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Forest Change in Phewa Lake Watershed Area between 2006 and 2020 A.D.

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Abstract

Nepal encompasses diverse ecological zones and comprises of a variety of ecosystems. It covers a wide altitudinal range (60-8848m) and is divided into five physiographic zones i.e., the Terai, the Siwalik, the Middle Mountains, the High Mountains, and the High Himalayas (HMGN/MFSC 1989). It occupies a mentionable place in the natural resources and richness of bio-diversity (FAO 2000) in the world figure. The main data used were two satellite images (False Color Composite) Landsat TM Image taken on 1990/11/10 and Landsat ETM + SLC off image taken on 2016/03/03. Also, Topographic Map no. 2883 (16A, 16B, 12C, 12D) of scale 1:25,000 dated 1998 produced by Survey department of Nepal was used for boundary delineation, accuracy assessment, ground truthing and geo-referencing. There is net reduction in the forest area by 471.67484 ha in the Phewa Lake Watershed Area between 1990 and 2020 A.D. Major portion of the forest area is converted into other than the forest area class by 10.521% which is greater than the area converted from other than the forest area to forest (6.255%). The reasons behind this reduction in the forest area might be road construction, landslides, and conversion into agricultural land.

Keywords: Forest Cover Change, Remote Sensing, GIS, Classification, Overlay, Satellite image, False Color Composite

Introduction

Nepal incorporates assorted environmental zones and includes an assortment of biological systems. It covers a wide altitudinal reach (60-8848m) and is separated into five physiographic zones, for example: the Terai, the Siwalik, the Middle Mountains, the High Mountains, and High Himalayas (HMGN/MFSC 1989). It involves a mentionable spot in the regular assets and wealth of bio-varieties (FAO 2000) on the planet. Five significant sorts of forest, for example: tropical, sub-tropical, temperate, coniferous, and alpine vegetation are found in Nepal (Jackson 1994). Nepal covers 39.6 percent of forest, which includes about 4.27 million ha (29%) of timberland and bush covers 1.56 million ha (10.6%) (ICIMOD 2007).

Despite the highly acclaimed success of Community forestry in curbing forest degradation, the forests of Nepal are declining in both quality and quantity. Several proximate causes and underlying driving forces (Geist and Lambin 2002) are responsible to accelerate the deforestation and forest degradation. The change in the land use system, mostly from forestland to agriculture land is a common practice. The main cause of land use change is the population growth in the global and local context. According to CBS (2001), the annual growth rate of population of Nepal is 2.25 per cent per year. Corresponding to human population growth, the livestock population has also increased over the successive years, which has kept additional pressure on the forest and grazing lands in the country. In addition, the increasing population is forced to remain in agriculture because of very limited opportunities in non-farm activities. Between 1990 and 2000, Nepal lost an average of 91,700 hectares of forest per year. This amounts to an average annual deforestation rate of 1.90 per cent, which was reduced to 1.35 per cent in 2000-2005 (Butler 2006).

The advancement exercises like extension in schooling and wellbeing administrations, the improvement of streets and power, enhancements in water system and horticultural and related innovations, and the entrance of business powers are definitely influencing land cover and environments of the territory. Past investigations completed by Brandon and Bottomley (1998), Chen (2000), Diouf and Lambin (2001), Kuntz and Siegert (1999), Lambin (1994), Mendoza S. what's more, Etter R., (2002), Vance and Geoghegan (2002) have stressed the significance of researching land cover elements as a gauge pre-requisite for the economical administration of normal assets. The information on "where are the changes" and "what are the reasons for the changes" is fundamental for the plan of suitable administration procedures. The comprehension of land cover change interaction and main thrusts will help strategy producers and asset directors to choose where the move ought to be made and what sorts of mediation are fundamental. Be that as it may, the assurance of such change had consistently been a troublesome occupation regarding both time utilization and cost adequacy. Be that as it may, with the approach of distant detecting advancements and GIS, these troubles have been enormously diminished. Thus, distant detecting has, presently, been utilized broadly in identifying worldly elements of land use through the investigation of satellite pictures covering a similar region procured on various dates (Mulders 2001).

Keeping these situations in mind, the current investigation endeavors to decide the adjustment in forest cover in the Phewa lake Watershed area somewhere in the range of 1990 to 2017 from the satellite images obtained on 1990 and 2020. Since Phewa Lake Watershed region is one of the profoundly significant and major watersheds in Kaski district, the appraisal of forest cover change may end up being productive for chiefs and land use organizers for plan and execution of reasonable and proper administration methodologies for maintainable use and protection of forest assets, at both local area and watershed level.

