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Mapping of Major Land Use Land Cover Dynamics and Its Driving Factors: A Case Study of Nepalgunj Sub-Metropolitan City, Banke, Nepal

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ABSTRACT

Understanding changes in Land Use Land Cover (LULC) is essential for managing and monitoring natural resources and development, particularly where urbanization is expanding. So, this study aimed to assess the level of changes in LULC of Nepalgunj Sub-metropolitan city using temporal Landsat satellite imageries of 1996, 2008, and 2020 AD, and the key drivers of LULC change were observed through a purposive household survey (N=140) with a sampling intensity of 0.5%. LULC maps were generated using initial unsupervised and later supervised classification. LULC changes were computed using the post-change detection classification technique. LULC map of 1996 AD, 2008 AD, and 2020 AD showed accuracy of 84.44 %, 85.45%, and 83.64% with a kappa value of 0.8381, 0.8497, and 0.829 respectively. Bareland, Human buildup, and grassland were found to have increased by 13.34%, 5.07%, and 29.62% respectively while sparse vegetation, dense vegetation, and water bodies were found to have decreased by 44.10%, 17.82%, and 13.34% respectively between 1996 and 2008. Likewise, there was decrease in grassland area (-26%), dense vegetation area (-9.48%), sparse vegetation area (-5%), water bodies (-0.12%), and increase in Bareland (+20%) and Human buildup (+20.6%) in between 2008 to 2020. Eight key drivers of LULC, development of infrastructure, government policy, plans, and land market, forest encroachment, forest, and its products, political condition, economic opportunities, and hotel and tourism activities, were recognized in the study area. Further research is required to determine the specific ramifications of the aforementioned LULC change drivers, as well as the area's long-term viability.

INTRODUCTION

Land, according to the FAO (1984), is defined as "all elements of a natural occurrence that might influence its use by man", which includes not only landforms and soils but also climate and flora, including existing forests. Similarly, land cover is the amalgamation of the physiological and biological condition of the land while land use land cover change is the change in the biophysical cover and use of land for different purposes (Steffen et al., 1992). Briassoulis (2009) suggests that land use land cover change is influenced by different biophysical and societal factors. Local temperature and weather, terrain, bedrock and soil type, surface water, and groundwater, according to her, are biophysical influences, whereas household size, age, gender, education, and occupation are sociological elements. The land changes, according to the purposes of human demand, either they are being used for recreation, shelter, materials extraction, and processing for the sake of economic purpose (Moua et al. 1993). Land used land cover changes impact directly to livelihood sustainability in most parts of the world (Maitima et al., 2010).

For the past few years, the physical materials of the earth's terrestrial surface had changed and are sure to change in the upcoming days (Dinka and Chaka, 2019). Both human and natural factors play a pivotal role to change taking place at local and global levels. The human effect is immediate and often direct whereas the effect of nature is only over a higher period. For Nepal and other underdeveloped countries, the major human-induced effect is population growth. Due to population growth, people encroach on forest and agricultural land that for human basic needs like food cover and shelter. Thus consequences of the above-mentioned activities are the vital reason behind land use land cover change (Lambin et al., 2001).

Land use land cover change (LULCC) is a regular process that results in a vital change in the environment on a global and local scale (Moran, 2010). Land-use and land-cover modification have vital consequences on the environment through their hazardous impacts on the quality of soil and water, biodiversity, microclimate, methane, and other greenhouse gases emission, decrease CO2 absorption, and hence, cause overall land degradation. LULCC can be used in a variety of disciplines, including planning, research, policymaking, and geography (Alkharabsheh et al., 2013). The study of LULCC serves to understand the functionality of inter-activities of man-land ecosystems, aids land-use planners in developing land-use policies, and aids in reducing the unfavorable impact of potential land cover change. The change in the surface structure is not feasible to identify by using traditional techniques.

Thus we need to use modern change detection techniques like Remote Sensing and GIS. Different temporal satellite imageries used in modern change detection techniques can provide inevitable information regarding land use analysis, vegetation, soil, and various aspects of landforms and streams (Rawat and Kumar, 2015). At the same instant Landsat, imageries are highly used in monitoring and mapping aspects due to their high spectral, spatial, and temporal resolution characteristics and free availability (Sadidy et al., 2009). Geospatial techniques can act a vital role in keeping, examining, and recovering biological, social, physical, and economic aspects of the land ecosystem (Awasthi et al., 2007; Sidhu et al., 2000). Various levels of study have been carried out on land use and land cover changes in the land ecosystem of Nepal by applying GIS and remote sensing approaches such as a study done by Shalaby and Tateishi (2007), Paudel et al (2016), Lamichhane and Shakya (2019), Rijal et al (2021), Wang et al (2020).

All of them had found out that every sector has now been facing a problem of urbanization. The expansion rate of urban land in the past thirty years has quadruply increased, with a total sum of 469 km² of urban land cover in 2010 (Uddin et al., 2015). Thus, there is a great influence on LULC changes. The information gained from this study will aid in identifying all of the LULCC drivers and in formulating policies and strategic plans for successful land management in Nepalgunj Sub-Metropolitan City. Therefore, the study will help to provide baseline information on Land Used Land Cover changes and detection over the past two decades. Nepalgunj sub-metropolitan city is densely populated and its result is highly identical to other cities of Terai. A very low land used land cover related research has been carried out in Banke and other cities of Terai.

Thus, the study area was selected to detect and figure out overall LULC change using RS and GIS techniques. The major aim is to find out the current pattern of land-use change in different periods between 1996 and 2020. The result and outcome are expected to be useful for policymakers and land-use planners for adorable land-use planning of the city.

MATERIALS AND METHODS

Study area

The study was carried out in Nepalgunj Sub-Metropolitan city of Banke district, with the physiography location of Latitude 28.0489°N, Longitude 81.62477°Eoccupied over 85.95sq km area. It is situated at about 85 Km southwest of Ghorahi and 16 km from nearby south of Kohalpur Bazar and 35 Km east of Gulariya. Its southern border lies near Bahraich district, Uttar Pradesh of India. It lies in the Terai plains and is intersected by Mahendra Highway. The 2011 census counted 1,38,951 from out of total 27892 households with males 70,887 and females 68,074 individuals with 20 percent growth in population since 2001 AD. It has a sub-tropical climate and is considered one of the hottest areas in Nepal as temperatures sometimes exceed 40^0 c. Nepalgunj sub-metropolitan city is a valuable asset with its socio-cultural, ecological, and economic significance.

