Liaison of Population Factor, Agriculture Expansion and Food Access in Forest Degradation Process: View from Ancillary Data Sources

Menaka Panta*, Kyehyun Kim, Cholyoung Lee, Taehoon Kim

Geoinformatic Engineering Department, GIS lab at Inha University

253 Yonghyun-dong, Namgu, Incheon 402-751, S. Korea

E-mail: menaka71@inha.ac.kr, kyehyun@inha.ac.kr

khsakura82@inhaian.net, daphnis83@inhaian.net

Tel: +82-32-875-4413, +82-32-860-7602

Fax: +82-32-863-1506

Abstract

Forest resources are either altered by natural or by human-induced factors; however, human-interventions are more aggressive and have influenced forest depletion in a variety of ways. We used ancillary data sources, GIS and simple statistics to assess the socioeconomic impact in forest degradation process. Pearson's correlation coefficient significantly showed (r = - 0.750 and - 0.788 at p = 0.01) a negative association between population and forest area lost for 1958 and 1978 respectively. Moreover, forest area lost and arable land growth has showed a strong negative correlation association significant (r = -.745 at p = 0.01) for 1958-1996 while association also negatively correlated and significant (r = -.485 at p = 0.05) for 1958-2001. Forest area lost and food insufficiency in 2001 also showed a strong negative association significant at (r = - .492, p = 0.05). Similarly, pressure on forest significantly increased from 2.4 people/ha to 17 people/ha during the same period. This shows the Terai forest is undoubtly susceptible with certain socioeconomic factors. This information could be useful and preliminary source to course of action for further probing of socioeconomic collision in deforestation and forest degradation processes in Nepal.

Keywords: Forest degradation, Human-induced factors, Influenced, Nepalese Terai, Ancillary data

1. Introduction

Forest resource and its status is necessarily important and required if forest to be managed effectively and protective measure developed and enforced (Boyd et al., 2002). It is widely recognized that human intervention in land utilization has changed forest cover over time. Further, land use change by human deeds has become a proximate factor that catalyses deforestation and forest degradation (Tole, 1998; Koop and Tole, 2001; Uusivuori et al., 2002). Population growth plays an important role in triggering tropical deforestation (Butler, 2001). However, research concise by Geist and Lambin (2002) on tropical deforestation realized that

populations virtually never work in isolation; rather, other socioeconomic factors mediate between population attributes and agricultural systems. Various studies and researches have been approaching for deforestation and forest degradation processes. MPFS reported that these processes in Nepalese Terai stirred with migration (MPFS, 1988) where >90% population were from hills which also play an important role in rising population pressure in Nepal. Rapidly growing population and arable land expansion are also causes of heavy pressure in Terai forest in recent decades (Rautiainen, 1999). Some stated that agriculture expansion has influenced the reduction in natural vegetation while expansion proceeds to meet the growing demand of population, is also a major threat in many developing countries (Brink and Eva, 2008; LRMP, 1986; JAFTA, 2001).

Scholastic attention has been ever growing about humans relations in forests in recent decades (Lambin, Geist, and Lepers, 2003; Lepers et al., 2005; Williams, 2002 cited in Redo et al., 2009). However, a few studies have been executed about population and natural resources (Gurung, 1989; Shrestha, 1999) in Nepal yet.Therefore, in this study we used ancillary data sources to analyse the relationship between socioeconomic factors and forest degradation process in Nepalese Terai. This information could be helpful to use as preliminary sources in the planning and decision-making level probing to the strategy against socioeconomic interference in deforestation and forest degradation processes in Nepal.

2. Methods and Materials

2.1 Study area

Terai region is a lowland tropical and subtropical belt of flat, alluvial land in Nepal. It covers nearly 17% of the total land of the country, 20 districts and ranges from 60-100 m from mean sea level. Terai region was sparsely populated before 1960 because it was infested with malaria (Darsi and Pradhan 1990). Migration started after malaria was eradicated in the early 1960s and infection rate was reduced from almost 90% in the early 1950s to much lower levels in the 1970s. Similarly, the infant mortality rate was reduced from 70% (1957) to zero in the early 1970s (Jung 2001, Guyatt and Snow 2004 in Joshi, 2006).

