Case Study

Land Use and Population Dynamics in the Kalikhola Watershed of Nepal

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Abstract

This study analyzes the nexus between population dynamics and land-use practices in the Mid-Hill region of Nepal. The paper focuses on spatial and temporal changes in land use between 1987 and 1999 in a typical watershed in the western mountains of Nepal where community forest projects were implemented by the government. The dynamics of population, land use, and land cover within the Kalikhola watershed are investigated by performing spatial analysis of digital land-use maps in ArcGIS. There is a net increase in forest cover of 16% in the Kalikhola watershed with a corresponding decrease in agricultural land, shrubland, and grassland. The population of highland communities has been significantly reduced because of problems due to the implementation of community forest projects. In this watershed, a significant area under agriculture in 1987 was found abandoned in 1999, most likely because of increased out-migration of the labour force and frequent attacks of wild animals.

Key Words: Land-use change; GIS analysis; watershed; population dynamics; Nepal.

1.0 Introduction

Nepal, a mountainous country with thousands of watersheds, is heavily dependent on its natural resource base. Owing to the rapid growth of population, insufficient agricultural production, low off-farm sector production, and concomitant developmental changes, natural resources—particularly public lands and forestlands—are overexploited to meet the basic needs of the people.

Forests, particularly in the hills of Nepal, are an integral part of the farming system and means of livelihood. During the 1980s and 1990s, the Nepalese government launched several community forest management and implementation projects, with international support, to improve people's livelihoods. Development projects without inclusive analysis of long-term environmental consequences fulfill short-term project goals; however, in the long term end users suffer the negative consequences of such projects (Seeland, 2000). Nepal's fragile natural resources, particularly cultivated lands, are now under serious threat in the hilly region.

A total of 103,968 ha of forest in the Siwaliks hills and plains area were cleared under the government's resettlement programme from the 1950s to the mid-1980s (MFSC, 1988). A comparison of 1978–1979 maps with those of 1994–1996 shows an annual national deforestation rate of 0.5%, ranging from 1.7% for southern Terai (plains areas) to 2.3% for middle mountain regions (MFSC, 1999). Estimating temporal land-use and land-cover changes with regard to population dynamics is essential for assessing the rate of these changes and the problems or impacts they cause and, hence, prediction of future impacts and trends.

Nepal is attempting to improve the condition of forest resources by increasing both the participation of all stakeholders and the capacity of local institutions that deal with natural resources. The results of community forest and leased forest projects during the 1980s and 1990s indicate that forest cover in the middle mountain area has increased (Gilmour, 1990). However, in other areas, because of destabilization of fragile mountain slopes through deforestation, agricultural expansion, excessive grazing and expansion of the road network, land degradation and soil erosion rates have increased (Ives and Messerli, 1989; Thapa and Weber, 1991). Soil losses ranged from 2.7 tonnes to 8.2 tonnes per ha in 1993 and up to 12.9 tonnes per ha in 1992. The higher soil losses were associated with red and finer-grained soils, which are useful for agriculture (Gardner and Gerrard, 2003). Agriculture has been extended at the cost of forestland, shrubland, and marginal and submarginal areas with very steep slopes without due consideration for the suitability of these lands for cultivation.

In this context, identification of the impact of community forest projects on land-use management of watersheds is important for identifying problems and planning future improvements. The objective of this study is to assess and analyze the spatial and temporal land-use changes of the Kalikhola watershed in two different years, 1987 and 1999, and to give possible reasons for changes in major land use. Moreover, the research highlights some of the issues around management and monitoring of land-use activities.

2.0 Description of Study Area

Kalikhola, one of the small watersheds in Nepal, lies in the Kaski district in the western mountain region of Nepal (see Figure 1). On the basis of elevation, the agricultural watershed has been classified into: lowland communities (1,000 m or below) and highland communities (above 1,000 m). Lowland and highland settlements have distinct differences in biodiversity and lifestyles of the people (Gurung, 1994). The watershed has a monsoon climate with a dry season normally spanning from November to May and a rainy season from June to October. A warm-temperate humid temperature and moisture regime prevails in most parts of the watershed except at higher elevations where the climate is cool-temperate. The south-facing and lower slopes are generally hotter and drier, and the north-facing and upper slopes are cooler and moister.

