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Internal Migration and Land Use and Land Cover Changes in the Middle Mountains of Nepal

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The movement of rural households from remote uplands to valley floors and to semiurban and urban areas (internal migration) is a common phenomenon in the middle mountain districts of Nepal. Understanding the causes and effects of internal migration is critical to the development and implementation of policies that promote land use planning and sustainable resource management. Using geospatial information technologies and social research methods, we investigated the causes and effects of internal migration on land use and land cover patterns in a western mountain district of Nepal between 1998 and 2013. The results show a decreasing number of households at high elevations (above 1400 m), where an increase in forest cover has been observed with a consequent decrease in agricultural land and shrub- or grassland. At lower elevations (below 1400 m), forest cover has remained constant over the last 25 years, and the agricultural land area has increased but has become geometrically complex to meet the diverse needs and living requirements of the growing population. Our findings indicate that internal migration plays an important role in shaping land use and land cover change in the middle mountains of Nepal and largely determines the resource management, utilization, and distribution patterns within a small geographic unit. Therefore, land use planning must take an integrated and interdisciplinary approach rather than considering social, environmental, and demographic information in isolation.

Keywords: *Internal migration; land use and land cover change; landscape fragmentation; community-based natural resource management; demographic dynamics.*

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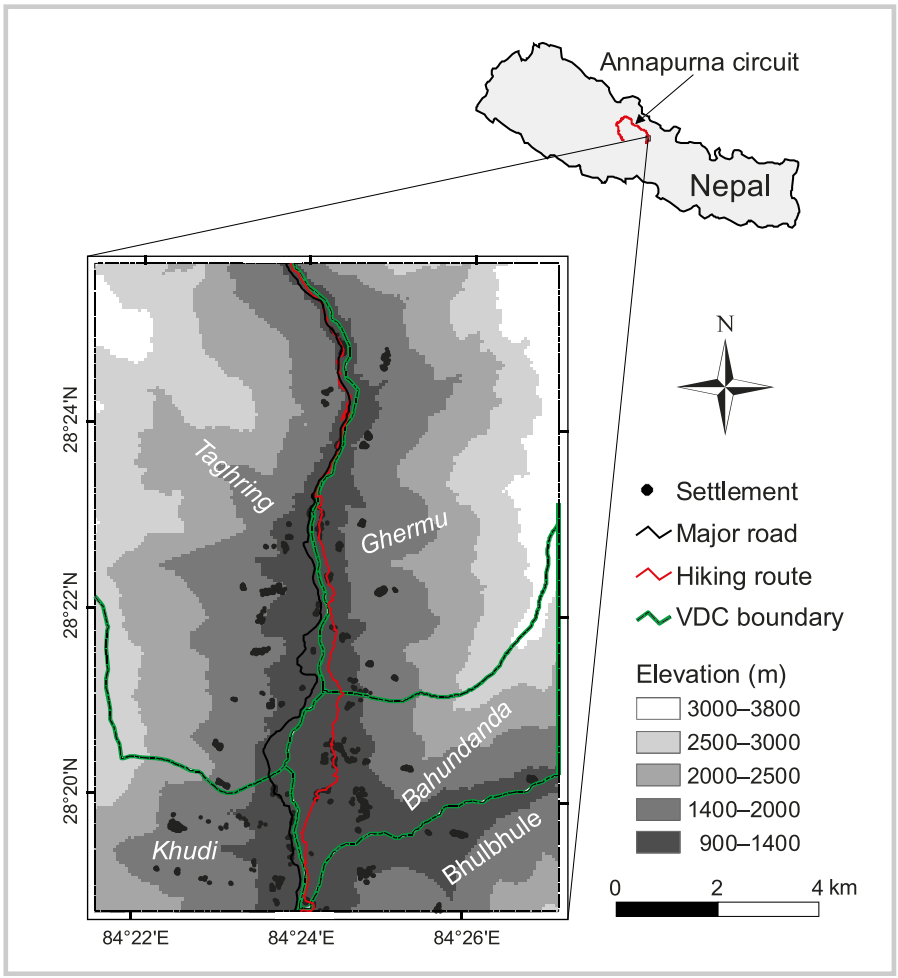
Introduction

