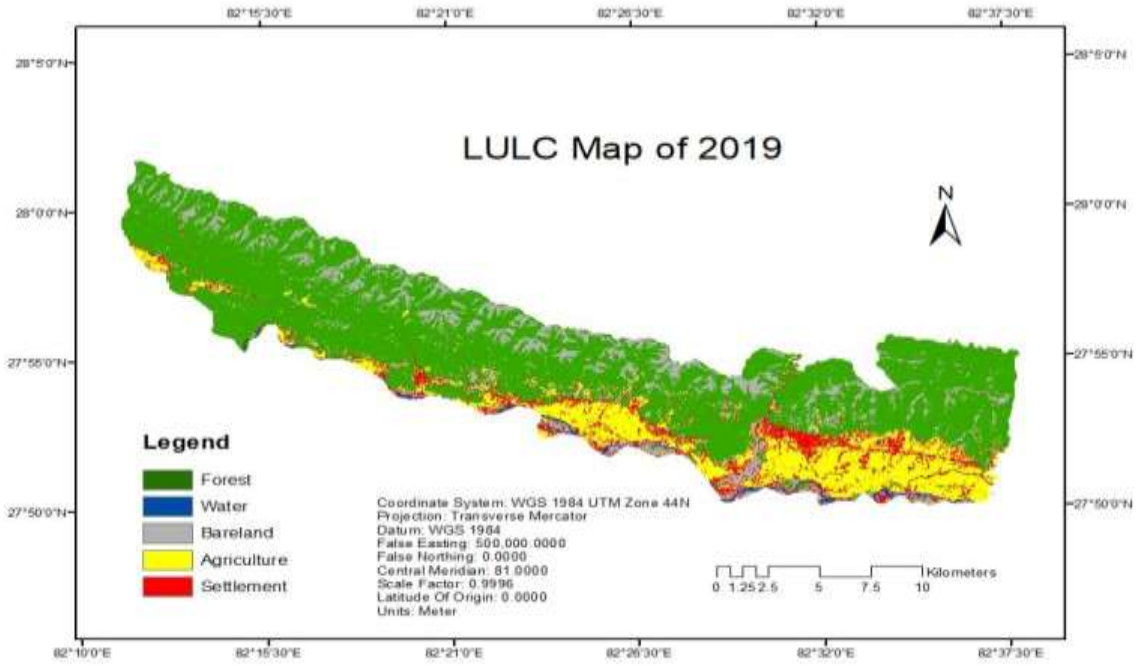


Figure 6: Land Use Land Cover Map 2019

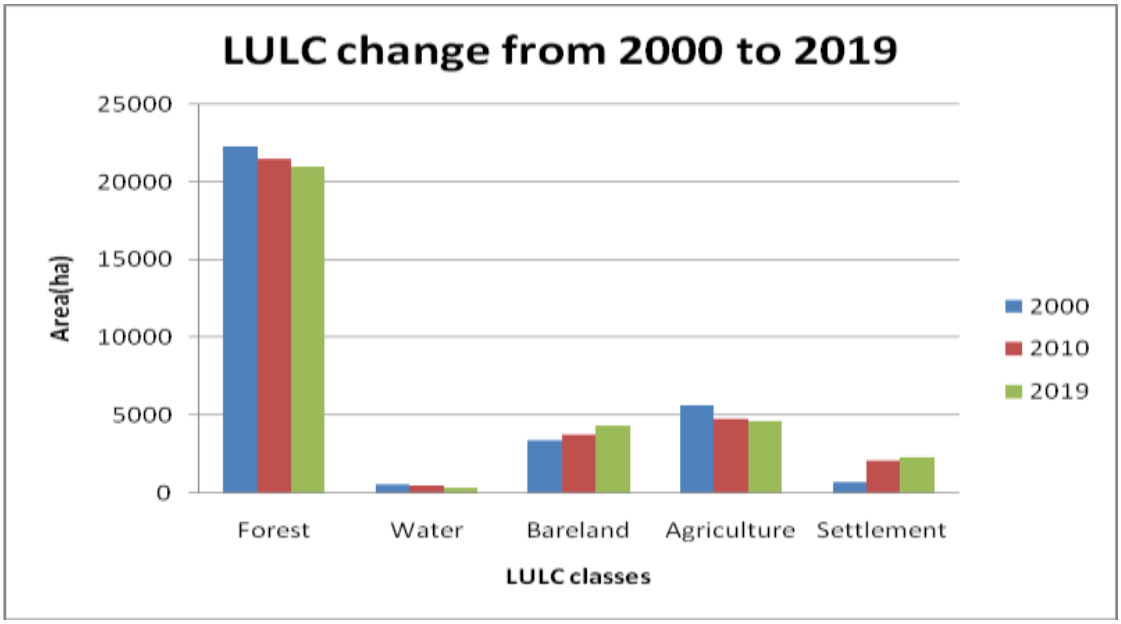


Figure 7: Histogram showing LULC change between 2000, 2010 and 2019

Rate of LULC change: The rate of land use land cover change is as shown in the table given below;

Table 4: Rate of Land-use Land-cover Change

		Rate of change (%)per year 2000 to 2010		Rate of change (%)per year 2010 to 2019	
S.N	LULC classes	Rate of increment	Rate of decrement	Rate of increment	Rate of decrement
1	Forest		0.38		0.26
2	Water		1.56		3.89
3	Bareland	1.01		1.66	
4	Agriculture		1.67		0.27
5	Settlement	11.62		0.80	

From the above table it seems that, settlement and bareland areas are increasing at the rate of 11.62 percent and 1.01 percent respectively, meanwhile the agriculture, water and forest are decreasing at the rate of 1.67 percent, 1.56 percent and 0.38 percent respectively from 2000 to 2010. From 2010 to 2019 settlement and bareland areas are increasing at the rate of 0.80 percent and 1.66 percent respectively, meanwhile the agriculture, water and forest are decreasing at the rate of 0.27 percent, 3.89 percent and 0.26 percent respectively.

