KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DHULIKHEL, KAVRE

GEOM 402: Remote Sensing

Final Report on

Monitoring Land Cover/Land Use Change of Pokhara-Lekhnath Metropolitan City using Remote Sensing via Supervised Classification

Group Members:

Nimesh Bhandari (04)

Sarjun Khatri (15)

Susan Mahatara (16)

Purna Bahadur Saud (22)

Submitted to:

Sanjeevan Shrestha

Sudeep Kuikel

Department of Geomatics Engineering

November 2022

Table of Contents

List of Table

List of Figures

ABSTRACT

Land use and land cover are essential for maintaining and managing the natural resources on the earth surface. A complex set of economic, demographic, social, cultural, technological, and environmental processes usually result in the change in the land use/land cover change (LULC). Pokhara Metropolitan is influenced mainly by the combination of various driving forces: geographical location, high rate of population growth, economic opportunity, globalization, tourism activities, and political activities. Urbanization and urban growth have been increased haphazardly. The main contributor to urban growth is internal migration and population growth in a natural way. There has been a high rate of internal migration from the neighboring districts including higher Himalayan and lower Himalayan Districts and population growth rate and density are high. This study illustrates that the land cover/ land use (LULC) (Agriculture, Forest, Built-up, Barren, Grassland, Water Body) and its changes using geo-spatial technology like Remote Sensing and GIS. The land cover has been detected for the years 2000, 2010 and 2020 using freely available Landsat Images. The approaches like Maximum Likelihood Classification (MLC) have been applied in ENVI for supervised classification. Observing the statistics generated from this study, over the time frame of 20 years (2000-2020), forest and built-up area was increased by 17.98% and 15.65% respectively, whereas water body, cultivated land, grassland and barren land were decreased by 0.25%, 35.41%, 5.94% and 6.15% respectively. there is higher rate of increasing the urban area and degrading the agricultural and open spaces. The concerned body should be aware of it and must implement the urban planning activities in an effective way for developing a sustainable city.

Keywords: Land Use, Land Cover, Supervised Classification, Remote Sensing, Satellite

1. INTRODUCTION

1.1 Background

Land cover (LC) is defined as the features that are present on the earth surface. Land use refers to the human induced changes for agricultural, industrial, residential or recreational purposes (Setturu et al., 2012). However, various literatures: ((Lambin et al., 2003); (Lira et al., 2012)) have often used the terminologies Land use and Land cover interchangeably. Land cover changes is referred as the conversion and modification of vegetation, changes in biodiversity, soil quality, runoff, erosion, sedimentation and land productivity (Li, 1996). The use of land has been changing ever since human's first began to manage their environment. Land use refers to the way and intent that the human manipulates the biophysical attributes for meeting their socio-economic requirements (Rawat & Kumar, 2015). From these theories, it can be formulated that a land cover is a generalized form of land use. However, land cover and land use changes are driven by the interaction of ecological, geographical, economic, and social factors associated with the human and landscape interaction and use of land resources to fulfill the required necessity (Zang & Huang, 2006).

The exposure of spatio-temporal change in land use/land cover (LULC) and is very essential to obtain sustainable land management which is understood as a process via which sustainability in its use is obtained by its effective utilization (Shrestha, Bhandari, et al., 2021). Furthermore, regulatory instruments like land use policies also play a vital role for their sustainable use (Shrestha, Nepali, et al., 2021). LULC change analyses and projection provides a tool to assess ecosystem change and its environmental implications at various temporal and spatial scale. The outcome from these analyses provides useful information regarding developmental, environmental and resource planning applications at regional as well as global scale (Chandran et al., 2012). LULC dynamics are analyzed through changes in the state of an object or phenomenon by observing it at different times.

Satellite Remote Sensing (RS) technique, integrated with Geographical Information System (GIS) aids in understanding the spatio-temporal change of land cover and land use. Remote Sensing data acts as a useful source of information and provides timely and complete coverage of any specific area and have proven useful in assessing the natural resources and monitoring the land use or land cover changes (Satyanarayana et al., 2001). GIS acts as a scientific tool for processing geographic data. It is responsible for integrating several aspects of real-world geographic data and collecting and operating and analyzing the data (Howari & Ghrefat, 2021). Remote sensing technique associated along with GIS provides a suitable platform for data analysis, update and retrieval (Singh, 1989).

1.2 Objectives

The principal objective of this project is to analyze the land use/ land cover changes between 2000, 2010 and 2020 using Remote Sensing and GIS technique.

The secondary objectives are:

- To create LULC map of Pokhara Lekhnath Metropolitan
- To detect change in land use over two decades of the study area.

2. METHODOLOGY

2.1 Study Area

Pokhara metropolitan is the largest metropolis of the country and the capital of Gandaki Province, Nepal (*Pokhara Lekhnath Becomes Largest Metropolitan City*, n.d.). It has an area of total 464.24 sq.km and is the second-largest city in terms of population (Raut et al., 2020). Geographically it lies in 83°48′ E to 84°09′ East Longitude and 28°05′ N to 28°21′ North Latitude. The study area is located 200 kilometers from west of the capital Kathmandu, Nepal. The altitude varies from 827 m to 1740 m from the Mean Sea Level (*Pokhara Lekhnath Becomes Largest Metropolitan City*, n.d.).