Local watershed communities reside in various hamlets under nine wards of the Armala Village Development Community (VDC). The mean population density for the Kalikhola watershed is 123 people/km^2, which is lower than the national average of 157 people/km^2 (CBS, 2001). Most farmers in the watershed depend on subsistence agriculture and pastoralism. Although the Kalikhola watershed lies 20 km east of Pokhara Sub-Metropolitan City planners and development workers

have not made this watershed a priority. Owing to limited budget and human resources in the Department of Soil Conservation and Watershed Management, government agencies are not able to focus their resources on all watersheds.

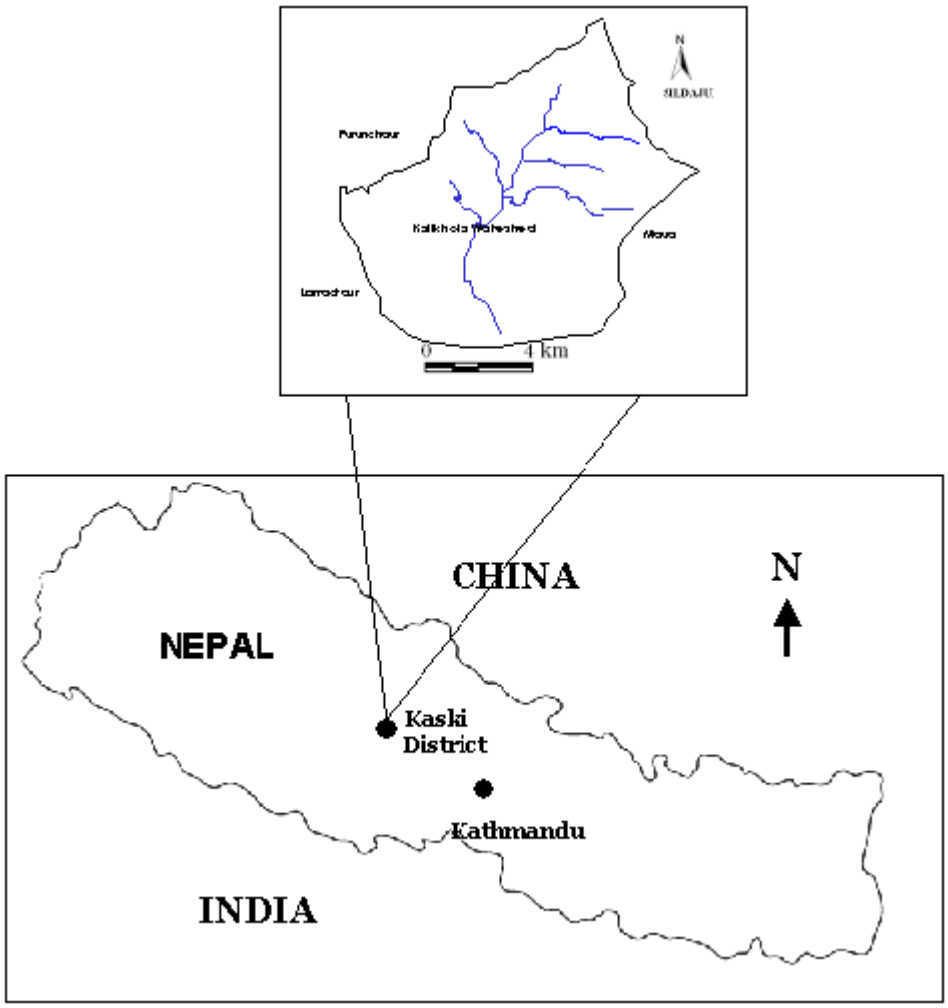

Figure 1. Location of the study area.