Accuracy Assessment: It was done for the LULC classified map of 2000, 2010 and 2019 by the help topographic map, google image and training sample collected from the field respectively. Both MS-Excel as well as ArcGIS 10.5 was used for the accuracy assessment of the images. User accuracy, producer accuracy, overall accuracy and Kappa coefficient was calculated. Results of the accuracy assessment are shown in the tables 5, 6 and 7 below:

Table 5: Accuracy assessment result of 2000

Classes	Forest	Agriculture	Water	Settlement	Bareland	Total	**User Accuracy (%)**
Forest	10	0	0	0	0	10	100
Agriculture	1	7	0	1	1	10	70
Water	1	1	6	0	2	10	60
Settlement	0	1	1	8	0	10	80
Bareland	1	0	0	0	9	10	90
Total	13	9	7	9	13	50	
Producer Accuracy (%)	76.92	77.78	85.71	88.89	75	**Overall Accuracy** 80%	
Kappa Coefficient: 0.75							

Table 6: Accuracy assessment result of 2010

Classes	Forest	Agriculture	Water	Settlement	Bareland	Total	**User Accuracy (%)**
Forest	12	1	0	0	1	14	85.71
Agriculture	2	10	0	2	1	15	66.67
Water	0	1	8	0	3	12	66.67
Settlement	0	2	0	10	0	12	83.33
Bareland	2	1	0	0	10	13	76.92
Total	16	15	8	12	15	66	
Producer Accuracy (%)	75	66.67	100	83.33	66.67	**Overall Accuracy** 75.76%	
Kappa Coefficient: 0.70							

