RESEARCH

DOI: 10.1007/s00267-003-0031-4

Forest Cover Change, Physiography, Local Economy, and Institutions in a Mountain Watershed in Nepal

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ABSTRACT / This study assessed changes in forest cover in a mountain watershed in central Nepal between 1976 and 2000 by comparing classified satellite images coupled by GIS analyses, and examined the association of forest change with major physiographic, economic, and local forest governance parameters. The results showed an increase in forested area (forest plus shrublands) by 7.6% during 1976–2000. Forest dynamism (changes including improvement, deterioration, gain, and loss) was highest in low-elevation, south-facing and less-steep slopes that were closer to roads. Proportionately the highest net improvement and gain to forested area also took place in those locations. Forest degradation occurred at twice the rate of improvement in high elevation areas (> 2300 m). Forests located in urban and semiurban areas (i.e., a market-oriented economy) experienced a proportionately higher amount of net improvement and gain than forests in rural areas (i.e., a subsistence economy). Among the three governance arrangements, proportionately the highest net improvement and gain took place in semigovernment forests (forested area legally under the forest department but with de facto control and claim of ownership by local communities and/or municipality) followed by formalized community forests (including leasehold). Government forests, which were mostly found in the southern high mountains and had virtually open access, remained relatively stable during the study period. Over 50% of the watershed forests have not come under community-based management despite favorable policy and more than two decades of government intervention with continuous donor support. The findings indicate that the present "one size fits all" approach of community forest handover policy in Nepal needs rethinking to accommodate biophysical and socioeconomic variations across the country.

Deforestation and forest degradation in developing countries have been major environmental concerns over the past few decades. The magnitude and consequences of those environmental problems are now reasonably clear; our understanding of the factors causing deforestation is, however, far from complete. Much of the uncertainty surrounding deforestation is due to incomplete and unreliable information about the ecological, economic, and social forces behind it (Brown 1993).

There has been a rising interest in developing and evaluating alternative methods of forest management to mitigate the current trend of deforestation and forest degradation. It is generally agreed that community-based forest management, with due considerations to location-specific conservation and development requirements, is in many cases a suitable approach for managing forest resources in developing countries (FAO 1997). There are, however, differences in opinion among researchers and policy-makers regarding how much authority to devolve to communities (Anderson 2000, Banerjee 2000, Fisher and others 2000). This confusion has been reflected in national forest policies of various governments aiming at decentralized forest governance. Nepal's community forestry, India's joint forest management, Laos's "focal site" approach, and Vietnam's "people-centered" approach are a few models exemplifying the variety of community-based forest management systems currently being implemented in the developing countries of Asia (see Bartlett 1992, Ligon and Narain 1999, Kumar 2000, Phuong 2000; Pravongvienkham 2000, Agrawal and Ostrom 2001).

In Nepal, the national government formally introduced community-based forest management in 1978 with the objectives of meeting the subsistence forestry needs of local people and abating ecological degradation (Kanel 1997). Since then it evolved continuously over the years. The present community forestry and lease-

KEY WORDS: Land cover changes; Remote sensing; GIS; Institutions; Land tenure; Nepal

Published online January 8, 2004.

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hold forestry programs have met with some notable successes in terms of improving the biophysical environment, rural livelihoods, and institutional development, particularly in the Middle Hills where the programs have been extensively implemented (Sterk 1998, JTRCF 2001). Because of these successes, Nepal is considered as one of the most progressive countries in the world in terms of community-based forest management.

Nepal's much lauded community forestry program, however, has in recent years been confronted with a high level of debate regarding the role of government agencies and local communities in the program implementation. The origin of the debate could be related to the variety of outcomes from the last 24 years of program implementation, which has led to some critical questions, such as: Are the local communities capable of sustainably managing all the existing forests in the country? If not, what factors affect their success or failure? Despite substantial research on community-based forest management during the last two decades (e.g., Bajracharya 1983, Gilmour and Fisher, 1991, Schreier and others 1994, Pokharel 1997, Jackson and others 1998, Agrawal and Ostrom 2001, Varughese and Ostrom 2001, Webb and Gautam 2001, Dongol and others 2002), these critical questions remain largely unanswered. A crucial need in addressing these questions is quantitative research linking biophysical changes in forests with governance arrangements (e.g., Schweik and others 1997, Gautam and others 2002, Nagendra 2002).

There are various methods that can be used in analyzing forest cover changes but the use of remote sensing and geographic information system (GIS) technologies can greatly facilitate the process. Repeated satellite images and/or aerial photographs are useful for both visual assessment of natural resources dynamics occurring at a particular time and space as well as quantitative evaluation of land cover changes (Tekle and Hedlund 2000). Analysis and presentation of such data can be greatly facilitated through the use of GIS technology (ESCAP 1997). A combined use of remote sensing and GIS technologies, therefore, can be invaluable to address a wide variety of resource management problems including the assessment of forest cover change and its causes.

This study is part of a broader research designed to assess the role of community-based forestry institutions in determining the status of forests in a typical mountain watershed in central Nepal, and to identify major factors determining the success of local communities in their efforts of managing local forest resources. The specific objectives of this study were: (1) to detect and document changes in forest cover of the watershed between 1976 and 2000, and (2) to examine if and how different institutional arrangements at the community level, along with major ecological and economic factors, were associated with those changes. Analyzing these relationships is important in order to understand the role and limitations of local forest governance institutions in forest cover changes, and to provide input for designing appropriate policy and implementation strategies for sustainable governance of remaining forest resources.