3.0 Research Methods

3.1. Mapping Data and Analysis

The digital data sets for this study were derived from hard-copy topographic maps published by the National Planning Commission (NPC), Nepal. According to the NPC, the 1987 topographic maps (1:50,000 scale) were compiled from ground-verified aerial photographs (1:50,000) by the Land Resources Mapping Project (LRMP), a collaboration between His Majesty's Government of Nepal (HMGN) and an external consultant (Kenting Earth Sciences Ltd., Ontario, Canada). The 1999 topographic maps (1:25,000) were compiled from 1:50,000 ground-verified aerial photographs and published by the Survey Department, HMGN, in 2001. These topographic maps contain information on land use, VDC boundaries, and topography. Because land-use information contained in both data sets (1987 and

1999) is based on aerial photographs at the same scale (1:50,000), the error arising from the difference in map scale is minimal. (This would depend on the minimal mapping unit, i.e., the smallest feature or polygon mapped, of both mapping projects; not necessarily on the scale of the photography.) The land and water use information from hard-copy topographic maps was digitized using ArcInfo™ 3.4 version. A comprehensive household survey regarding land-use management of the Kalikhola watershed was carried out. Only land, forest and human resources related information was used in this analysis.

The Kalikhola watershed area was clipped from the digital topographic maps of the Kaski district. The 1987 land-use map has a different land-use classification scheme from the 1999 map. For the purposes of comparison and to facilitate the investigation of land-use changes that occurred between these periods, a standardized land-use classification was created by merging similar land-use categories (see Table 1).

Table 1. *Classification of Land Use in the Kalikhola Watershed*

Land-use types	General Description
Agricultural Land	Areas allocated to rain-fed crop production, mostly of cereals in subsistence farming
Forest Land	Areas covered by trees; predominant species are Uttis (*Alnus nepalensis)* and Chilaune (*Schima wallichii)*
Bush/Shrubs	Land covered by small trees, bushes and shrubs and mixed with grasses
Fallow/Grazing Land	Noncultivated areas

The total area in each land-use category was then recalculated and converted into hectares and the percent covered by each land use was determined.

3.2. Survey Data and Analysis

Prior to primary data collection, one of the authors interacted with community leaders, District Development Committee Kaski and District Agriculture Office, Nari Sewa (Women Group) NGO and contact persons and Village Development Committee (VDC) officials in order to get acquainted and to explain the goals of the research.

Apart from a review of village and district records and other published literature, a three pronged data collection method was employed, with household surveys, open-ended interviews and participatory rural appraisal workshops. The field surveys were conducted from April to August, 2004. The sample size for the household survey was determined using the systematic random sampling method devised by Arkin & Colton (1963:21). A sample size of 121 was obtained from a total of 1097 households. Qualitative data were also obtained through informal, unstructured and open-ended interviews with key informants including local leaders, elderly community members and schoolteachers. Qualitative data helped verify and enrich the quantitative data obtained from the survey. For the livelihood analysis, data were analyzed using the Statistical Package for the Social Sciences (SPSS). A chi-square test was employed at $p<0.05$ level to examine the difference in various indicators between high and lowland communities. The study area was divided into two categories (more and less than 1200m) to analyze the land use,

livelihoods and population dynamic of the study area. This paper focused on the land use and population dynamics on the basis of information obtained from participatory rural appraisal (PRA) and secondary information sources. Farmer's perceptions obtained from informal meeting and PRA workshops organized in the study area. Moreover, land use and population information were considered from secondary sources which is verified by the group discussion and PRA workshop.

4.0 Results and Discussion

4.1 Population dynamics between 1987 and 1999

Most farmers in the watershed depend on subsistence agriculture and pastoralism. In fact, forest products such as firewood, fodder, timber, and other products are basic resources for farmers' livelihoods. The Kalikhola Watershed Community was awarded the "Jarajuri Prize-1989" by the Nepal Government for successful implementation of a Community Forestry Program (Armala VDC, 2003). The nursery of the District Forest Office (DFO) provided seedlings of Uttis (*Alnus nepalensis*) to local farmers at the beginning of the forestry project. The Uttis tree grows quickly and creates a green environment within a short period of time. However, the wood and leaves of this plant should not be used for fuel or animal fodder. When used for fuel, the wood gives off a great deal of smoke, which eventually causes lung disease in regular users. According to local farmers' estimations, 75% of the forestland is covered by this tree. Because of restrictions concerning the use of Uttis for fuel or animal fodder, farmers think this community forest project is not productive or supportive of their livelihoods.

