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Illustration of Rapid Urban Growth in Surkhet Valley of Nepal via Land Use and Land Cover Dynamics

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Abstract

Surkhet Valley hosts Birendranagar City which is the capital of Karnali Province of Nepal and there is a rapid change in the landscape of this valley. This change can be attributed to its designation as an administrative capital and the leading economic center of the province. Thus, this study aimed to observe the changing land use and land cover (LULC) patterns of Surkhet Valley. Object-based image analysis was carried out for image classification for Landsat images of years 1989, 1999, 2009, and 2019. Key findings, for the area of 103.15 km^2 Surkhet Valley, showed decreasing area of cultivated lands and increasing spatial coverage of built-up areas. The cultivated lands that measured 42 km^2 for the year 1989 had plummeted to just 28.23 km^2 in 2019. On the other side, the area covered by built-up class was only 1.16 km^2 in 1989 which rose to 15.41 km^2 in 2019. The changes in LULC coverage of other classes such as forests, shrub/grassland, sand, and water were negligible. The rate of change in the area of LULC classes built-up and cultivation was near but in the opposite direction. Built-up had an increasing rate of 0.49 km^{2}year^{-1} while cultivation area had a decreasing rate of -0.46 km^{2}year^{-1}. When the built-up area of 2019 was compared to the base area of 1989 it had a gain of 1270.46% indicating its rapid growth in the past three decades. These reflected an increasing trend in spatial coverage of built-up areas indicating rapid urban growth.

1. Introduction

Urbanization is invariably linked to development in contemporary urbanization (Menashe-Oren & Bocquier, 2021). As the economic development of the world has increased due to excessive industrialization, the world population has also increased significantly. Now, a higher number of people are moving to cities in search of livelihoods and ease of access to services. This flocking of people to cities leads to urbanization. The definition of urbanization can be pertained to three concepts population growth, increase in the built-up area of cities, and the modification in the lifestyles of urban people. Growth and development of industrialization, modernization, and globalization are accompanied by changes in population, society, economy, culture, politics, and ideology (Chaolin, 2020) leading to urbanization. Many scholars have argued that urbanization reflects changes across entire societies and is a multidimensional reflection of physical, spatial, institutional, social, economic, and population characteristics.

Besides, there are lots of issues associated with urbanization when it is unplanned. Urbanization increases environmental degradation significantly in Pakistan, Bangladesh, Sri Lanka, and Nepal (Qayyum et al., 2021). Unplanned urban development leads to a deficiency in waste management which will exacerbate pollution in the environment of the urban area (Sarker et al., 2021). A decrease in vegetation in the city area as in Kolkata of India (Chatterjee & Majumdar, 2022) and Kathmandu Valley of Nepal (Shrestha & Acharya, 2021) can alter the microclimate of the urban area and the periphery. The shift in land use pattern in the current decade can be attributed to accelerated urbanization which builds at the expense of agricultural land (Ning et al., 2023). Many studies suggest that urban expansion intensified urban problems including urban heat islands and climate change (Wang et al., 2021). The natural landscape has been reduced by the encroachment of urban pavement surface (Mallick et al., 2023) which in turn introduces issues of waterlogging and sewage issues. Addressing such issues in advance needs the research of activities in the past, present, and future of an urban area so that urbanization information could be incorporated into planning.

The United Nations took 2007 as a milestone event as the number of the population residing in urban areas overtook the number in rural settings estimated the milestone event occurred in 2007 (United Nations DESA, 2018). Over 4 billion people were living in urban areas in 2017 indicating that over half of the world's population are residents of urban settings. More than 80% of the population live in urban areas across most high-income countries whereas 50% to 80% of people do so across most upper-middle-income countries but in many low to lower-middle-income countries, the majority still live in rural areas (Ritchie and Roser, 2018). The Pan-Third Pole's average urbanization rate increased to 57.7% in 2014 as compared to 28.1% in 1961 (Feng et al., 2021). In South Asia, Nepal is one having a higher population growth rate of 1.72 after Afghanistan (2.24) and Pakistan (1.84) for 2020-2025, and an urban growth rate of 3.9 (United Nations DESA, 2018). This urban growth rate is the highest among Asian nations. The population growth by migration from surrounding areas (Rai et al., 2020) is a major reason for urban growth but in Nepal, ad-hoc political decisions were keys to incorporating rural areas into municipal boundaries (Bhattarai et al., 2023) to depicting higher urban population. Such activities resulted in a population jump in the total urban population from 17.1 % in 2011 to 23 % in 2014 and 66.08 % in 2017 (Bhattarai et al., 2023). The real urbanization in Nepal was observed around nodes of the road network or at the historical trade routes (Pokharel et al., 2021). Cities like Pokhara and Bharatpur saw built-up area increments of 300% to 500% (Rai et al., 2020).