Table 7: Accuracy assessment result of 2019

Classes	Forest	Agriculture	Water	Settlement	Bareland	Total	**User Accuracy (%)**
Forest	14	0	0	1	0	15	93.33
Agriculture	1	13	0	1	0	15	86.67
Water	0	1	8	0	1	10	80
Settlement	0	1	0	10	1	12	83.33
Bareland	1	0	1	0	8	10	80
Total	16	15	9	12	10	62	
Producer Accuracy (%)	87.5	86.67	88.89	83.33	80	**Overall Accuracy** 85.48%	
Kappa Coefficient: 0.82							

Forest Cover Change: According to the study or the Land use land cover map the forest area has been decreasing since 2000 to 2019. The forest has been changed to the following classes as shown in the table;

Table 8: Area of forest changes

	Area of forest change in ha	
	2000 to 2010	**2010 to 2019**
Forest Unchanged	20633	19743
Forest to Water	7	4
Forest to Bareland	927	1345
Forest to Agriculture	288	162
Forest to Settlement	463	218

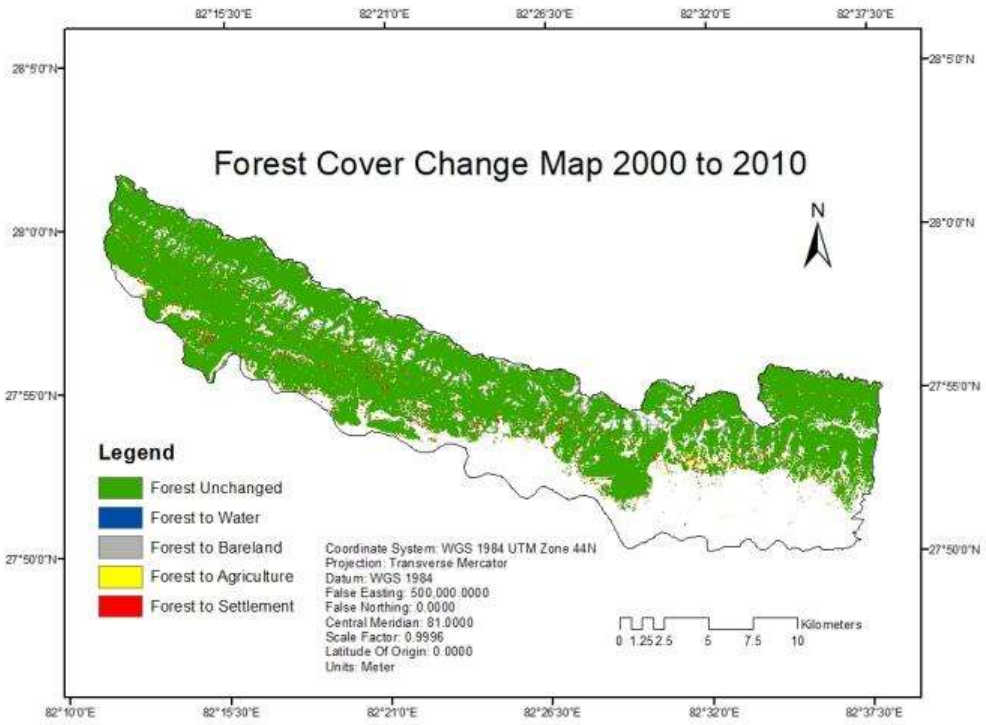


Figure 8: Forest Cover Change Map 2000 to 2010

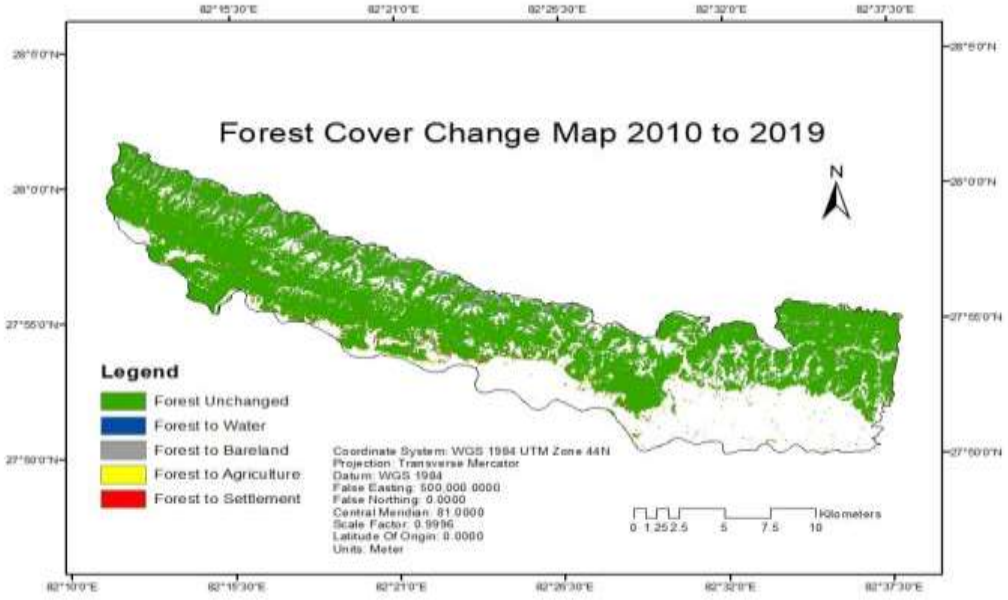


Figure 9: Forest Cover Change Map 2010 to 2019