The Department of Survey, Kathmandu, provided the topographical digital maps on the shapefile (DoS). Applying Arc GIS 10.8, the study metropolitan area was extracted out from the topographic map through using a clipping tool. Geographic Information System (GIS) as well, as Remote Sensing was used to studying the pattern of land use/land cover change (LULC) (RS). For assessment of the land cover of the study region, the Landsat 5 Thematic Mapper satellite image (TM) 1996 (30m resolution), Landsat 7 Enhanced Thematic Mapper satellite image (ETM+) 2008, and Landsat 8 operational land imager (OLI) 2020 satellite images were used.

Table 1. Details of the remotely sensed data used in the study

Landsat 5	1996	TM	1-7	16 days	30 *30	144/040	12 Nov 1996
Landsat 7	2008	ETM^+	1-11	16 days	30*30	144/040	8 Nov 2008
Landsat 8	2020	OLI	1-14	16 days	30*30	144/040	23 Nov 2020

Landsat TM for 1996, Landsat $ETM^+$for 2008, and Landsat OLI TIRS for 2020 imageries were downloaded freely through the USGS website (earthexplorer.usgs.gov).Atmospheric, Radiometric, and Sun angle corrections for each of the Landsat imageries were executed. Initially, an unsupervised image classification system was used, and a later supervised approach consisting of likelihood parameters was run to enhance the correctness of the land use classification for the images of all 3 different dates (1996, 2008, and 2020).

For calculation of accuracy Supervised classification was used based on ground station training data and knowledge. For the assessment of LULCC, the Landsat TM for 1996, Landsat ETM+ for 2008, and Landsat OLI TIRS for 2020 were analyzed. These were converted to vectors by using the conversion tool on ARC GIS 10.8. (Paudyal et al., 2017). These shapefiles were classified into six types of land used a system that is Water bodies, Human buildup, Barren land, Grassland, Sparse vegetation, and Dense vegetation area to detect the land-use change of Nepalgunj metropolitan by applying various colors contrasts to divide land use classes. The comprehensive land-use changes over time were calculated by applying geometric calculation.

In the process of identification of driving factors, the primary data regarding LULC changes drivers were gathered out through direct field observation, purposive household survey (N=140, sampling intensity 0.5%), key informant interview (N=15), and discussion of focus group (N=10) while the secondary data viz The land use dynamic and its different aspects of the numeric data analysis and interpretation were performed on Microsoft Excel.

Table 2. LULC classes used for classification

S.N	LULC Types	Description
1	Water bodies	River, lakeand Pond
2	Human buildup	Road, building, and other human-created infrastructure
3	Barren land	Sandy areas, exposed areas after soil erosion and landslides. Harvested agricultural land, Quality of soil is poor.
4	Grassland	Shrubland, bushes, Not harvested agricultural land
5	Sparse vegetation	Immature trees, degraded forests, urban planted trees
6	Dense vegetation	Not degraded and matured forest area

RESULTS AND DISCUSSION

Area Statistics of Temporal LULC

The use of Landsat TM image 1996, ETM^+ image 2008, and Landsat 8 image 2020 find out the major land use and land cover class change setting in the studied Sub- Metropolitan city. The image was classified as water bodies, human buildup, barren land, grassland, sparse vegetation, and dense vegetation area for the study years 1996, 2008, and 2020.

