Scientific Research Publishing

Land Use/Land Cover Change Detection in Pokhara Metropolitan, Nepal Using Remote Sensing

Sanjeev Kumar Raut, Puran Chaudhary, Laxmi Thapa

Survey Department, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Kathmandu, Nepal
Email: sanjeev.raut@nepal.gov.np, sanjeevraut.4@gmail.com

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. In addition to this, geographically steep slope, rugged terrain, and fragile geomorphic conditions and the frequency of earthquakes, floods, and landslides make the Pokhara Metropolitan region a disaster-prone area. The increment of the population along with infrastructure development of a given territory leads towards the urbanization. It has been rapidly changing due to urbanization, industrialization and internal migration since the 1970s. The landscapes and ground patterns are frequently changing on time and prone to disaster. Here a study has been carried to study on LULC for the last 18 years (2000-2018). The supervised classification on Landsat Imagery was performed and verified the classification through computing the error matrix. Besides, the water bodies and vegetation area were extracted through the Normalized Difference Water Index (NDWI) and Normalized Difference Vegetation Index (NDWI) respectively. This research shows that during the last 18 years the agricultural areas diminishing by 15.66% while urban area is increasing by 13.2%. This research is beneficial for preparing the plan and policy in the sustainable development of Pokhara Metropolitan.

Keywords

Error Matrix, Land Use/Land Cover (LULC), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Supervised

Image Classification, Remote Sensing, Urban Growth

1. Introduction

Every living and non-living object is sustained on the land surface which is directly and indirectly affected by the structure of the land surface. The land use refers to the purposes associated with that cover like raising cattle, recreation, or urban living. Land use also relates to the land cover in various ways and effects with various implications. The different societal factors were related to population structure and dynamics, technology, socio-economic organization, culture, institutions, education, employment, and political situation systems which shape LULC pattern change (Briassoulis, 2000). 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 migration from the neighbouring districts including higher Himalayan and lower Himalayan Districts and population growth rate and density are high. As a result, LULC has been changing due to such continuous occurrences of human and natural phenomena. LULC cover pattern is always influencing by the natural hazard and disaster phenomenon around the study area, where the river morphology and geomorphic hazards are always dominance leading possibility of a high amount of disaster of human life and property. Remote sensing is a science and technology that helps to gather information about objects on the surface of the earth without direct contact. The Landsat imagery has been successfully used in detecting the urban sprawl and change detection of city area using remote sensing technology (Goswami & Khire, 2016).

The frequent naturally-occurring of sinkholes changing the different land use patterns and overall decreasing overall productivity (Rijal, 2017). The problem arises from the hazardous expansion of the urban centre, lacking standard norms and regulations, improper spatial planning and unwanted population growth is the need of the present time. A severe deficiency of plan and policy for preparedness and overcome against the proper land use planning were key characteristics of a developing country. The Government of Nepal has implemented a new plan and policy of Land use in the different use case for sustainable development. Only after the suitable and effective land use policy, there would be food security, user-friendly environment, well settlement, and planned organization (Ministry of Land Reform and Mangement, 2015). There was the enlargement of urban by 6.33% to 51.42% while cultivation area shrinkage by 60.73% to 20.27% from 1977 to 2010 (Rimal, 2012).

This research helps to identify the root causes of the haphazard spreading of urbanization patterns for the last 18 years. Similarly, the output from this re-

search can be sourced as a reference for preparing plan and policy for other metropolitan offices in Nepal. The final expected outcome of this research is to analyze how the agricultural land is decreasing and the overall effect of population growth in urbanization.

2. Study Area

Pokhara metropolitan is a gregarious and headquarters of the western development region as well as the capital of province 4 Nepal. It is one of the largest city in terms of the area a total area of 464.94 sq.km and second-largest city in terms of population. Geographically it lies in 83˚58'30" to 84˚02'03" East Longitude and 28˚10'00" North to 28˚16'00" North Latitude surrounded by green hills. The study area is located 200 kilometres from west of the capital Kathmandu, Nepal. The altitude varies from 827 m to 1740 m from the Mean Sea Level. The average maximum temperature in summer varies between 30˚C and 32˚C and in winter minimum 6˚C to 8˚C. It is popular for tourist destinations which is richer in natural heritage, especially lakes and mountains. The study area contains two popular lakes are Begnas and Rupa. The winter and spring seasons are generally clear and sunny. The highest temperature was recorded at 38.5˚C on 4th May 2013, while the lowest temperature was recorded at 0.5˚C on 13th January 2012 (Fort, Adhikari, & Rimal, 2018). Figure 1 shows the location map of the study area.