Objectives

The present study aims to assess the change in the forest cover in the Phewa Lake Watershed area (excluding urban area) between 1995, 2005 and 2020.

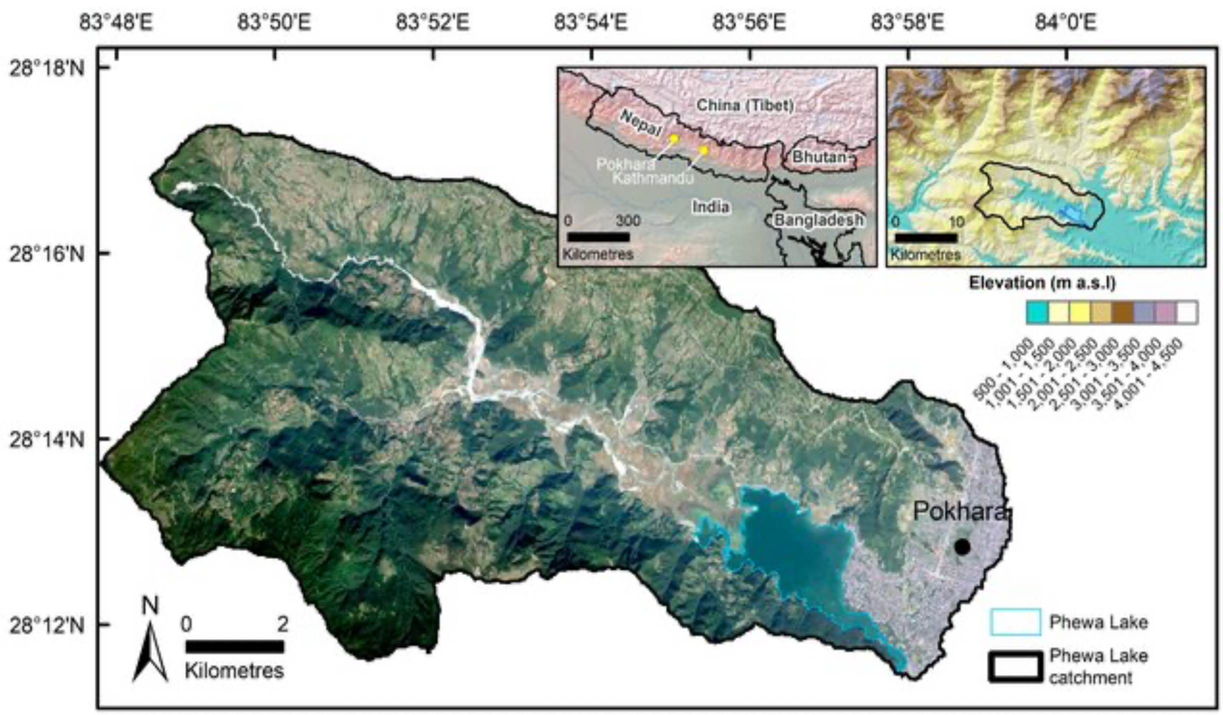
Materials and Methods

The Study Area

The Phewa Lake Watershed area lies in the southwestern part of Kaski District, Nepal. The Phewa Lake Watershed has an area of 112.28 km^2 excluding the urban area. It includes six wards of Pokhara Metropolitan City including Dhikurpokhari, and Bhadaure-Tamagi. The study area lies within the latitude of 28^{0}11’39” to 28^{0}17’25” N and longitude of 83^{0}47’51”to 83^{0}59’17” E. The altitudinal range varies from 793m to 2508.81m. Forests consist of predominant species; *Schima wallichii*, *Castanopsis Indica, Alnus nepalensis* and in some parts of Bhadaure-Tamagi, *Shorea robusta* is found. The climate of the watershed falls in the tropical to sub-tropical monsoon type with a mean annual rainfall of 4160mm.The mean annual temperature of the study area ranges from 22.5°C to 23.5°C.

Figure 2

Study Area.



Source: Watson, C. S., Kargel, J. S., Regmi, D., Rupper, S., Maurer, J. M., & Karki, A. (2019). Shrinkage of Nepal’s second largest lake (Phewa Tal) due to watershed degradation and increased sediment influx. *Remote Sensing*, *11*(4), 444.