Environmental issues in Nepal have been much discussed since Eckholm (1975) proposed the theory of Himalayan environmental degradation. This suggests that population growth in the hills and mountains leads to deforestation and environmental degradation associated with soil erosion, downstream flooding, and silting of rivers and streams. The National Forest Inventory conducted in 1994 indicated that the forested area in Nepal declined from 38.1% in 1978–1979 to 29% in 1994 (Acharya et al 2011) and that the annual loss in the plains and hills was 1.3% from 1978–1979 to 1990–1991 and 2.3% from 1978–1979 to 1994 (Härkönen 2002). Previously, Ives and Messerli (1989) reported that upland forest area had remained more or less constant despite population growth. Other studies have shown that forest cover in the hills and mountains of Nepal has increased since the launch of Nepal's community forestry program in 1978 (Gautam et al 2003; Kanel 2004; Tachibana and Adhikari 2009; Pandit and Bevilacqua 2011; GoN 2013; Niraula et al 2013). Resource assessment conducted between 2010 and 2014 showed that the forest occupied 40.36% of the total area of Nepal and that the middle mountain regions have greater forest cover (37.8%) (DFRS 2015).

Migration from upland villages and other factors—such as decreasing land productivity, employment opportunities, social and political instability, and natural hazards—have led to farmland abandonment (Khanal and Watanabe 2006; Shrestha and Bhandari 2007; Tacoli 2009; Massey et al 2010; Gentle and Maraseni 2012). Approximately one third of agricultural land in the middle mountains of Nepal has already been abandoned (Paudel et al 2012), whereas semiurban environments on the valley floors have experienced a growth in population, unplanned expansion of settlements, increased demand

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FIGURE 1 Location of the study area. (Map by Tiejun Wang)



for natural resources, and intensive farming (Brown and Shrestha 2000; Jaquet et al 2015).

Many studies have focused on international migration for employment and its socioeconomic consequences (Poertner et al 2011; Maharjan et al 2012; Adhikari and Hobley 2015; Jaquet et al 2015; Sunam and McCarthy 2016). In contrast, the effects of internal migration on natural resource management have not been investigated. Internal migration, defined as the movement of rural households from remote uplands to the valley floors and to urban and semiurban centers, is a common and increasing phenomenon in the middle mountains of Nepal (Chapagain and Gentle 2015; Jaquet et al 2016). The national population and housing census for 2011 showed that between 2001 and 2011, depopulation occurred in 27 mountain districts of Nepal (GoN 2012a, 2012b). Rural to urban migration is having a considerable socioeconomic and environmental effect in the middle mountains of Nepal (Grau and Aide 2007). Understanding how internal migration affects land use and land cover (LULC) is critical to the effective design and implementation of policies that promote development and sustainable natural resource management (Sherbinin et al 2008). However, the internal migration and its impact on LULC change have not been well documented in Nepal.

The objective of this study was to examine how internal migration affects LULC distribution in the middle mountains of Nepal. The results provide information to assist with land use planning and sustainable resource management in Nepal.

Study area

The study area is located in the Lamjung district of Nepal and covers 5 village development committees (VDCs)—Ghermu, Bahundanda, Bhulbhule, Taghring, and Khudi—with elevation ranging from 900 to 3800 m above sea level (Figure 1). The Lamjung district is home to indigenous Gurung communities, with a population in 2011 of 167,724 people in 42,079 households (GoN 2012b). The study area lies in the Annapurna Circuit, an internationally known trekking route in the Annapurna

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mountain range of Nepal. The opening of this route to foreign visitors in 1977 created new sources of employment for local people, including in hotels and accommodations in private homes, grocery shops, and teahouses and as trekking guides and porters, all of which resulted in the migration of people from high-elevation uplands to valley floors. In the study area, there is a community-based forest management regime, and the livelihoods of the local communities mainly depend on subsistence agriculture and livestock raising. Remittances from foreign employment have become one of the major sources of income in Lamjung communities in recent decades (Cedamon et al 2017).

Material and methods

LULC field data collection

The LULC data for satellite image classification and verification were collected in September 2014, using a stratified random sampling strategy. Four strata—forest, shrub- or grassland, agricultural land, and other (bare land, built-up areas, and water bodies)—were identified using very-high-resolution Google Earth images and based on visual interpretation and prior field experience. The size of the sample plots was 90×90 m; each had a relatively homogeneous LULC. The geographic coordinates of the plot center were recorded using a global positioning system (GPS) receiver with a positional accuracy of 5–20 m. Reliable ground data are required to run the classification algorithms. However, precise observation and confirmation of historical land use was impossible, because the study period stretched more than 2 decades and neither historical maps nor high-resolution satellite images were available before 2005 for retrieving such detailed land cover information. As a consequence, the land use history of each sample plot was collected from personal interviews with local farmers. Multiple individuals were interviewed for each plot to reduce potential bias. The sample points were separated by at least 500 m to reduce the potential effect of spatial autocorrelation. In total, 100 sample plots, with constant LULC throughout the period under study (1988 to 2013), were described and randomly divided into 2 groups to train (60%) and test (40%) the classification algorithm.

