International Journal of Geography, Geology and Environment

P-ISSN: 2706-7483
E-ISSN: 2706-7491
IJGGE 2019; 1(2): 17-22
Received: 25-03-2019
Accepted: 08-05-2019

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Dynamics of land conversion in Kathmandu district

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Abstract
Land cover change detection and updating a land cover map is prerequisite to understand the land cover change dynamics and for the sustainable management of forest resources. Urbanization has serious effect on the forest area in capital city but such studies are limit in Nepal. Thus this study was objectively conducted to assess land use land cover in Kathmandu district using spatio-temporal technique. Imageries of Thematic Mapper of 2000, 2010 and OLI 8 of 2021 were downloaded from USGS earth explorer. The maximum likelihood supervised classification was performed to classify the imageries of 2000, 2010 and 2021. The accuracy assessment of was performed of all the classified map. The maps showed the status and change detection in Forest, Bareland/Road, and Settlement and Water bodies from 2000 to 2010, from 2010 to 2021. The classified map of Kathmandu district showed that the area of Forest, Bareland/Road, Settlement and Water bodies was 19087.21, 14500.09, 3597.69 and 4160.03 ha respectively in 2000. The area of Forest, Bareland/Road, Settlement and Water bodies was 11489.35, 21200.51, 4390.42 and 3415.66 ha respectively in 2010. Similarly, the classified map of 2021 showed that the area of Forest, Bareland/Road, Settlement and Water bodies was 12732.08, 17917.47, 7034.4 and 3661.88 ha respectively in 2021. Over all accuracy of thematic was 76.47, 82.92 and 93.16% of the classified map of Kathmandu district of 2000, of 2010 and of 2021 respectively. The forest area was decreased by 7597.86 ha between 2000 and 2010, this was decreased by 1242.73 ha between 2010 and 2021 which was over all decreased by 6355.13 between 2000 and 2021. Barenland/road was increased by 3417.05 ha between 2000 and 2021 and about same increasing pattern was recorded with 3436.71 ha between 2000 and 2021. The effect of road construction, bare land and new settlement was clearly recorded in 21 years period.

Keywords: land cover, forest, settlement landsat, remote sensing

Introduction
The encroachment is defined as intrusion on a person's territory, rights, etc. or gradual advance beyond usual or acceptable limits. This gradual disturbance in the forest due to human activities is called forest encroachment. Population pressure and poverty are the main two factors stimulating forestland encroachment. Forests provide new areas for agriculture and a range of subsistence products. With increasing population, more families search land for agriculture and settlement or look for fuel wood or timber. There are several reasons of shrinking the forest. Illegal logging, grazing, infrastructure development, fire, encroachment (conversion of forest into agriculture and other land), fire, natural disaster (such as land slide, flood, erosion, bank cutting) are the key reasons. Deforestation and forest degradation are consequences of the causes. The encroachment is a challenging issue in developing countries. Generally, people encroach the land for different purpose. Poor people encroach the land to live or to build house while the rich and medium family encroach the land to extend their business. The business may be the extension of agriculture land, industry, school or other structures. These are the common problem in developing countries like Nepal. The people buy small piece of land nearby the forest after that, they encroach the forest and convert into agricultural land. The process of conversion of forest into other land use is the slash and burn process.

The land use pattern of a region is an outcome of natural and anthropogenic factors and their utilization by man in time and space. Land is becoming scarce resource due to immense agricultural and demographic pressure. Hence, information on land use and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing

demands of increasing population. Deforestation is the conversion of forest to another land use type. Forest degradation is a more subtle process. In both processes human encroachment on forest land is a driver where forest land is cleared and opened for cultivation, settlement or other development activities. Encroachment i.e. illegal conversion area of the forest land into other landuse is another major cause of disturbance to forests and other wooded lands in Nepal (FAO, 2010) [8].