Urbanization has accelerated, especially in the capital cities of developing countries (Wang et al., 2021). Such cities are well-developed and can invest more resources in planning and management which is difficult for developing/new cities (Zhang et al., 2022). The research in urbanization also mostly revolves around capital cities or large cities that play a crucial role in attracting resources for the management of urban issues. The paucity of research on urban growth in newly urbanized areas like Surkhet Valley persuaded to conduct this research. The timely build-up of the knowledge product should support tackling the challenges to be faced during the process of urbanization.

Surkhet Valley, in the Siwalik Hills of southwest Nepal, is a Doon Valley and core part of Birendranagar Municipality. Most urban area of the municipality is situated in the center part of this valley. Birendranagar Municipality gained headquarter status of the Karnali Province in Nepal after changes in administrative policies and the reformation of political boundaries. This provincial capital is a major hub of trade and commerce (Shrestha & Rijal, 2017) in the region and possesses connectivity to the major towns of neighboring provinces with land and air transportation. The status of the capital city, nearness to other major towns of the country, the development of infrastructures, and having services/facilities played vital roles in the immigration of people from surrounding villages, towns, and places of distant locations to this place. The National Urban Development Strategy, drafted by the Ministry of Urban Development (MoUD), Government of Nepal, had identified Birendranagar Municipality as one of the fastest-growing urban areas of Nepal (MoUD, 2017). The population database of the Central Bureau of Statistics (CBS) of Nepal showed a population growth of 621% from 1981 to 2015 in this Municipality, but for the same period, the population growth of the Surkhet District was only 133%. With this growth of population, the urban built-up area had also been expanded simultaneously. In the monsoon of 2014 some buildings constructed over dry river beds were flooded (Nepal Disaster Report 2015) showing the evidence of disorganized built-up developments and haphazard urban growth. Preventing such disorderly urban growth necessitates timely research on urbanization patterns and the incorporation of such findings into planning.

Research, regarding the urban growth in Nepal (Ishtiaque et al., 2017; Karna et al., 2013; Rimal et al., 2017; Thapa & Murayama, 2009), are mostly focused in country's capital city and its adjoining towns that make Kathmandu Valley. These researches focused on land use and land cover (LULC) changes, their patterns, and trends. These analyses cannot tell the overall urban-growth situations of Nepal as five of the seven highly growing municipalities having growth rates of above 5% were outside Kathmandu Valley (MoUD, 2017). These rapid growth of towns and the lack of research in urbanization outside Kathmandu Valley necessitates this research urban growth of Surkhet Valley. As Surkhet Valley holds one of the rapidly growing Birendranagar City, the research of tracking past land use dynamics becomes vital and the knowledge of which would be applicable in sustainable urban planning and managing current environmental issues born from urbanization. Thus, the main purpose of this research is to determine the LULC patterns over different decades and to know how the built-up area has been growing.

2. Data and Methods

2.1. *Study Area*

The research site for this study is shown in Figure 1. The area encompasses Surkhet Valley located in Birendranagar Municipality of western Nepal. The area of this valley was 103.15 km2. The climate here resembled that of tropical to subtropical in nature with an annual average temperature of 21.47°C annual average rainfall of 1609 mm (Bhandari, 2013). The major city area is located in the central part of the valley, the northern part of the valley is occupied by forests, and the southern part has cultivated lands. Water from this valley is drained into the Bheri River located in the South.

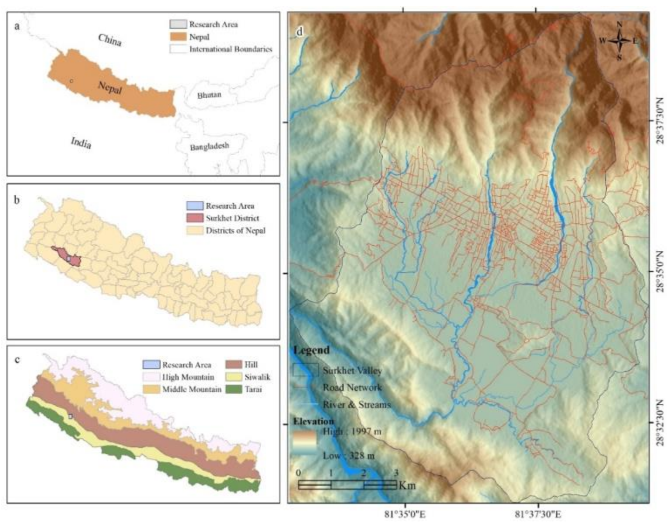

Figure 1. Location of Research Area in a) South Asia, and b) Nepal (districts), with c) Physiography, and d) Details of Elevation, road, and Streams