Study Area

The study was carried out in the Upper Roshi Watershed situated in the western part of Kabhrepalanchok district in the Middle Hills of Nepal (Figure 1). The Middle Hills, located between the High Mountains in the north and the *terai* (low flatlands) in the south, is one of the most densely populated hill areas in the world. It is in this region, the community forestry program has been extensively implemented. The Upper Roshi Watershed was selected for the study because the watershed is reasonably representative of the Middle Hills and one of the pioneer areas for implementing community forestry in Nepal.

The Upper Roshi Watershed covers an area of 15,335 ha. Altitude varies between 1420 m to 2820 m above sea level. The climate is monsoonal 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 of the watershed except at higher elevations (above 2000 m) where the climate is a cool-temperature type. The microclimate varies considerably with elevation and aspect. Three rivers, Punyamata, Bebar, and Roshi, along with their numerous tributaries drain the area, which later converge at the southeastern corner of the watershed into the Roshi River.

The watershed can be divided into fertile, relatively flat valleys along the rivers and surrounding uplands with medium to steep slopes. Agricultural lands in the valleys are under intensive management with multiple cropping systems and are mostly irrigated. Rain-fed agriculture, with or without outward facing terraces, is practiced on rest of the agricultural land, which is not suitable for crop production without strong soil and water conservation measures because of their high erodability and low productivity (ICIMOD 1994).

Forests are mostly confined to higher elevations and consist of both natural mixed broadleaf forests as well as pine plantations. A single large block of natural forest in the southern high mountains represents around 50% of the total forest area of the watershed.

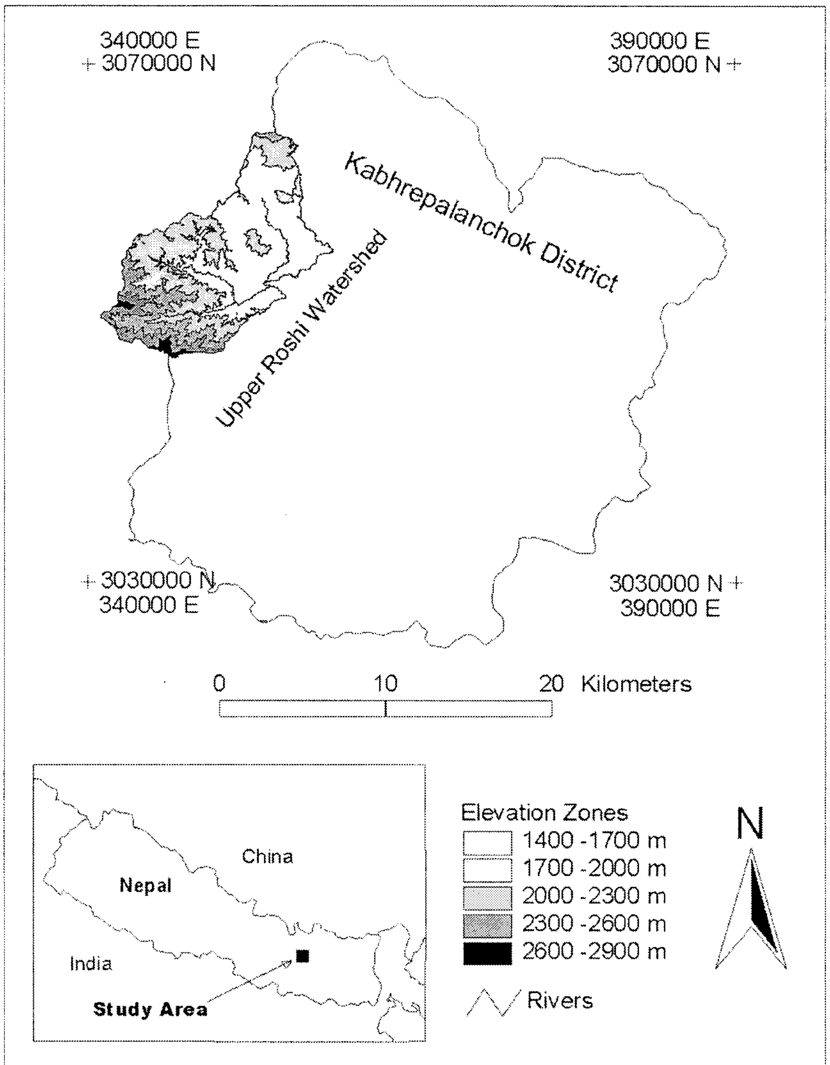

Figure 1. Location of the Upper Roshi Watershed within Kabhrepalanchok District, Nepal.

The rest of the forests are generally fragmented and scattered over the agricultural landscape.

Many of the lower elevation forests have been handed over to the local forest user groups (FUGs) under the community forestry program of the government implemented in the area since 1978. Under this program, local people from different caste, ethnic, and interest groups organize themselves into a FUG and collectively manage the forest according to negotiated and approved management agreements following a series of decision-making processes (see Bartlett 1992, HMGN 1995). Records available in the district forest office (DFO) at Kabhrepalanchok show that by the end of 2000, a total of 2135 ha of public forest land in the watershed had been handed over to 63 FUGs, consisting of 6808 households; many other user groups were awaiting formal registration. The Australian Agency for International Development has been supporting the implementation of community forestry program through successive bilateral projects since the inception of the program.