According to survey 2014, Nepal is one of the ten least urbanized countries in comparison to South Asia in a haphazard way where the level of urbanization was 18.2% and the rate was 3% (Bakrania, 2015). The main contributor to urban growth is internal migration and population growth in a natural way. There has been a high rate of internal migration from the neighboring districts including higher Himalayan and lower Himalayan Districts and population growth rate and density are high (Raut et al., 2020). As a result, the city richer in natural heritage, especially lakes and mountains and also a popular tourist destination, has been facing haphazard land use change because of such human and natural phenomena that ultimately, is triggering the deterioration of natural beauty of Pokhara along with degradation of agricultural land to built-up area year by year.

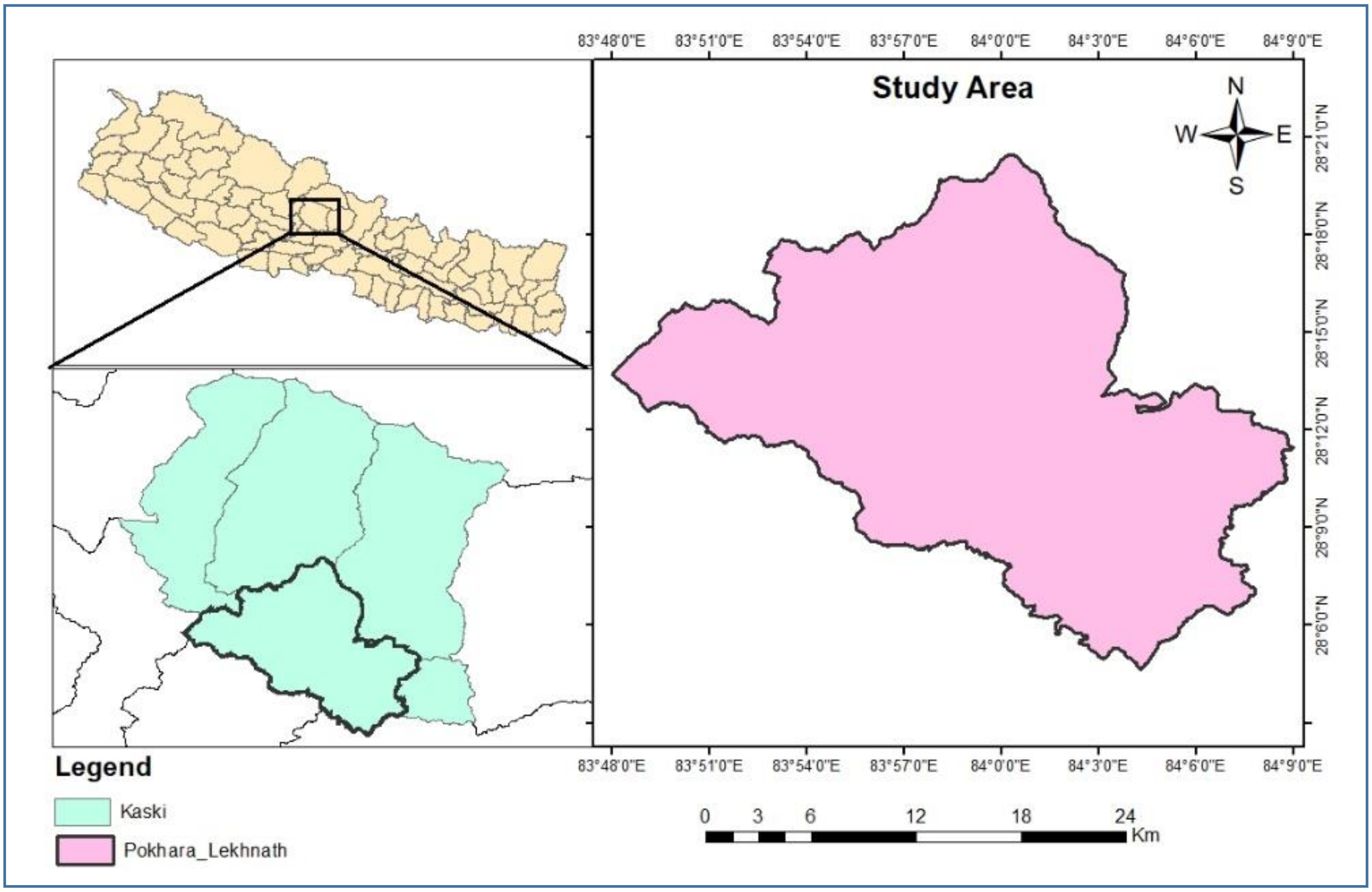

Figure 1. Map Showing Study Area

2.2 Workflow

All the procedures of acquisition of datasets, processing and techniques applied for refining them and determining land use and land cover changes are highlighted below.

