REMOTELY SENSED INVESTIGATIONS OF FOREST CANOPY DENSITY DYNAMIC IN TROPIC COMBINE WITH LANDSAT AND FIELD MEASUREMENT DATA

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ABSTRACT

Forest canopy density is an essentially important for maintaining the diversify flora and fauna in the tropic. But, the natural and human disturbances have an influence over the inconsistency of forest canopy density. So, forest canopy density (FCD) has been threatened in the tropic since a decade. The objective of this study was to examine the dynamics change of the forest canopy density in tropical forest Chitwan, Nepal combine with field survey and remote sensing data. The field survey data of 2001 such as canopy cover percentage, dbh so on and some human disturbances were used. Similarly, Landsat TM 1988 and ETM+ 2001 have also used to predict the dynamic changes of the FCD over the period. Moreover, nonparametric Kruskal- Wallis test has performed for the validation of the results. Data analysis revealed that very few factors i.e. the number of trees, path, and fire had realized statistically significance at P=<0.05. Therefore we concluded that detail analysis could be needed incorporate with additional socioeconomic, climatic, biophysical and institutional factors for the better understanding of the forest canopy dynamic in particular location.

KEY WORDS: Forest canopy density, Human disturbances, Dynamic change, Remote Sensing, Tropical forest

1. INTRODUCTION

Tropical rainforest has been under tremendous human induced and natural changes in recent days (Shu, 2003). Achard *et al* (2002) reported that an annual rate of forest degradation in the humid tropics was 2.3 million ha or 0.20% of the total forest area. Remote sensing has enabled the acquisition of land use and land cover information across with spatial & temporal scale (Agrawal *et al.*, 2003). It is advantageous and realizing more efficient, cost effective in consisting manner to perform the studies in larger area (Zawadzki *et al.*, 2005). Further, it is an important tool for mapping and monitoring vegetation (Schmidt, 2003). It has typically been used to assess rates of deforestation (Myers, 1988). However, Tuominen & Pekkarinen (2005) mentioned that most forest inventory work have still far been based on the use of medium resolution satellite imagery, such as Landsat TM.

So far remotely sensed investigations of forest dynamic have rarely been studied combining with GIS data. The application of RS & GIS technique is still in primitive stage in many developing countries such as Nepal. So, the main objective of this study was remotely sensed investigation of canopy density dynamic in tropic combine with Landsat and field measurement data.

2. METHODS AND MATERIALS

2.1 Study area

A southwest part of (83°54'45" & 84°48'15" E and 27°21'45" & 27°52'30" N) Chitwan district in Nepal was selected for the study. Chitwan district is almost a lat valley slope slightly towards the South. Mainly 3 forest types dominate the study area namely *Shorea robusta*, mixed hardwood and reverine khair- sissoo forest. *Shorea robusta* forest is dominant forest species of this region which is recognized by one of the commercially valuable timbers. It is also one of the protected species of natural forest in the Terai region of Nepal.