Forest Encroachment Trend and Rate: According to the Division Forest Office Lamahi, the large forest area was encroached while constructing East – West highway form mid 19s to 2000. More than 1000 ha of the forest were encroached near roadside as well as southern and northern sides of the road. At first the encroachment of the forest was high up to 2000 and then afterwards encroachment goes on decreasing from 2000 to 2019 as shown in the fig. below.

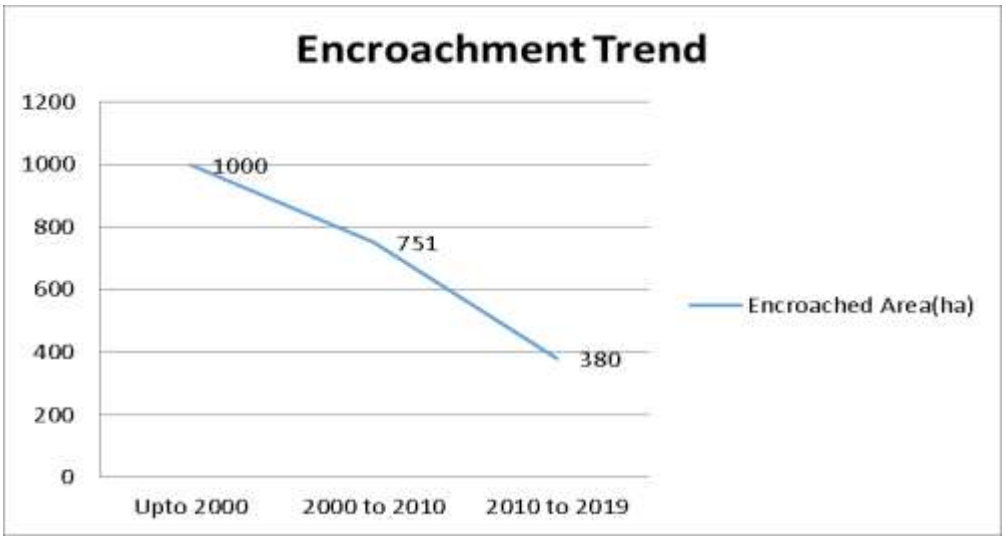


Figure 10 Trend of Forest Encroachment

Status of the forest encroachment and rate of change is shown in the table below;

Table 9: Status of forest encroachment and change rate

Year	Forest Area(ha)	Encroachment(ha)	Rate of Encroachment Change (%)	Rate of Encroachment(%) per year in total forest area	Rate of Encroachment(%) per year in total area
2000	22320	1000			
2010	21490	751	2.82(decrease)	0.35	0.23
2019	20992	380	7.29(decrease)	0.20	0.12

From the above table it seems that the annual rate of encroachment is decreasing year after year.