Methodology

Data Collection Method

The main data used were two satellite images (False Color Composite); Landsat TM Image taken on 1990/11/10 and Landsat ETM + SLC off image taken on 2020/03/03. Also, Topographic Map no. 2883 (16A, 16B, 12C, 12D) of scale 1:25,000 dated 1998 produced by Survey department of Nepal was used for boundary delineation, accuracy assessment, ground truthing and geo-referencing. Moreover, Global Positioning System (GPS) was used for ground truthing and signature assignment in supervised classification of the satellite image.

Satellite Image Pre-Processing

Landsat ETM + SLC off satellite image of 2020 was geo-referenced to the coordinate system of WGS 84, projection: UTM, Zone 45N and Landsat TM satellite image of 1990 was geo-referenced at the co-ordinate system of WGS 84, projection: UTM, Zone 44N. To lessen the image distortion effects, both images were re-projected into Topo -Map Projection system of Spheroid: Everest 1830, Datum: Everest 1830, Central Meridian 87^0, Scale factor at central meridian: 0.9999, false easting: 500000m, false northing: 0.

Field Sampling and Ground Truthing

Fieldwork was carried out to collect data for training samples and validating land cover interpretation from satellite image of 2006, and for qualitative description of the characteristics of each land cover class. Stratified random sampling method was used for the collection of training samples. The size of the pixel is 28.5m*28.5m, as per image of 1990 and 30m*30m, as per image of 2006, so to match with the pixel size of the image, the training sample plot of 30m * 30 m was taken. These samples were taken at least 60m away from the boundary of the land use. Forty Ground Control Points (GCPs) were observed which have the true reflectance of the images. Other ancillary data and historical data dated 1990 & 2020, were also collected by the key informant's survey.

Land Cover Classes

For the purpose of this study, the total area of the Phewa Lake Watershed was divided into 3 land cover classes: forest area, lake area and other than forest area (cultivation land, settlement area, river, road etc. that excluded any forest area or lake area). Out of the 40 GCPs, 30 GCP locations were observed in the forest cover and 10 GCP locations were taken from other than forest cover type. During the field observation, forest condition, forest type and species composition were also observed.

Image Classification and Accuracy Assessment

The image classification was carried out in ERDAS Imagine 9.2. A supervised classification technique with the maximum likelihood algorithm was applied. Supervised classification is the process of using a known identity of specific sites (through a combination of fieldwork, analysis of aerial photography, maps and personal experience) in the remotely sensed data, which represent homogenous examples of land cover types to classify the remainder of the image. These areas are commonly referred to as training sites (Jensen 1996). A total of 170 training sites were given to the satellite image of 1990 and 155 were given to satellite image of 2020. After the classification, 3*3 windows were run for smoothing the classification results. After the classification in ERDAS 9.2, the classification maps were polygonised and exported to ARCVIEW 3.2a for further analysis.

For the quantitative accuracy assessment of the image classification, Kappa statistics was applied. Kappa quantifies how much better a particular classification is when compared to a random classification. First, the confusion matrix was generated through GIS overlay of the classified images and the test samples. Then, Kappa coefficient "**K**hat" was computed by using the formula (Jensen 1996):

$$\widehat{K} = \frac{N \sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} X_{i+} X_{+i}}{N^2 - \sum_{i=1}^{r} X_{i+} X_{+i}}$$

Where,

r is the number of rows in the error matrix,

X_{ii} is the number of observations in row i and column i,

X_{+i} and X_{i+} are the marginal totals for row i and column i respectively, and N is the total number of observations.

While evaluating classification accuracy, Monserud and Leemans (1992) suggested the use of a subjective scale, where Kappa values >80% were considered excellent. In this study, the Kappa coefficient was obtained to be 81.34%.

Detection of Land Cover Change

The exported images were in ARCVIEW 3.2 and later converted to raster with pixel size 30m*30 m and these images were overlaid to detect the change in forest cover. The resultant change in the forest area is the function of conversion of the lake to the forest area, other than forest to the forest area and vice versa (Table 1). It was found that there was an increase in the forest area (0.093% of total area) from the conversion of the lake to the forest, whereas there was decrease in the forest area (0.028% of total area) from the conversion of the forest to the lake.

Figure 2

Land cover types classified from Landsat ETM+ SLC off image, 2017 A.D.