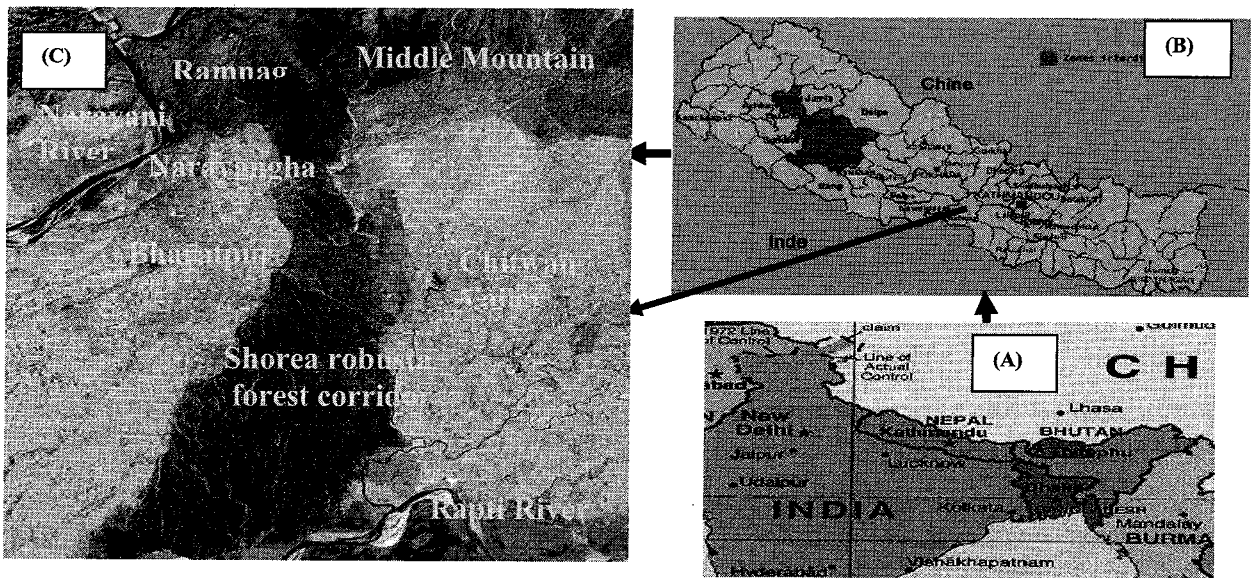


Figure 1. (A) Indicate Nepal in Asia, (B) indicate Chitwan in Nepal and (C) FCC 231 of ASTER Image 2005 shows the study area Chitwan indicated by black arrow from (B).

2.2 Data used

Forest parameters, anthropogenic factors, and topographic map as well as satellite imagery has collected from ITC, The Netherlands as a secondary source data. Landsat TM of 1988 and ETM+ of 2001 were used for FCD prediction. Topographic map of scale 1: 25000 have used to geometric correction of satellite imagery. Forest Canopy Density (hereafter FCD Mapper) and Integrated Land and Water Information System (hereafter ILWIS) has also used. Furthermore, MS word, Excel and statistical test has also used in this analysis.

2.3 Data analysis

The image processing has done and processed images were classified through FCD Mapper. Mapping tropical areas are complex and challenging because of similarities in spectral signatures between different classes (Helmer *et al.,* 2002). To overcome this problem Forest Canopy Density Mapper has used to classify the FCD which is based on four biophysical indices namely: Advance Vegetation Index, Bare soil Index, Shadow Index and Thermal Index. It calculates the reflectance of satellite imagery and gives result in categorical 11 classes with percentage (1-10, 11-20, 21-30+...so on).

Forest parameters such as mean height of tree, the number of the tree, dbh and forest canopy cover % and anthropogenic factors such as grazing, path, fire, debarking, so on were analyzed using MS excel spread sheet. Statistical test such as nonparametric Kruskal-Wallis test has performed to validate the outcomes.

3. RESULTS

Images analysis proved that there was a lot of canopy fluctuation in the study area during the 13 years period. Although many studies stated that canopy has adversely affected by many natural & anthropogenic factors since a decade. Controversy, this study has proved that forest canopy density has increased by 5.5 % from 1988-2001.

3.1 Possible effect of human disturbances on FCD alteration

Some of the anthropogenic factors for instance grazing, fire, girdling, lopping, coppicing, stumps, debarking and path could spatially and temporally alter the forest canopy cover. Fig. 2 & 3 also confirm this.

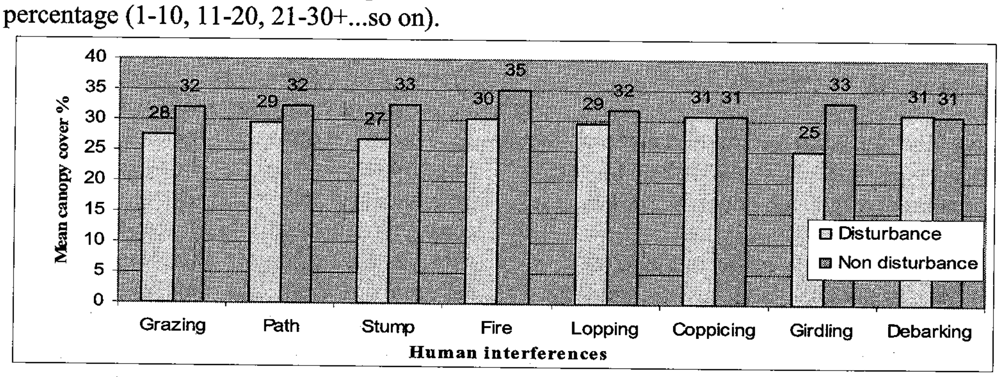


Fig. 2. Canopy cover % relation with disturbed and undisturbed area (site 1)