Causes of the Encroachment: For knowing about the causes of encroachment some informal open ended questions were asked to the AFO, Rangers of the Division as well as Sub-Division Forest Office and to the individuals who have been living in the area for an extensive period of time. According to them at first people settle in the roadside i.e. the land that belongs to Department of Road and then while expanding the road they shift little bit towards the forest leading forest encroachment. Maximum settlement and agricultural land of the municipality are the encroachment of the National Forest since mid-19th Century.

At first East-West highway was constructed in the forest due to which the encroachment of the forest started. Upto *panchayat* era, people used to fear about the forest laws but now a days people remove the poles used of the forest boundary demarcation and encroach the forest. Encroachment in the municipality was done by both governments as well as by the people themselves. Many area of the forest was encroached by the government for making the army camp, APF camp, governmental schools, etc.

People who encroaches the forest are supported by the political parties so it is difficult to remove them. According to AFOs and rangers, the law about the encroachment is good but it is not implemented. Main problem for removing the encroachment are the political parties and without removing the older encroachment it is difficult to remove the newer one. Rapti River beside the municipality is also the major causes of the encroachment. In the rainy season river sweep away the land, houses etc of the people and those people in search of livelihood encroach the forest area. According to them main causes of encroachment were inappropriate forest policy, flood in the Rapti River, poverty, political decisions, population pressure, and migration from hills to Terai etc.