2.2. *Datasets*

The primary datasets used for this research were images of Landsat Satellites of different periods. Images from Landsat are freely available and have a long history of imaging from the 1970s. As this research aimed to observe LULC change from the past three decades, images from Landsat 5 (TM), Landsat 7 (ETM+), and Landsat 8 (OLI) were accessed. The Visible bands and Near-Infrared of these satellites are almost in the same range of 0.45 – 0.69 μm and 0.76 - 0.90 μm respectively, which makes possible for comparisons in different temporal dimensions. The path/row of the image scenes for this study area were 143/40 and 144/40. The images used were level 1 terrain precision correction (L1TP) datasets from the years 1989, 1999, 2009, and 2019 that were acquired making a temporal resolution of 10 years. Secondary data sources available from the Department of Survey (DoS) were also acquired which were used during the validation of LULC papered

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from the Landsat images. The datasets included past land-use maps and topographic maps. Some LULC maps were validated using Google Earth imagery as some of the historical imageries available from 2000 AD to present times. Figure 2 indicates the research steps.

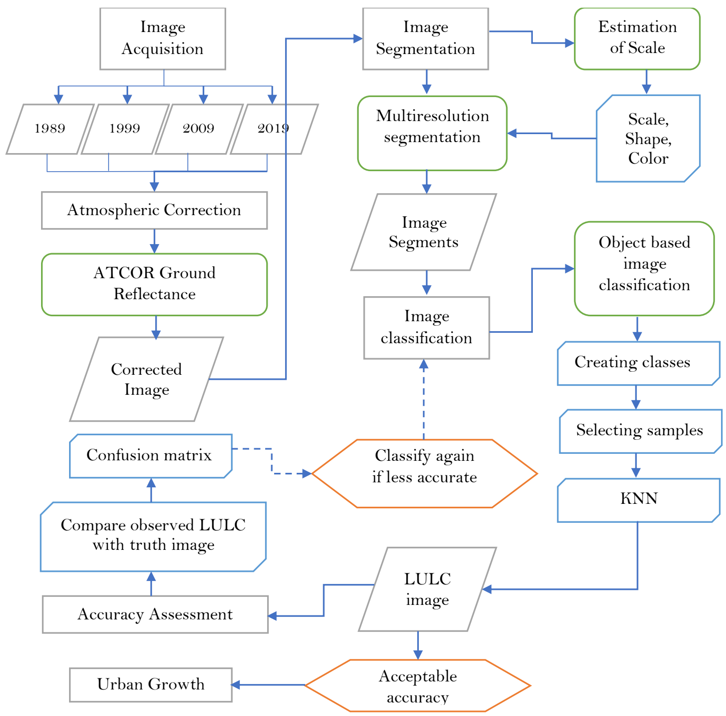

Figure 2. Flow Chart of Methods Applied in LULC Classification of Landsat Images

2.3. Method for LULC Classification

LULC classification in this research was based on Object-based image analysis (OBIA) (Hay & Castilla, 2006). Before analysis these images were atmospherically corrected in the ATCOR atmospheric correction module available in PCI Gematica 2016. The method of OBIA provides better classification results with higher accuracies (Shrestha et al., 2022). The OBIA for image classification involves two steps: image segmentation and object classification.

First, an image was segmented into objects representing a relatively homogeneous group of pixels by selecting the desired scale, shape, and compactness criteria (Cheng & Han, 2016). The Estimation of Scale Parameter (ESP) tool (Drăguţ et al., 2010) determined 3 as suitable scale values for Landsat images having 30 m spatial resolution. Similarly, during image segmentation shape and compactness values were considered as 0.1 and 0.3 respectively which were determined after numerous iterations. The image segmentation process was carried out in eCognition software with the above parameter and values. The segmented image consisted of image objects/segments/regions as basic units that were considered for the classification procedure.

The second step was the classification of objects, from a segmented image, for which a k-nearest neighbor (KNN) algorithm available in eCognition was used. KNN is a supervised classification method. In this classification, the segmented image was classified into six classes. Those six classes were built-up, cultivation, forest, shrub/grass, water, and sand. Training samples were selected from the objects based on the field knowledge and the image bands behind the objects. Image classification was done separately for the years 1989, 1999, 2009, and 2019.

The results of image classification were compared with geographically-true data collected from sources like topographic sheets, and Google Earth images of different times and field surveys for accuracy assessment. The comparisons were developed into an error matrix which provided classification accuracy and characterized the error (Foody, 2002). With the help of this error matrix table different accuracies like producers' accuracy, users' accuracy, and overall accuracy were estimated along with the Kappa coefficient. Accuracy assessment was done for the years 1989, 1999, 2009, and 2019 separately. When the accuracy was found lesser the classification process was repeated for LULC by changing or increasing the number of training samples. Once the acceptable accuracies of LULC maps were obtained then they were used in change detection.