Landsat satellite images and ancillary topographic data

Three ortho-rectified Landsat images were downloaded from the U.S. Geological Survey EarthExplorer site (USGS 2017), namely, Landsat Thematic Mapper (20 November 1988), Landsat Enhanced Thematic Mapper Plus (31 October 2001), and Landsat Operational Land Imager (24 October 2013). The Landsat images were geometrically rectified using 1:50,000 topographic maps; the processing used a second-order polynomial and nearest-neighbor interpolation with less than 0.5 pixels (15 m) of root-mean-square error. The thermal and panchromatic bands of these images were excluded from the analysis. Only 6 bands from each image with a spatial resolution of 30 m were stacked and reprojected to Universal Transverse Mercator zone 45N, datum WGS84. The images chosen for our specific study area were free of clouds and snow.

Topographic information, including elevation, slope, and aspect, were derived from the 30-m Advanced Spaceborne Thermal Emission and Reflection Radiometer global digital elevation model with vertical accuracies between 10 and 25 m (USGS 2014). The digital elevation model data were geometrically coregistered with the Landsat images using a second-order polynomial and nearest-neighbor interpolation. The topographic data were combined with the Landsat images to improve the LULC mapping accuracy.

Support vector machine

To classify the LULC types, we used a support vector machine algorithm, which is a supervised nonparametric statistical learning technique that makes no assumptions concerning the underlying distribution of the training datasets (Mountrakis et al 2011). The support vector machine algorithm has been found to be superior to traditional classifiers such as the maximum likelihood classifier (Huang et al 2002; Kavzoglu and Colkesen 2009); it was selected for the study because of its ability to handle small sample sizes (Mantero et al 2005) and its effectiveness in classifying heterogeneous landscapes (Warner and Nerry 2009).

Accuracy assessment

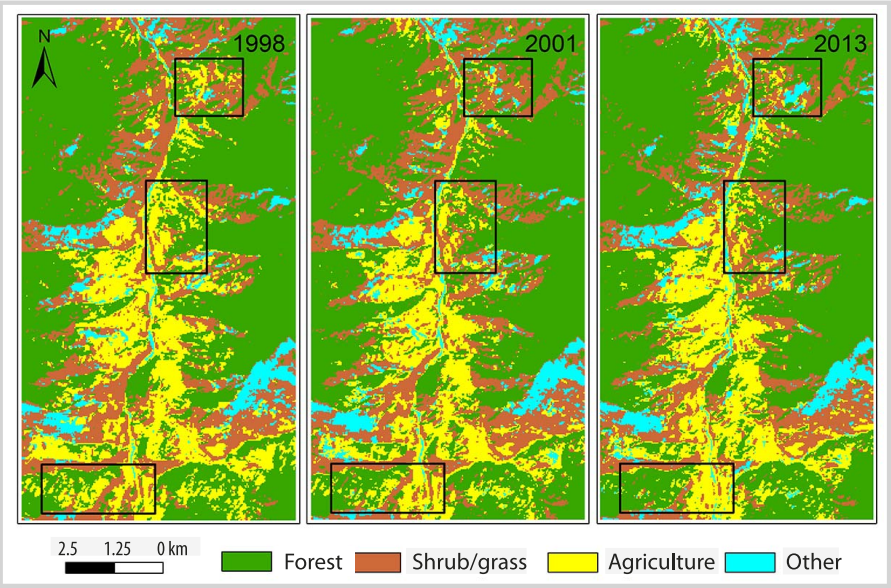
Accuracy of the classified LULC maps was assessed using a combination of overall accuracy, producer's accuracy, user's accuracy, errors of commission and omission (Jensen 1986), and kappa coefficient (Cohen 1960). The kappa coefficient and its variance were used to compare the classification accuracies of the maps using z-tests (Congalton 1991). A z value greater than or equal to 1.96 indicates a statistically significant difference at 95% confidence between 2 kappa coefficients, which corresponds to a 2-sided P value less than or equal to 0.05. The detailed steps of LULC classification are presented as a flow diagram in the supplemental material (Figure S1: http://dx.doi.org/10.1659/MRD-JOURNAL-D-17-00027.S1).