Figure 11: Field observed encroached area

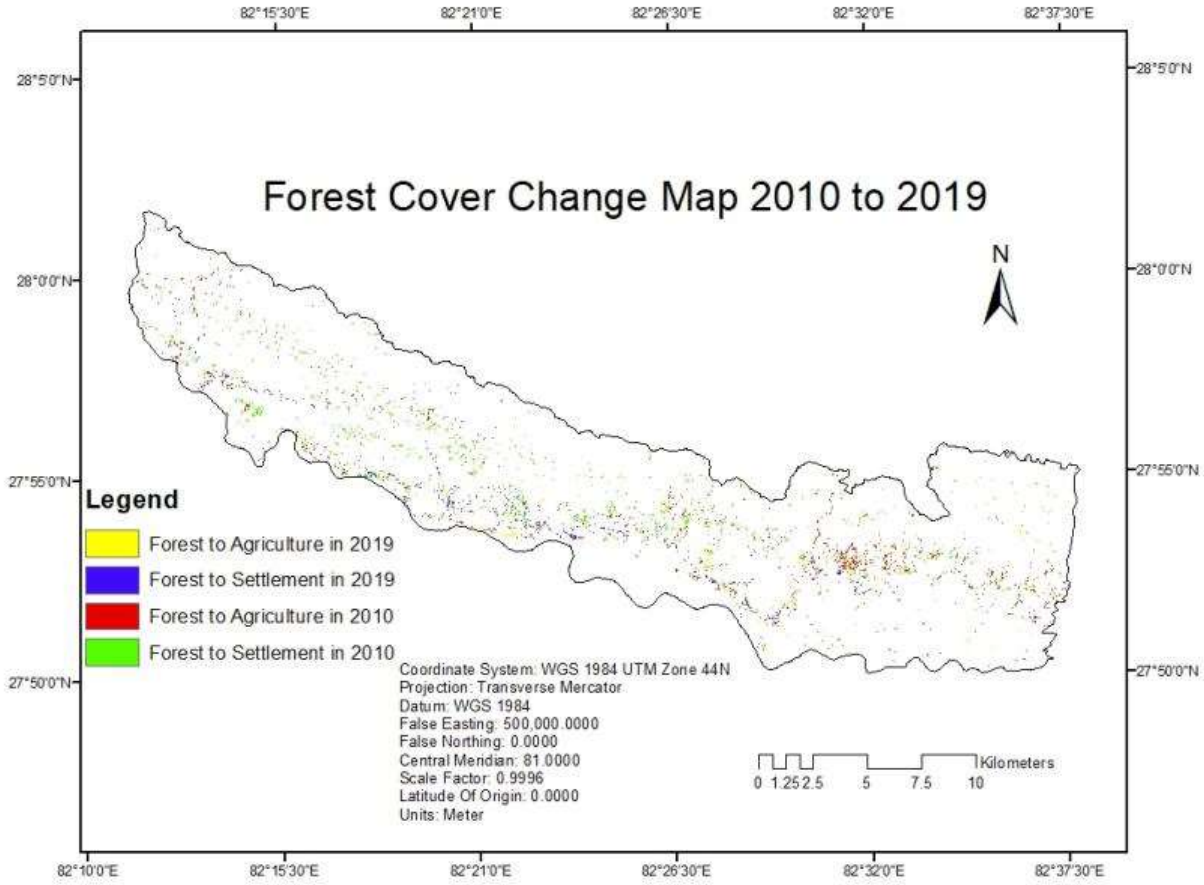


Figure 12: Encroached Map 2000 to 2019

DISCUSSION

Through the classification and analysis of multi-date Landsat images of 2000, 2010 and 2019 shows that Lamahi has been experiencing rapid LULC change. The result shows that the forest area has decreased i.e. by 4.07% over the period of 19 years. The result shows that settlement has increased by 4.86% from 2000 to 2019, thus the increment is mainly due to the conversion of forest and agricultural land to settlement. According to the statements of the key informants the Forest were converted into agricultural land and settlement due to encroachment activities. Similar trend of conversion can also seen in other LULC change studies conducted in Nepal by various researchers (Gautam *et al.*, 2002; Awasthi *et al.*, 2002; Pandey *et al.*, 2016; Neupane *et al.*, 2017).

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A major change in land use of the area is the decrease in agricultural land by 990 ha (3.04%). The reason behind this is the conversion of agricultural land into settlement to accommodate increasing population and rapid urbanization as 31.42 of agricultural land is found to be converted into settlement since 2000 to 2019. According to National Population and Housing Census published by CBS, the population of Lamahi municipality has increased from 28279 in 1991 to 47655 in 2011. According to Ishtiaque *et al.* (2017) urban area has expanded by 4.1 times in last three decades and most of this expansion occurred with the conversions of 31% of agricultural land. According to Thapa and Murayama (2009), a large share of agricultural space was transformed to urban/built-up areas in different time periods. Thapa and Murayama (2009) reported that the urban/built-up areas in the Kathmandu valley had a noticeable increase, from 3% (2,010 ha) of the total land in 1967 to 14% (9,717 ha) in 2000, showing spatial patterns of urbanization with consistent (5%) growth between 1991 and 2000. They also reported that 4.4% of the agricultural land was converted into built-up from 1991 to 2000. Most of the agricultural lands in the valley floor and near existing built-up areas (along roads in concentric pattern) were transformed into urban/built-up lands (Thapa and Murayama, 2009; Ishtiaque *et al.*, 2017). The result shows that from 2000 to 2019, 1328 ha of the forest cover were converted into other land use classes i.e. bareland, agriculture and settlement.

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According to DFO, Lamahi, the encroachment of the Lamahi municipality was more than 1000 ha up to 2000. Even if there was no data compiled about the encroachment of the municipality but in whole Dang district total encroachment was found to be 2685 ha compiled up to 2010 (DOF, 2017) and there exists lack of data updating of forest encroachment. According to the study total encroachment of Lamahi municipality was found to be 1131 ha from 2000 to 2019.
Government of Nepal has given use rights to use forest land of Dang district to different institutions such as governmental schools and colleges, Nepal Army camp etc. as lease from 1990-2000 (DOF, 2017). In this study forest area given as lease are also included in the encroachment area.The annual rate of encroachment was high during the period 1990s to 2010 because of changes in river courses and also due to the construction of roads, transmission lines, human encroachment etc.