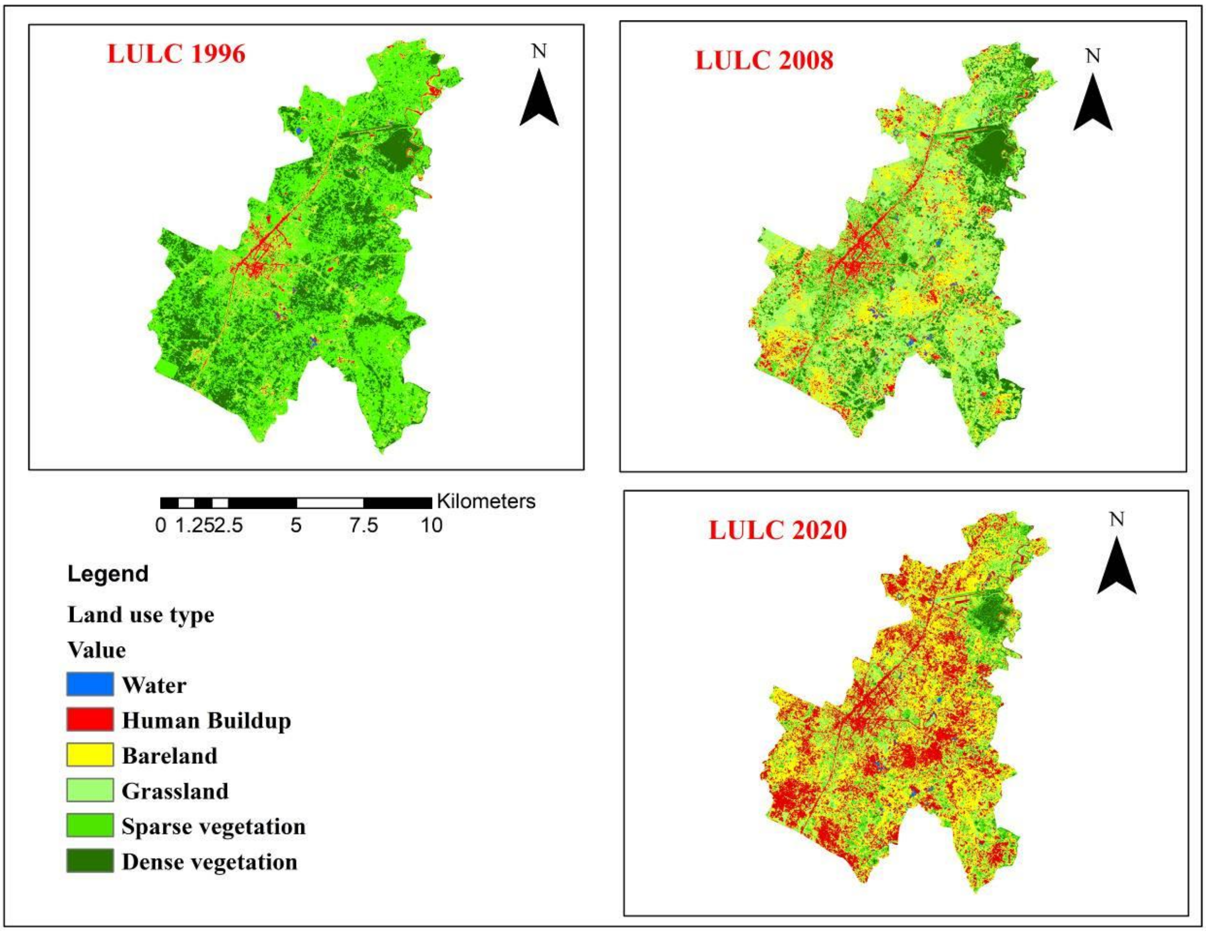

Figure 1. LULC map of Nepalgunj Sub Metropolitean

Table 3 Area Statistics of Temporal LULC

S.No	Land cover	1996		2008		2020	
		Area (Sq Km)	%	Area (Sq Km)	%	Area (Sq Km)	%
1	Water bodies	0.593055	0.69	0.5157	0.6	0.41256	0.48
2	Human buildup	2.5785	3	8.0793	9.4	25.785	30
3	Bareland	4.03965	4.7	18.0495	21	35.2395	41
4	Grassland	4.821795	5.61	35.2395	41	12.8925	15
5	Sparse vegetation	48.9915	57	12.8925	15	8.595	10
6	Dense vegetation	24.9255	29	11.1735	13	3.02544	3.52
	Total	85.95	100	85.95	100	85.95	100

The GIS satellite image, and its data analysis of the study area, find out that land use for Sparse vegetation was maximum at 48.9915 sq km (57%) area, followed by Dense vegetation at 24.9255 sq km (29%), Grassland area at 4.821 sq km (5.61%%), Bareland 4.03 sq km (4.7%), Human buildup 2.57 sq km (3%) and Water bodies 0.59 sq km (0.69%) out of a total land area of 85.95 sq km for 1996 A.D. Similarly, an analysis of 2008 A.D. figure out that the land-use change as in the sequences of Grassland 35.2395 sq km (41%), Bareland 18.04 sq km (21%), Sparse vegetation 12.89 sq km (15%), Dense vegetation 11.17sq km (13%), Human buildup 8.0793 sq km (9.4%) and Water bodies 0.51 sq km (0.6%). Likewise, Grassland 12.895 sq km (15%), Bareland 35.23 sq km (41%), Sparse vegetation 8.59 sq km (10%), Dense vegetation 3.023 sq km (3.52%), Human buildup 25.783 sq km (30%) and Water bodies 0.41 sq km (48%) were in 2020 A.D.

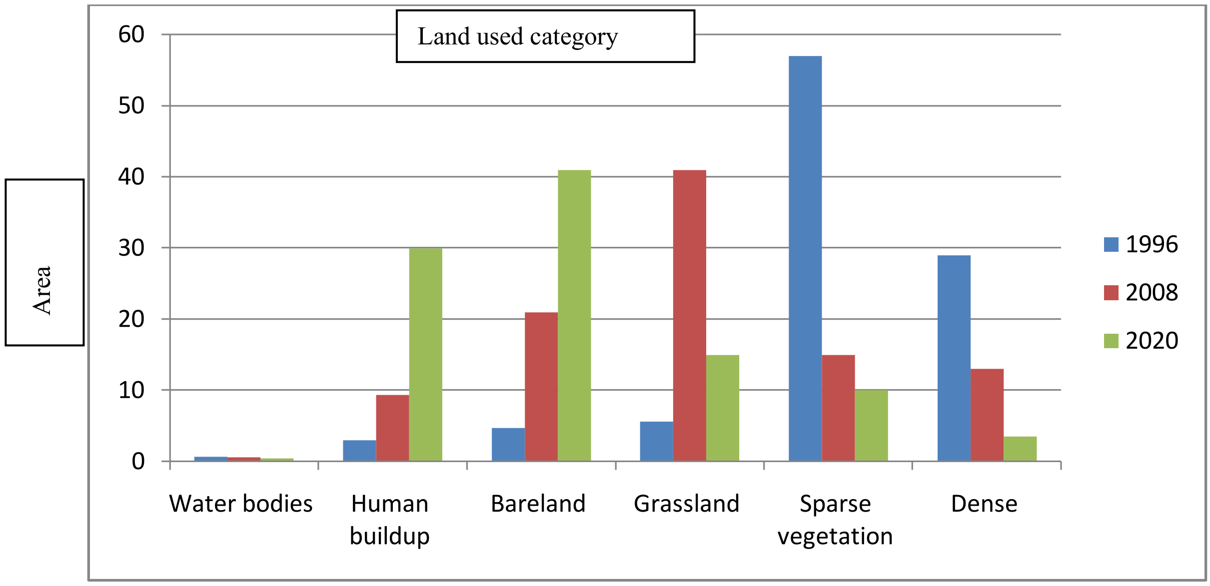

Figure 2. Land cover changes in different years

Temporal LULC Change Analysis

LULC change from 1996 AD to 2008 AD

During the 12 yrs, from 1996 to 2008 area of human buildup, bareland and grassland were increase whereas the area of water bodies and both sparse and dense vegetation decreased. The conversion of water bodies, human buildup, barren land, sparse vegetation, and dense vegetation is shown in table 4 and figure 3.

Table 4. Land cover change from 1996 to 2008

1996	2008 (Area in %)					
	Water bodies	Human buildup	Bareland	Grasland	Sparse vegetation	Dense vegetation
Water bodies	0.5	0.05	0.01	0.005	0.003	0.122
Human buildup	0.07	1.4	0.9	0.4	0.11	0.12
Bareland	0.005	2.7	1	0.3	0.45	0.245
Grassland	0.015	2.75	1.46	0.39	0.6	0.395
Sparse vegetation	0.003	1.8	12	18	9	16.197
Dense vegetation	0.007	0.7	5.63	21.905	4.837	4.079