Landscape fragmentation analysis

Three landscape fragmentation metrics—percentage of landscape (PLAND), edge density (ED), and area-weighted mean patch size (AREA_AM)—were calculated in FRAGSTATS software (McGarigal et al 2012) to quantify LULC change patterns. PLAND is the sum of the areas of all patches of the corresponding patch type divided by the total landscape area; this gives a measure of what

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FIGURE 2 LULC in the study area, 1988–2013. Areas highlighted by the black rectangles indicate some obvious changes.



percentage of the landscape consists of a particular patch type. ED is the sum of the lengths of all edge segments involving the corresponding patch type divided by the total landscape area. ED is expected to increase when there is high spatial heterogeneity. AREA_AM is the sum, across all patches of the corresponding patch type, of the corresponding patch metric value multiplied by the proportional abundance of the patch (ie patch area divided by the sum of patch areas). Increase in patch size indicates a merger of patches and thus a decrease in fragmentation of that patch type.

Focus group discussions

Nine focus group discussions were conducted with local community members. The number of participants in each focus group ranged from 4 to 10, and their locations were purposively selected to represent the study area and to ensure the representation of different castes, classes, ethnicities, and genders. The objectives of the study were shared with the participants, and their consent to record information was obtained before discussions (Kumar 1987; Powell and Single 1996). Discussions were guided by a list of questions that addressed trends in internal migration, migration pull and push factors, trends in development, perceived socioeconomic changes, environmental changes and their implications, and LULC change in the research area. Migration-related records kept by the VDC offices were used to triangulate the information received from focus group participants.

TABLE 1 *Z* statistic comparing the performance of classification maps for 1988, 2001, and 2013, with overall accuracy and kappa coefficient.

	1988	2001	2013	Overall accuracy (%)	Kappa coefficient
1988	—			87.5	0.833
2001	0.36	—		90.0	0.867
2013	1.20	0.85	—	95.0	0.933

Results

Land use and land cover

LULC maps for 1988, 2001, and 2013 are shown in Figure 2. Mapping accuracies ranged between 87.5% and 95%, and the kappa coefficients were between 0.83 and 0.93; this indicates that the classification results are reliable. The kappa *z*-test indicated that there were no statistically significant differences among the accuracies of the 3 classification maps (Table 1), which confirmed that these classification maps were appropriate to use in further analyses.

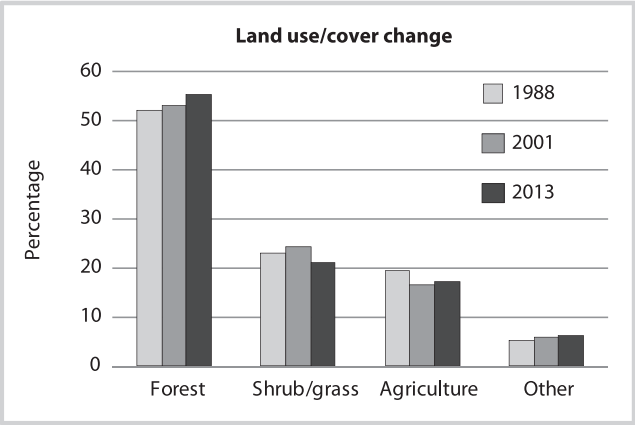
There was a gradual increase in forest area from 52.2% in 1988 to 55.3% in 2013. Shrub- and grassland increased by nearly 1.5% from 1988 to 2001 and then decreased by 3% between 2001 and 2013. Agriculture decreased by 3% from 1988 to 2001 and then increased from 2001 to 2013. Similar to the trend for forests, the "other" category (bare land, built-up areas, and water bodies) also increased from 1988 to 2013 (Figure 3).

Landscape fragmentation

Based on the distribution and migration patterns of households, the study area was divided into 2 elevation zones (above and below 1400 m) to explore the

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FIGURE 3 Percentage of change in LULC, 1988–2013.



fragmentation patterns of each LULC type and their relation to internal migration.