After then, population growth and migration has accelerated and human intervention has expanded with infrastructural development and resettlement program launched by the government. Terai is recognized as richest economic zone in terms of agriculture and forests land and the most favourable region for economy development (ADB, 2005). Due to sound geographical viability Terai has a greater availability of agricultural land and the largest commercially exploitable forests in the past. However, the forests are being increasingly destroyed because of growing population, demands for timber and agricultural land.

2.2 Data collection and data analysis

There were quite a lot of difficulties to get the time series data of forest cover and land use change at district level in Nepal due to lack of field surveys data, complexities in data gathering and updating and high cost for data purchasing. However, some data are collected by various institutions for their own purposes that were made available in the present context in this research. Some of these data sources are Central Beaure of Statistic (CBS, Govt. of Nepal), Ministry of Forest and Soil Conservation (MFSC, Govt. of Nepal), and other authorized institutions. Data on total forest area and population in 1958, 1978, 1991 and 2001 of 20 Terai

districts were available from secondary sources. However, migration data was not available except for 1991-2001. Similarly, we used ArcGIS 9.0 software to map the temporal changes in forest area in Terai during 43 years and SPSS for simple statistical analysis such as descriptive, correlation and regression analysis.

3. Results

3.1 Forest resource depletion trends

Figure 1 stated that in most of the Terai districts, forest covers was depleted noticeably during the period of 1958-1978 and the depletion in forest covers was accounted for >15-30% in 6 districts, >30% in 8 districts out of 20 districts. Data further revealed that there was >30% of

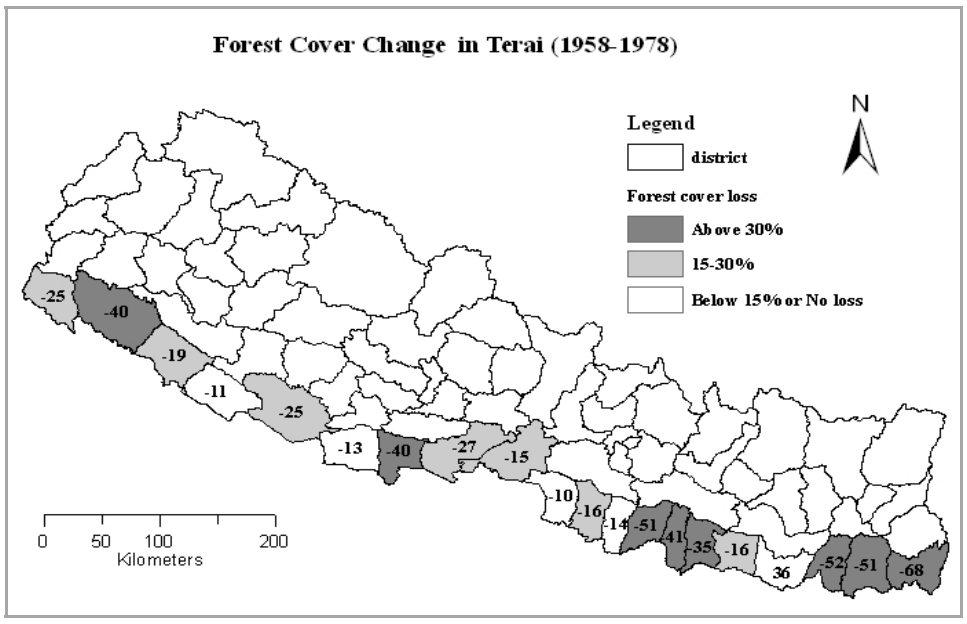

Figure 1 Forest covers changes between 1958 and 1978.

forest covers depletion in between 1958-2001. Among them, Bardiya and Parsa accounted the largest forest covers lost by 80/80% and followed by Jhapa 79%, Sunsari 74%, Chitwan 67% and Kanchanpur 66% (Figure 2).In most of the districts forest covers was depleted by >40% of the total forest covers of the district.

In 1958 the total forest covers was accounted for almost 2,299 thousand ha but the forest covers was reduced to 1,149 thousand ha in 2001. Besides this, from 1958 to 1978 almost 630,937 ha and in between 1978-2001 almost 448,429 ha which is a total of 1,079,366 ha of forest area was disappeared during the last 43 years in Terai districts.