2.4. Method for LULC Change and Urban Growth

The image classification produced the spatial coverage of each LULC class in the Surkhet Valley at different times. Here changes in each LULC category were compared to produce accumulated/declined areas, trends of change, and rate of change in each LULC category.

The area of each LULC class was plotted against the year as a line graph. This showed the trend of whether the area of LULC class was increasing or decreasing in the span of three decades. Secondly, a stacked bar diagram was plotted for the changes that occurred in each decade of each LULC class. This depicted whether the amount of area was gained or lost from a particular LULC class. Also, the change rate for a particular LULC class was estimated as the ratio of the changed area between two dates to the period between those two dates. For example, if a LULC class had area A in the prior time at year 1 and area B in the latter time at year 2 then thechange rate would be estimated as:

Change rate for LULC class=(area B-area A)/(year 2-year 1)

The unit of such change rate would be km^2yr^{-1}. The positive sign of the change rate would imply an increasing rate (growth rate) and negative sign of the change rate would indicate a decreasing change rate. This change rate can also be expressed in percentages when multiplied above equation by 100.

The change map was created to express the spatial growth of urban areas and the decline in the agricultural lands for Surkhet Valley. A post-classification comparison was done to know the sources of LULC that were converted into built-up classes.

3. Result and Discussion

3.1. LULC Classification

The classification produced spatial coverage of six LULC classes namely, built-up, cultivation, forest, sand, shrub/grassland, and water for each year 1989, 1999, 2009, and 2019 as represented in Figure 3. The total area of Surkhet Valley is 103.15 km^2 and the area covered by each LULC class is presented in Table 1.

In the year 1989, most of the area in Surkhet Valley was occupied by forest and cultivated lands. Forests and cultivation had areas of 42 km^2 and 49.5 km^2 respectively. The area of the built-up portion was only 1.16 km^2 at that time. Similarly, sand-covered areas and water bodies measured very less. After a decade in the year 1999, the area of built-up experienced a slight increase whereas there was a decrease in LULC classes of cultivation and shrub and grassland. The increase in built-up area is visible in Figure 3. The area had been increased from 1.16 km^2 to 3.30 km^2 in the span of 10 years. The area of cultivated lands had been reduced by almost 2%. The cultivationThe cultivation area in 1999 measured 39.83 km^2. For the year 1999, we can see that almost half of the research area is covered by forest with an area measuring 51.54 km^2. Coming to year 2009, there was not much change in forests and shrub/grassland LULC classes as we compare to that of 1999 but major alterations were observed in built-up and cultivation. The area of built-up had increased whereas the cultivated lands appeared to be reduced further. Devkota et al. (2023) also found Birendranagar City (Surkhet Valley) to be replacing agricultural lands with impervious urban lands. The built-up area had increased by 53.15% in 10 years from 1999 to 2009. The area of cultivated lands had a decadal decrease of almost 4%. Again for the year 2019, it can be observed that the forest, cultivation and built-up area were the major LULC classes that experienced the changes. Each of them had occupied 49.06, 27.37, and 15.4 percentages of total area respectively.

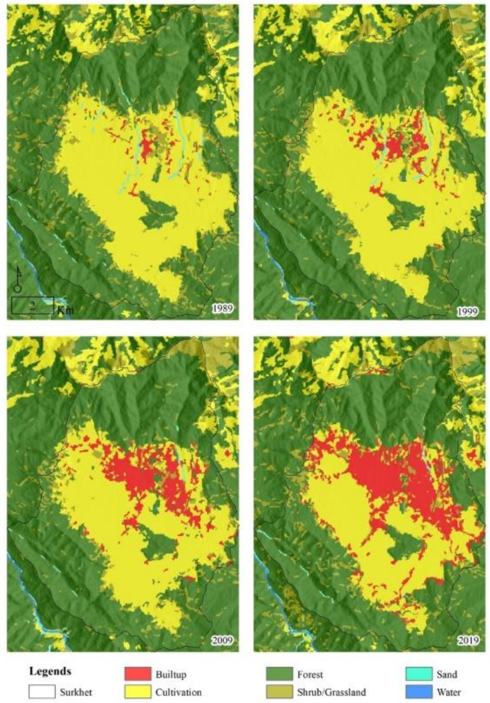

Figure 3. LULC Classification Outputs for Years 1989, 1999, 2009, And 2019

Table 1. Area of LULC Classes for the years 1989, 1999, 2009, and 2019

LULC	Area of 1989		Area of 1999		Area of 2009		Area of 2019	
	km²	%	km²	%	km²	%	km²	%
Built-up	1.16	1.13	3.30	3.20	8.61	8.35	15.90	15.41
Cultivation	42.00	40.72	39.83	38.61	35.75	34.66	28.23	27.37
Forest	49.50	47.99	51.54	49.96	50.99	49.43	50.61	49.06
Sand	1.02	0.99	0.57	0.55	0.21	0.21	0.30	0.29
Shrub/grassland	9.45	9.16	7.89	7.65	7.56	7.33	8.08	7.84
Water	0.01	0.01	0.03	0.03	0.02	0.02	0.03	0.03