In the upper elevations (>1400 m), the PLAND of forest cover increased because of the merging of small patches of forests (ie the number of discrete forest patches had decreased) (Figure 4). The decrease in ED from 2001 to 2013 and increase in AREA_AM confirms that merging of forest patches has occurred. In contrast, since 1988, the PLAND of agricultural land has decreased by 4%, with a decrease in both ED and AREA_AM, indicating more compact or circular plots. The fluctuation in shrub- and grassland, which first increased and then decreased in PLAND, ED, and AREA_AM, indicates that they are becoming smaller and more compact, and in some cases circular in shape. The PLAND of the "other" class increased gradually, followed by an increase in ED with fluctuation in AREA_AM.

In contrast, at lower elevations (<1400 m), the PLAND of agriculture increased, as did both AREA_AM (from 245 ha in 1988 to 546 ha in 2001 and 725 ha in 2013) and ED (Figure 4). This shows that agricultural land is increasing but becoming geometrically complex or irregular. Forest ED increased by 5% from 1988 to 2013 without a significant change in PLAND, suggesting that forests are constant in area but changing in shape (becoming more elongated). Shrub- and grassland AREA_AM and PLAND decreased during the same period, while ED increased, indicating that this LULC category is becoming smaller and more irregular in shape. The "other" class increased in AREA_AM and ED, suggesting that these LULC categories are becoming larger and more aggregated but irregular in shape.

Household migration trends

As reported by focus group participants, migration trends varied according to village location. Based on focus group discussions, changes in the number of households were recorded at 10-year intervals: 1983, 1993, 2003, and 2014. For most villages, there was a decrease in the number of households located above 1400 m, while below 1400 m, the number of households gradually increased (Figure 5). Households that received income from jobs, pensions, or remittances from family members employed overseas had higher migration rates than other households.

Migration was higher among young people (15–25 years old) and those separated from their families. However, even where the number of households is constant, the number of household members has decreased; in these cases, older people are looking after and occupying the home (Fox 2016). According to the national population census (GoN 2012a), 1 in every 4 households (25.4%; 1.38 million households) reported that at least 1 member of the household was absent. The highest proportion (44.8%) of absent family members are aged 15 to 24 years. However, young people who could not afford to buy land and build a house at a lower elevation often remained in the villages with their families. People older than 50 years, most of whom have lived in the same village for decades, wanted to maintain their rural livelihoods and their relationships with the community. In some cases, people who received money from family members working abroad built 2 houses: a small one in their village to maintain contact with their local community and a second one on the valley floor to take advantage of income opportunities.