Leasehold forestry is another form of community-based forest management system implemented by the government since 1992. Under the leasehold forestry program, patches of degraded forestlands are given to a self-formed small group (5–10 members) of local people living below the poverty line for intensive forestry operations including agroforestry and horticultural forestry (HMGN 1995). The program had initial support from the Food and Agriculture Organisation of the United Nations and the International Fund for Agricultural Development. A total of 128 households living below the poverty line were managing 110 ha of degraded forest land in the watershed by the end of

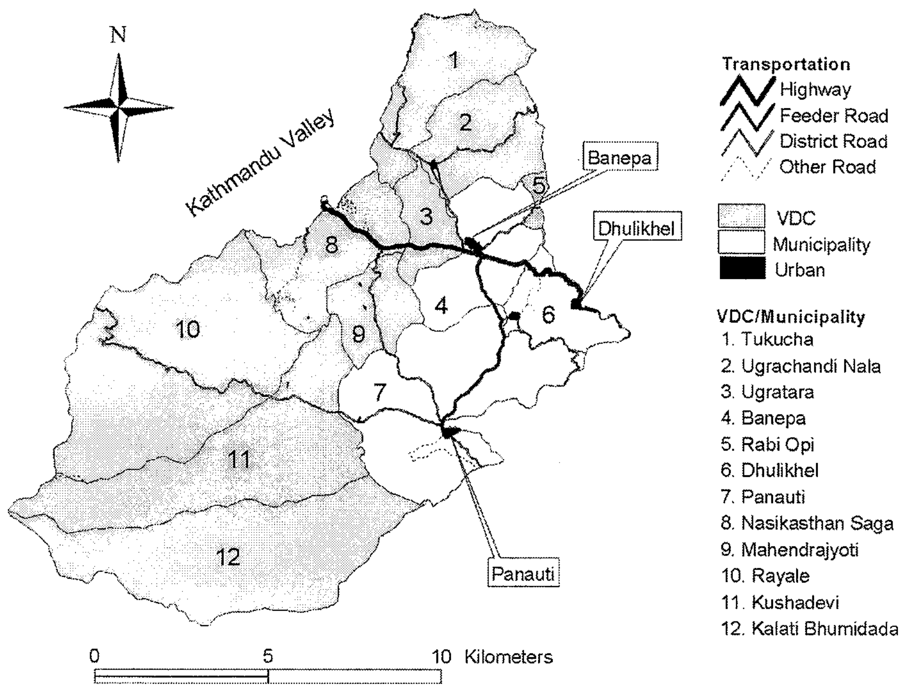

Figure 2. Village Development committees, municipalities, roads, and major towns (Banepa, Dhulikhel, Panauti) in Upper Roshi watershed.

2000 under the leasehold forestry program (Singh and Shrestha 2000).

The development of the watershed is not uniform. The Punyamata River valley in the eastern part of the watershed is one of the most fertile and economically important areas in Kabhrepalanchok district, where most of the commercial activities are concentrated. All three towns (Banepa, Dhulikhel, Panauti), which are connected to the Kathmandu valley by all-weather roads, are located in and around these lowlands (Figure 2). The local economy and employment opportunities of these urban and semiurban municipal areas differ from the rural areas. Urban residents have alternative sources of energy for cooking and heating, most of the households do not raise livestock, and very few households depend on agriculture for their total livelihoods. Instead, urban residents have shops and other businesses. Municipal areas can thus be characterized as having a market-oriented economy, where forest management objectives are mainly for watershed protection and recreation. The rest of the watershed, on the other hand, is rural and characterized by an agriculture-based subsistence economy, where forest is an integral component of people's daily livelihood strategies.

Data and Sources

The study is primarily based on remote sensing and GIS technologies. The main data used in the research included a Landsat multispectral scanner satellite image (hereafter referred as MSS image) from 20 December 1976 and an Indian Remote Sensing satellite image from 7 March 2000 (IRS-IC, LISS-III; hereafter referred as IRS image). Eight black-and-white aerial photographs of 1:50,000 scale from 1978 were used for collecting ground reference information for classification and accuracy estimation of classified MSS image. Four photographs were used as training material for land-cover classification and the other four were used for testing the accuracy of classification results. Four topographic maps of 1:25,000 scale, published in 1995 by the Survey Department, His Majesty's Government of Nepal (HMGN), and digital topographic data with contour intervals of 20 m produced by the same agency were also used.

The ground reference information required for the classification and accuracy assessment of the IRS image was collected from the field in January–April of 2001. Additionally, forest patch level information on forest types and condition and history of land use provided by the local people and direct observation in the field was collected using a self-designed format.

Methods

Image Processing

Subsets of the satellite images and the aerial photographs were rectified first for their inherent geometric errors. The IRS image was registered to the digital topographic maps in the Modified Universal Transverse Mercator coordinate system using distinctive features such as road intersections and stream confluences that were clearly visible in the image. A total of 20 points were used for registration of the IRS image subset with a rectification error of 0.1083 pixels. the MSS image was registered to the already registered IRS image through an image-to-image registration technique with a rectification error of 0.1612 pixels. The photographs were scanned, saved in TIFF format, and registered to the digital topographic maps in the same manner as the IRS image.