3.2. Accuracy assessment

Table 2 shows the accuracy assessment for LULC classification of each year from 1989 to 2019. For year 1989 overall accuracy was 86.39% with kappa coefficient of 78.39%. Similarly, the overall accuracy and kappa coefficient for year 1999 was 89.44% and 83.23% respectively. It can be noticed in Table 2 that the LULC classification is getting more accurate in following years. In the year 2009 the overall accuracy and kappa coefficient were 90% and 84.57% respectively. Highest accuracies were obtained for LULC classifications of year 2019 where overall accuracy was of 91.39% and kappa coefficient was of 86.66%. The accuracy results are higher in present LULC classification approach than in Rijal et al. (2018) where overall accuracies for classifications were between 83 and 86 percentages for Birendranagar City who had used maximum likelihood classification (MLC). The MLC adopted by Twayana et al. (2020) is also no more than 86.82%.

Table 2. Accuracy Coefficients of LULC Classification for the year 1989, 1999, 2009, and 2019

LULC	1989	1999	2009	2019
Overall Accuracy	0.8639	0.8944	0.9000	0.9139
Kappa coefficient	0.7839	0.8323	0.8457	0.8666

Research area presented in this study matches to that of Rijal et al. (2018) though their research was carried in slightly different perspective linking urbanization to the impacts of flooding. LULC classes in both the studies were primarily same, major being built-up, forests, cultivated lands, and shrub/grasslands. The area of LULC class with main emphasis i.e., built-up, was found to be 0.85, 1.13, 5.84, and 6.5 km² for the year 1989, 2001, 2011, and 2016 in Rijal et al. (2018). Results of built-up LULC class from present research were slightly different and it measured 1.16, 3.30, 8.61, and 15.90 km² for the years 1989, 1999, 2009, and 2019. The extent of built-up area for the same or near-same years were estimated greater in this research. This difference in the results can be attributed to different classification approaches used in each studies as present research had used object based classification rather than the pixel based classification of past research. However the trend of built-up area is increasing in both the studies but the present study reveal higher urban growth.

In Rijal et al. (2018) the cultivation land of 70.05 km² in 1989 (28.5%) was decreased to 60.05 km² in 2016 (25.30%) and forest area estimated as 137.03 km² in 1989 (55.74%) was decreased to 133.42 km² in 2016 (54.39%). In this research, Surkhet Valley was occupied by 49.5 km²of cultivated lands in 1989 (40.72%) and this was reduced to 28.23 km² in 2019 (27.37%). Similarly, forests coverage was 42 km² in 1989 (47.99%) and was increased to 50.31 km² (49.06%) in 2019). Form these observations, it can be determined that decrease in cultivated lands was greater than decrease in forested areas but it is not sure which of these decrease was converted into, and caused increase in, built-up area since change analysis was not done. As the cultivated lands were decreased in three decades built-up area had been increased but there was very little change in forest area. While most of the croplands of core valley altered into concrete covered areas, some of the cultivated lands in northern hilly areas were converted into forested areas (Devkota et al., 2023). So, the major changes in cultivated lands and built-up area can be related by reverse relation and can be said that conversion of crop fields into urban area was observed in Surkhet Valley. This was further clarified by change detection conducted which is shown in Table 3.

Similarly, when the result of present study for Surkhet valley when compared to the findings of Birendranagar and Kathmandu in Figure 4 shows some interesting results. The share of built-up area at latest time was lesser in Rijal et al. (2018) than from this study. Also, the share of built-up area in Surkhet valley from present research and in Kathmandu valley (Rimal et al., 2017) was quiet similar indicating the rapid urban growth in capitals (Ishtiaque et al., 2017; Rijal et al., 2018).

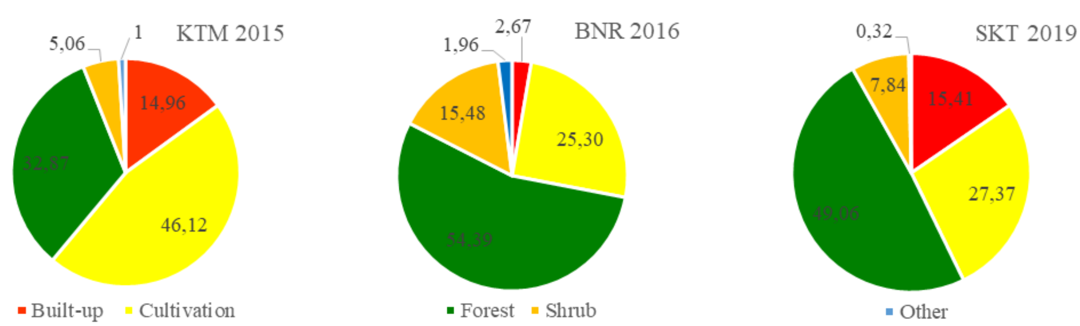

Figure 4. Comparison of LULC Classes (in percentages) from Birendranagar Municipality (BNR 2016 from Rijal et al. 2018), Surkhet Valley (SKT 2019 from present study), and Kathmandu Valley (KTM 2015 from Rimal et al. 2017)