3. Methodology

3.1. Data Sets and Software

The study was based on both primary and secondary data information. The primary information is obtained through field observation while secondary information is collected from the Pokhara Metropolitan office as well as the Survey Department, Ministry of Land Management, Co-operatives and Poverty Alleviation. Table 1 shows the list of datasets that are used in research.

For image preprocessing, processing and classification, Erdas Imagine 2014 and ArcGIS 10.4.1 were used.

3.2. Methods

Figure 2 shows the overall flowchart of the methodology starting from the image data collection followed by image pre-processing and finish with the LULC maps. The individual band for different years were downloaded from USGS portal.. The individual band was stacked to get final composite layer. Pre-Processing is the initial step of processing which is carried out to correct for any distortions due to the characteristics of the image systems and imaging conditions. Besides, it includes the clipping of administrative study area with satellite imagery. All the images were free from error except 2011 which consisting of scan line errors. Scan line errors were occurred by malfunctioning of some scanning sensors. The scan line error was corrected from the Landsat toolbox in

ArcGIS 10.4.1. Here the value of error pixel was corrected by averaging the value of neighbouring pixels.

For image classification, supervised image classification was performed in Erdas Imagine 2014. The most commonly used algorithms are ISODATA clustering algorithms (Abbas, Minallh, Ahmad, Abid, & Khan, 2016). In this research,
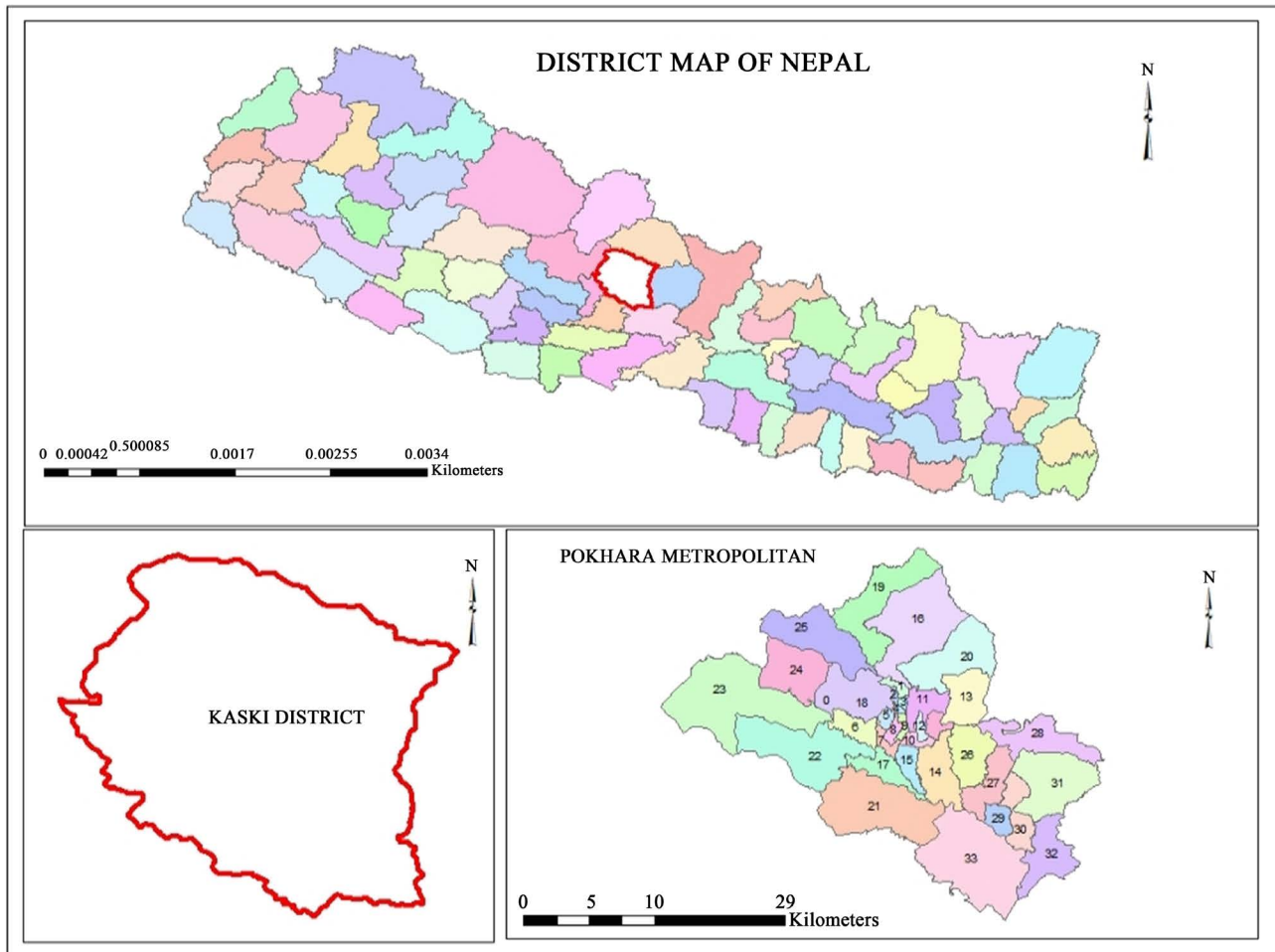
Figure 1. Showing the study area.