We used a supervised maximum likelihood classification method for the classification of the satellite images. Training areas corresponding to each classification item (hereafter, land-cover class) were chosen from the field data, in case of the IRS image, or through stereoscopic and digital interpretation of the aerial photographs, in the case of the MSS image. The images were classified into three land-cover classes, corresponding to forest; shrublands, and other use, using Environment for Visualizing Images (ENVI) Version 3.2 (Research Systems Inc., Colorado, USA). The overall classification accuracies were 86.2% and 86.3% for MSS and IRS images, respectively. Forest included natural forests and established pine plantations with estimated 75% or more of the existing crown covered by trees. Land covered by shrubs, bushes, young forest regeneration, and degraded forest areas (estimated tree crown cover < 10%) were included in the shrublands class. The rest of the area, including grasslands, cultivated lands, barren lands, settlements, roads, construction sites, and other built-up areas were combined together under a single class, "other use."

The classified images, after sieving, clumping, and filtering (3 × 3 median filter), were exported to Arc View GIS Version 3.1 (ESRI; Redlands, California, USA) from ENVI, and the rest of the analyses were performed in the GIS environment. Sieving removed isolated classified pixels using blob grouping, clumping helped maintain spatial coherency by removing unclassified black pixels (speckles or holes) in classified images, and filtering smoothed the classified images (Richards 1994). Before further analyses, polygons of < 0.5 ha in size were eliminated from both the polygon themes in Arc Info GIS (ESRI). This elimination was necessary to minimize the effects of classification error arising from resolution differences between the MSS (57 × 57 m) and IRS (23.5 × 23.5 m) images while at the same time not significantly altering the area under each land-cover class.

The presence of shadow in some parts of the images was a major problem encountered during classification of the images. To solve this problem, the shadow-covered areas were classified as separate classes and were combined later to the respective classes with the help of ground reference information. Other possible sources of errors in the classification of land cover included relief, slope, and aspect. Relief can lead to image distortions in mountainous regions, while slope and aspect can influence the natural spectral variability (Teillet and others 1982). Despite these limitations, reasonably good classification accuracies were obtained because of a thorough knowledge of the study area by one of the authors (APG) and use of sufficient ground reference information.

Detection of Forest Cover Change and its Relationship with Various Factors

The land-cover polygon themes for 1976 and 2000 were overlaid in Arc View GIS and polygons of forest improvement (shublands in 1976 converted to forest in 2000), deterioration (forest in 1976 converted to shrublands in 2000), loss (forested area lost to other use), and gain (forested area gained from other use) were mapped. The polygon theme of changes was then overlaid with the following GIS layers one at a time, to assess the spatial relationships between forest cover change and the respective factors: (1) 300 m elevation zones, (2) aspects, (3) slopes, (4) 500 m interval road buffers, (5) village development committees (VDCs; lowest political administrative unit in rural areas of Nepal)/ municipalities; and (6) forest types based on governance arrangements. A brief description of the GIS layers used and data sources is presented in Table 1.

Results and Discussion

Forest Cover Changes

The areas under forest, shrub, and other use in 1976 and 2000 are presented in Table 2 and spatial coverage of these land cover classes is shown in Figure 3. The results show that forest area increased by about 15% from 1976 and the area under shrub and other use declined between 1976 and 2000.

Shrublands include degraded forest and young forest (i.e., regeneration), which can either grow to high forest after protection or be converted to an other use. Shrublands may also represent an intermediate phase in the conversion of nonforest to forest (Figure 4). A shrubland in the study area (and Nepal) can thus be considered as an interface between the forest and nonforest uses and thus forms an important component of forest land use.

Table 1. GIS layers used in investigation of spatial relationships between forest dynamics and some major factors

GIS layer	Data source
Polygon theme of changes in forested area (1976–2000)	Obtained through digital image processing of satellite images from the respective periods and GIS analyses.
Elevation zones	Screen digitized from contours on 1995 digital topographic maps.
Aspects	Derived from digital elevation model based on 20-m interval contours.
Slopes	Derived from digital elevation model based on 20-m interval contours.
Road buffers	Roads were digitized from 1995 topographic maps and buffered at 500-m intervals.
VDCs/municipalities	Digitized from 1995 topographic maps. VDCs represent subsistence economy and municipal areas as market-oriented economy in the analysis.
Forest governance types	Boundaries of community, semi-government and government forests were identified and delineated on enlarged topographic maps taking established features such as streams, roads and ridges as references and with the help of FUG leaders and local forestry staff; those boundaries were digitized latter in Arc View GIS. The three governance types are defined as follows: (1) Community forests: forests managed by community FUGs and leasehold groups that are formally registered in the District Forest Office (DFO); (2) Semigovernment forests: forested areas that were legally under the authority of DFO but with de facto control and claim of ownership by local communities and/or municipalities. The DFO informally recognized those local claims and resource ownership; and (3) Government forests: forested areas under the direct control of the DFO and without any form of collective action by the local people.