3.3. LULC Change and Urban Growth

Total spatial coverage of each LULC classes presented in Table 1, from years 1989 to 2019, were plotted in line graph as shown in Figure 5 to represent the trend of change for particular LULC over the decades. From the line graphs it is obvious that in three decades much of the changes had occurred in cultivation and built-up area. The former LULC class continued decreasing while latter one was increasing steadily. Total coverage of cultivation land was 40% at the beginning of year considered in this and this share was decreased to near 27% at 2019. On the other side the built-up area, that covered an area of only about 1% in the year 1989, had increased and reached near 15% of total area at the end of 2019. So, for 3 decades the cultivated lands were decreasing at rate of 0.45% per year or it can be said that cultivation lost 0.464 km^2 of its land to other classes in each year. Similarly, the rate of increase for built-up area for last three decades in Surkhet Valley was 0.48% per year which equals the addition of 0.491 km^2 annually.

The trend of decrease or increase in forest and shrub/grassland is very less as compared to cultivation and built-up. Forests had added 1.03% and shrubs/grassland had lost 1.32% in their category from other LULC classes in three decades. Other LULC class of sand, and water didn't have significant changes and their line appeared constant throughout the 3 decades.

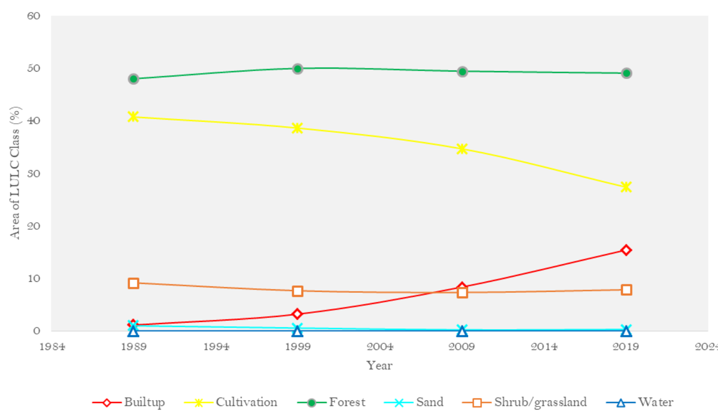

Figure 5. Changes in Area of LULC Different Decades (in percentages) to Show the Trend

In present study the change rate for built-up, cultivation, and forests were 0.49 km^2yr^{-1}. , -0.46 km^2yr^{-1}. , and 0.037 km^2yr^{-1}. respectively for last three decades. This showed that the decrease of cultivated land is greater than all other changes in the area. A study conducted in same area, which comprise analysis of 27 years, have different change rates of LULC classes. The rate of change in built-up, cultivation and forests were 0.21 km^2yr^{-1}. , -0.3 km^2yr^{-1}. , and -0.13 km^2yr^{-1}. respectively Rijal et al. (2018). While comparing the change rates (Figure 6) it can be seen that the changes in built-up and cultivated lands were found greater in present study while there is opposite change rate in forest lands. The increase in built-up area and decrease in cultivated land was found more than double by present research than past study. This is obvious form the present study that built-up area are increasing and cultivated lands are decreasing rapidly that is depicted in Figure 8.

Both the Surkhet Valley and Kathmandu Valley are bowl shaped and their central part has extensive area with slopes less than five degrees. This makes the area more accessible and preferred for construction of new buildings and infrastructures though the land is suitable for cultivation. The change rate in LULC classes was estimated for Kathmandu valley from past studies as presented in Figure 6. The study by Ishtiaque et al. (2017), that analyzed LULC for years 1989 and 2016 in Kathmandu valley, had estimated change rates of 3.28 km^2yr^{-1}. , 0.77 km^2yr^{-1}. , and -3.95 km^2yr^{-1}. for built-up, forests and cultivation respectively. A similar research done in same area by Rimal et al. (2017) found the change rates of 3.85 km^2yr^{-1}. , -0.47 km^2yr^{-1}. , and -2.79 km^2yr^{-1}. for respective LULC classes. So, it can be said that built-up area in Kathmandu Valley was increasing on average of 3.565 km^2yr^{-1}. in last three decades. On contrary the agricultural lands were decreasing at the

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rate of 3.37 km^2yr^{-1}. in Kathmandu Valley. This results of urban growth in terms of built-up area and decrease of cultivable lands was similar for Surkhet and Kathmandu valleys but the change rates are far greater in the latter place. Increase rate in built-up area after 1989 in Kathmandu Valley was 8 times greater than that of Surkhet Valley whereas decrease rate in agricultural lands was 5 times greater.