Table 1. Showing the list of datasets used in research

Acquisition Date	Data Category	Spatial Resolution (meter)	Band Properties	Source
5 April 2000	Landsat 7, ETM	30 m	Multispectral	https://www.usgs.gov/land-resources
30 Dec 2011	Landsat 7, ETM+	30 m	Multispectral	https://www.usgs.gov/land-resources
23 Nov 2018	Landsat 8, OLI	30 m	Multispectral	https://www.usgs.gov/land-resources
Dec 2018	Planet Scope	3m	R, G, B, and NIR	https://www.planet.com/explorer (Only for research purposes)
Dec 2018	Administrative Map	-		Pokhara Metropolitan Office
Field survey	Ground Truth (Reference Data)	-		GPS
1999/2000	Topographic Map	1:25,000 (scale)		http://nationalgeoportal.gov.np/ (Survey Department, Nepal)
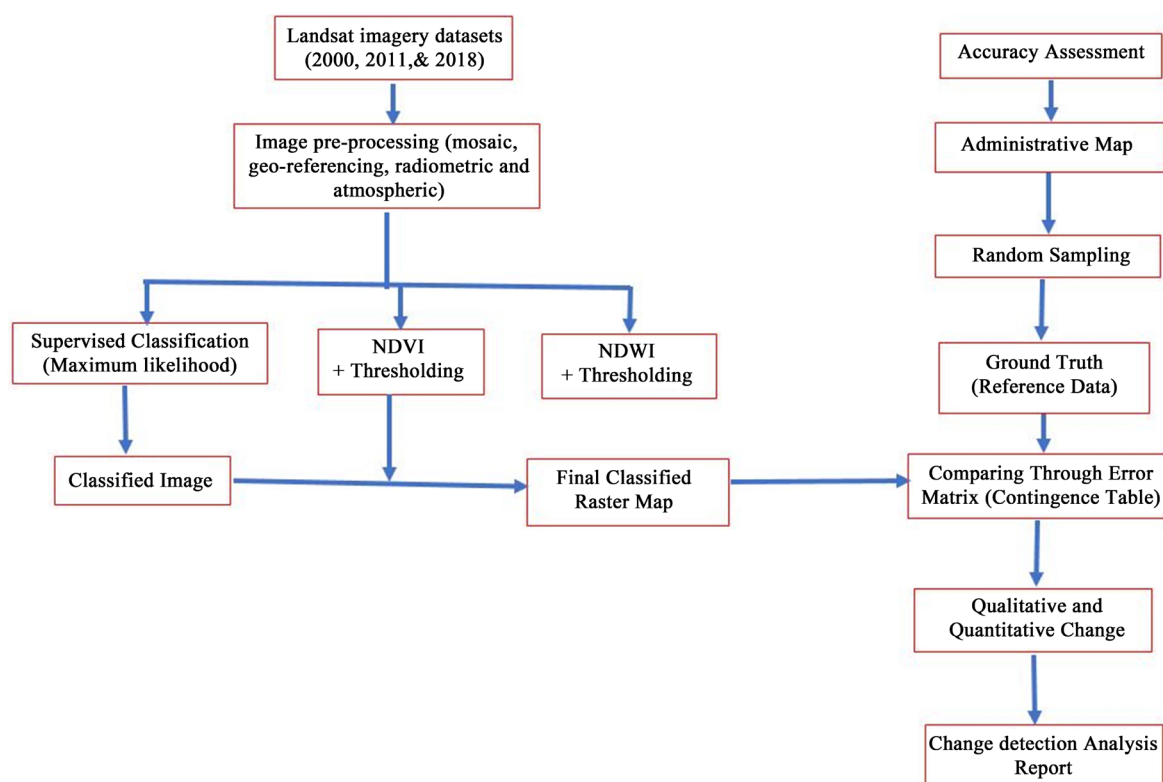
Figure 2. Overall workflow for the research methodology.