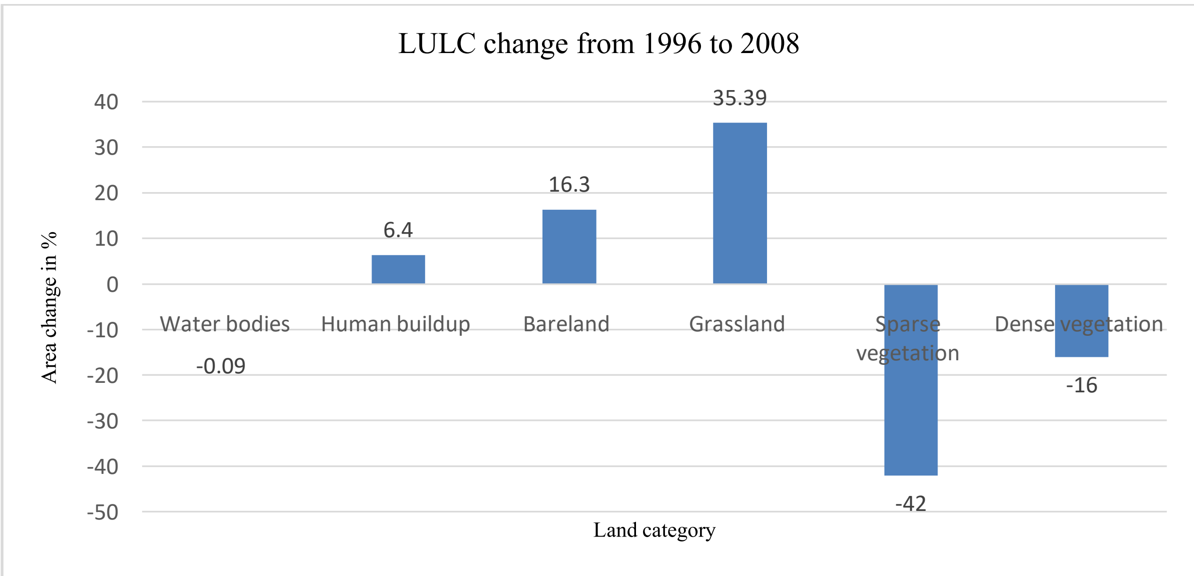

Figure 3 LULC change from 1996 to 2008

Here figure 3 show the change in area in % from 1996 to 2008 AD. Here negative value i.e downward orientation of water bodies, sparse and dense vegetation indicates mean increment is negative (i.e decrease in total area).

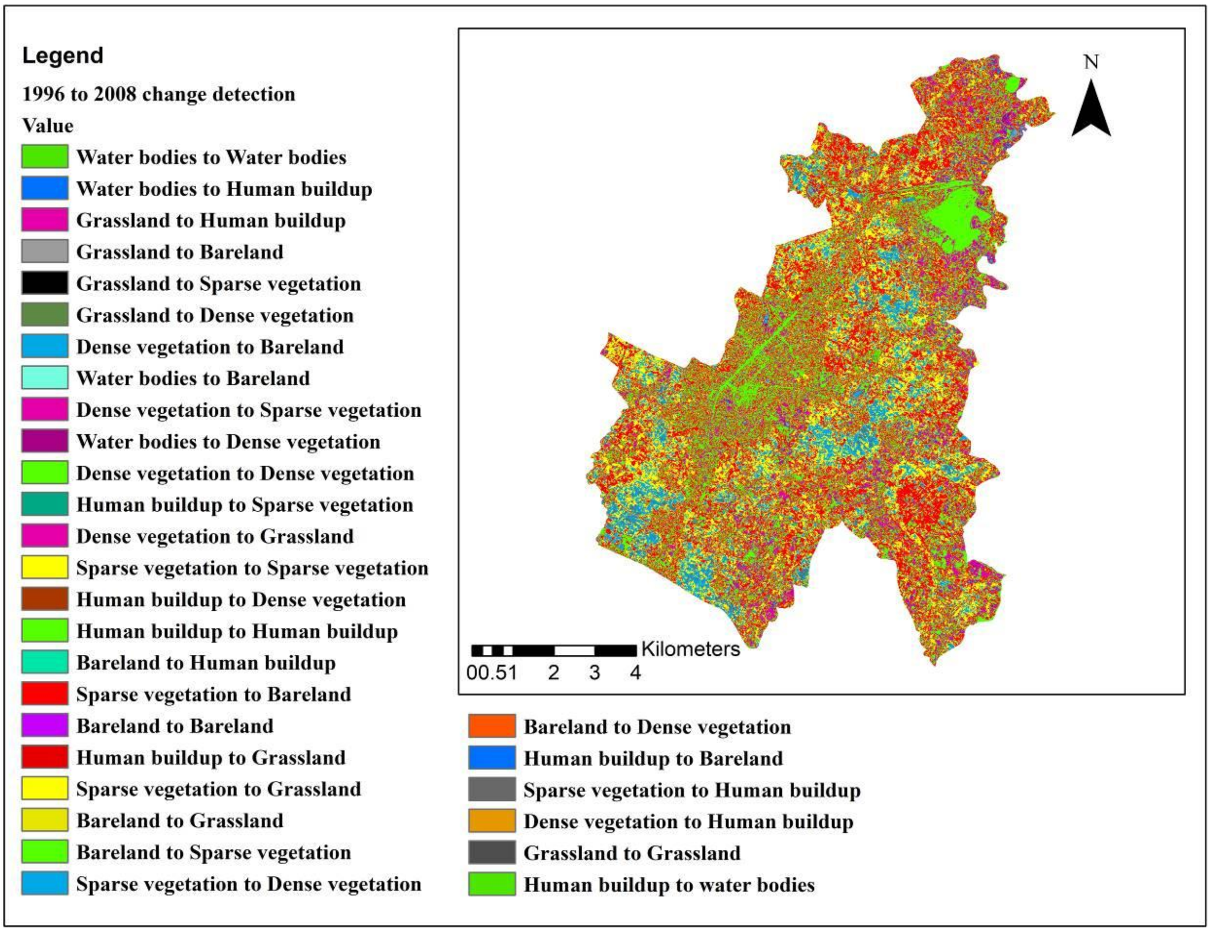

Figure 4: 1996 to 2008 land-use change

Here figure 4 illustrates detailed land use and the land cover change of Nepalgunj Sub Metropolitan city. Different colors were used to indicate each of the land cover changes. The comparison between land use maps of 1996 to 2008 showed the remarkable change in sparse vegetation area (-44.10%), Dense vegetation area (-17.82%), water bodies (-0.17%), Bareland (+13.34%), Human buildup (+5.07%) and grassland (+29.62%).

LULC change from 2008 to 2020 AD

During the 12 yrs, from 2008 to 2020 AD area of human buildup and bareland were increased whereas the area of grasslands, water bodies, and both sparse and dense vegetation decreased. The conversion of water bodies, human buildup, barren land, sparse vegetation, and dense vegetation is shown in table 5 and figure 5.