Although Encroachment is posing serious threat to forest, there is lack of concrete policy and plan to deal with this problem. Therefore, forest encroachment has become a chronic problem in natural resources management regime in Nepal's Terai. The problem of encroachment keeps on escalating during the period of Political unrest and political fluidity in the country. Human encroachment on forestland gives rise to the change in another type of landuse. Further, Land use change by human activities i.e. encroachment has become a proximate factor that catalyses deforestation and forest degradation (Tole, 1998 [25]; Koop and Tole, 2001). Hence, detecting the change in landuse due to encroachment of the forest at different spatial and temporal scales could provide useful information for planning and sustainable management of forests. Satellite remote sensing has been widely used to detect forest change, assess rates of reforestation or deforestation, and update existing forest maps (Myers, 1980) [19]. This study was objectively carried out to assess encroached areas of forest in Kathmandu district and estimate the encroached areas.

2. Materials and Methods

2.1 Study Area: The study area is Kathmandu. Kathmandu is a district located in Kathmandu Valley, Bagmati Province of Nepal. It covers an area of 433.6 km² and is the most densely populated district of Nepal with 1,744,240 inhabitants in 436,355 households in 2011. The district is located from 27°27′E to 27°49′E longitude and 85°10′N to 85°32′N latitude. In the urban center, the temperature fluctuates between 32 °C in summer (June– July) to -2 °C in winter (December–January). The annual rainfall of district is 176.4ml. The dominant tree species in this zone are oak, elm, maple and others, with coniferous trees at higher altitude.