Table 2. Area under three land cover classes in 1976 and 2000

	1976		2000		Change 1976–2000	
Land use	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forest	5339.3	34.8	6133.3	40.0	+794.0	+14.9
Shrubland	1318.9	8.6	1031.4	6.7	−287.5	−21.8
Other use	8677.0	56.6	8170.5	53.3	−506.5	−5.8

An investigation of changes in forested area of the watershed revealed that of the total 6658.2 ha of forest and shrub in 1976, 64.3% remained unchanged until 2000, 12.6% improved, 4.1% deteriorated, and 19.1% was lost to other use 1976–2000. The loss of forested area to other use, however, was compensated by gain (26.7%) from other use, and there was an overall 7.6% net gain in forested area during the study period (Figure 5).

Relationships Between Forest Dynamics and Some Major Physiographic, Economic, and Institutional Factors

Forest dynamics and elevation. The results show that forested areas in the lower elevations were more dynamic than forested areas in higher elevations. The rate of forest deterioration in low elevation was more than twice that of forests located at high elevations (> 2300 m). Loss of forest to other use in the 1700- to 2000-m elevation zone was also slightly higher than gain in that zone. Proportionately the highest net improvement and gain to the forested area occurred in the lowest (1400 to 1700-m) elevation zone (Table 3).

The following three factors might have contributed to a higher level of forest dynamism in lower elevation areas. First, most of the settlements in the watershed are located below 2000 m, so a higher level of human–forest interaction can be expected in these areas compared to higher elevation forests. The high elevation forests, although having virtually open access, benefited from lower extraction pressure due to their relatively distant, inaccessible locations and remained mostly stable during the period. Second, most of the forestation and community forestry activities that positively contributed to forest cover were concentrated in lower elevations. Third, emergence of new economic opportunities over the study period might have changed the living strategies of some households in lowland areas, thereby changing the demands on forest products.

Forest dynamics and aspect. The results show that forested areas in southern (including south, southeast, and southwest) slopes experienced more pronounced

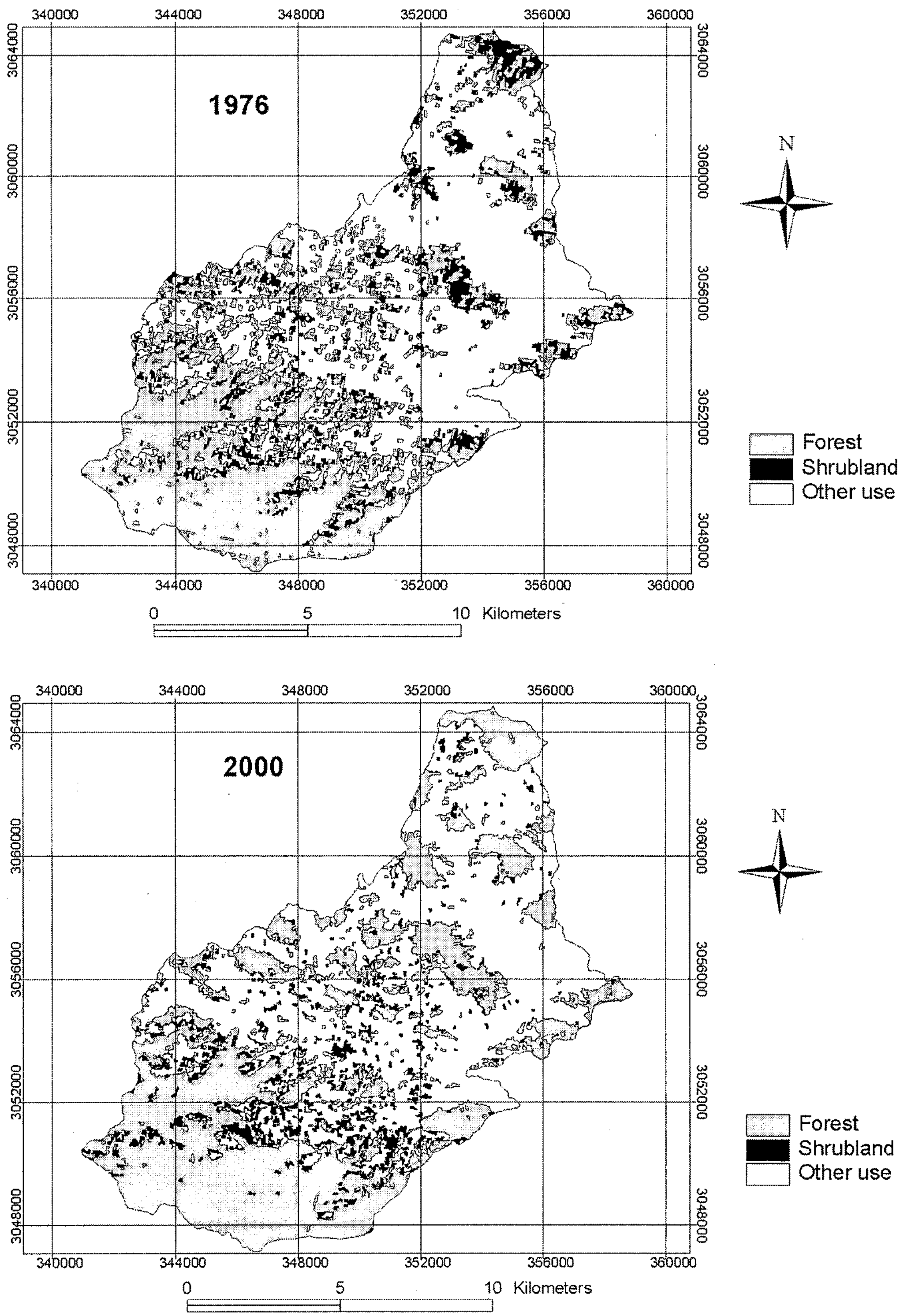

Figure 3. Area under forest, shrubland, and other use in Upper Roshi Watershed in 1976 (top), and 2000 (bottom)

dynamism compared to the northern slopes. The highest level of dynamism occurred in south aspect forests, followed by the flat areas, and with the lowest dynamism found in north and northwest facing slopes. Typical east and west aspects experienced intermediate levels of change (Table 4).