Table 5. LULC change from 2008 AD to 2020 AD

2008	2020 (Area in %)					
	Water bodies	Human buildup	Bareland	Grasland	Sparse vegetation	Dense vegetation
Water bodies	0.35	0.007	0.0046	0.108	0.027	0.1034
Human buildup	0.0005	8	0.3	0.023	0.67	0.4065
Bareland	0.003	6	7.89	2.68	2.497	1.93
Grassland	0.0025	8.9	14	11.343	6.473	0.2815
Sparse vegetation	0.004	1.37	12.2454	0.3	0.285	0.7956
Dense vegetation	0.12	5.723	6.56	0.546	0.048	0.003

There was decrease in grassland area (-26%), dense vegetation area (-9.48%), sparse vegetation area (-5%), water bodies (-0.12%), Bareland (+20%) and Human buildup (+20.6%) between 2008 to 2020.

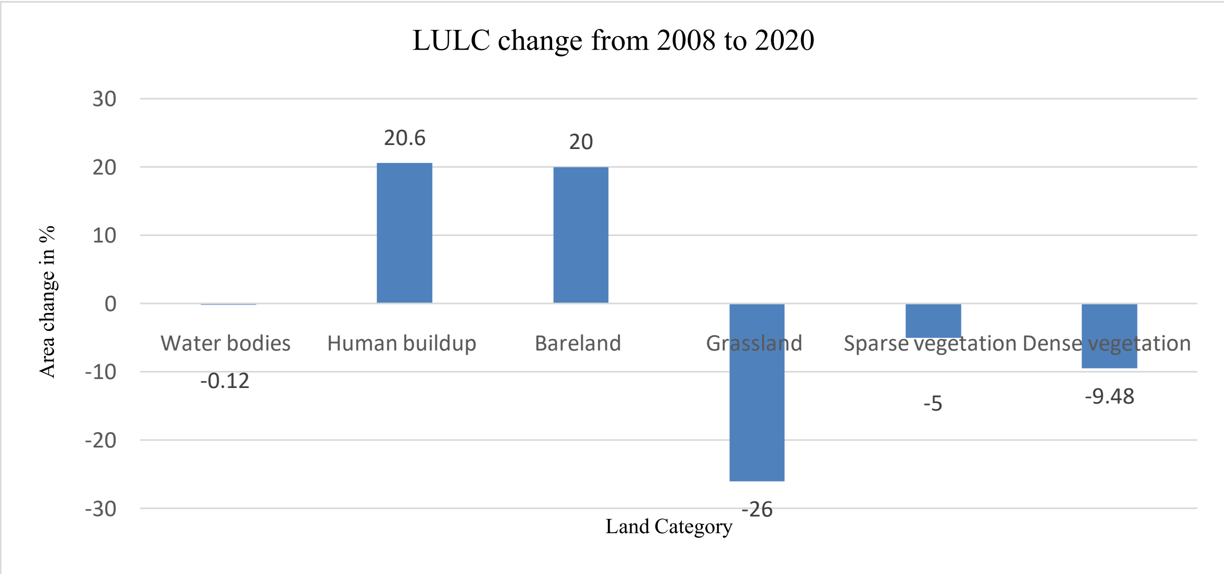

Figure 5. LULC change from 2008 to 2020

Here figure 5 shows the change in area in % from 2008 to 2020 AD. Here negative value i.e downward orientation of grassland, water bodies, and sparse and dense vegetation indicate mean increment is negative (i.e decrease in total area).

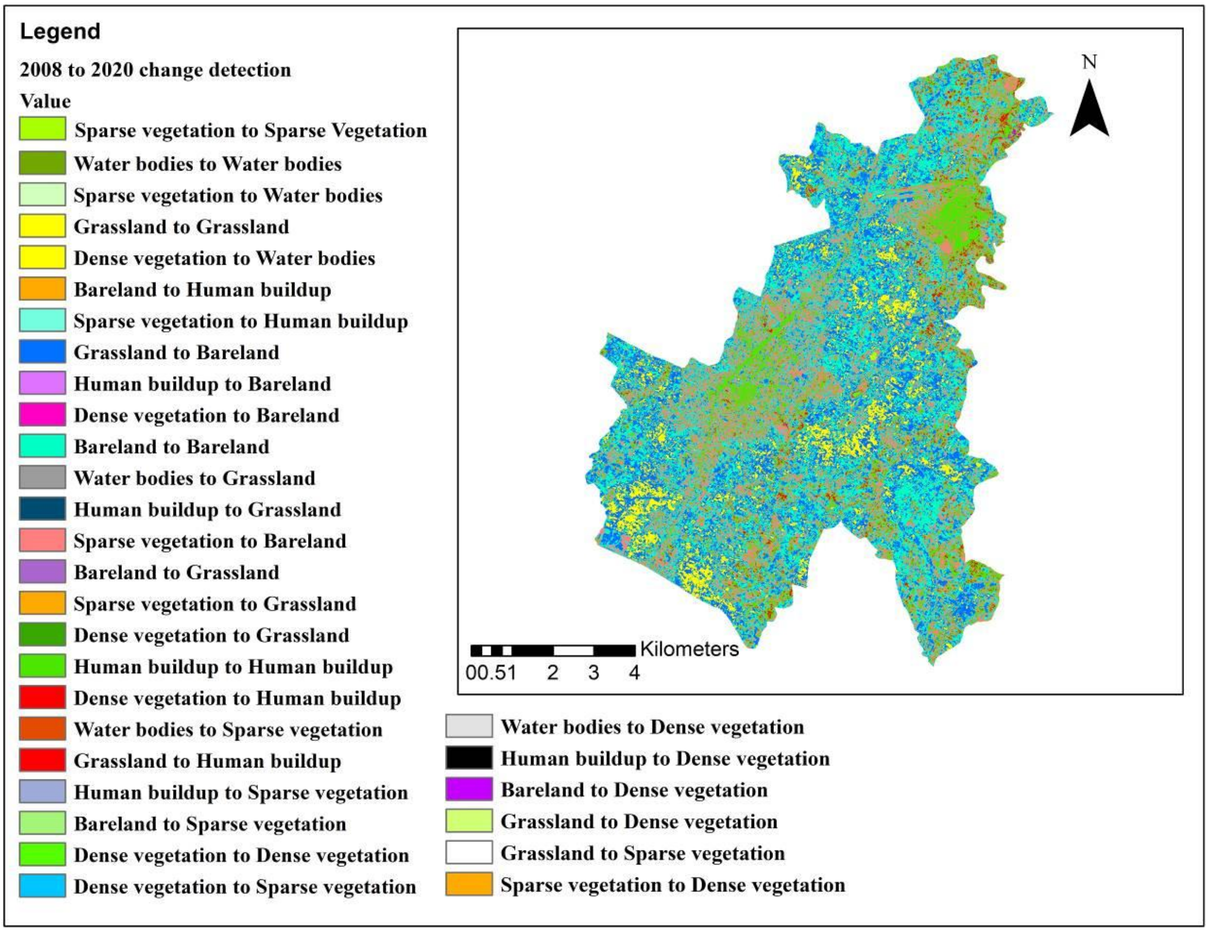

Figure 6. LULC changes from 2008 to 2020

Here, figure 6 illustrates detailed land use and land cover change in Nepalgunj Sub Metropolitan city. Different colors were used to indicate each of the land cover changes.