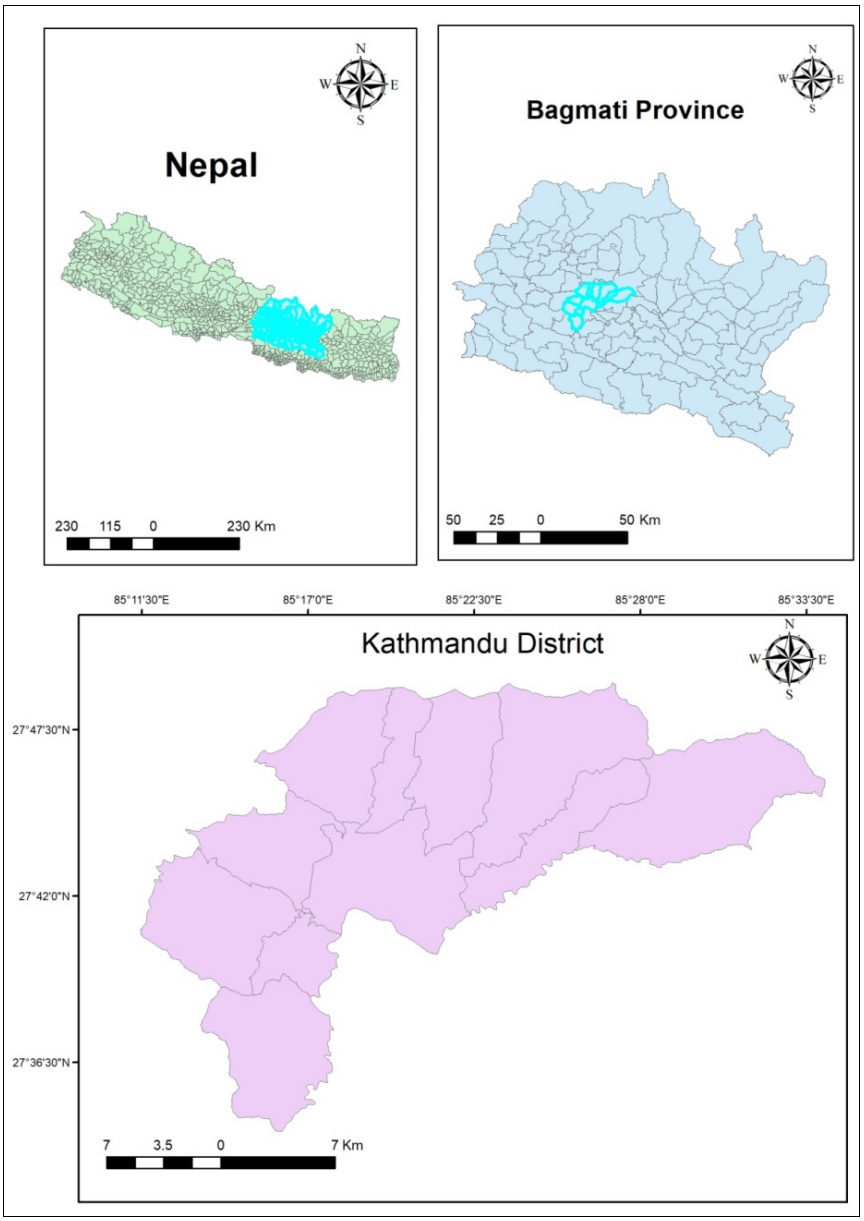


Fig 1: Map Showing Study Area

2.2 Data Collection: Primary and secondary data were collected. In addition to these spatial data was also collected to analyze the effect of LULC on forest of Kathmandu district. Primary data were collected from field observation, key Informant Interviews and Focus Group discussion while the secondary data and information were collected from record in Division Forest Office, Kathmandu, books, reports, journals, and community forest operational plans to meet the research objectives.

2.3 Data Analysis: Two Landsat 7 ETM+ and one Landsat 8 OLI/TIRS Satellite images dated 2000, 2010 and 2021 were used to find a change between these periods. Both satellite images were downloaded from the United States Geological Survey (USGS) official website (https://earthexplorer.usgs.gov/). Priority was given to the data with less cloud cover and sensor noise, and at the same time attention was made for acquiring images with smaller seasonal variations. Details of the Image are given in the Table 1.

Table 1: Landsat Image Details

WRS (Path/Row)	Scene ID	Sensor	No. of Bands	Spatial Resolution	Date of available image
Path = 141 Row = 41	LE07_L1TP_141041_20000327_20170212_01_T1_ANG	Enhanced Thematic Mapper	7	30*30	2000/03/27
Path = 141 Row = 41	LE07_L1TP_141041_20100510_20100911_20_T1_ANG	Enhanced Thematic Mapper	7	30*30	2010/05/10
Path = 141 Row = 41	LC08_L1TP_141041_20210516_20210525_02_T1_MD5	Operational Land Imager and Thermal Infrared Sensor	11	30*30	2021/05/16

Creating Composites: Landsat data were formed by multiple band compositions according to sensor acquire and multiple images of year-long were present. Here, a single representative image of the whole year was made by combining multiple bands and images for enhancement of the image.

Training sample collection: First of all, four land cover classes which represented the total land cover of the study area were determined as: i. Bareland/Road, ii. Forest, iii. Settlement and iv. Water bodies. Maximum possible training samples were taken for each class. Obtained training points were merged into respective classes. Then Interactive Supervised Classification was done to obtain composite landsat image having four feature classes.

Accuracy Assessment: The accuracy assessment was carried out to prove the completeness of image classification of 2000, 2010 and 2021. The accuracy was calculated using true earth values and total sample number obtained in Error Matrix. The formula used was true earth value divided by total sample and multiplied by hundred to get result in percentage form.

Post Processing: Composite Landsat image having four feature classes was firstly clipped into the Boundary of Kathmandu district and Local bodies applying "Extraction by Mask" which differentiated the land cover into the boundary. Further, it was subjected to manipulation to obtain a smooth image. Finally, a layout map was created and extracted to obtain the final land use land cover map of the Kathmandu district and Local Bodies of Kathmandu district of year 2000, 2010 and 2021.

Change Detection and Analysis: LULC change detection of Local Bodies of Kathmandu district between 2000 and 2021 was done using Intersect of Geo-processing tool in ArcGIS platform. New field, Change in Class and Area Change were added to the attribute table in order to calculate area change from one class to other between the time period of 2000 to 2021. The numerical analysis of land use land cover dynamics was then done through Microsoft Excel.

Google Earth: Google earth was used for the selection of the study site, including its “historical imagery” function, classification, and accuracy assessment of Landsat images. It was also used to download images of the study area and extract different features on the ground.

3. Result and Discussion

Result and discussion are presented based on the objectives of the research. Assessment of encroached areas, estimation of encroached areas purposes of encroachment and land use land cover change of Kathmandu district and Local Bodies respectively.