Migration push and pull factors

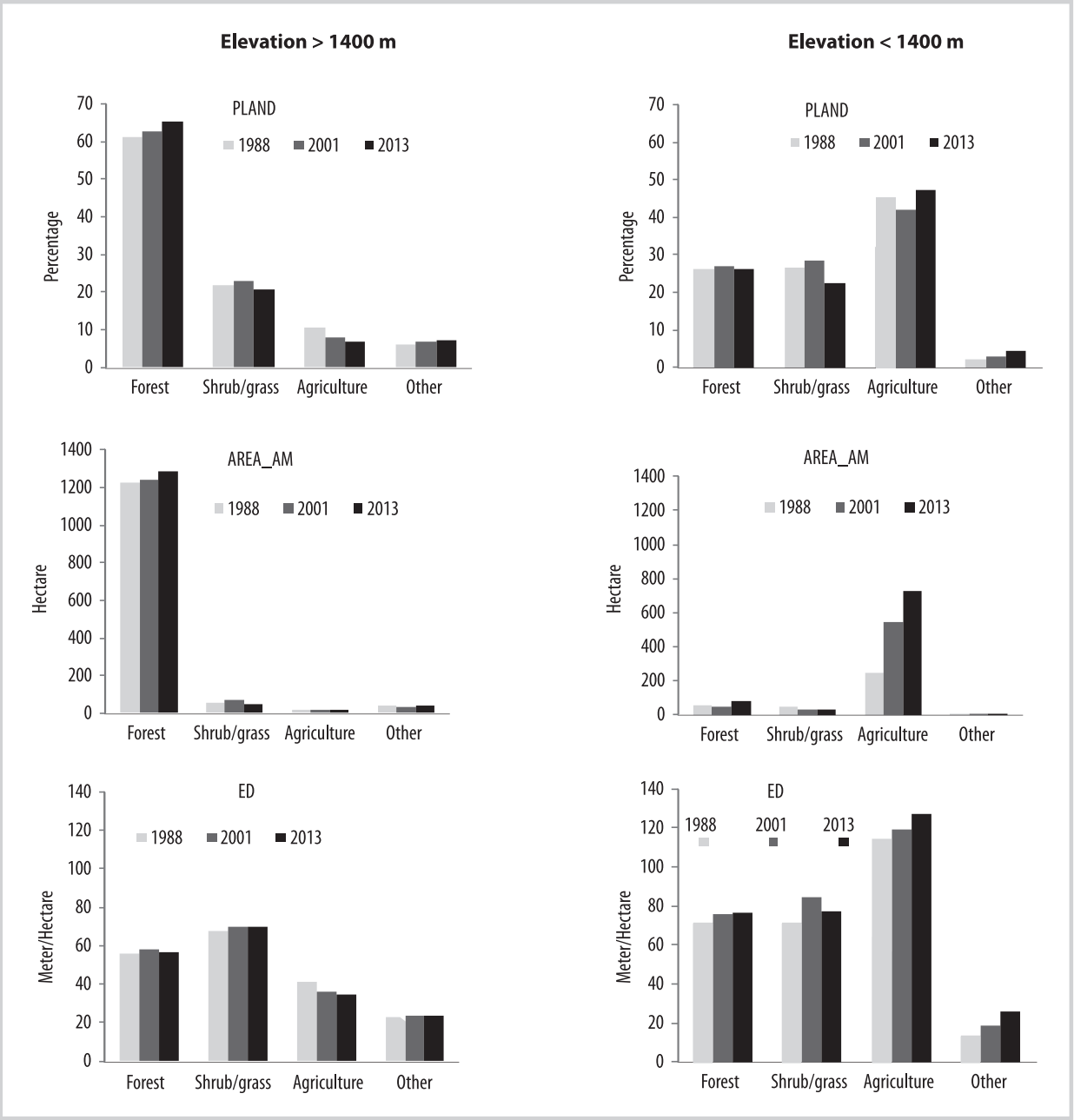
Focus group participants reported that populations are decreasing in higher elevations because of both the pull and push factors of migration. The push factors were scarcity of agricultural labor and the resulting high labor costs, decreasing farm productivity, water stress and reductions in crop yield, lack of employment, and reduced benefits from subsistence agriculture. The major pull factors encouraging migration to lower-elevation communities included proximity to roads, better services, income opportunities, and fertile land with irrigation facilities.

Many young people, especially young men, have gone abroad for employment, other income opportunities, and education, leaving behind parents, women, and children. The resulting scarcity of labor for agriculture has caused an increase in labor wage rates. This is consistent with the results of other studies (eg Jaquet et al 2015; Sunam and Goutam 2015). According to focus group participants, the erratic rain- and snowfall, frequent droughts, and delayed monsoons have reduced agricultural productivity. Thus, a number of farmers have decided not to continue farming. Studies (Gautam and Andersen 2016; Gentle and Thwaites 2016) have shown that environmental factors, including the impacts of climate change, have negatively affected agricultural productivity and forced farmers to move out of agriculture in rural areas of Nepal.

The opening of the Annapurna trekking route and the construction of the Beshisahar–Manang road along the

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FIGURE 4 Landscape fragmentation patterns above and below 1400 m elevation as measured by percentage of landscape (PLAND), area-weighted mean patch size (AREA_AM), and edge density (ED).