LULC change from 1996 AD to 2020 AD

The conversion of water bodies, human buildup, barren land, sparse vegetation, and dense vegetation from 1996 to 2020 AD is shown in the below table and figure. During the 24 years, area of human buildup and bareland were increased, grassland initially increased up to 2008 and then decreased whereas water bodies, dense and sparse vegetation area was continuously decreased from 1996 to 2020.

Table 6. LULC changes from 1996 to 2020 AD

1996	2020 (Area in %)					
	Water bodies	Human buildup	Bareland	Grasland	Sparse vegetation	Dense vegetation
Water bodies	0.36	0.05	0.03	0.16	0.06	0.03
Human buildup	0.03	1.87	0.21	0.18	0.39	0.32
Bareland	0.025	0.86	2.84	0.34	0.38	0.255
Grassland	0.023	3.8	0.6	0.72	0.372	0.095
Sparse vegetation	0.031	16	17.94	11.71	8.699	2.62
Dense vegetation	0.011	7.42	19.38	1.89	0.099	0.2

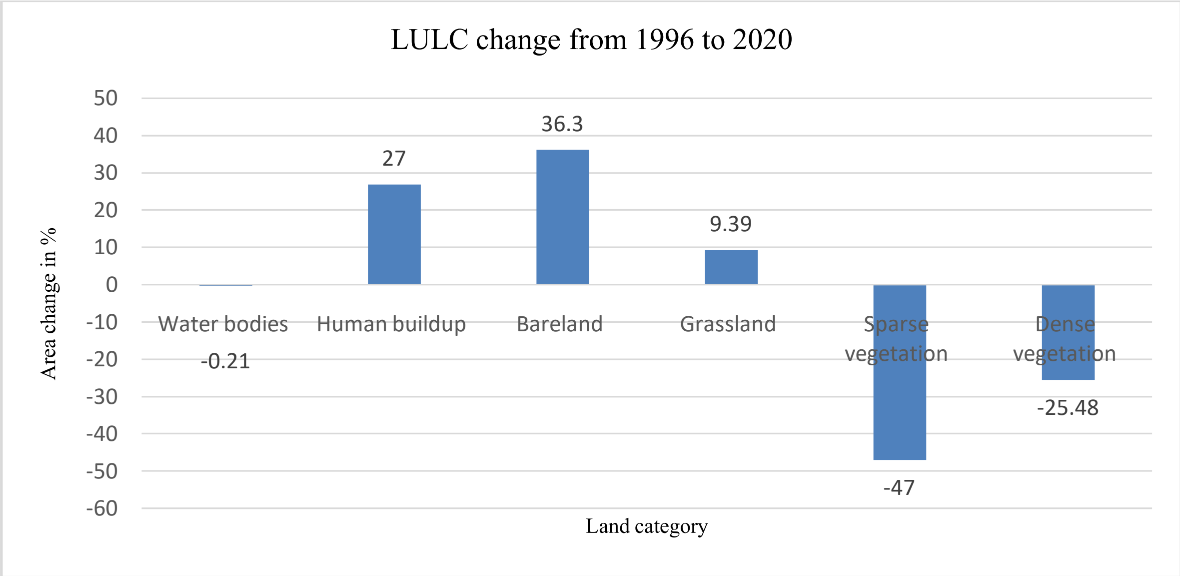

Figure 7. LULC changed from 1996 to 2020 AD

Here above figure 7 depicts the land used land cover changes from 1996 to 2020 AD. Here Upward orientation (Positive values) of Human buildup, Bareland, and Grassland indicate an increment of their area in comparison between 1996 to 2020 AD. Similarly, the area of Sparse vegetation and Dense vegetation decreased in 2020 AD in comparison to 1996 AD.