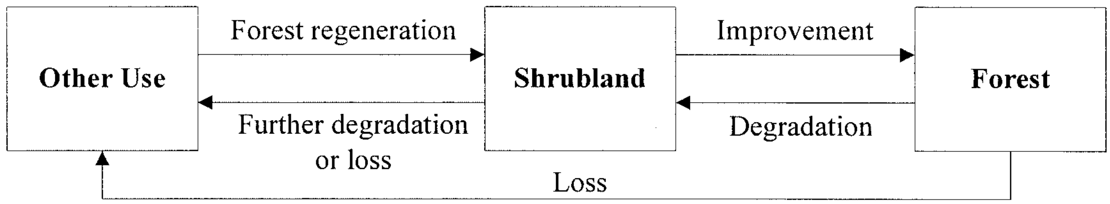

Figure 4. Common pathways of forest cover change in the Middle Hills of Nepal.

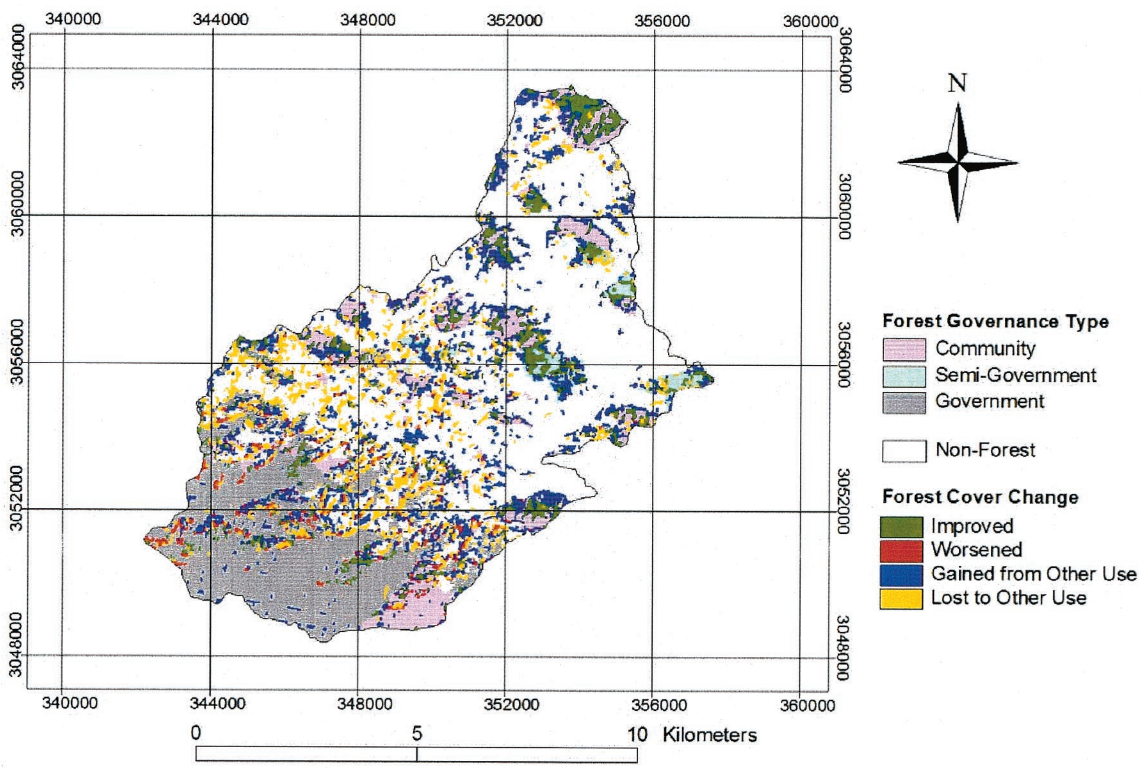

Figure 5. Location and extent of changes in forested area of Upper Roshi watershed in between 1976 and 2000.

Southern aspects have different microclimates than northern aspects. The south-facing slopes are hotter and drier than northern slopes because these slopes are generally exposed to solar radiation for a longer period of the day. The north slopes, on the other hand, are cooler and moister, and colonization of tree and shrub species is more evident (Jackson 1994). The results of a recent study conducted in Roshi watershed showed that pine plantations on northern slopes were significantly richer in woody species compared to southern slopes (Gautam and Webb 2001).