The annual rate of encroachment has been found to decrease in the three successive study periods mainly because of effectiveness of the implementation of government interventions to combat illegal encroachment and formation of community forest in Dang district. Even though,

buffer or fringe areas nearby East – West highway are much affected by encroachment due to increase in population i.e. 28279 individuals to 47655 individuals increased from 1991 - 2011 (CBS, 2011).

Land policies such as Land (Measurement) Act of 2019 (1962) is responsible for legalizing forest areas for private ownership. Specifically Section 6 (5) of the Act with the fourth amendment of 1978 has been outstanding to measure and provide title to the one who has cultivated and been holding the titles since the 'past' with or without any proof of the ownerships. According to the Department of Survey, Lamahi land of Dang district was surveyed in 1972 and given land owner certificate to the land holders. Due to this reason after 1972 more forest land were encroached i.e. cleared because of getting land owner certificate but due to the political influence from 1979-1989 the encroached forest land ownership was given to encroachers. By1972 encroached forest land have been converted to big settlement, agricultural land. Besides, these land registration policies, there are some other policies that provided full authority to the government to distribute significant area of land (be it forests or barren under government ownership) for specific purposes (COMFORT, 2006). According to the staffs of Department of survey, survey of the district should be done in each 10 years by the government but from 1972 to till now survey is not done in Dang district due to which encroachment is high.

The policies concerned with various infrastructure development programs such as construction of roads/highways, high-tension lines and canal, resettlement, housing and city development of the government have substantially contributed to forest encroachment. Similar study was carried out in Bangladesh in 2005 to know the causes of the encroachment by Iftekhar. According to him main causes of encroachment were inappropriate forest policy, unfavorable market economy, political decisions, population pressure and persistent poverty, migration etc. which are quite similar to the causes of encroachment of my study.

CONCLUSION AND RECOMMENDATION

This study using satellite imagery, GIS and other socioeconomic data has been able to reveal the LULC change in the Lamahi municipality. The quantitative evidence from this study reveals LULC change in the study area. From the analysis of the obtained results, generalization of the statements given by key informants and through various literature reviews following conclusions were drawn;

1) The analysis of classified image of 2000 reveals that the major land cover was forest covering an area of 68.36 percent whereas, agriculture was found to be the major land use occupying 17.29 percent of the total land. Bareland and settlement occupied 10.44 percent and 2.18 percent respectively and rest 1.73 percent of the total area was water.
2) The analysis of classified image of 2010 reveals that the major land cover was forest covering an area of 65.82 percent whereas, agriculture was found to be the major land use occupying 14.61 percent of the total land. Bareland and settlement occupied 11.54 percent and 6.55 percent respectively and rest 1.48 percent of the total area was water.

3) The analysis of classified image of 2019 reveals that the major land cover was forest covering an area of 64.29 percent whereas, agriculture was found to be the major land use occupying 14.26 percent of the total land. Bareland and settlement occupied 13.39 percent and 7.03 percent respectively and rest 1.03 percent of the total area was water.
4) The results show that the forest cover has decreased at the rate of 0.38% and 0.26% from 2000 to 2010 and 2010 to 2019 respectively and changed to the other classes such as agriculture, settlement and bareland.
5) Most of the forest area has been converted into agricultural land and settlement during 2000 to 2019.
6) Encroachment was high before 2000 i.e. more than 1000 ha according to the Division forest office then from 2000 to 2010 it was 751 ha and from 2010 to 2019 it was 380 ha.
7) Annual rate of encroachment was 2.82 % (decreasing) and 7.29 % (decreasing) during 2000 to 2010 and 2010 to 2019 respectively.
8) Main causes of the encroachment were found to be construction of the East- West highway between the forest, Flood in the Rapti River, poor implementation of the forest laws and the power of the political parties as well as government.
9) Rapid encroachment of forest land has been experienced along highways and near settlements. It is due to the concentration of migrants from the hill and proximity to highways (East-west and north-south)
10) Landless squatters and flood victims were the main encroachers of the forest.