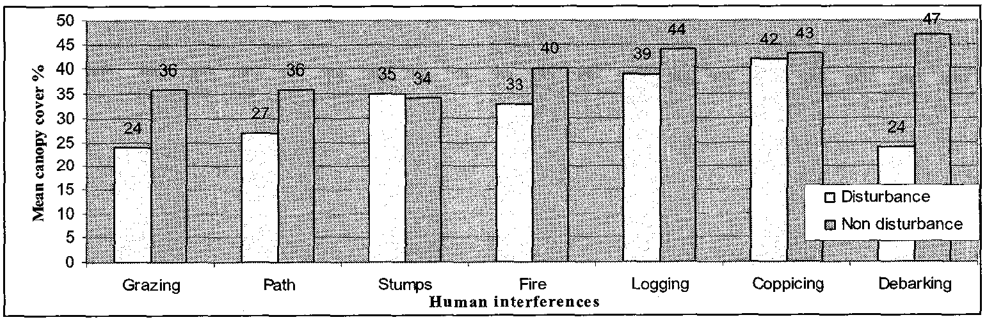
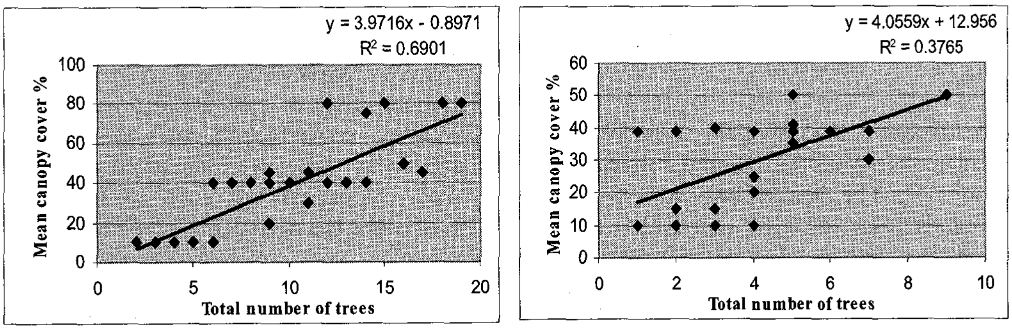


Fig. 3. Canopy cover % relation with disturbed and undisturbed area (site 2)

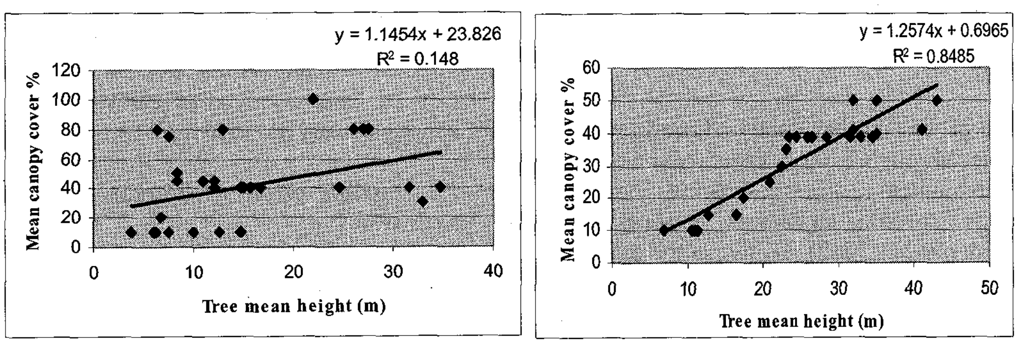
3.2 Relationship between forest parameters and FCD alteration

Forest parameters & canopy density didn't show very strong relationship in statistical term in this analysis. The number of trees $R^2 = 0.6901$ (Fig. 4 A) and the tree mean height $R^2 = 0.8485$ (Fig .5 B) seemed more correlated with canopy density than the other parameters. Moreover, mean dbh showed the negligibly very weak relationship with canopy density so we didn't carried out the result. However, total number of trees (Fig. 4 A) showed the statistically significance at P = <0.05 level.



(A) (B)

Fig. 4. The relationship between canopy density and the number of trees in site (A) and site (B)



(A) (B)

Fig. 5. The relationship between canopy density and the tree mean height in site (A) and site (B)

4. DISCUSSION

The qualitative and quantitative improvement of the forest have observed in 2001. It showed that the forest condition was comparatively much better in 2001 than in 1988.