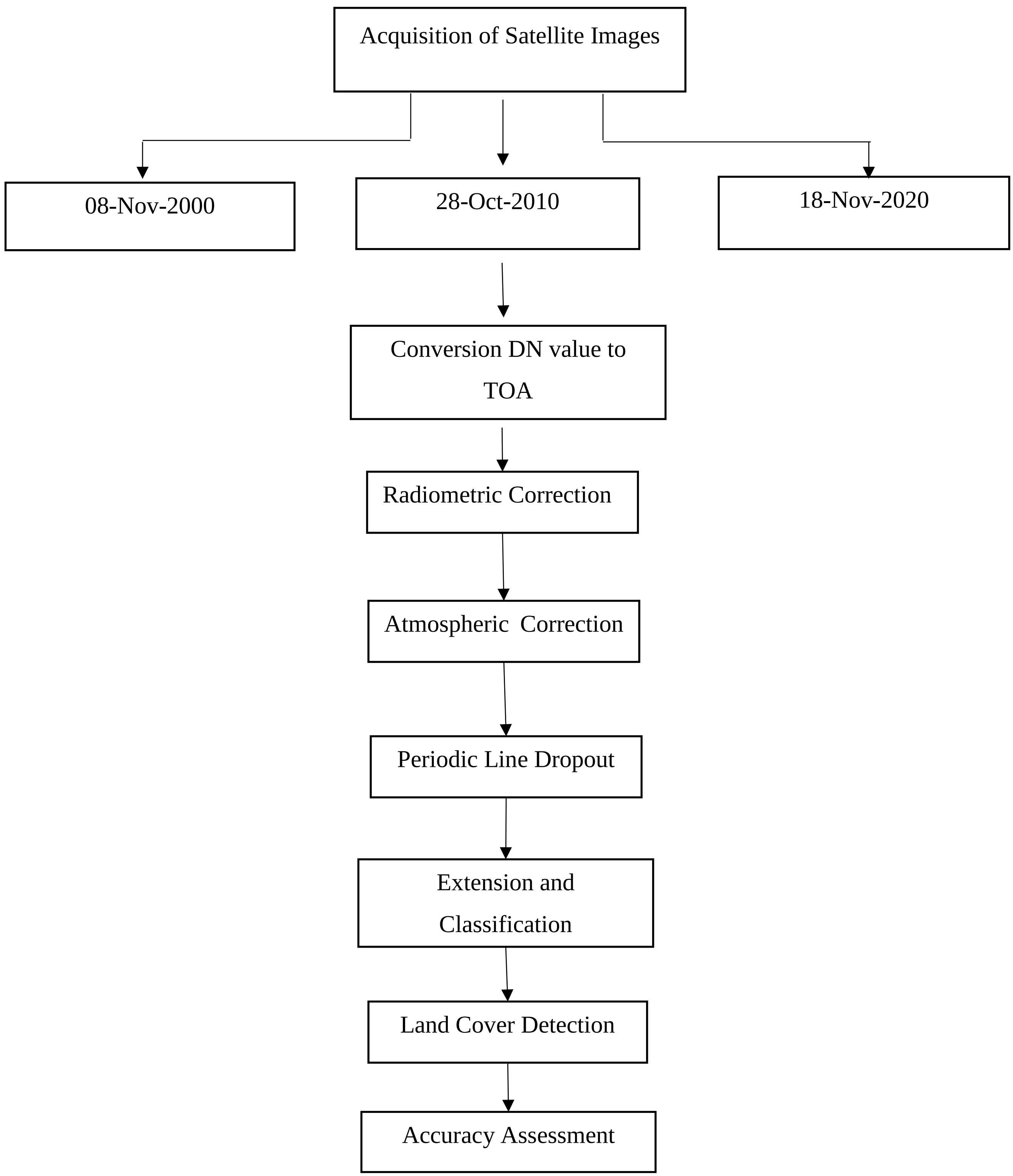

Figure 2: Workflow Diagram

2.2.1 Data Sets and Software

The study was based on secondary data information. Landsat images of resolution 30m for the years 2000, 2010 and 2020, with the time interval of decades, were acquired for land cover change analysis.

Table 1. Data Specifications used for this Study

Data Type	***Acquisition Date***	***Band***	***Resolution***	***Source***
LandSat7, ETM	Nov 8, 2000	Multispectral	30 m	USGS
LandSat7, ETM +	Oct 28, 2010	Multispectral	30 m	(https://earthexplorer.usgs.gov/)
LandSat8 OLI	Nov 18, 2020	Multispectral	30 m	

For image preprocessing, processing and classification, ENVI Software (*Image Processing & Analysis Software | Geospatial Image Analysis Software | ENVI®*, n.d.) was used and final LULC map was prepared in ArcGIS Software (*ArcGIS Desktop | Desktop GIS Software Suite*, n.d.)**.**

A series of sequential operations; radiometric calibration, atmospheric correction, geometric correction, and mask were performed in the image preprocessing step, for this study

2.2.2 Conversion of DNs to TOA

The DN values were changed into TOA reflectance by using the empirical formula of gain and bias of reflectance of three band which are available in the metadata file. The empirical formula used is:

$$\text{TOA reflectance} = \text{gain} * \text{DN} + \text{offset}$$

2.2.3 Radiometric Correction

The purpose is to correct for distortions and errors introduced in image due to atmospheric conditions, viewing geometry, satellite sensor errors and similar other errors that degrade image quality. For radiometric correction we used the empirical formula given by the Landsat mission. We used given expression for correcting the TOA:

$$\text{Corrected TOA} = \frac{\text{T1}}{\sin(\text{sun angle})}$$

2.2.4 Atmospheric Correction

Atmospheric correction was done to reduce or correct errors in the digital numbers of images that occurred due to atmospheric effect. All of the images used in remote sensing for particular task may not be acquired at same environmental condition. The images can be acquired at different season, different illumination condition i.e. different time of the day and different solar inclination. So, atmospheric correction is needed. Dark Object Subtraction method is used for Atmospheric correction. All three images are atmospherically corrected.

2.2.5 Periodic Line Dropout

Periodic line dropout is mainly caused by failure of one of the sensors of the push broom sensor, due to which line scanned by it appears dark or by transmission failures. This is removed by using replacement, average line or correlation band method. Landsat gap fill extension is used for removing periodic line dropout. In our acquired satellite imagery, LandSat7 ETM image of the year 2000 was suffered from scan line errors and was removed through this technique.

2.2.6 Extraction and Classification

Finally, the subset of satellite images of respective time series has been performed for extracting the study area by taking georeferenced outline boundary of Pokhara Lekhnath Metropolitan City as AOI (Area of Interest). After demarcating AOI, the training samples were extracted to apply as an input for the supervised image classification. Respective land cover maps for each study year were prepared using ArcGIS software. Quality assessment of prepared land cover maps was done based on confusion matrix in ENVI software.