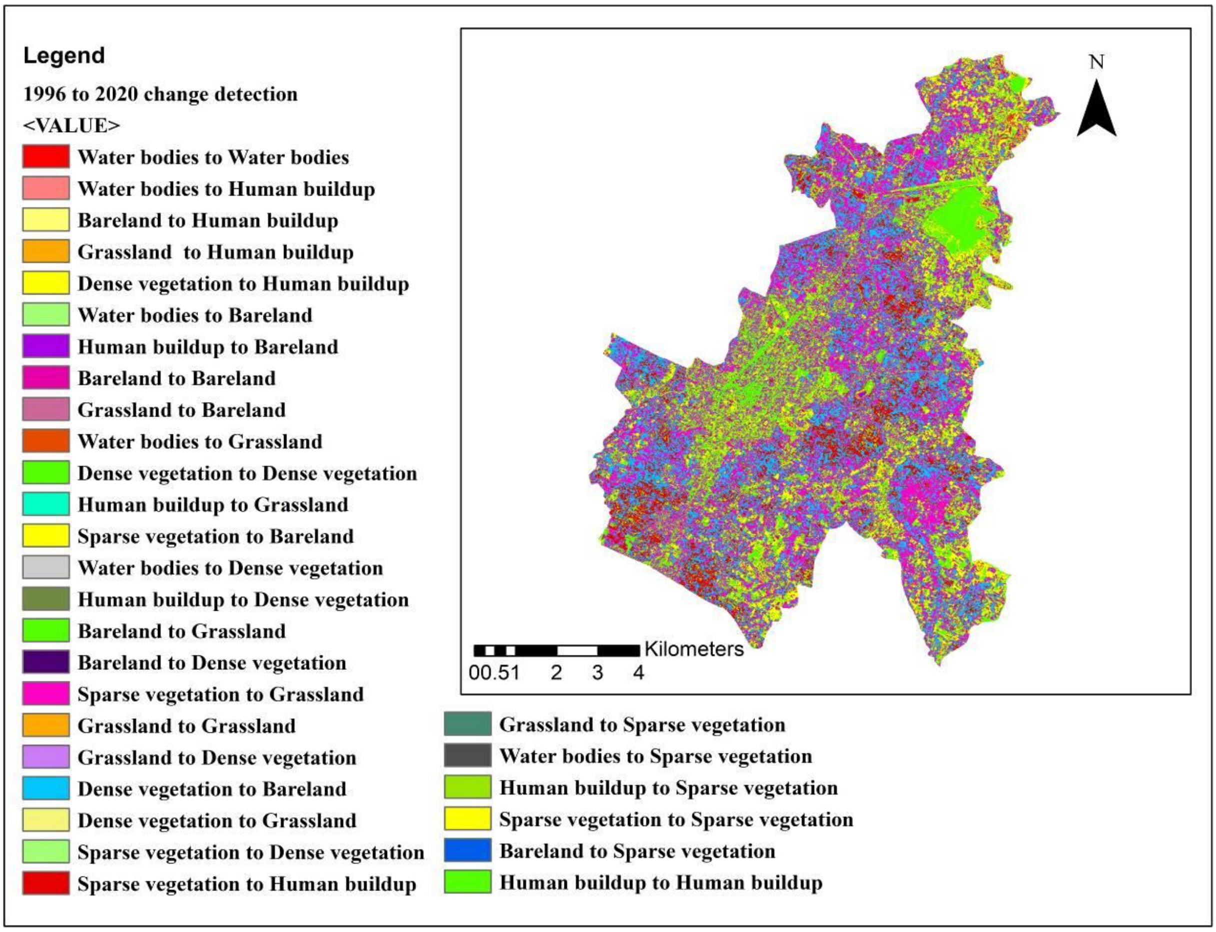

Figure 8. LULC change from 1996 to 2020

Here, figure 8 illustrates detailed land use land cover change from 1996 AD to 2020 AD of

Nepalgunj Sub Metropolitan city. Different colors were used to indicate each of the land cover changes.

Accuracy assessment

Altogether 155 (45, 55, and 55) ground truth positions were collected with the help of Google earth images for 1996, 2008, and 2020 AD respectively. The confusion matrix shows the accuracy in the classification of three different land use land cover maps of 1996 AD, 2008 AD, and 2020 AD. The LULC map 2008 AD shows the highest accuracy with an overall accuracy of (85.45%) followed by 84.44 % and 83.64% in 1996 and 2020 respectively. The classified image of 2008 shows the highest kappa value of 0.8497 followed by 0.8381 in 1996 and 0.829 in 2020 AD respectively. Since classified maps' Kappa value was within 0.81-1, they are perfect and meet the accuracy assessment.

(Note: According to Landis et al. 1977 considers 0-0.20 as slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1 as almost perfect. Fleiss considers kappa > 0.75 as excellent, 0.40-0.75 as fair to good, and < 0.40 as poor).

$$\text{OA in \%} = \frac{\text{Number of correct pixels} * 100}{\text{Total number of pixels}}$$

$$\text{UA in \%} = \frac{\text{Correctly classified pixels} * 100}{\text{Classified total pixels}}$$

$$\text{PA in \%} = \frac{\text{correctly classified pixels} * 100}{\text{Reference total pixels}}$$

$$K = \frac{P_0 - P_e}{1 - P_e}$$

Figure 9. The formula used for accuracy assessment

Where:

OA = Overall accuracy

UA = Users's accuracy

PA = Producer's accuracy

K= Kappa coefficient,

P_0=Proportion of correctly classified pixels

P_e=Proportion of correctly classified pixels by chance

(Bharatkar and Patel, 2013)

Table 7. Accuracy assessment of LULC map 1996 AD

MAP 1996/Ground truth	Water	Human buildup	Bareland	Grassland	Sparse vegeta	Dense vegeta	Total	UA(%)
Water	4			1			5	0.8
Human buildup		6	1				7	0.85714
Bareland		1	4		1		6	0.66667
Grassland			1	5		1	7	0.71429
Sparse vegeta		1			11		12	0.91667
Dense vegeta						8	8	1
Total	4	8	6	6	12	9	45	84.44%
PA(%)	**100%**	**75%**	**67%**	**83%**	**91.67%**	**88.89%**		

Table 8. Accuracy assesment of LULC map 2008 AD

MAP 2008/Ground truth	Water	Human buildup	Bareland	Grassland	Sparse vegeta	Dense vegeta	Total	UA(%)
Water	3		1				4	0.75
Human buildup		7	1	1			9	0.77778
Bareland			10		2		12	0.83333
Grassland				12	1	1	14	0.85714
Sparse vegeta					9	1	10	0.9
Dense vegeta						6	6	1
Total	3	7	12	13	12	8	55	85.45%
PA(%)	**100%**	**100%**	**83%**	**92%**	**75.00%**	**75.00%**		

Table 9. Accuracy assesment of LULC map 2020 AD

MAP 2020/Ground truth	Water	Human buildup	Bareland	Grassland	Sparse vegeta	Dense vegeta	Total	UA(%)
Water	2						2	1
Human buildup		10	2	1			13	0.76923
Bareland			14		2		16	0.875
Grassland		1	1	9	1		12	0.75
Sparse vegeta					7	1	8	0.875
Dense vegeta						4	4	1
Total	2	11	17	10	10	5	55	83.64%
PA(%)	**100%**	**91%**	**82%**	**90%**	**70.00%**	**80.00%**		

Major drivers for land-use change drivers

As per, the primary information obtained from the 140 respondents from the field illustrated in figure 10, the land-use change driving factors were related to past reactions and events of the respondents. According to respondents, the eight key drivers were recognized in the study area and they dependent on population growth (21.42%); infrastructure development (16.42%); government plans, policy, and land market (15%); forest encroachment (12.86%); forest and its products (10.71%); political condition (10.72%); economic opportunities (8.59%) and hotel and tourism activities (4.28%).