The juxtaposition of forestland and farmland presents other challenges to farmers. First, forest animals such as monkeys, bears, and jackals regularly attack field crops and domestic animals. Since local people cannot legally shoot wild animals, farmers are unable to protect their field crops. Ultimately, fifty-two farmers were forced to abandon cultivated lands in the vicinity of the forest. Second, natural disasters such as landslides, late monsoons, and hailstones present other major obstacles for agriculture. Consequently, food deficit is a chronic problem for most households, forcing household members to supplement their income with military service, seasonal labor, or trade. Because of these problems, the population of highland communities between 1987 and 1999 decreased 35.19%, which contradicts the findings of other studies on community-managed forestry (see Table 2). Since there is a wide diversity of wildlife in the community forest of the Kalikhola watershed, wildlife farming and use of products for meat, trophies, and souvenirs could be an attractive source of income for community members. However, due to lack of clarity around wildlife farming in the legislation, this potential has not been explored.

Table 2. *Total Population in the Highland and Lowland Communities of the Kalikhola Watershed*

Description	1987	1999	Population change (1987–1999)
Highland communities: Situated on more than 1,200 m altitude includes the settlements of the following wards: 4, 7, 8 and 9.	4,141	2,683	-35.19% (decrease)
Lowland communities: Situated on less than 1,200 m altitude includes the settlements of the following wards: 1, 2, 3, 5 and 6	2,081	4,571	+54.47% (increase)

Source: Armala VDC Office Report, 2002.

4.2 Land-use change

In this watershed, at elevations greater than 1,300 m, the land cover is mainly forest with Uttis (*Alnus nepalensis)* and Chilaune (*Schima wallichii*) species. Some other forest species, such as Katus (*Castanopsis indica*) and Simal (*Bombaz ceiba*), are also found at this elevation. Some areas are cultivated with millet, mustard, and maize. Because of frequent hailstorms and heavy wind, this area is more vulnerable to soil erosion. On mountains with elevations between 2,023 m and 2,100 m, the land cover is mainly rainfed paddy, maize, and cash crops such as peanuts, white potatoes, and mustard. For mountains at an elevation of between 1,000 m and 1,300 m land cover is dominated by cultivated paddy, wheat, and mustard. The lowland areas have pastures and meadows. Most settlements are located at an elevation level between 1,000 m and 1,700 m; very few people live above 1,700 m.

The land-use maps of 1987 and 1999 are presented in Figure 2 and the areas under the four land-use classifications during the two periods are shown in Table 2. Results show that land use in the watershed has changed considerably from 1987 to 1999. In general, areas under forest increased and those under rainfed agriculture, shrubs, and grasslands decreased. Forest area increased from 39.57% to 56.04% of total area between 1987 and 1999, an increase of 16.47%. During the same period, agricultural land cover decreased from 45.21% to 41.52%, a net decrease of 3.69%. Similarly, grazing land decreased from 8.79% to 2.31% and bush/shrubs from 6.43% to 0.12%.

The percentage change in various land-use classes between 1987 and 1999 shows that 8% of agricultural land in 1987 was converted to other classes, whereas bush/shrubs and fallow/grazing land decreased by 98% and 73%, respectively (see Table 3). However, forestland increased 41% during the same period. Figure 2 shows that a small percentage of agricultural land was changed into forestland and almost 100% of bush and shrubs was also changed into forestland.