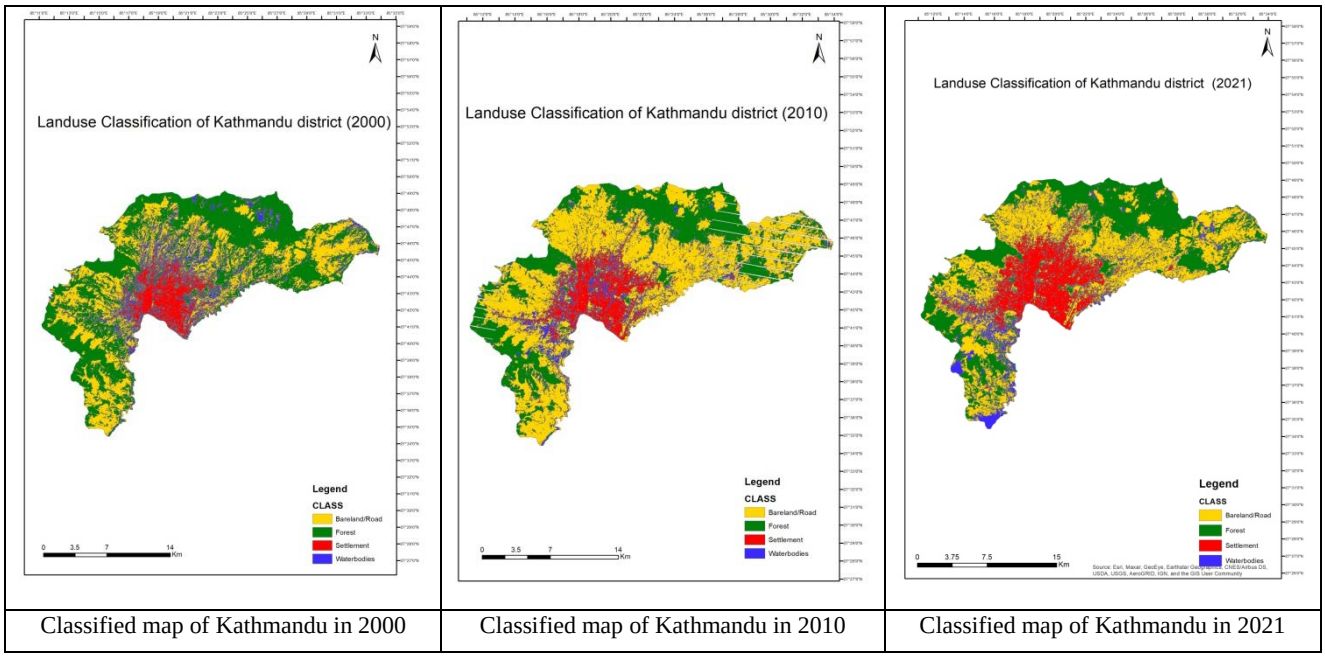
3.1 Land use and Land cover Change of Kathmandu district (2000, 2010 and 2021)

The image classification of 2000 showed that 19087.21ha, 14500.09ha, 3597.69ha and 4160.03 ha was covered by Forest, Bareland/Road, Settlement and Water bodies respectively. Similarly, the image classification of 2010 showed that 11489.35ha, 21200.51ha, 4390.42ha and 3415.66 ha was covered by Forest, Bareland/Road, Settlement and Water bodies respectively. Likewise, the image classification of 2021 showed that 12732.08 ha, 17917.47 ha, 7034.4 ha and 3661.88 ha was covered by Forest, Bareland/Road, Settlement and Water bodies respectively. The difference between LULC 2000 and LULC 2010 showed decrease in Forest and Water bodies by 7597.86 ha and 744.37ha respectively and increase in Bareland/Road and Settlement by 6700.42ha and 792.73ha respectively.

Similarly, the difference between LULC 2000 and LULC 2021 showed decrease in Forest and Water bodies by 6355.13ha and 498.15ha respectively and increase in Bareland/Road and Settlement by 3417.05 and 498.15ha respectively. Likewise, the difference between LULC 2010 and LULC 2021 showed increase in Forest, Settlement and Water bodies by 1242.73ha, 2643.98ha and 246.22 respectively and decrease in Bareland/Road by 3283.04ha (Table 2 & figure 2).