Because of warmer conditions, southern slopes are more suitable for settlement and for general agricultural use. This may have induced a higher rate of agricultural expansion into forested areas on southern slopes. However, as the cultivation on many of the southern slopes eventually experienced diminishing productivity due to rapid soil erosion and nutrient depletion, those cultivated areas may have been abandoned and left for forest regeneration and/or plantation establishment. There is evidence from the hills of Thailand (Fox and others 1995) and Honduras (Kammerbauer and Ardon 1999) that declining soil productivity and increased weed competition leads to the eventual abandonment of agricultural plots after a few seasons, and this phenomenon may apply in Kabhrepalanchok; further research will determine whether this indeed was the case. Labor shortages caused by out-migration of male members to Kathmandu and other urban areas was another important reason for the

Table 3. Percentage change in forested area by elevation zones between 1976 and 2000

		Percentage of forested area in 1976				
Elevation zone (m)	Forested area in 1976 (ha.)	Unchanged in 2000	Improved in 2000	Deteriorated in 2000	Lost to other uses in 2000	Gained from other uses in 2000
1400–< 1700	1591.5	40.4	22.8	4.6	32.3	57.5
1700–< 2000	2282.1	54.1	13.3	4.4	28.2	25.4
2000–< 2300	1638.4	81.8	9.2	3.3	5.7	11.0
2300–< 2600	962.5	91.5	2.0	4.7	1.8	8.4
≥2600	183.8	98.6'	0.2	0.4	0.7	10.1

Table 4. Percentage change in forested area in different aspects between 1976 and 2000

		Percentage of forested area in 1976 (%)				
Aspect	Forested area In 1976 (ha.)	Unchanged in 2000	Improved in 2000	Deteriorated in 2000	Lost to other uses in 2000	Gained from other uses in 2000
Flat	817.5	46.7	18.0	5.8	29.4	41.0
North	1267.5	78.3	8.1	1.7	12.0	15.9
Northeast	939.3	71.4	14.2	2.8	11.6	21.0
East	697.7	61.1	17.8	4.9	16.2	28.7
Southeast	512.8	52.8	16.8	9.2	21.4	48.2
South	408.8	46.1	15.2	10.9	27.6	44.6
Southwest	370.5	47.8	15.8	5.7	30.8	35.3
West	582.5	63.7	9.9	2.5	23.7	24.4
Northwest	1061.7	75.5	6.1	1.5	16.9	13.0

abandonment of unproductive agricultural lands in recent years (Jackson and others 1998).

Forest dynamics and slope. The results show that among the five slope categories, the highest level of forest dynamism occurred in slopes of < 13% and least dynamism in slopes of > 50%. The slope range of 25%–38%, where the highest amount (42%) of the forest cover exists, experienced an intermediate level of change during the study period. Proportionately the highest net improvement occurred in medium slopes (13%–25%), with the highest proportion of gain occurring low to medium slopes (0–25%) (Table 5).

The higher rate of forest dynamism on low slopes suggests an increase in human pressure on the forests in these areas, resulting in a higher rate of forest deterioration and loss. However, the forestation programs and communities' involvement in forest management contributed to substantial forest improvement and gain in these areas from nonforest uses (Gautam and others 2002).

Forest dynamics and accessibility. The proportion of forested area in 1976 that remained unchanged in 2000 increased with the increase in distance from the roads. Only 43.9% of forested areas within 500 m distance remained unchanged from 1976 to 2000, whereas 87% of the forested areas farther than 2.5 km from roads were unchanged during the same period. Forest deterioration exceeded improvement in 2–2.5 km from the roads, and loss was slightly higher than gain in 1–1.5 km from the roads. Proportionately the highest net improvement and net gain to the forested area also occurred within 500 m of the roads (Table 6).

The findings of this study suggest that a higher rate of forest loss in areas closer to the roads, in comparison with the more remote areas is expected because of higher pressure on the resource brought about by market forces and other socioeconomic factors. A higher amount of forest gain and improvement in an area of better accessibility, however, is generally an unexpected trend in many development scenarios. We suggest that a higher concentration of forestation activities occurred close to the roads than far away, because costs of seedling transportation and monitoring would be lower, hence, accessibility could be one of the reasons for high forest gain in those areas, counteracting the negative impact of market pressure. Effective monitoring of the community forests by local user groups organized (both formally and informally) under the community forestry program, and involvement of local municipalities in protection of forests could also have

Table 5. Percentage change in forested area in different slope ranges between 1976 and 2000

		Percentage of forested area in 1976				
Slope range (%)	Forested area in 1976 (ha.)	Unchanged in 2000	Improved in 2000	Deteriorated in 2000	Lost to other uses in 2000	Gained from other uses in 2000
0–< 13	825.5	46.7	18.1	5.8	29.4	47.4
13–< 25	1110.0	55.7	20.8	3.2	20.3	38.2
25–< 38	2892.3	66.4	11.4	4.1	18.2	22.2
38–< 50	1527.5	73.2	7.2	4.0	15.5	17.9
≥50	302.8	78.2	5.4	3.8	12.6	14.7

Table 6. Percentage change in forested area with changes in distance from roads between 1976 and 2000

		Percentage of forested area in 1976				
Distance zone (m)	Forested area in 1976 (ha.)	Unchanged in 2000	Improved in 2000	Deteriorated in 2000	Lost to other uses in 2000	Gained from other uses in 2000
0–< 500	1121.7	43.9	21.0	2.9	32.1	57.3
500–< 1000	1475.0	52.7	19.0	4.3	24.1	32.7
1000–< 1500	1033.3	55.9	15.3	5.6	23.3	22.2
1500–< 2000	734.4	70.0	9.2	4.3	16.6	19.4
2000–< 2500	446.6	69.6	4.5	6.2	19.7	25.0
≥2500	1847.3	87.0	4.1	3.3	5.6	9.0

contributed to increased forest cover in more accessible areas (Webb and Gautam 2001, Gautam and others 2002).