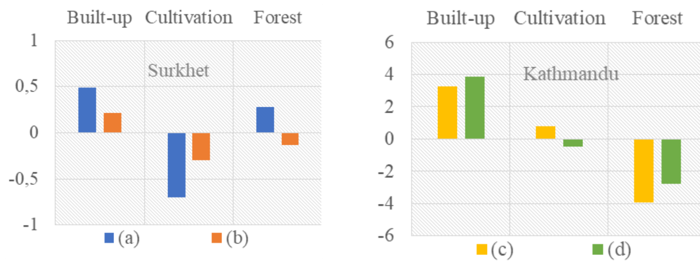
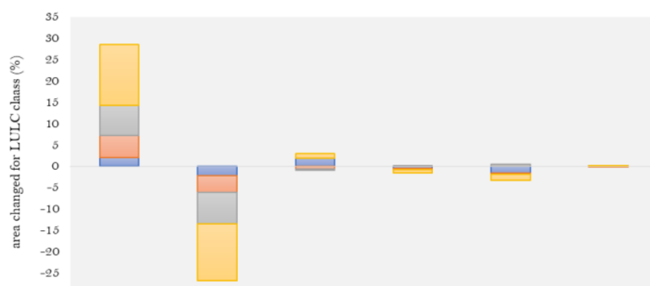


Figure 6. Comparisons of Change Rate of LULC Major Classes in Last Three Decades for (a) Surkhet Valley (present study), (b) Birendranagar Municipality Rijal et al. (2018) (c) Kathmandu Valley (Ishtiaque et al., 2017), and (d) Kathmandu Valley (Rimal et al., 2017). Change rate are presented along Y-axis (unit: km^2yr^{-1})

Location of built-up area in these researches indicated that over the years the central, and fertile part of the valley, which is agricultural lands. This conversion was observed mostly around old cities and along the roads. This trend was similar for Surkhet Valley and Kathmandu Valley where former place hosts headquarters of Karnali province of Nepal and latter place hosts headquarters for Government of Nepal.

Similarly the bar diagram in Figure 7 showed the accumulation or removal in each LULC classes for individual decades and in total for Surkhet Valley. It is vivid that there were greater changes in built-up and cultivation in each of last three decades. The conversion was much larger in last decade of 2009 to 2019.



	Builtup	Cultivation	Forest	Sand	Shrubs/grassl and	Water
1989-2019	14,28	-13,35	1,07	-0,70	-1,32	0,02
2009-2019	7,06	-7,29	-0,37	0,08	0,51	0,01
1999-2009	5,15	-3,95	-0,53	-0,34	-0,32	-0,01
1989-1999	2,07	-2,11	1,97	-0,44	-1,51	0,02

Figure 7. Changes in LULC Classes Over the Decades (in percentages)

In the decade 1989-99 there was change of around 2% in each categories of cultivation, built-up and forest where there was addition in built-up and forest and reduction in cultivation. The following decades of 1999-2009 and 2009-19 showed significant changes only in two classes i.e., cultivation and built-up. In decade 199-2009 there was 5.15% addition in built-up and 3.95% decrease from cultivation. Similarly in decade 2009-19, built-up had addition of 7.06% of total lands and 7.29% of total lands were reduced from cultivation area. So in three decades 14.74 km^2 lands were accumulated in built-up area and in same time cultivation lost 13.77 $km^2$of land area. Figure 8 represents the addition in built-up area and decrease in cultivation area for three decades in Surkhet Valley.

Table 3 presented the result of post-classification comparisons between the years 1989 and 2019 which give the insights in the conversion of LULC classes from one to another or what remained unchanged in last 30 years. It can be observed loss in individual LULC classes from 1989. Most significant losses were from cultivation, sand, shrub/grassland, and water. These LULC classes had lost 37.41%, 83.26%, 75.26% and 40% from their total class area of 1989 respectively.