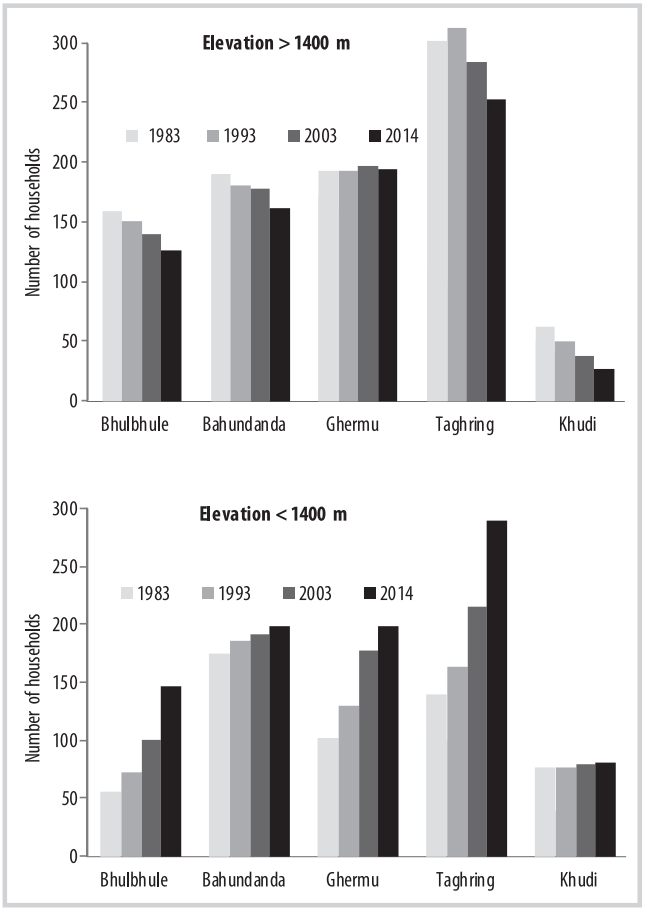


Marsyangdi Valley after 1997 increased migration to the valley floor. For example, one of the hamlets of Ghermu VDC, Ghermu Phant, had 7 households in 1983 but 39 in 2014. The route created various commercial developments and employment opportunities, including in new hotels and home accommodations, grocery shops, vegetable farms, and restaurants and as tourist guides, cooks, and porters. At both high and low elevations, there was a decrease in the number of large domestic animals, including cows, buffalos, and bulls, and an increase in sheep and goats, which eat less and are easier to manage. In general, people had moved away from traditional agriculture and livestock raising and attempted to diversify their income sources.

Focus group participants reported that migration has led to agricultural land abandonment at high elevations and resulted in a decline in soil fertility, with some abandoned lands undergoing frequent landslides and soil erosion and some dominated by invasive species. Taghring villagers reported that about 20% of the village's agricultural land had been abandoned. The agricultural lands that are farthest from settlements and that are

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FIGURE 5 Changes in the number of households from 1983 to 2014 above and below 1400 m elevation in the 5 VDCs in the study.



relatively less fertile are abandoned first. Consequently, many agricultural practices have changed, including reductions in crop intensity and area planted.

Discussion

Our research found an increase in forest cover at higher elevations as trees and shrubs colonized abandoned agricultural land. In contrast, a gradual increase in the land area used for agriculture was identified at lower elevations. Even though the number of households increased at lower elevations, forest cover in these areas remained constant between 1988 and 2013. At both higher and lower elevations, other land covers, such as bare land and built-up areas, increased over the same period.

At higher elevations, people have abandoned agricultural lands, as reported in other studies conducted in Nepal (Khanal and Watanabe 2006; Paudel et al 2012; Jaquet et al 2016; Sunam and McCarthy 2016). These abandoned lands have gradually reverted to forest. Gautam et al (2003) found a similar trend in one of the mountain watersheds of Nepal, where forest cover increased and replaced agricultural areas. Similar trends have been observed in other places, including Chile (Díaz et al 2011), Puerto Rico (Lugo and Helmer 2004), Spain (Melendez-Pastor et al 2014), and France (Sanz et al 2013). Our research revealed that agricultural lands that are more distant from settlements and have less fertile soil are abandoned sooner than land close to human settlements with fertile soil. In addition, agricultural practices have reduced cropped area and crop intensity because of lack of labor, high labor costs, and decreases in agricultural productivity, as reported in other parts of world (Robson 2010).

Community-based forest management programs have also contributed to increases in forest cover through the establishment of tree plantations and forest protection measures. These measures have reduced cultivation, restricted open grazing, reduced the number and intensity of forest fires, and helped to promote natural regeneration in the area we studied. Our results are comparable with the findings of other studies conducted in different parts of Nepal (Gautam et al 2002; Gautam et al 2003; Kanel 2004; Nagendra et al 2007; Tachibana and Adhikari 2009; Pandit and Bevilacqua 2011; GoN 2013; Niraula et al 2013). Along with the gradual increase in forest cover through the merger of patches, there has been an increase in ED, suggesting that forests are more heterogeneous and irregular or elongated in shape. These findings are comparable with those of Gautam et al (2003) and Uddin et al (2014). Furthermore, Robson (2010) and Robson and Berkes (2011) stated that agricultural abandonment brings changes in patch sizes and edge effects, as well as the spatial heterogeneity, of the forests. Our study shows a positive trend toward forest protection and natural regeneration following the implementation of community-based resource management in Nepal.