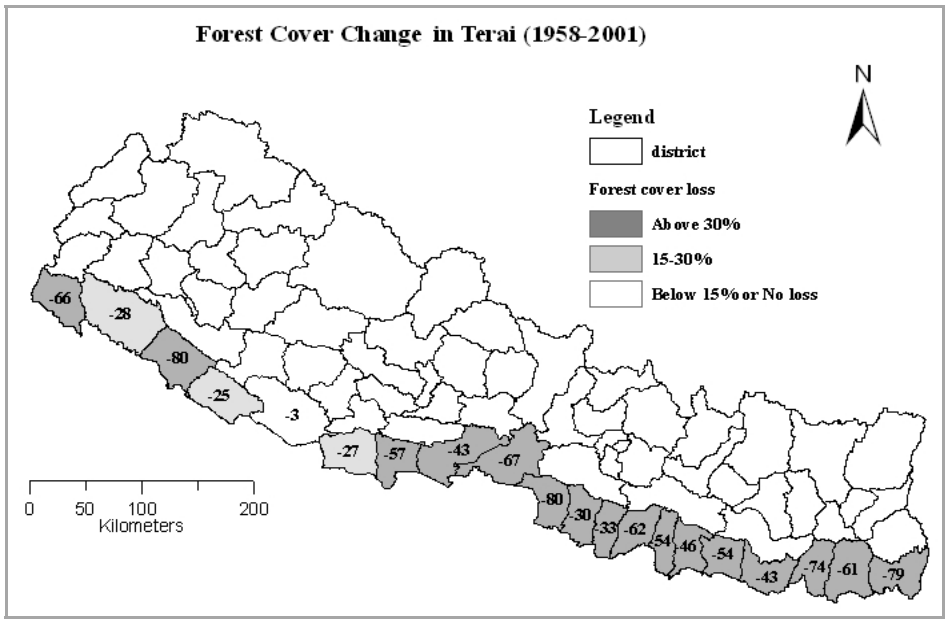

Figure 2 Forest covers changes between 1958 and 2001.

The per capita availability of forest area was also decreased considerably during the 43 yrs period in Terai. It was 0.69 ha in 1958 but was sharply reduced with 0.29 ha at 1978 while steadily followed for the rest years and was reached at 0.10 ha per capita in 2001.

3.2 Chronological growth flow of population and forest area in Terai

Table 1 showed that a mean lost of forest area by -1.89%/yr whereas mean population growth was increased by 3.14%/yr during 1958-2001. This shows the effect of population growth in forest area loss (negative growth of forest) in Terai. Additionally, the pressure on forest land was also increased significantly from about 2.4 people/ha in 1958 to 17 people/ ha in 2001. The details of the descriptive statistics are presented in Table 1.

Table 1 Descriptive statistics

Indicators	N	Minimum	Maximum	Mean	Std. Deviation
Forest growth (%)	20	-3.77	-.08	-1.89	1.094
Population growth (%)	20	1.92	4.90	3.14	0.841
Population forest ratio 1958 (No./ha)	20	.30	6.20	2.34	1.912
Population forest ratio 1978 (No./ha)	20	1.00	11.50	5.58	3.932
Population forest ratio 1991(No./ha)	20	1.90	27.90	13.05	8.287
Population forest ratio 2001(No./ha)	20	2.40	32.80	16.91	10.366
Immigration in Terai from1991-001(%)	20	3.96	42.06	16.74	12.835

3.3 Relationship between population growth and forest area loss in Terai

To perceive the relationship between the growth of forest area and the population between 1958, 1978, 1991 and 2001, growth of both variables was calculated and correlation and regression analysis has performed. Following equation was used to calculate the growth of forest area and population.

$$G_{rate} = (FA/BA)^{(1/N)} - 1$$

Where,

BA = Base year forest area or population considered at 1958
FA = Final year forest area or population considered at 2001
N = Number of total year (42 year)

Pearson correlation analysis has performed using the total population and forest area of 1958, 1978, 1991 and 2001 to find the association between changes forest area in respect to population increases. The correlation coefficient showed a significant ($r = -.750$ and $r = -.788$ at $p = 0.01$ level) result for 1958 and 1978 respectively, but a weak association has shown for 1991 and 2001. However, the in-migration trend didn't show statistical relation with forest loss in Terai.