This study also agreed with other authors. Eva & Lambin (2000) mentioned that fires are an important disturbance which affects the land cover change. Similarly, grazing, timber harvesting, fuelwood cutting & fodder removable from the forest have created the pressure in Terai forest (Hobly, 1996). Unlikely, the effect of coppicing is considered to be a canopy increasing factor in this analysis (Fig. 2 & 3). Because of its specific nature in some species, coppicing has capacity to increases forest canopy coverage. As revealed from the data debarking in site 1 and girdling in site 2 negatively affects the FCD. However, debarking in site 2 didn't affect on canopy alteration so the debarking could be recorded from the sample plots just few days or months later that interference has occurred. It is interesting to note that the stumps remain for long period in the ground and at the same time, the area could be covered by surrounding crowns. Finally, the nonparametric Kruskal –Wallis test has executed the number of the trees, path and fire significance at P=<0.05 but the test failed to detect significant for the other variables.

Remote sensing data could useful to provide required information for updating stand inventories (Danson and Curran, 1993; Wulder *et al.,* 2004 in Sivanpillai *et al.,* 2006). Makela (2004) also estimated forest stand parameters using Landsat TM and existing stand-level forest data. However in this analysis forest parameters & canopy density didn't show very sharp relation. Whether the large no. of trees or small, large dbh or small do not have such matter to form the canopy dense but it could be affected by biometry of the forest such as species composition, morphological characteristics of the tree. Some species are broad leaves type whereas others are coniferous. Broad leaves forest type definitely can make crown dense & closer hence canopy cover belongs this type could be denser.

5. CONCLUSION

It is concluded that site associated factors are closely related with alteration of FCD in the study area. Based on this analysis, FCD with mentioned factors did not show the sharp distinction. Therefore to explain the dynamic alteration of FCD is difficult unless detail analysis and understanding of the other additional factors. So, forest canopy is complex phenomena and could be affected by various factors. In this analysis we didn't cover all the factors that have possibilities to affect the forest canopy alteration. Detail study of additional factors such as biophysical (vegetation type, soil type, altitude, slope & aspect, rainfall & temperature), physical (roads & trails, urban/settlement, other infrastructures) and socioeconomic (demography, education, employment opportunities, institutional strengthen etc.) and so on should be analyzed in comprehensive way.

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References:

Achard, F., Eva, S., Mayaux, P., Gallego, J., Richards, T., and Malingreau, J.P. 2002. Determination of Deforestation Rates of the World's Humid Tropical Forests. *Science 297: 999 - 1002.*

Agrawal, S., Joshi, P.K., Shukla, Y., and Roy, P.S. 2003. Spot-Vegetation multi temporal data for classifying vegetation in South Central Asia. *Communicated to current Science Journal, 2003.*

Eva, H., and Lambin, E.F., 2000. Fires and Land- cover change in the tropics: a remote sensing analysis at the landscape scale. *Journal of Biogeography, 27, 765-776*

Hobley, M., 1996. Participatory Forestry: The process of change in India and Nepal. London: *Overseas Development Institute.*

Helmer, E.., Ramos, O., Lopez, T., Quinones, M., and Diaz, W. 2002. Mapping the Forest Type and Land Cover of Puerto Rico, a Component of the Caribbean Biodiversity Hotspot. *Caribbean Journal of Science, Vol.38, No.3-4, 165-183.*

Makela, H., and Pekkarinen, A., 2004. Estimation of forest stand volumes by Landsat TM imagery and stand – level field - inventory data. *Forest Ecology and Management 196 (2004)245-255*

Myers, N., 1988. Tropical deforestation and remote sensing. *Forest Ecology & Management 23:215-225.*

Shrestha, N. K.1999. Community forestry in danger. Forest, trees and people Newsletter, *11,* 33-34.

Schmidt, S.K., 2003. Hyperspectral Remote Sensing of Vegetation Species Distribution in a Saltmarsh. *International Institute for Geoinformation Science and Earth Observation, ITC, The Netherlands. PhD thesis 2003.*

Shu, G.N., 2003. Detection and Analysis of Land cover Dynamics in Moist Tropical Rainforest of South Cameroon. *Unpublished M.sc thesis, ITC the Netherlands.*

Sivanpillai, R., Smith, C.T., Srinivasan, R., Messina, M.G., and Wu, X. B., 2006. Estimation of managed loblolly pine stands age and density with Landsat ETM+ data. Forest *Ecology and Management 223 (2006) 247-254.*

Tuominen, S., and Pekkarinen, A., 2005. Performance of different spectral and textural aerial photograph features in multi-source forest inventory. *Remote Sensing of Environment 94 (2005) 256-268.*

Zawadzki, J., Cieszewski, C.J., Zasada, M., and Lowe, R.C., 2005. Applying Geostatistic for investigation of forest ecosystems using remote sensing imagery. *Silva Fennica 39(4): 599-617.*