six different types of land cover like Built-up land, Cultivated Land, Water Body, Forest Cover, Open Field, and Barren Land are selected for the research. In supervised classification consists of three steps: 1) training steps, 2) classification stage and 3) output stage (Lillesand, Kiefer, & Chipman, 2004). Once the image was classified, it is always mandatory to check the accuracy The error matrix constitutes N * N elements based on ground truth data (reference data) against classified image where N indicates a total number of classes.

The two indices NDVI and NDWI are calculated from the multispectral sensors for extraction of the vegetation and water bodies, respectively. NDVI is the common and well known index since the beginning of Landsat. NDVI is correlated with plant physiological stress and photosynthetic process. That helps to find different problems like greenness, chlorophyll contents, and water content in soil etc. NDVI a remote sensing index used to measure the plant health and differentiate the green vegetation from non-green vegetation. NDWI is also remote sensing index used to measure the water molecules of the vegetations through the NIR and SWIR bands. The index value higher than zero is considered to be water surface and lower than zero is non-water surface. The different thresholds value is used for extracting the respective water bodies. The threshold value is 0.2 in NDVI for distinguishing vegetation area from non-vegetation area (Taufik, Syed Ahmad, & Azmi, 2019). NDVI helps to determine the condition of the plant of different areas whether it is deteriorated, unchanged or improved (Wijitdechakul, Sasaki, Kiyoki, & Koopipat, 2017). Wijitdechakul had proposed

Greenness detection using NDVI and water content detection using NDWI. The index value higher than zero is considered to be water surface and lower than zero is non-water surface (McFeeters, 2013). NDVI shows the crop growth, nutrient information, chlorophyll and protein assessment (Qiu et al., 2018). The range of index value for both NDVI and NDWI lies between −1 to1.

The change detection of land cover change over time from digital data involves a comparison of two or more images in raster, vector, or other 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 18 years.