Table 3. *Comparison of Land-Use Change*

Land-use class	1987			1999			Land-use change (%)
	Area (meter)	Area/ha	%	Area (units)	Area/ha	%	1987–1999
Agricultural Land	13,326,268.61	1,332.62	45.21	12,239,667.82	1,223.96	41.52	-8.15
Bush/Shrubs	1,895,646.99	189.56	6.43	36,101.13	3.61	0.12	-98.09
Fallow/Grazing	2,590,330.61	259.03	8.79	681,053.79	68.10	2.32	-73.70
Forestland	11,661,197.71	1,166.11	39.57	16,516,621.25	1,651.66	56.04	41.63
Total		2,947.33	100		2,947.33	100	

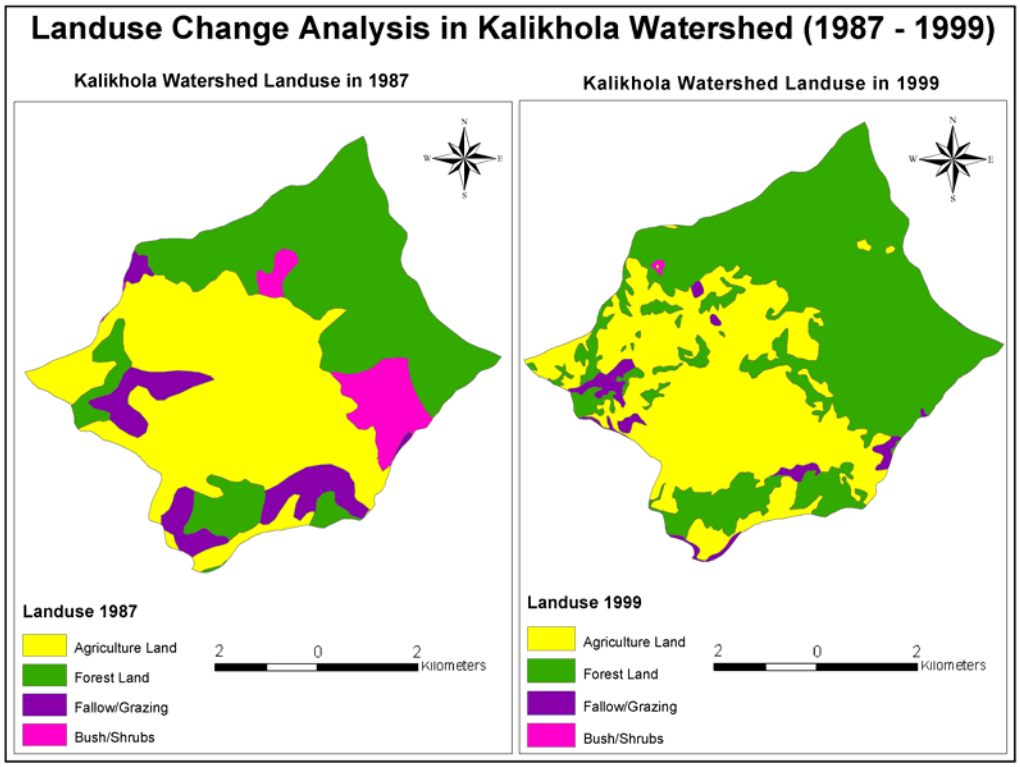

Figure 2. Land-use change analysis in the Kalikhola watershed.

Although forest area increased between 1987 and 1999, few areas of forestland were converted into crops. Migration of people from neighboring villages to the forest was allowed by the forest user committee.

The observed trends of increasing forest and decreasing agricultural areas in the watershed could be explained by the following three reasons. First, a few major factors influence the ability and the desire to grow crops. For example, a substantial proportion of the agricultural lands in the study area is on gradients above 15%, where slope stability and soil erosion are of critical concern (ICIMOD 1994). Those steep agricultural fields have suffered from rapid soil erosion and nutrient depletion, which forces farmers to abandon their agricultural plots after a

few seasons of cultivation. In addition, some earlier research in the study area showed that many people have abandoned unproductive agricultural lands in recent years because of a labour shortage caused by the outmigration of males for wage labour in the capital city of Katmandu and in the neighboring country of India (Group Discussion, 2004). In addition, the establishment of some livestock cooperatives in the watershed has attracted the local community to livestock farming rather than agriculture. These cooperatives not only provide local farmers with the loans to start livestock farming, they also help them trade the milk. Altogether this is much more attractive than growing crops.