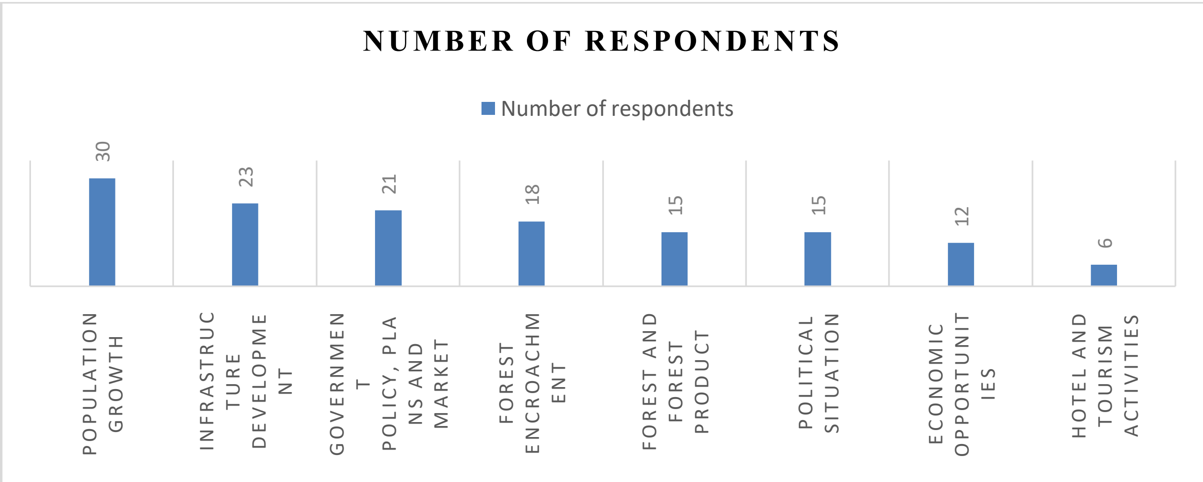

Figure 1. Number of respondents

In various wards, residents had been involved in the production of alcohol and its related activities due to livelihood limitations. This needed a huge quantity of firewood and was considered the major driver of deforestation. In Nepalgunj sub-metropolitan city, the study find out that key factors for change in land use were different socio-economic related phenomena, i.e. population growth, development of infrastructure, government plans, policy, land market, forest encroachment, economic opportunities in different sectors, industry, health, finance, etc. The change in the land pattern was found interlinked with forest and its products (timber, NTFPs, and firewood), unsustainable and not the legal practice of harvesting, population growth, politics, encroachment, governmental policies and plans, massive land plotting and its market, resettlement, development of infrastructure, excessive grazing, and technology. A large number of households in past i.e during 1996 and 2008 A.D. were largely dependent directly on forest products for the major source (firewood and timber). Besides, local people used excessive timber as a source of construction work, which consequently reduced the forest cover area. In present days i.e 2020 AD population increment was considered one of the major drivers of change in land use. Lots of people migrated from the hills sides of Karnali province to settle in the city area. Besides, due to the growth of the land market, large and uncultivated cultivated lands and open fields had been plotted and sold into small pieces.

A similar type of study done in the Dang district by Kc (2019) shows that the dense vegetation was decreasing at the rate of 0.2% per year. Another study done in the Chitwan district between 1976 and 2001 by Panta et al (2008) shows that there is a loss of forest cover at the rate of 0.6%. Similarly, another study done by Bhattarai and Conway(2008) in the Bara district of Nepal found that there is forest cover loss at an annual rate of 0.72%. The present study also shows that there is a loss in dense vegetation. Increase in the human buildup. There is an increment in the human build-up from 1996 to 2020 by 27%. A similar type of study done by Bist et al (2021) in the Mohana watershed observed the trend of increment in the human build-up. Nepalgunj is the major commercial hub of the Lumbini Province and Karnali Province so, many people from rural areas had migrated to urban areas. Internal migration and population growth are the main causes for the increment in buildup areas. Kc et al (2017) observed that migration plays important role in LULC change. According to the Central Bureau of Statistics (2011), the population density of Nepalgunj was 1561 (person/sq. km). Rapid urbanization is responsible for the conversion of densely vegetated areas into build-up areas (Wang et al., 2020). This has increased the human build from 1996 to 2020. Wang et al (2020) in their study found that there was an increment in grasslands indicating that forest lands are being degraded and replaced by grasslands. Our study also reveals that there was a huge increment in grassland from 1996 to 2008 but the increment rate was slightly decreased from 2008 to 2020. The decrease in grassland from 2008 to 2020 is due to rapid urbanization and increment in human-built up as mentioned above. Our study reveals that water bodies had slightly decreased from 1996 to 2020. Attri et al (2015) observed that the influence of economic upliftment and population growth were the key factors for the LULC change in watershed. The decrease in water bodies may result in various problems such as lack of drinking water, and polluted water with negative effects on the water ecosystem.

Regmi et al (2020) in the Phewa watershed also observed that foreign employment, soil erosion, road construction, and excessive use of chemical fertilizer were the reasons for the increment of barren land. The study done by Regmi et al (2020) and Bist (2020) has found that population growth, road construction (infrastructure development), and migration are major drivers of the LULC change. The studies were done by Ishtiaque et al (2017), Khanal et al (2019), and Paudel et al (2016) reported that rapid urbanization and lack of strengthing policies governing land conversion were also the drivers of LULC. Pandey et al (2016) suggest that encroachment, illegal harvesting, infrastructural development, population growth, forest grazing, and forest fire are the main drivers of LULC change. Our study also has similar findings to theirs. According to the local respondent, the main driver of LULC change is population growth (21.42%) followed by infrastructural development (16.42%), government policy, plans and land market (15%), forest encroachment (12.86%), forest and forest product (10.71%). Hotel and tourism activities (4.28%) have less impact on the LULC change.

CONCLUSION

The assessment of LULCC and its associated drivers was carried out through social survey techniques and geospatial tools. The application of temporal satellite imageries is cost as well as time-effective. It is quite useful in the LULC maps generation and detection process. There was a drastic change in LULC in Nepalgunj sub-metropolitan city during the study periods (1996 to 2008 and 2008 to 2020). Bareland, Human buildup, and grassland were found to have increased by 13.34%, 5.07%, and 29.62% respectively while sparse vegetation, dense vegetation, and water bodies were found to have reduced by 44.10%, 17.82%, and 13.34% respectively between 1996 and 2008. Likewise, there was decrease in grassland area (-26%), dense vegetation area (-9.48%), sparse vegetation area (-5%), water bodies (-0.12%), Bareland (+20%) and Human buildup (+20.6%) between 2008 to 2020.. Approximately eight key drivers have been recognized in the study area that induced the land cover changes and creates a risk to the available land resources. The examined land use and dynamics will aid in making decisions to mitigate this dramatic land cover shift in this Metropolitan city.

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