The regression coefficient of determination between the growth of forest area and population for 1958-1978 was found to be low $R^2 = .182$. Similarly, regression coefficient of determination for the year 1991-2001 showed comparatively lower $R^2 = .138$ than the previous period. Moreover, it was noticeably a very low $R^2 = .016$ observed for the period 1958-2001.

3.4 Relationship between population, arable land expansion, food deficit and forest area

We also performed the correlation analysis for the growth rate of arable land, food deficit and forest area loss to observe the effect of these factors in forest degradation process in Terai. Our analysis revealed that forest covers lost has significantly associated ($r = -.745$ at $p = 0.01$ level) and ($r = -.485$ at $p = 0.05$ level) with arable land expansion during 1958-1996 and 1958-2001 respectively. A strong negative association has found between the rate of growth increment in arable land and forest area lost over time. We also applied regression analysis to explain the forest covers lost with respect to the rate of arable land expansion. The regression coefficient of determination was found quite higher $R^2 = .565$ for 1958-1996 while coefficient of determination slumped with $R^2 = .236$ for 1958-2001 comparatively lower than the previous years.

Similarly, the correlation coefficient between forest area lost and food deficiency showed the negatively association significance with $r = -0.492$ at $p = 0.05$. This indicates that food deficiency is positively associated with forest area lost in Terai. We further analyzed the regression and regression coefficient of determination showed $R^2 = .242$ between two variables for the year 2001 in Terai.

4. Discussion and conclusion

It is widely assumed that farmers and poor are considered to be main agents in deforestation process in Nepal. Most of the poorest and hungriest groups of people primarily depend on arable and forest land. Various studies confirmed that cause of Terai forest degradation was associated with the agriculture expansion to meet the food requirements of the growing population and migrants (UNDP, 1997; DFRS, 1999). An empirical study carried out by Culas (2007) indicated

that deforestation has been positively linked with agricultural production and while excessive deforestation also jeopardizes the agricultural productivity (Maertens et al., 2006). Similarly, a decreased by 156.3 thousand ha area of non-agricultural land in between 1991/92-2001/02 where woodland and forest area was abruptly decreased from 108.8 thousand ha in 1991/92 to 37.2 thousand ha in 2001/02. This could be caused by shifting the land use and some area of land under permanent crops has increased (CBS/Agriculture Monograph, 2006). However, result showed that district with higher percentage of households reporting insufficient of agriculture production to feed their family was also associated with low forest area in Terai. It could be due to the pressure increased day by day on the forest land to meet the requirement of the agriculture land and other forest products to growing population in the Terai region of Nepal.

As Brink and Eva (2008) emphasized the effect of population growth in agricultural expansion, we also found that population has influenced on both forest degradation and agriculture land expansion. However, contradictly Sire´n and Brondizio (2009) found that deforestation rates neither correlated with indigenous population nor with external populations. As Namaalwa et al. (2007) concluded, we also realized that such types of study is useful for policy makers interested in designing alternative intervention programs for ensuring sustainable forest resources use while simultaneously promoting food access and agricultural production. The lack of spatio-temporal information at regional level makes it difficult to further analyze the impacts of various socioeconomic factors and population increase on the potential of future forest cover losses. Although, remotely sensed data sets provided over the past three decades for land cover studies and deforestation estimation (Boyd et al., 2002; Eva and Fritz, 2003). Due to limited capacity for purchasing and interpretation of remote sensing data, however, is sophisticated and expensive (Eva and Fritz, 2003), and uses of such data in developing country is still fewer. Moreover, availability of research grant and data assemble/purchase are still a major constrains. Confronted with this, optimal utilization of ancillary data sources is further warranted in the countries like Nepal where investigations are still limited and updated information is urgent, decisive and exigent. The information provided here could be preliminary source, imperative and advantageous to the planning and decision-making level for sustainable forest resource management process.

Acknowledgements

This research was made with financial support through INHA UNIVERSITY Research Grant. The authors also would like to thank the anonymous reviewers of this manuscript.