Table 2: Land use Land cover change of Kathmandu district between 2000, 2010 and 2021

S.N.	LULC Classes	LULC 2000 (ha)	LULC 2010 (ha)	Difference between 2000 & 2010 (ha)	LULC 2021 (ha)	Difference between 2000 & 2021 (ha)	Difference between 2010 & 2021 (ha)
1	Forest	19087.21	11489.35	Decreased- 7597.86	12732.08	Decreased- 6355.13	Increased-1242.73
2	Bareland/Road	14500.09	21200.51	Increased- 6700.42	17917.47	Increased-3417.05	Decreased-3283.04
3	Settlement	3597.69	4390.42	Increased- 792.73	7034.4	Increased- 3436.71	Increased-2643.98
4	Water Bodies	4160.03	3415.66	Decreased- 744.37	3661.88	Decreased- 498.15	Increased-246.22



Classified map of Kathmandu in 2000	Classified map of Kathmandu in 2010	Classified map of Kathmandu in 2021

Fig 2: Landuse Classification of Kathmandu district (2000, 2010 & 2021)

Accuracies were 76.47, 82.92 and 93.16% of the classified map of Kathmandu district of year 2000, 2010 and 2021 respectively.

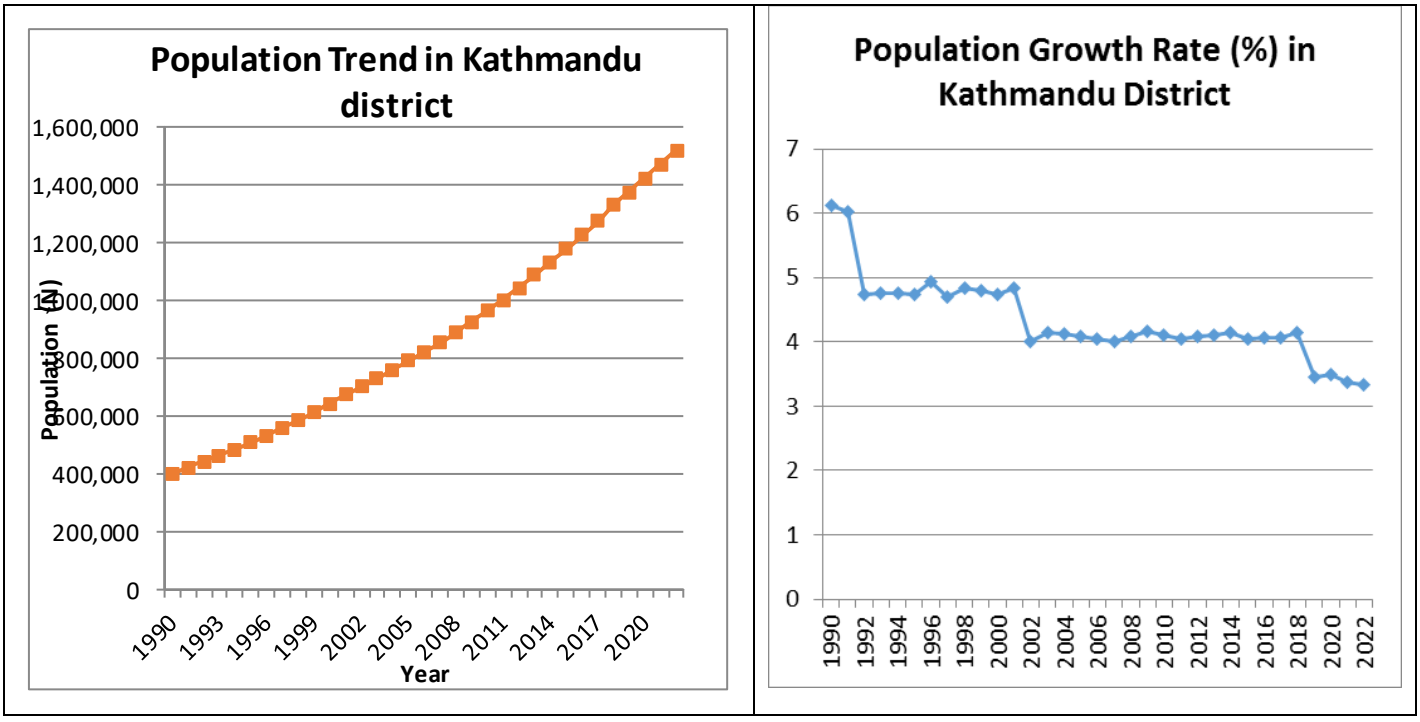


Fig 3: Population Dymnamis of Kathmandu

The population has been increasing rapidly in Kathmandu district. It was only 398,000 in 1990 in Kathmandu while this is 1,521,000 in 2022. The rate of population of growth 6.13 % annually in 1990 but this growth is becoming low these days with 3.33 in 2022.

3.2 Discussion

According to the result obtained, the forest area was decreased in large amount between 2000 and 2010 i.e. by 7597.86 ha however the forest area was increased after 2010 upto 2021 by 1242.73 ha which may be due to the effective effort from Government of Nepal in conservation and promotion of Forest resources through various programs and supportiveness to all concerned stakeholders of forest inside Kathmandu district. Another important reason is increasing forest area in Kathmandu may be effective efforts of forest users to manage the community forest. Another important reason may be the protection of forest through National Park. Infact, Nagarjun forest was announced as National Park in 2002. Another important reason of increasing forest area may be shifting of energy of the local people towards biogas from fuelwood consumption.