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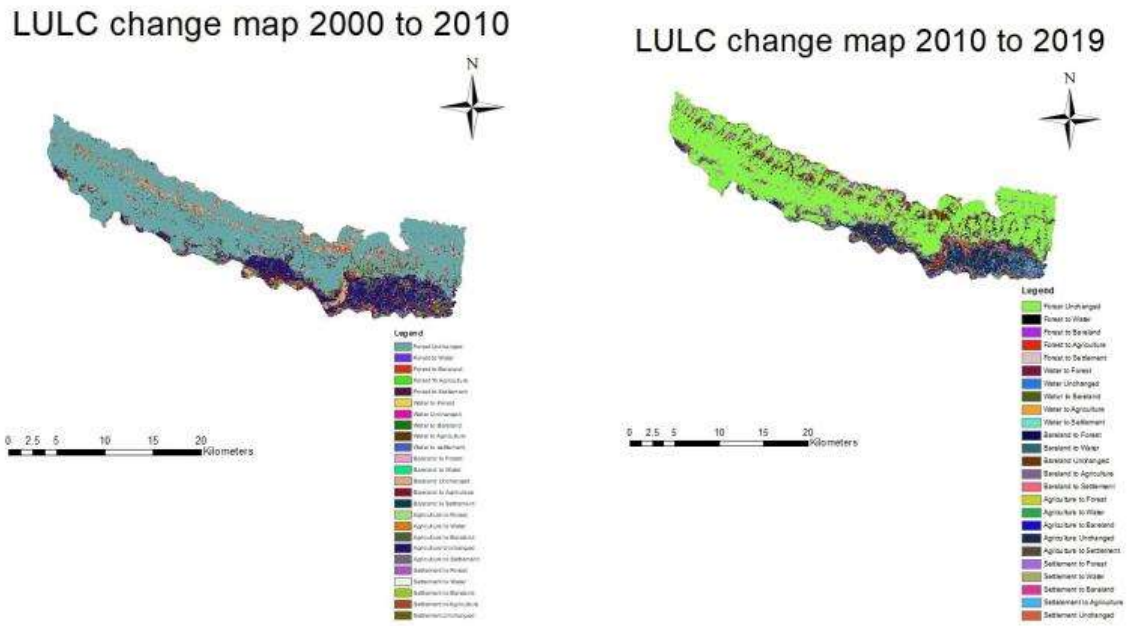
Appendices

Appendices I: LULC Change map



Appendices II: Checklists

1) When was the area of the Lamahi encroached?
2) What was the encroachment status of Lamahi up to 2000?
3) Who were the encroachers?
4) What were the reasons behind the encroachment?

Appendices III: Key Informants Details

Name	**Profession**
Puran Chaudhari	AFO Division Forest Office
Chhote Lal Chaudhari	AFO Sub-Division Forest Office
Sankhar Pd. Gupta	DFO Division Forest Office
Anup Kumar Thapa	Auditor living in the area for extensive period of time
Santosh K.C	Farmer living in the area for extensive period of time

Appendices IV: GPS Co-ordinates of Encroached area

S.N	X	Y
1	658889	3082210
2	658430	3082130
3	648225	3085000
4	648075	3085161
5	647855	3085136
6	645266	3082940
7	644838	3083868
8	644207	3083863
9	641637	3085823
10	634460	3086803
11	633125	3087126
12	632553	3087385
13	640838	3086026
14	648268	3085888
15	618966	3094720
16	621453	3093311