References

ADB, 2005. Nepal Regional Strategy for Development. Asian Development Bank.NRM Working Paper Series No. 3, Nepal Resident Mission.

Butler, R. 2001. A Place Out of Time: Tropical Rainforests and the Perils They Face. http://rainforests.mongabay.com/

Boyd, D.S., Foody, G.M., Ripple, W.J. 2002. Evaluation of approaches for forest cover estimation in the Pacific Northwest, USA, using remote sensing. Applied Geography Vol. 22, pp. 375-392.

Brink, A.B., Eva, H.D.2008.Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach. Article in Press.Applied Geography xxx (2008) 1-12.

CBS/Monograph Agriculture, 2006. Monograph Agriculture Census Nepal, 2001/02. Government of Nepal Planning Commission Secretariat Central Bureau of Statistics, Nepal.
Culas, R. 2007. Deforestation and the environmental kuznets curve: An institutional perspective. Ecological Economics, Vol. 61, pp. 429-437.
Darsi Jr, R. F., Pradhan, S. P., 1990. The mosquitoes of Nepal: Their identification, distribution and biology. Mosquito Systematics, vol. 22, pp. 69-130.
DFRS, 1999. Forest Resources of Nepal (1987 – 1998). HMGN, Department of Forest Research and Survey, Ministry of Forests and Soil Conservation, HMGN, Kathmandu.
Eva, H., Fritz, S.2003. Examining the potential of using remotely sensed .re data to predict areas of rapid forest change in South America. Applied Geography Vol. 23, pp. 189 –204.
Gurung, H.B. 1989. Regional patterns of migration in Nepal. East-West Population Institute East-West Center, Honolulu, Hawaii.
Geist, H.J., Lambin, E.F. 2002. Proximate causes and underlying driving forces of tropical deforestation. Bioscience, vol. 52, pp. 143–150.
JAFTA, 2001. "Information System Development Project for the Management of Tropical Forest." Activity Report of Wide Area Tropical Forest Resources Survey, Nepal. Japan Forest Technology Association, Kathmandu.
Joshi C. 2006. Mapping cryptic invaders and invasibility of tropical forest ecosystems: Chromolaena odorata in Nepal. PhD Dissertation, ITC, Enschede, The Netherlands.
Koop, G., Tole, L. 2001. Deforestation, distribution and development. Global Environment Change, vol.11, pp. 193–202.
LRMP, 1986. "Land Utilisation Report." His Majesty's Government of Nepal, Survey Department/Land Resource Mapping Project, Kathmandu.
MPFS, 1988. Master Plan for Forestry Sector in Nepal, Main Report: Ministry of Forest and Soil Conservation, Kathmandu, Nepal, 292 p.
Maertens, M., Zeller, M., Birner, R. 2006. Sustainable agricultural intensification in forest frontier areas. Agricultural Economics, vol.34, pp.197–206.
Namaalwa, J., Sankhayan, P.L., Hofstad, O. 2007.A dynamic bio-economic model for analyzing deforestation and degradation: An application to woodlands in Uganda. Forest Policy and Economics Vol. 9, pp. 479– 495.
Rautiainen, O. 1999. Spatial yield model for Shorea robusta in Nepal. Forest Ecology and Management, vol. 119, pp. 151-162.
Redo, D., Bass, J.O.J., Millington, A.C. 2009. Forest dynamics and the importance of place in western Honduras. Applied Geography Vol. 29, pp. 91–110.
Shrestha, N.R. 1990. Landlessness and migration in Nepal.Westview Press, Boulder, Colo.
Shrestha, N.R. 1999. Population pressure and land resources in Nepal: A revisit, twenty years later. The Journal of Developing Areas 33: 245-268
Sire´n, A.H., Brondizio, E.S. 2009. Detecting subtle land use change in tropical forests. Applied Geography Vol. 29, pp. 201–211.
Tole, L. 1998. Source of deforestation in tropical developing countries. Environmental Management, vol. 22, pp. 19–23.
UNDP, 1997. Country Background. United Nations Development Program: http://www.nepali.net/undp/
Uusivuori, J., Lehto, E., Palo, M., 2002. Population, income and ecological conditions as determinants of forest area variation in the tropics. Global Environment Change, vol. 12, pp. 313–323.