4. Results ad Discussion

LULC Images

Figures 3-5 show the classified image for the years 2000, 2011 and 2018 respectively. The red, light green, dark green, orange, white and blue colour indicates the built-up, grass, forest, cultivation, barren and water body respectively. While comparing the classified image from 2000 to 2018, 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 18 years. The pattern are changing haphazardly due to human
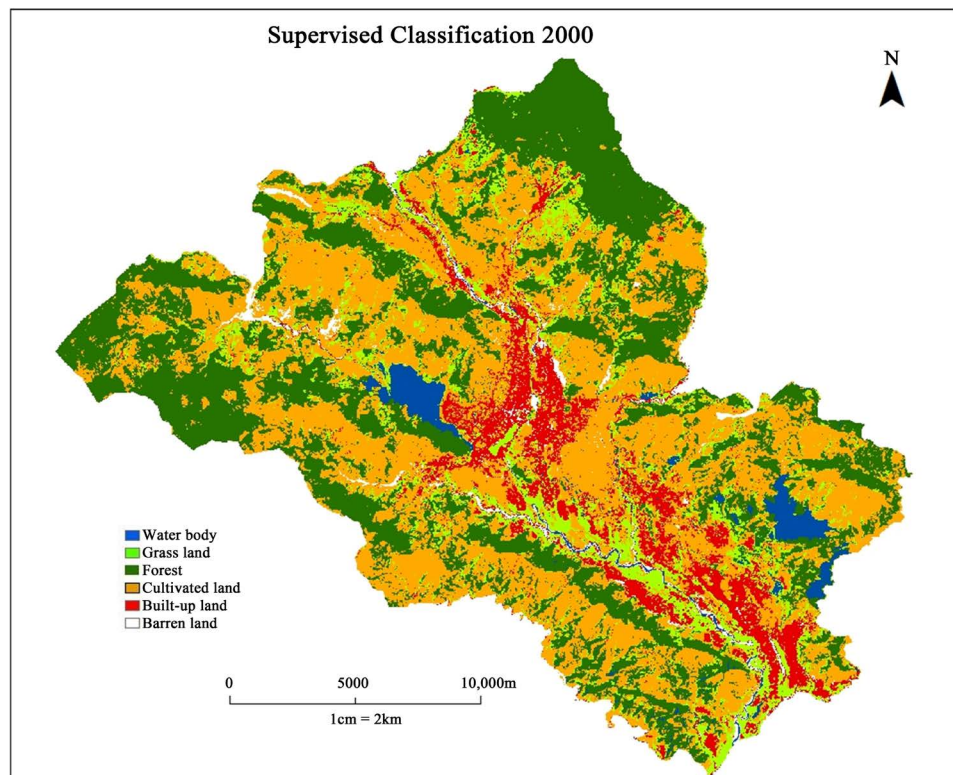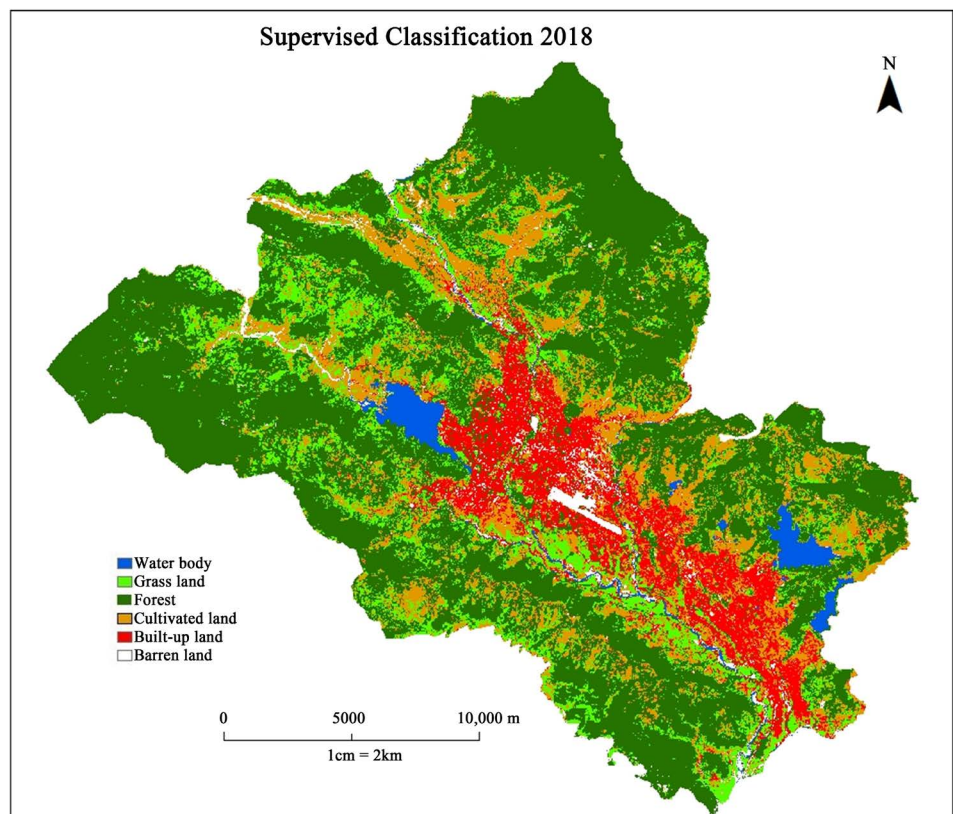