Second, regulations resulting from the Forest Act of 1993 and 1995 have contributed to an increase in forest area. In Nepal, community forestry was formally introduced in 1978 with the objectives of reducing ecological degradation and increasing the supply of basic forest products for subsistence needs (Kanel, 1997). It is now a major strategy in the country's forest policy and is the most prioritized forestry program (Bartlett, 1992; HMGN/ADB/FINNIDA, 1988). During the last 28 years of community forest implementation, about 1.2 million ha (or 25%) of national forests have been handed over to more than 14,000 local community forest user groups. These user groups constitute about 35% of the country's total population (Kanel, 2006).

Third, conversion of degraded forest, shrublands, and grassland into forest under the community forest program implemented by the government since 1979 with the assistance of the Department for International Development (UK) and other donor agencies has contributed to an increase of forest cover. Figure 3 compares the area in hectares by land-use type in 1987 and 1999.

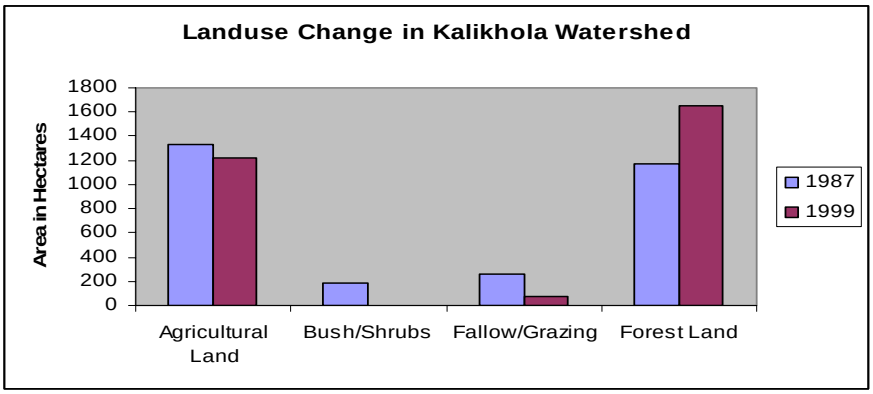

Figure 3. Land-use change in the Kalikhola watershed.

5.0 Conclusion and Policy Implications

Land-use study is of fundamental significance, since land resources play a strategic role in the determination of people's economic, social, and cultural progress.

The general trend observed by the present study is a decrease in agricultural land, shrubland, and grazing land and an increase in forestland. A growing number of wild animals frequently attack and destroy the crops. The community forest committee has controlled access to the forest and this has had a negative impact on agricultural production. The local farmers traditionally used forest grass, leaves, and small branches of plants for mulching and composting but this is no longer

allowed under new community regulations. The quantitative evidence of land-use dynamics presented here support the findings of some earlier studies (Acharya, 2002; Brown and Shrestha, 2000; Jackson et al., 1998; Yadav and Dhakal, 2000), which concluded that community forest projects are successful in producing greenery in degraded land, increasing forest areas, and encouraging local communities in husbandry. Changes in the increment of forest cover provides some evidence of ecological sustainability; however, the decreasing trend in area dedicated to farmland has raised some questions regarding the possible continuation of the observed trends in the future. These findings also signify, to some extent, challenges of livelihood sustainability of the Kalikhola watershed communities. The major concerns of the highland communities are wild animals and newly planted trees, both of which directly affect their livelihoods. Possible solutions to these concerns could include compensation schemes for wildlife damage and hunting access in the forest. Such schemes could help meet the objectives of protecting nature and providing means of livelihood for the local population in remote areas of Nepal. Analysis of land-use change indicates the effect that land management and community forest policies have had over this period. It serves as a stepping stone for understanding trends and land-cover changes. The overall results of this study demonstrate the ability of GIS as an effective tool for detection and quantification of long-term patterns of land-use change.

6.0 Acknowledgments

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