2.2.7 Land Cover Detection

To perform land cover detection, a supervised classification method with Maximum Likelihood Classification (MLC) was applied in the ENVI software. MLC is considered as one of the most acceptable and used supervised classifications with remotely sensed satellite imagery data. Six different types of land cover classes like Built-up land, Cultivated Land, Water Body, Forest Cover, Open Field, and Barren Land were selected. Supervised classification consists of three steps: 1) training steps, 2) classification stage and 3) output stage (Lillesand et al., 2015). The training datasets were generated on the respective satellite imageries for the particular time interval in the study area, using the ‘ROI’ tool in ENVI. Generated training datasets were evaluated and refined successively based upon the spectral reflectance curve since almost most of the accuracy of MLC depends upon the choice of training datasets. For Image classification, the 'Classification Workflow' module was used. Preliminary extracted training datasets were used for training the MLC classifier. Eventually, images for respective time intervals were generated. Once the image was classified, it is always mandatory to check the accuracy.

2.2.8 Accuracy Assessment

Accuracy assessments of classified images have been performed to compare the classified pixels with their corresponding location in the real-world ground. To conduct an accuracy assessment, another ground truth sample points were created based on the image visualization in Google Earth Imageries for respective time interval. Thus, created sample was further used for testing over the classified image using, 'Confusion Matrix Using Ground Truth Image' in the post-processing module of ENVI. This resulted in outcomes such as Confusion Matrix (Error Matrix), overall accuracy, producer accuracy, user accuracy, and kappa coefficient along with other additional information. Kappa value and other statistical parameters for respective time intervals were obtained with a significance value that indicated efficiency. In conclusion, land cover map for respective time interval were prepared and the change detection of land cover change over time was determined from digital data that involved a comparison of three images in vector data format, even though all techniques of change detection in remotely sensed images are a comparison in raster format. The final graph of change detection was produced to visualize for last 20 years.

3. RESULTS AND DISCUSSIONS OF LAND COVER/ LAND USE CHANGES

Figure below shows the classified image for the years 2000, 2010 and 2020 respectively. The red, light green, dark green, orange, white and blue color indicates the built-up, grass, forest, cultivation, barren and water body respectively. While comparing the classified image from 2000 to 2020, there is a gradual increase in the built-up and forest area while decreasing the open area, agricultural area and grassland. The urbanization is increasing mainly in city area and occupying the open space. The open spaces were encroached due to devasting earthquake of 2015. The agricultural areas and grassland areas were being decreased during the last 20 years. The pattern is changing haphazardly due to human activities. Areas covered with agriculture and forest are being replaced by the buildings and infrastructure. The concrete jungle is increasing in exponentially. The figure below shows that urban growth is cumulating in haphazard manner and development process is not balanced way. The water body seems somehow decreased but forest area seems increased. It seems that some areas of agriculture were changed to forest area as there is lack of farmer and internal migrations. Some of the barren lands were also converted to forest area and settlement area. While comparing result of image 2000 with 2020, there is drastic change in land use pattern. Apart from that there is tremendous increase in the human settlement and physical constructions is proceeded in random ways.