Figure 3. Classified Image for 2000.
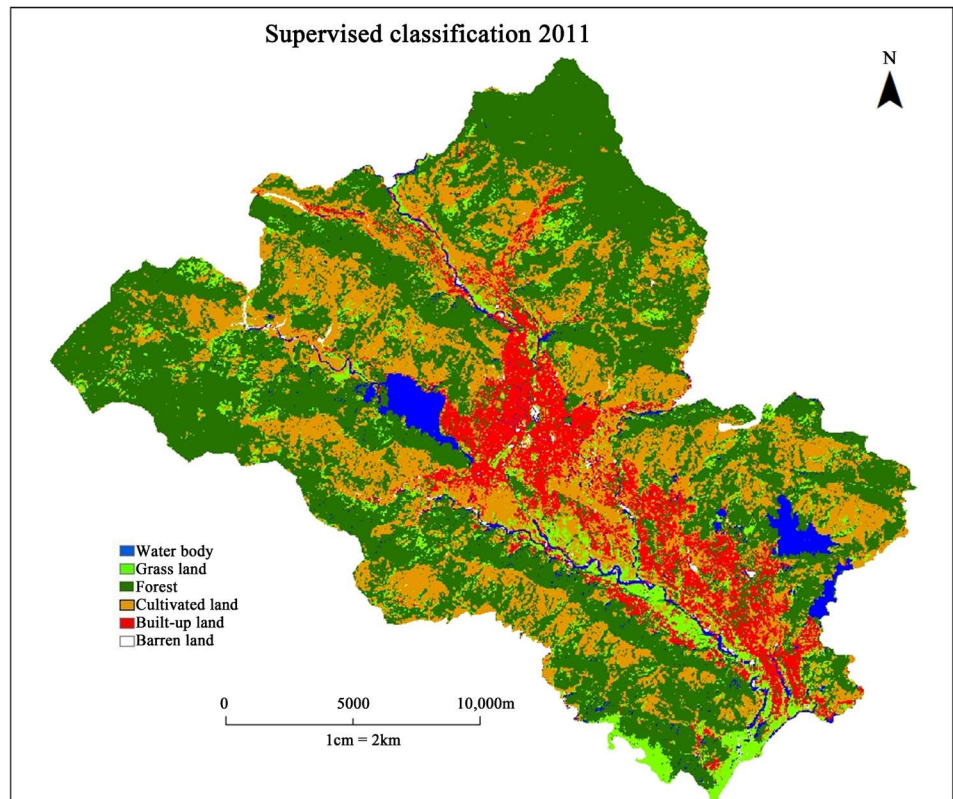
Figure 4. Classified Image for 2011.

Figure 5. Classified Image for 2018.

activities. In past areas covered with agriculture and forest are being replaced by the buildings and infrastructure. The concrete jungle is increasing in exponentially. The figure shows uraban growth is 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 area 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 2018 there is drastic change in land use pattern. Apart from that there is tremoundsly increasing in the human settlement and physical constructions more in random ways.

Accuracy Assessment

The accuracy of the classified image was assessed after computing the error matrix. This is a tool Accuracy Assessment in the Erdas Imagine for computing accuracy of image classification. Here the contingency table was formed after comparing the location of classified pixels with the ground truth pixels. The reference points were collected from the planet satellite imagery (spatial resolution of 3 m) and topographic base map. The reference points altogether 91 were collected based on a strategy of simple random sampling. The ground truth in.txt format containing the spatial locations and raster value of each attribute was imported in the classified image. The co-ordinates system must be in the same extent otherwise it could not perform the results. Here different fields X, Y, class, and reference represents the easting, northing, predicted a class value and referenced class value, respectively. The error matrix of 6 * 6 size was generated for consecutive three different years. The overall accuracy for 2000, 2011 and 2018 is 85.71%, 70.33% and 70.33% respectively. The kappa value for 2000, 2011 and 2018 are 0.82, 0.64 and 0.64 respectively. Here kappa value for every classification is higher than 0.60 which considered being good classification. Table 2

Table 2. Accuracy assessment from error matrix.