Though Nepal's policy is emphasized on to maintain the forest area at least 40%, land fragmentation and conversion agriculture area into urban area is the main problem (Sharma, 2015) [29]. Most of the forest land is converted into infrastructure development particularly The forest patches were handed over for different purposes such as hydropower generation, transmission lines, public buildings, waste disposal, city parks, mining for cement industries, landfill sites, settlements, sites for factory, drinking water supplies, cableway construction, construction of towers for communication, irrigation canals and roads. The analysis of the data showed that the area of forest converted to non-forestry uses was 263.8 ha per year, on an average, ranging from 84.1 ha in 2010 to 518.7 ha in 2011. This is completely matching with this result of this research work. The study done by FRA, 2014 showed that the forest area of Kathmandu was 15,129 ha, this value was differed from the present research work. The reason behind this may be forest management practice adapted by the users. There are several causes of land use land cover in Nepal but one of the important causes is the infrastructure development and extension particularly in urban area. The plotting of agriculture land and building of road, park, water storage tank and other public building are generally constructed inside the forest. In addition, the office building of government supported academic institutions is made inside the forest. These are important reasons of conversion of forest land into non-forest land.

4. Conclusion and recommendation

The map was produced to show the status of Forest, Bareland/Road, Settlement and Water bodies of 2000, 2010 and 2021. The classified map of Kathmandu district showed that the area of Forest, Bareland/Road, Settlement and Water bodies was changed from 2000 to 2010, 2010 to 2021 and 2000 to 2021. The forest area was decreased between 2000 and 2010, 2010 and 2021 and 2000 and 2021. On the other hand, road/baren land and settlement areas were increased between 2000 and 2010, 2010 and 2021 and 2000 and 2021. the increasing areas in these thematic classes showed clear effect on forest area. The research will be useful for policy maker and scientific community especially to understand the change detection in urban areas.

Further conversion of forest area must be controlled through management in collaboration with the local community as early as possible. Management policy should be implemented and the area should be emphasized for restoration of forests. Effect of land use and land cover change was monitored using remote sensing analysis which can be useful tool for forest manager and policy maker.