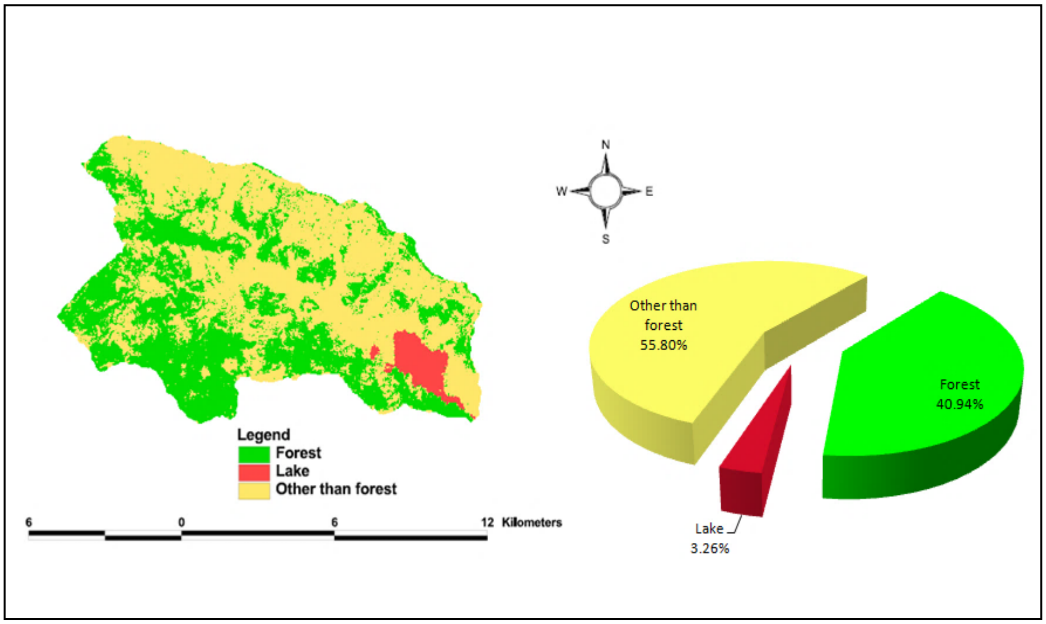
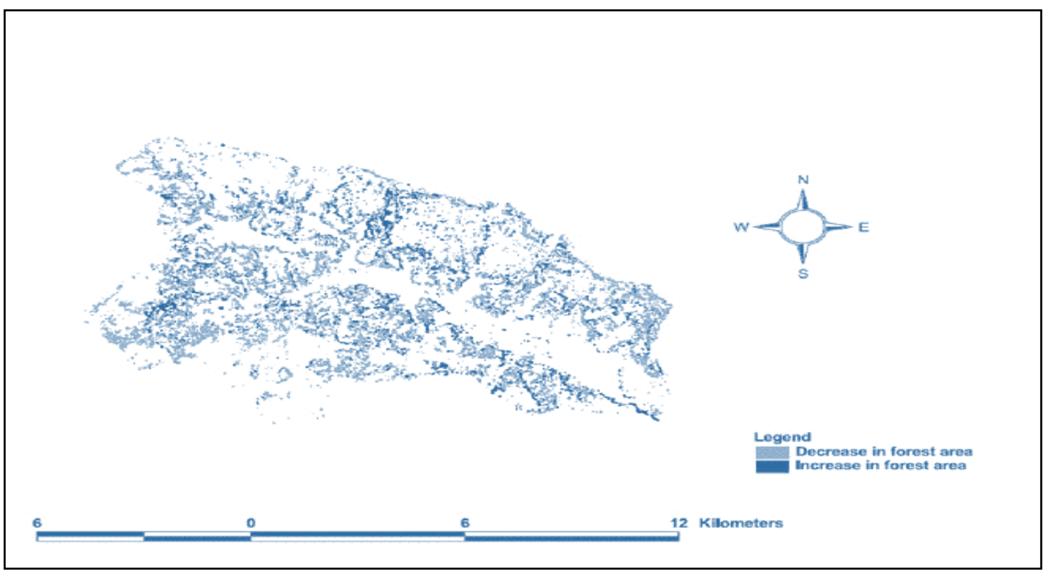


Figure 3

Land Cover Change between 1990 and 2020 A.D



This led to a net increase in forest by 0.065% of the total area of the watershed from the conversion of the lake to the forest and vice versa. Similarly, 6.255% of the total area was converted to the forest from the areas other than the forest whereas 10.521% of the total area was converted to other than the forest from the forest. This led to a net decrease in forest by 4.266% of the total area of the watershed from the conversion of other than the forest to the forest and vice versa. Hence, it was found that the net reduction in the forest area between 1990 and 2020A.D. is 471.675ha (4.201% of total area of watershed).

Figure 4

Land Cover Change between 1990 and 2020 A.D.