	Water Body	Forest	Barren	Cultivated	Built-up	Grassland	Year
Producer Accuracy	85.71%	100%	93.33%	93.75%	62.5%	78.57%	2000
User Accuracy	100%	100%	93.33%	62.5%	100%	78.57%	
Overall Accuracy			85.71%				
Kappa			0.82				
Producer Accuracy	78.57%	100%	33.3%	87.5%	75%	42.86%	2011
User Accuracy	78.57%	84.21%	71.43%	51.85%	75%	75%	
Overall Accuracy			70.33%				
Kappa			0.64				
Producer Accuracy	84.62%	100%	50%	52.63%	73.33%	64.29%	2018
User Accuracy	100%	88.89%	87.5%	58.82%	73.33%	40.91%	
Overall Accuracy	70.33%						
Kappa			0.64				

shows the accuracy assessment for the different three years.

Change Detection

The forest area has increased by 18.85% and this is due to the open field and barren land has transferred into the forest area. It is a good sign of environmental perspectives as well as fresh air for human life. But in the cultivation area, it was decreased by 34.32% and maximum land was changed into a residential area and another class. The main causes of the decrease in cultivated land are unnecessary planning for residential, industrial, and commercial purposes. In the case of Nepal, there is no integrated land-use policy for conserve cultivated land. The grassland area has decreased by 3.05%. The maximum area of grassland was found along the edges of the Seti River due to deposition of alluvial soil. Some of the grasslands were occupied by informal settlement due to earthquakes. Many people are living 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.

According to UN 2014, the urbanization rate in Nepal is 18.2% (DESA, 2014). But in our case the built-up has increased by 13.52% and of barren land decreased by 4.94%. The maximum open field, grassland and agricultural area has transferred into built-up. The land-use change incorporates some factors including the exogenous ones such as advancement in technology, migration, market availability, infrastructural availability, government policies and, natural hazards, etc. Similarly, the endogenous factors such as regional economy, socio-economic and cultural trend, demography, geographical condition, and road accessibility, site and ecology contribute significantly to a combination of the exogenous ones for the land-use change ("Chapter 6—Social and economic issues," n.d.). The change detection for 2000-2018 is given in Figure 6.

5. Conclusion

The study has concluded that there is a maximum change in land use between periods 2000 to 2018. The urban area is increasing rapidly. There is continuously
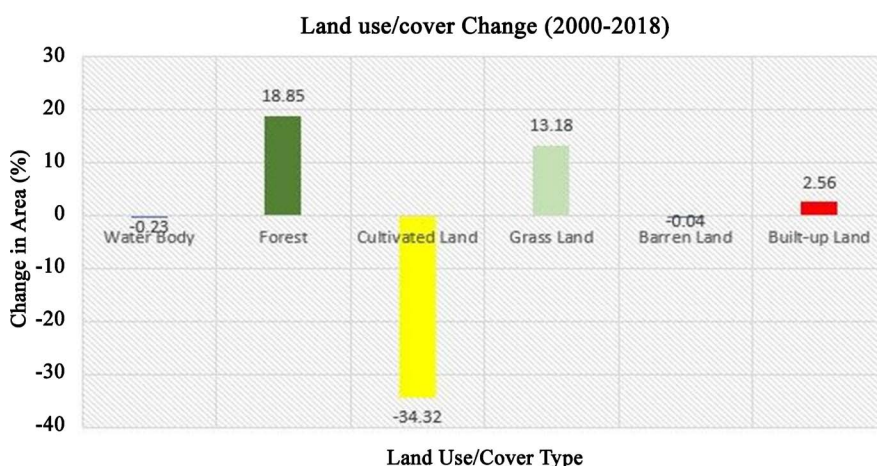
Figure 6. Change Detection for 2000-2018.

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 current landuse pattern is different from the last 5 years pattern. Therefore, 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. Though the performance of the classification results is satisfactory there are some limitations. The spatial resolution of Landsat image is low comparing to others. 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 government of Nepal might use this information for making new plan and policy on implementing the urban planning and smart city implementation.