Forest cover remained constant at lower elevations during the study period despite increases in household numbers. This stability is because of a combination of conservation measures and sustainable utilization of the forest by the local communities. Other factors contributing to stability may include (1) local people using biogas and solar energy sources, as well as liquid petroleum instead of fuelwood for cooking; (2) a reduction in the number of large livestock needing forest fodder; and (3) the opportunity for local people to diversify income by off-farm work associated with tourism. These factors have significantly decreased environmental pressures on low-elevation forests. Our research shows that in contrast to the theory of Himalayan environmental degradation (Eckholm 1975), population growth does not necessarily result in forest degradation.

Agricultural lands at lower elevations have expanded to meet the needs of a growing population. Our findings indicate that these increases occurred by displacing shrub- and grassland cover. The conversion of shrubland to agricultural land occurred for 2 reasons: conversion of forest to agricultural land was strictly prohibited under community-based natural resource management, and improved irrigation facilities enabled people to expand

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agricultural land into what had been shrub cover. In the area we studied, people are adopting intensive cultivation methods and using modern technologies, including fertilizers, hybrid seeds, irrigation, and seasonal vegetable farming with polythene tunnels. Brown and Shrestha (2000) highlighted that cultivation area and intensity have increased, but only where water was available. At the same time, agricultural land became more geometrically complex, as shown by the increase in ED. This increase was because of settlement expansions and associated developments such as road construction. Gautam et al (2003) also found increased fragmentation of lowland agricultural areas in the middle mountains of Nepal as a consequence of expanded settlement areas and new infrastructure.

The bare and built-up areas increased at low elevations because of the expansion of settlements, with increased incidence of landslides and erosion associated with poorly planned road construction. At higher elevations, the frequency of landslides and soil erosion has increased in abandoned lands, also causing bare land to increase (Smadja 1992; Khanal and Watanabe 2006; Jaquet et al 2015). Khanal and Watanabe (2006) concluded that geomorphic damage occurs at abandoned land sites before plant colonization. Smadja (1992), in her study of the middle mountains of Nepal, also concluded that deintensification leads to poor maintenance and slope instability, causing gully formation and landslides. Our research found that some abandoned lands were undergoing landslides and erosion and some were being colonized by invasive species, as reported by Jaquet et al (2015).

Internal migration is a typical phenomenon in the middle mountain region of Nepal and is taking place in an unplanned way. Agricultural land abandonment, colonization by invasive species, a decline in soil fertility, and the increasing incidence of landslides and erosion, when combined with increasing intensive land use and unplanned expansion of settlements and associated infrastructure development in the lowlands, are having negative consequences for the environment and food security. Similar experiences of rural–urban migration, land abandonment, and LULC change are reported in other parts of world, especially in developing countries such as Argentina, Chile, China, India, and Mexico (Izquierdo and Grau 2009; Robson and Nayak 2010; Díaz et al 2011; Chen et al 2014; Liu et al 2016; Agarwal and Agrawal 2017; Liu 2017). The results of these studies provide insights into the ongoing landscape transitions following migration. Our research suggests that internal migration largely determines the use, management, and distribution of resources and therefore sustainable development in depopulated mountainous areas.

Conclusions

Our research has shown that there is an increasing trend toward migration from upland areas to valley floors and roadheads and that these population movements are playing an important role in LULC change in the middle mountains of Nepal. Motivation for migration was found to be higher among young men, which resulted in an increase in the proportion of older people, women, and children in the villages. Households with members working in foreign employment with regular and reliable incomes and pensionable salaries have a higher rate of migration than other groups. The analysis of LULC change shows that in abandoned agricultural areas at higher elevations, there is an increase in forest cover and a reduction of shrub- and grassland. In contrast, at lower elevations, forest area has remained constant even though there has been an increase in household numbers. Agricultural land at lower elevations has increased in area in the past 25 years but has become geometrically more complex. At lower elevations, increasing populations, intensive land use, and poorly planned settlements, along with the associated infrastructure development, have resulted in environmental pressures and food security issues. To address this challenge, the Nepalese government must formulate policy and development activities to regulate internal migration and introduce land management policies that take into account the changing demographic dynamics and their consequences. LULC change is a result of the interaction of multiple factors, and land use planning must use integrated approaches that consider the social, environmental, and demographic changes essential for sustainable development.

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Supplemental material

FIGURE S1 LULC classification procedure.

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