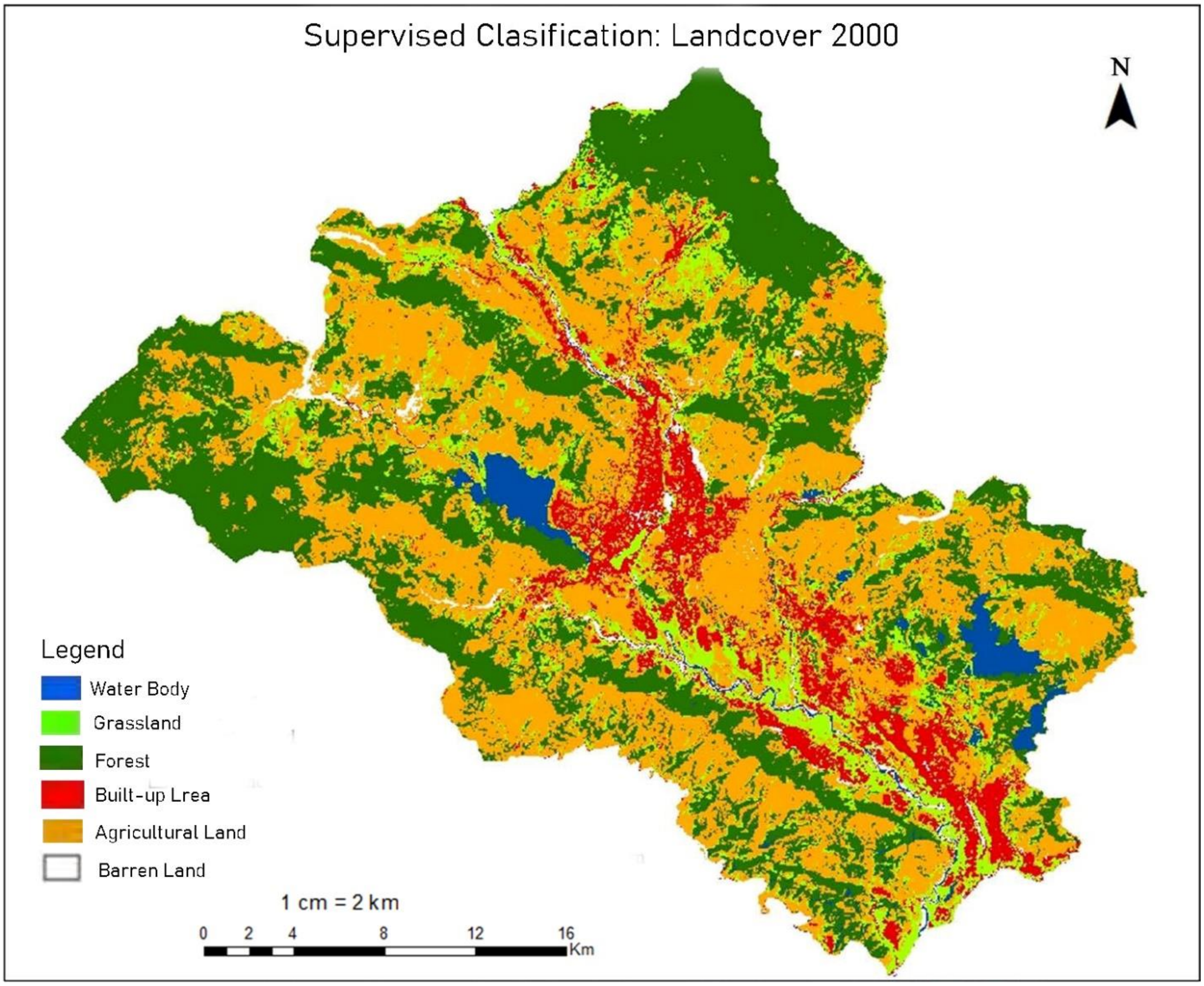

Figure 3. Classified Image for 2000 A.D

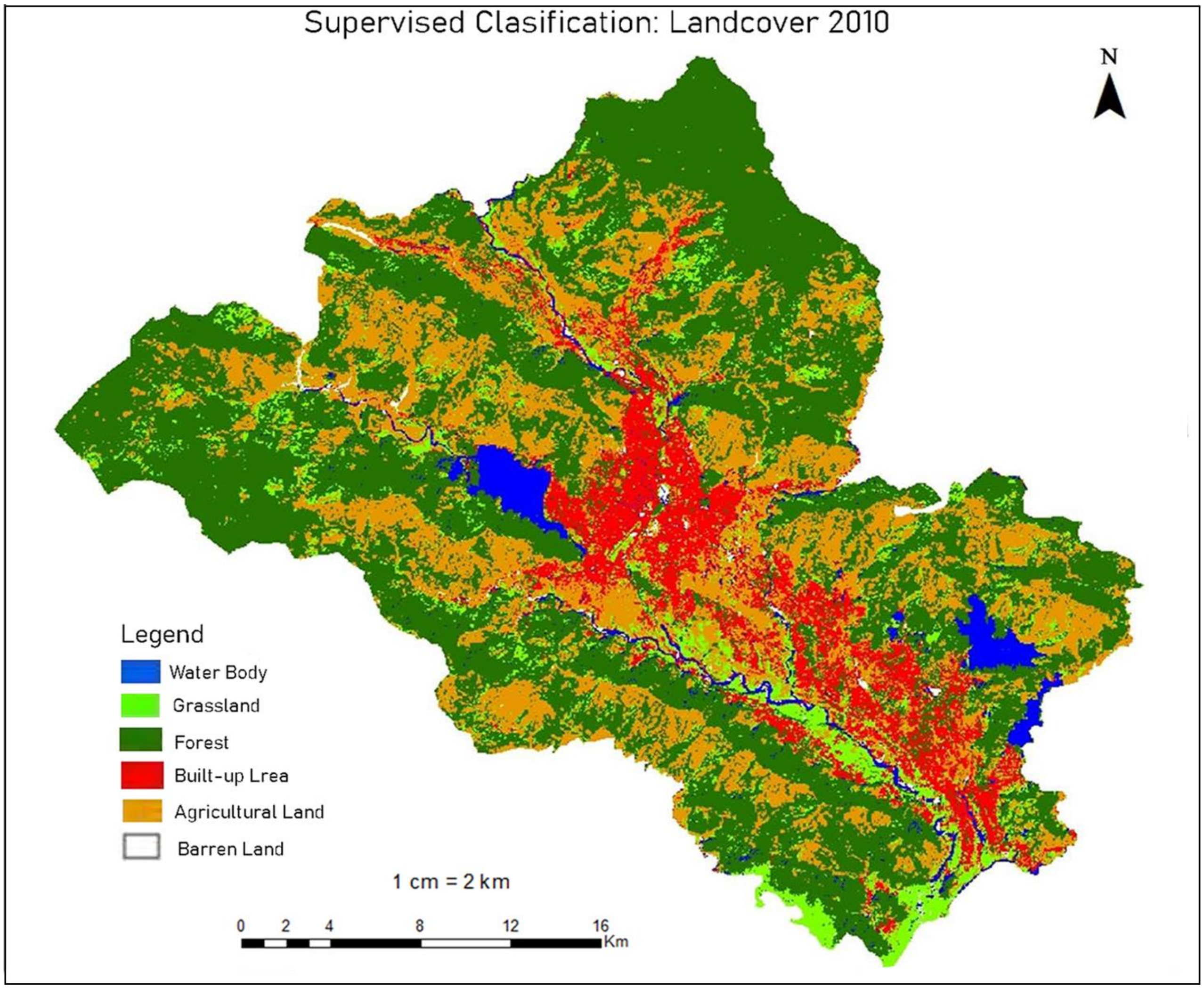

Figure 4. Classified Image for 2010 A.D

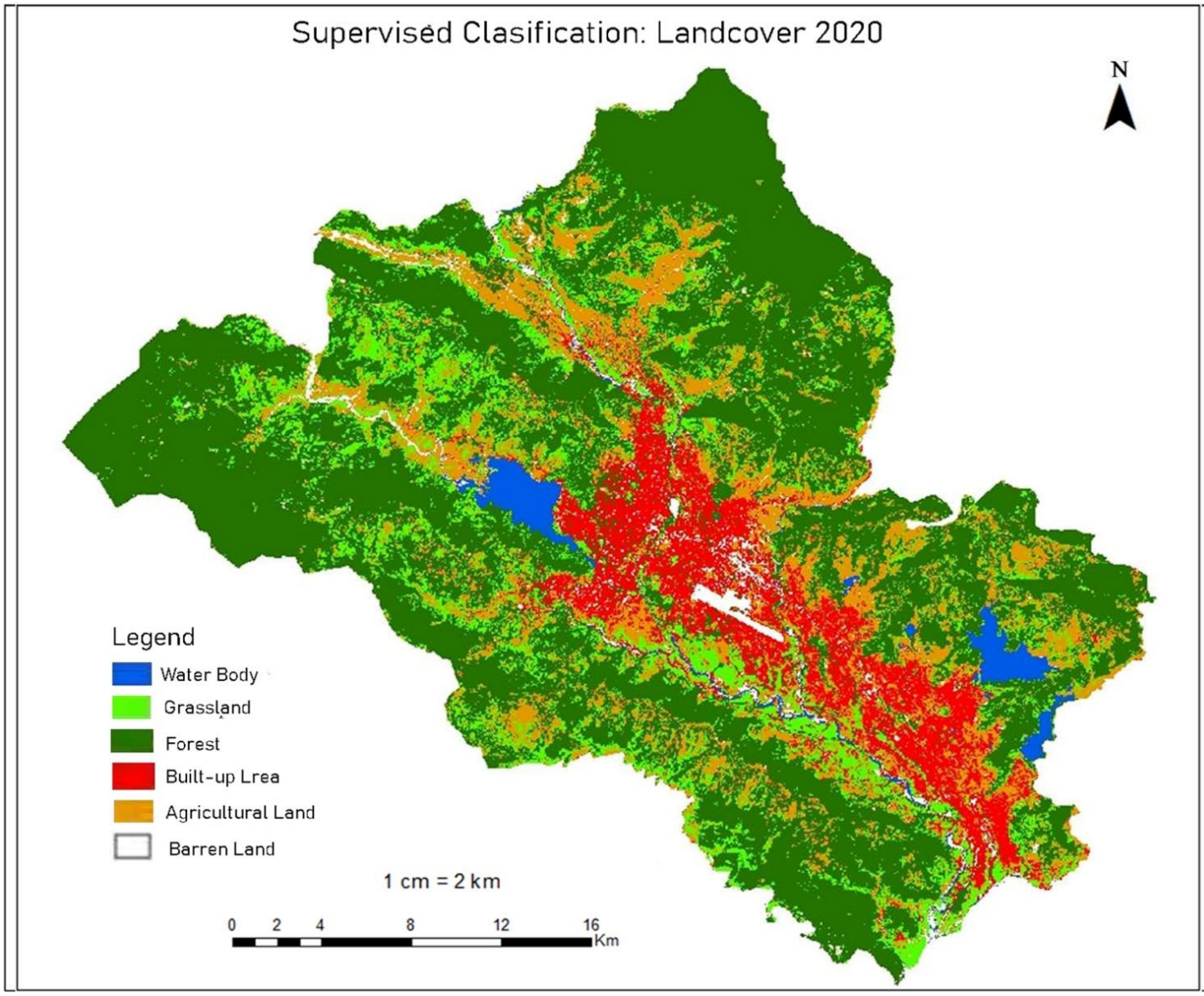

Figure 5. Classified Image for 2020 A.D

3.1 Change Depiction in Figure

The study illustrated that the forest area has increased by 17.98% and this is due to the open field and barren land has transferred into the forest area. It is a positive sign of environmental perspectives as well as fresh air for human life. But in the cultivation area, it was decreased by 35.41% and maximum land was changed into a residential area. The main causes of the decrease in cultivated land are unnecessary planning for residential (land plotting), industrial, and commercial purposes. The grassland area has decreased by 5.94% which used to be prevailed in maximum area along the edges of the Seti River and other perineal rivers. Some of the grasslands and open area were occupied by informal settlement due to earthquakes. Majority of the population resides in the city area. They are involving in their own business and avoiding traditional agriculture. As a result, cultivated lands are decreasing and transferring to the barren, grazing, and grassland. But in our case the built-up has increased by 15.65% and of barren land decreased by 6.15%. The maximum open field, grassland and agricultural area has transferred into built-up. The land-use change incorporates some factors including the external ones such as advancement in technology, migration, market availability, infrastructural availability, government policies and, natural hazards, etc. Similarly, the internal factors such as regional economy, socioeconomic and cultural trend, demography, geographical condition, and road accessibility, site and ecology contribute significantly to a combination of the external factors for the land-use change.