Reference

1. Acharya KP, Dangi RB, Acharya M. Understanding the forest degradation in Nepal. Unasylva. Food and Agriculture Organization of the United Nations. 2011;62(238):31-38.
2. Awasthi KD, Balla MK. Degraded Lands in Mid-hills of Central Nepal: A GIS appraisal in quantifying and planning for sustainable rehabilitation. Pokhara, Nepal. 2000.
3. Bauer ME, Burk TE, Ek AR, Coppin PR, Lime SD, Walsh TA, *et al*. Satellite Inventory of Minnesota forest resources, 2000.
4. Chopping PR, Bauer ME. Digital change detection in forest ecosystems with remote sensing imagery, Remote Sensing Reviews. 1996;13:207-234.
5. COMFORTC. Report on Government Managed Forest Management including Collaborative Forest Management (CFM) and Encroachment in Rupendehi district, Livelihood and Forestry Programme, Terai Component, 2003.
6. COMFORTC. Baseline Assessment of the Encroachment status in Western Terai Landscape Complex. Community Forestry Research and Training Centre (COMFORTC), Kathmandu, Nepal, 2006.
7. Congalton R. A review assessing the accuracy of classification of remotely sensed data. Remote sensing environment. 1991;37:35-46.
8. FAO. Global forest resource assessment, country report Nepal. Food and Agriculture Organization of the United Nations, FRA2010/144 Rome, 2010a.
9. Gardner R, Gerrard J. Soil Loss on Non-cultivated Land in the Middle Hills of Nepal. Physical Geography. 2001;22(5):376-393.
10. Gautam AP, Webb EL, Shivakoti GP, Zoebisch MA. Land Use Dynamics and Landscape Change Pattern in a Mountain Watershed in Nepal, 2003.
11. GoN. Strategy for Forest Encroachment Control, 2012. Government of Nepal. Nepal, 2012.
12. Jensen JR. "Introductory Digital Image Processing. New Jersay: Trentice Hall. Kanel, K.R., 2002. Terai Arc landscape programme, A lecture note. WWF, Nepal, 1996.
13. Kiefer RW. Remote Sensing and Image Interpretation, third edition, 1994 by John Wiley and Sons, Inc. 1994, 598.
14. Lambin EF. Monitoring forest degradation in tropical regions by remote sensing: some methodological issues. Global Ecology and Biogeography. 1999;8(3–4):191–198.
15. Langran G. Forest Monitoring Using Temporal GIS Techniques. GIS'92 Symposium, Vancouver, British Columbia, 1992.
16. Lilles TM, Kiefer RW, Chipman JW. Remote sensing and Image interpretation. John Wiley and Sons. New York, USA, 2004.
17. Mas JF. Monitoring Land –Cover Changes: A comparison of change detection techniques." International Journal of Remote Sensing. 1999;20(1):139-152.
18. Meyer WB. Past and Present Land-use and Land-cover in the U.S.A. Consequences. 1995, p.24-33.

19. Myers N. Conversion of Tropical Moist Forests. National Academy of Sciences. Washington, DC, 1980.
20. Panta M, Kyehyun K, Joshi C. Temporal mapping of deforestation and forest degradation in Nepal: applications to forest conservation. Forest Ecology and Management. 2008;256:1587–1595.
21. Pathirana S. Distribution of Errors in a Classified Map of Satellite Data. Geocarto International. 1999, 14(4).
22. Phong LT. Analysis of Forest Cover Dynamics and Their Driving Forces in Bach Ma National Park and its Buffer Zone using Remote Sensing and GIS, 2004.
23. Sapkota. Forest encroachment problems and solution: study of Kanchanpur district (in Nepali). Hamro Kalpabrikshya. 2012;22(25):1-5.
24. Singh A. Digital Change Detection Techniques Using Remotely Sensed Data. International Journal of Remote Sensing. 1989;10(6):989-1003.
25. Tole L. Source of deforestation in tropical developing countries. Environ. Manage. 1998;22;19–23.
26. Turker M, Derenyi E. GIS Assisted Change Detection Using Remote Sensing. Geocarto International, 2000, 15(1).
27. USGS. A Landuse and Land Cover Classification System for Use with Remote Senser Data, Geological Survey Professional Paper 964 (Washington, USA), 1972.
28. Wyatt BK. Vegetation Mapping from Ground, Air and Space – Competitive or Complementary Techniques ? Vegetation Mapping: From Patch to Planet. John Wiley and Sons Ltd, 2000.
29. Sharma UR. Use of forest land for national-priority infrastructures in Nepal. Banko Jankari. 2015;27(1):61-65.