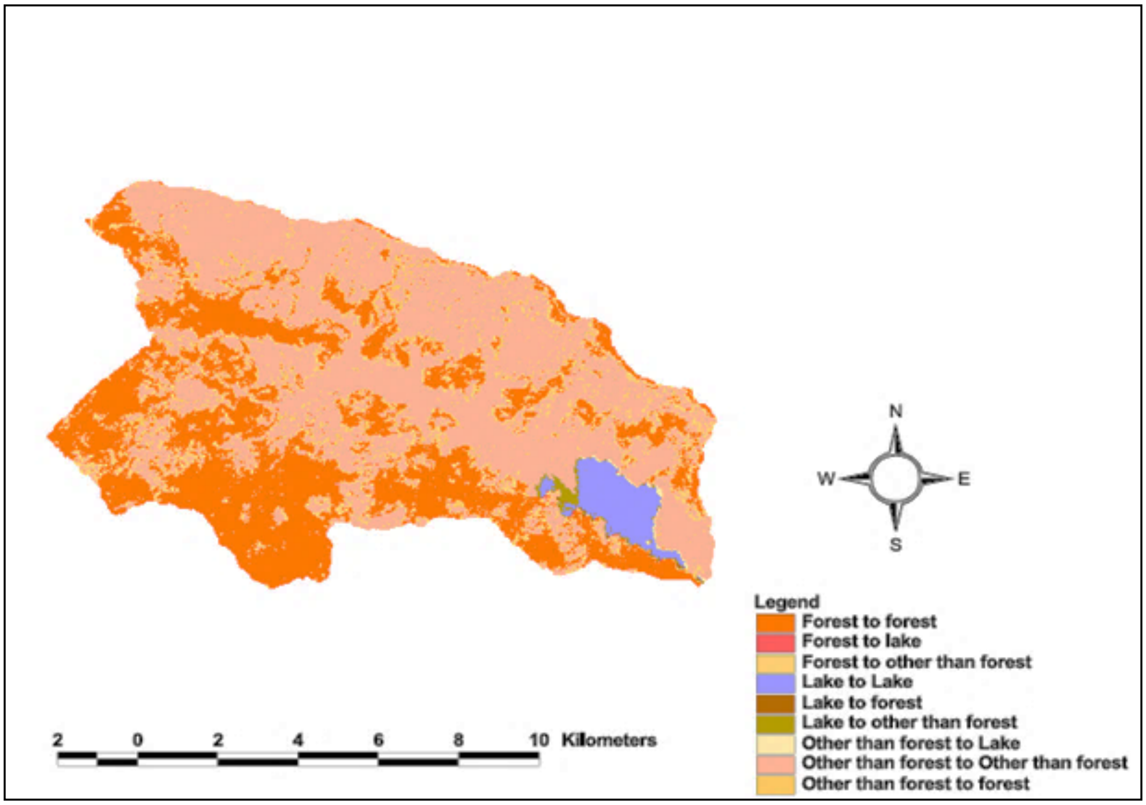


Table 1

Change in the Forest Area

Source	Increase %	Decrease %
Lake	0.093	0.028
Other than forest	6.255	10.521
Total Change (%)	6.348	10.549

Net change in % Area	- 4.201
Change in Forest Area in m^2	- 4716748.4
Change in Forest Area in Ha	- 471.67484

Watershed Area, where there has been either increase in the forest area or decrease in the forest area between 1990 and 2017 A.D. despite of the implementation of the community forestry, the forest area is declining. However, it is not appropriate to attribute the reduction of the forest area as a failure of the community forestry because had there not been community forestry, this decrease in the forest area might have had escalated beyond our imagination. The probable reasons behind the decrease in the forest area might be the construction of the road, extension of agricultural areas, landslides and increase in settlement areas.

Concluding Remarks

From the examination, it is reasoned that the forest cover has diminished from 1990 A.D. to 2017 A.D. There is net decrease in the forest area by 471.67484 ha in the Phewa Lake Watershed Area between 1990 and 2020 A.D. Major portion of the forest area is converted into other than the forest area class by 10.521%, which is greater than the area converted from other than the forest area to forest (6.255%). The reasons behind this reduction in the forest area might be road construction, landslides, and conversion into agricultural land. Based on these conclusions, following recommendations are made:

- Plantation program should be continued in the open area.
- Awareness program about the benefits of forest (livelihood benefits, environmental benefits) should be launched in those areas facing high deforestation.
- Promotion of using alternative resources like bio-gas, solar power etc. might be an alternative to halt this severe reduction in forest cover.

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