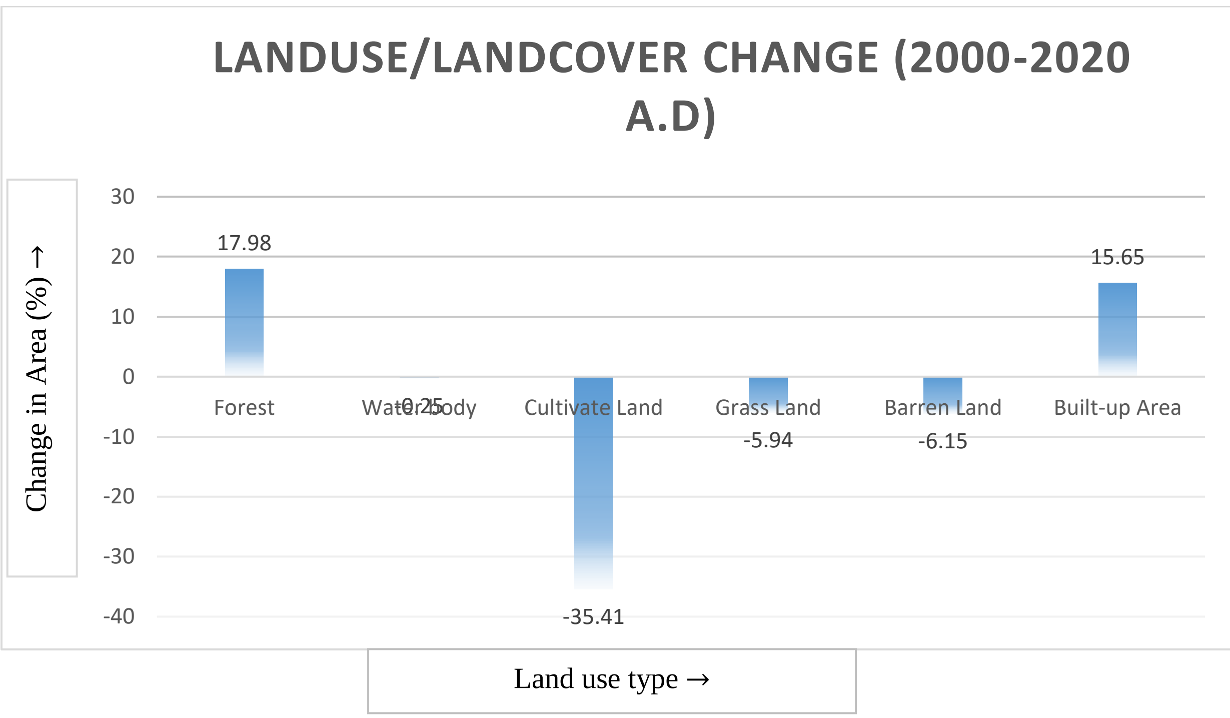

Figure 6. Bar-graph Depiction of Percentage of Land Use Change

3.2 Accuracy Assessment Outcome

3.2.1 Overall Accuracy: The percentage of overall accuracy was calculated using following formula:

$$\text{Overall accuracy} = \frac{\text{Total number of correct samples}}{\text{Total number of samples}} * 100\%$$

The accuracy of the land cover classification from supervised techniques were evaluated and presented as an error or confusion in the form of matrix table. The results of confusion matrix for supervised is tabulated below:

Table 2. Confusion Matrix Table

	Water Bodies	Forest	Built-up area	Cultivation Land	Barren Lands	Grassland	Row Total	User's Accuracy
Water Bodies	7	0	1	0	0	0	8	87.5
Forest	0	49	1	1	2	0	53	92.45
Built-up area	0	0	4	1	0	0	5	80
Cultivation Land	0	1	0	10	1	0	12	83.33
Barren Lands	0	1		2	10	0	13	85
Grassland	0	2	0	1	1	5	9	100
Column Total	7	53	6	15	14	5	100	
Producer's accuracy (%)	100	96.07	66.67	71.42	85	100		

$$Overall\ accuracy\ = \frac{(7+49+4+10+10+5)}{100} = 85\%$$

3.2.2 Kappa Statistics: Kappa coefficient (K) is a measure of the agreement between two maps considering all elements of error matrix. It is defined in terms of error matrix as given below:

$$K = \frac{\text{Obs} - \text{Exp}}{1 - \text{Exp}}$$

Where, Obs = Observed correct, it represents accuracy reported in error matrix (overall accuracy)

Exp = Expected correction, it represents correct classification

We have Overall accuracy (Obs)= 85%= 0.85

Then Exp =?

For this,

Error matrix showing the products of row and column accuracy assessment marginals is calculated based on Table below:

Table 3: Product of row and column from Confusion Matrix table

	Water Bodies	Forest	Built-up	Agricultural Lands	Barren Lands	Grassland
Water Bodies	7*8=56	53*8=424	6*8=48	15*8=120	14*8 = 112	5*8=40
Forest	371	2809	318	795	742	265
Built-up	35	265	30	75	70	25
Agricultural Lands	84	636	72	180	168	60
Barren Lands	91	689	65	195	182	65
Grassland	63	477	54	135	126	45
Total	700	5300	587	1500	2420	500

Grand Total = Sum of products of row and column marginals

= 700 + 5300 + 587 + 1500 + 2420 + 500 = 11007

Total correct = Sum of products of diagonal = 3302

Expected Correction (Exp) = 3302/11007 = 0.3

<u>Calculation of K:</u>

Now we have values of observed correct and expected correct.

Observed correct = 0.85

Expected correct = 0.3

As we know that,

$$K = \frac{Obs - Exp}{1 - Exp}$$

$$=> \ K = \frac{0.85 - 0.3}{1 - 0.3} = 0.7857$$

Kappa coefficient of 0.7857 implies that the classification process was avoiding 78.57% of the error that a completely random classification would generate.