Acknowledgements

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

(n.d.). *Chapter 6 Social and Economic Issues*. http://www.fao.org/3/v9926e/v9926e08.htm

Abbas, A. W., Minallh, N., Ahmad, N., Abid, S. A. R., & Khan, M. A. A. (2016). K-Means and ISODATA Clustering Algorithms for Land Cover Classification Using Remote Sensing. *Sindh University Research Journal (Science Series), 48,* 315-318.

Bakrania, S. (2015). *Urbanisation and Urban Growth in Nepal* (pp. 1-3). GSDRC Helpdesk Research Report.

Briassoulis, H. (2000). *Land Use, Land Cover and Soil Sciences, Vol. 1. Factors Influencing Land-Use and Land-Cover Change*.

Desa, U. (2014). World Urbanizations Prospects. *Journal of Petrology, 369,* 1689-1699.

Fort, M., Adhikari, B. R., & Rimal, B. (2018). Pokhara (Central Nepal): A Dramatic Yet Geomorphologically Active Environment versus a Dynamic, Rapidly Developing City. In *Urban Geomorphology* (pp. 231-258). Amsterdam: Elsevier Inc. https://doi.org/10.1016/B978-0-12-811951-8.00012-6

Goswami, M., & Khire, M. V. (2016). Land Use and Land Cover Change Detection for Urban Sprawl Analysis of Ahmedabad City Using Multitemporal Landsat Data. *Inter-*

national *Journal of Advanced Remote Sensing and GIS, 5,* 1670-1677.
https://doi.org/10.23953/cloud.ijarsg.51

Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2004). *Remote Sensing and Image Interpretation* (5th ed.). Hoboken, NJ: John Wiley & Sons Ltd.
https://doi.org/10.2307/634969

McFeeters, S. K. (2013). Using the Normalized Difference Water Index (NDWI) within a Geographic Information System to Detect Swimming Pools for Mosquito Abatement: A Practical Approach. *Remote Sensing, 5,* 3544-3561.
https://doi.org/10.3390/rs5073544

Ministry of Land Reform and Management (2015). *Singhdurbar, Kathmandu. Land Use Policy 2015 Government of Nepal Ministry of Land Reform and Management (MoLRM).*
http://search.proquest.com/docview/1300125506?accountid=8330%255Cnhttp://library
.anu.edu.au:4550/resserv?genre=article&issn=0190292X&title=Policy+Studies+Journal
&volume=8&issue=6&date=1980-07-01&atitle=Land+Use+Policy&spage=984&aulast=
Windsor&sid=ProQ:Pro

Qiu, C., Liao, G., Tang, H., Liu, F., Liao, X., Zhang, R., & Zhao, Z. (2018). Derivative Parameters of Hyperspectral NDVI and Its Application in the Inversion of Rapeseed Leaf Area Index. *Applied Sciences, 8,* 1300. https://doi.org/10.3390/app8081300

Rijal, M. L. (2017). Characterization of Sinkholes Affected Area of Thulibeshi Phat, Armala, Kaski, Nepal. *Journal of Institute of Science and Technology, 22,* 17-24.
https://doi.org/10.3126/jist.v22i1.17735

Rimal, B. (2012). Urbanization and the Decline of Agricultural Land in Pokhara Sub-Metropolitan City, Nepal. *Journal of Agricultural Science, 5,* 54-65.
https://doi.org/10.5539/jas.v5n1p54

Taufik, A., Syed Ahmad, S. S., & Azmi, E. F. (2019). Classification of Landsat 8 Satellite Data Using Unsupervised Methods. In *Intelligent and Interactive Computing* (pp. 275-284). Lecture Notes in Networks and Systems No. 67, Singapore: Springer.
https://doi.org/10.1007/978-981-13-6031-2_46

Wijitdechakul, J., Sasaki, S., Kiyoki, Y., & Koopipat, C. (2017). UAV-Based Multispectral Image Analysis System with Semantic Computing for Agricultural Health Conditions Monitoring and Real-Time Management. In *Proceedings 2016 International Electronics Symposium* (pp. 459-464). Denpasar.