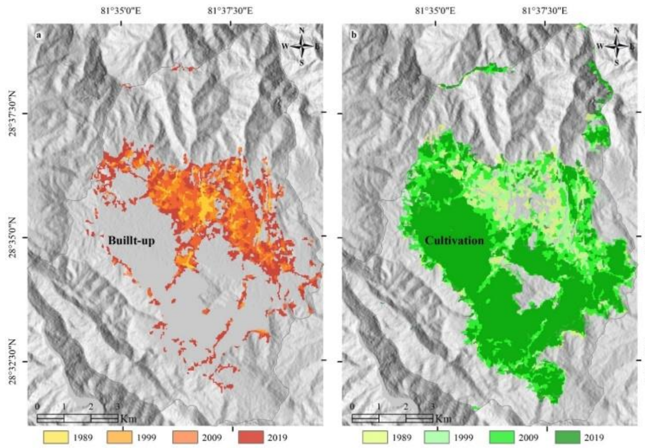


Figure 8. Rapid Urban Growth Depicted by Increasing Built-Up Area (a) & Decreasing Agricultural Lands (b)

Major portions of cultivation had been changed into built-up which accounted for 12.28 km². Small portions of cultivation had converted into forests and shrub/grassland that changed area measured 1.54 km² and1.84 km² area respectively. In forest, 3.79 km² of its area had transformed into shrub/grassland whereas change into other classes is less. But again, 4.55 km² of shrub/grassland had changed into forests. So, the loss of shrub/grassland to forests was greater than reverse. Some 1.58 km² of shrub/grassland had changed into built-up. Only 16.74% of sand area that measured 0.171 km² had remained unchanged in its category. Remaining 0.851 km²of sand area had been converted into other classes major being built-up, cultivation, and forests. Here, we can observe that the gain in area of built-up is 1270.46% of which most is from the cultivated lands.

Table 3. Change Area (in km²) of LULC Classes from 1989 to 2019

		LULC of 2019 (km²)							Loss (%)
		Builtup	Cultivation	Forest	Sand	Shrub/ grassland	Water	Total	
LULC of 1989 (km²)	Builtup	1.114	0.031	0.002	0.000	0.017	0.000	1.164	4.254
	Cultivation	12.280	26.290	1.542	0.034	1.841	0.017	42.003	37.409
	Forest	0.476	0.770	44.384	0.079	3.794	0.001	49.503	10.341
	Sand	0.453	0.184	0.132	0.171	0.082	0.000	1.022	83.260
	Shrub/ grassland	1.576	0.952	4.548	0.017	2.352	0.003	9.447	75.107
	Water	0.000	0.005	0.000	0.000	0.000	0.008	0.014	40.000
	Total	15.899	28.231	50.607	0.302	8.085	0.029	103.152	
	Gain (%)	1270.456	4.622	12.572	12.775	60.684	153.333		

Many researches concludes that in urban centers of developing nations the agricultural lands were being converted into built-up area (Khan et al., 2020; Rimal et al., 2018; Roy et al., 2015). The decreasing trend of cultivated lands had also observed in Birendranagar Municipality (Rijal et al., 2018) but it had not shown whether it was converted into built-up area or other LULC classes. In this regards, current study had found that major part of built-up area in Surkhet Valley had been developed by replacing the cultivated lands which is shown in Figure 7. When the post-classification comparison was done for the LULC images of 1989 and 2019 it was found that 12.28 km² of agricultural lands had been converted into built-up area in span of three decades. The ain percentage is 1270.456 which is way beyond than that of large cities like Pokhara (300%) and Bharatpur (500%) of central Nepal in same span of time. This clearly indicated that Surkhet Valley is growing very rapidly in Nepal than other cities.

4. Conclusion

This research estimated the area covered by LULC classes of past three decades and utilized the results to track the expansion of built-up area in Surkhet Valley. The preparation of LULC maps for Surkhet Valley from 1989 to 2019 indicated the LULC classes are changing and steep alterations were observed especially in the case of built-up and cultivated lands. The urban area had been increasing rapidly considering the area of small area of the valley and this growth of urban area is replacing the prime agricultural lands. The rapid urban growth is indicated by its share of area of only 1% in 1989 reaching almost 15% in 2019. The rate of increase in built up area is high in the area and this rate is escalating as years passes by. In 2019, we can see the northern half of the valley covered by built-up area traversing east west and few traces of linear development were observed in north south direction and around the periphery of the Surkhet Valley. In this span of 30 years highest loss in terms of percentage is for sand which belonged to the riverine area, which depicts that riverine area which can acts as buffer zone in flooding conditions are also being converted into urban areas. Similarly, when the spatial coverage is checked it was found that cultivated lands had lost most of its area to the built-up areas where 42 km^2 agriculture areas in 1989 was squeezed to 27.37 km^2 in 2019 and this will increase the dependency on imports when self-production does not suffice.

Slowly these changes in the LULC classes, where built-up area had increased at expense of agriculture lands, would lead to many environmental problems. So, it is vital to incorporate the findings of this research into the municipal plans of infrastructure development and environmental management. The maps clearly indicated where the urban growth is happening so as policy intervention can be taken to make the development in more sustainable manner. Present research had observed only LULC dynamics but, still, there is extensive research is required to quantify the impacts of urbanization in the area. Besides, the urban growth trajectories can be tracked utilizing results of present research and various scenarios of municipal development plans.

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