4. CONCLUSION AND RECOMMENDATIONS

The study has concluded that there is a maximum change in land use between periods 2000 to 2020. The urban area is increasing rapidly. There is continuously increasing in encroachment and human activities. It means there is a need for planned settlement. Pokhara metropolitan should make suitable and effective land use planning policy and implement it. The agricultural area is decreasing and converting into the built-up area and other grazing lands. Agricultural land provides food for the survival of human being. So, decreasing of cultivated lands is not good for the country. The land-use change should be studied precisely to make good land use planning and management policy for the future. The supervised image classification shows a greater extent of accuracy. The user's knowledge, skills aid in properly classification from the supervised way. All the features were classified properly and accurately. Nevertheless, the research was carried out in short span of time and ground truth was collected from images. To conclude, there is higher rate of increasing the urban area and degrading the agricultural and open spaces. The concerned body should be aware of it and must implement the urban planning activities in an effective way for developing a sustainable city.

5. REFRENCES

ArcGIS Desktop | Desktop GIS Software Suite. (n.d.). Retrieved November 24, 2022, from https://www.esri.com/en-us/arcgis/products/arcgis-desktop/overview

Bakrania, S. (2015). Urbanisation and urban growth in Nepal. *Governance. Social Development, Humanitarian Response and Conflict (GSDRC), Applied Knowledge Services of University of Birmingham, Birmingham, UK. Http://Www. Gsdrc. Org/Wp-Content/Uploads/2015/11/HDQ1294. Pdf*.

Bringezu, S., Schütz, H., Pengue, W., O'Brien, M., Garcia, F., Sims, R., Howarth, R. W., Kauppi, L., Swilling, M., & Herrick, J. (2014). *Assessing global land use: Balancing consumption with sustainable supply*. United Nations Environment Programme Nairobi, Kenya.

Chandran, R. T. S., Joshi, N. V., Julka, P., Kumar, U., Aithal, B. H., Mesta, P., GR, R., Mukri, V., & Series, S. C. (2012). *Landslide Susceptible Zone Mapping in Uttara Kannada, Central Western Ghats*.

Howari, F. M., & Ghrefat, H. (2021). Chapter 4 - Geographic information system: Spatial data structures, models, and case studies. In A.-M. O. Mohamed, E. K. Paleologos, & F. M. Howari (Eds.), *Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering* (pp. 165–198). Butterworth-Heinemann. https://doi.org/10.1016/B978-0-12-809582-9.00004-9

Image Processing & Analysis Software | Geospatial Image Analysis Software | ENVI®. (n.d.). Retrieved November 24, 2022, from https://www.l3harrisgeospatial.com/Software-Technology/ENVI

Jatana, N., & Currie, A. (2020). Hitting the Targets. The Case for Ethical and Empowering Population Policies to Accelerate Progress towards the Sustainable Development Goals. *Population Matters: London, UK*.

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources*, *28*(1), 205–241.

Li, X. (1996). A review of the international researches on land use/land cover change. *ACTA GEOGRAPHICA SINICA-CHINESE EDITION-*, *51*, 558–565.

Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote sensing and image interpretation* (7th ed.). John Wiley & Sons.

Lira, P. K., Tambosi, L. R., Ewers, R. M., & Metzger, J. P. (2012). Land-use and land-cover change in Atlantic Forest landscapes. *Forest Ecology and Management*, *278*, 80–89.

Pokhara Lekhnath becomes largest metropolitan city. (n.d.). Retrieved November 23, 2022, from https://kathmandupost.com/national/2017/03/13/pokhara-lekhnath-becomes-largest-metropolitan-city

Raut, S. K., Chaudhary, P., & Thapa, L. (2020). Land use/land cover change detection in Pokhara Metropolitan, Nepal using remote sensing. *Journal of Geoscience and Environment Protection*, *8*(8), 25–35.

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

Satyanarayana, B., Thierry, B., Seen, D. L., Raman, A. V., & Muthusankar, G. (2001). Remote sensing in mangrove research–relationship between vegetation indices and dendrometric parameters: A Case for Coringa, East Coast of India. *22nd Asian Conference on Remote Sensing*, 5–9.

Setturu, B., Aithal, B. H., Sanna Durgappa, D., & Ramachandra, T. V. (2012). Landscape dynamics through spatial metrics. *Proceedings of India GeoSpatial Conference, Epicentre, Gurgaon, India*, 7–9.

Shrestha, R., Bhandari, S., & Twayana, R. (2021). MONITORING LAND COVER/LAND USE CHANGE USING REMOTE SENSING AND GIS TECHNIQUE AT DHULIKHEL AND BANEPA MUNICIPALITY, NEPAL. *International Journal of Current Research in Science Engineering & Technology*, *3*(5). https://www.researchgate.net/profile/Sijan-Bhandari-4/publication/351598504_MONITORING_LAND_COVERLAND_USE_CHANGE_USING_REMOTE_SENSING_AND_GIS_TECHNIQUE_AT_DHULIKHEL_AND_BANEPA_MUNICIPALITY_NEPAL/links/609f35c992851cfdf332e552/MONITORING-LAND-COVER-LAND-USE-CHANGE-USING-REMOTE-SENSING-AND-GIS-TECHNIQUE-AT-DHULIKHEL-AND-BANEPA-MUNICIPALITY-NEPAL.pdf

Shrestha, R., Nepali, P. B., & Dahal, T. P. (2021). Towards Sustainable Land Management: State-of-the-Art in Land Use Policies of Nepal. In *Examining International Land Use Policies, Changes, and Conflicts* (pp. 351–369). IGI Global.

Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing*, *10*(6), 989–1003.

Zang, S., & Huang, X. (2006). An aggregated multivariate regression land-use model and its application to land-use change processes in the Daqing region (northeast China). *Ecological Modelling*, *193*(3–4), 503–516.