Forest dynamics and local economy. As described earlier, forestry requirements and forest management objectives of urban and semiurban residents within the municipal areas are different than those of rural people in the watershed. Because of these differences, different trends in forest cover changes can be expected between municipal areas and the rest of the watershed.

Sixty-seven percent of the forested area within VDCs and 41% in municipalities remained unchanged from 1976 to 2000. A proportionately higher rate of forest improvement and gain took place in municipal areas compared to VDCs (Table 7). These findings disagree with findings from earlier research, which found that accessibility contributed to forest loss in Kabhrepalnchok and Sindhupalchok districts (Mahat and others 1986). It should be noted, however, that less than 13% of the total forested area in the watershed was under the municipalities at all times, and this difference in sample size warrants a certain degree of caution in the interpretation of these results.

Forest dynamics and institutions. Researchers have documented the role of community-based institutions in explaining forest conservation in Nepal (e.g., Varughese 1999, Webb and Gautam 2001) and many other locations around the world (e.g., Gibson and others 2000). In a study conducted recently in the Roshi watershed of Kabhrepalanchok, it was found that VDCs with formalized community forests had significantly higher shrubland-to-forest conversion during 1978–1992 compared to the VDCs without formal community forests (Gautam and others 2002). Those findings were based on an indirect assessment of the impact of community forestry in the absence of forest-specific spatial information on community-managed forests. In an attempt to directly assess the role of local forestry institutions on forest cover change, the polygon theme of forest governance type (Table 1) was overlaid with the polygon theme showing the location and extent of changes in forested areas during 1976–2000.

The results show that of the three forest governance types that were in existence in 2000 (community, semigovernment, and government), proportionately the highest net improvement as well as gain took place in semigovernment forests, followed by formally registered community (including leasehold) forests. Around 50% of the total forested area that was under direct control of the district forest office and without any local collective action, remained relatively stable during the period, although deterioration was substantially higher compared to improvement in government forests of high elevation areas as mentioned above (Table 8).

Table 7. Percentage changes in forested area in subsistence and market-oriented economies in between 1976 and 2000

		Percentage of forested area in 1976				
Type of local economy	Forested area in 1976 (ha)	Unchanged in 2000	Improved in 2000	Deteriorated in 2000	Lost to other uses in 2000	Gained from other uses in 2000
Subsistence	5967.0	67.0	9.9	4.4	18.7	23.3
Market-oriented	691.2	40.9	35.5	1.7	21.9	55.8

Table 8. Changes in forested area between 1976 and 2000 within geographical spaces that were under three governance arrangements in 2000

		Percentage of forested area in 1976				
Governance type	Forested area in 1976 (ha.)	Unchanged in 2000	Improved in 2000	Deteriorated in 2000	Lost to other uses in 2000	Gained from other uses in 2000
Community	1516.1	62.3	28.4	2.1	7.2	28.8
Semigovernment	327.9	45.3	37.5	0.9	16.2	39.3
Government	3433.6	82.7	5.4	3.7	8.2	10.7

In order to know whether the above results were influenced by ecological factors rather than the institutional arrangements (particularly elevation), the study also analyzed the trends of forest cover change in the community and semigovernment forests in the lower elevation (1400–1700 m) and higher elevation (> 1700 m) areas separately. The findings show that for community forests, the proportional improvement (34.6%) as well as gain (36.3%) was higher in the lower elevation area compared to the improvement (24.7%) and gain (24.3) at higher elevation. The trend, however, was opposite in the case of semigovernment forests. Improvement and gain in this governance type was proportionately higher (49.3% and 45.5%, respectively) in the higher elevation area compared to the improvement and gain (32.2% and 36.5%, respectively) in the lower elevation. This inconsistency in the trends of forest regeneration between the two governance types indicates that elevation was not a major factor influencing changes in forest cover.

The finding of this study that proportionately the highest amount of shrubland-to-forest conversion (i.e., improvement) and gain took place in forested areas of de facto community control (semigovernment) indicates that legal transfer of resource ownership is not an important precondition for successful forest conservation at the local level if the collective efforts of local users have received informal recognition by the concerned government authorities. In fact, the community forests and some of the semigovernment forests in the study area were quite similar in terms of forest use pattern and monitoring systems. One distinct difference between the two governance systems was the involvement of local municipalities in conservation of some of the semigovernment forests. From this point of view, the results indicate that a joint effort by local forest users and local agencies improves the prospects for successful forest conservation at local level (see also Webb and Khurshid 2000).

A relatively stable condition of the government forests during the study period can be explained by their general remoteness, far from the settlements and lower level of extraction pressure compared to other forests, rather than effective monitoring or enforcement by the forestry staff. Interviews with local forestry staff and local people revealed that forested areas under government control have virtually open access; the district forestry staff members are mostly engaged in community forestry activities after the implementation of a community forestry program.

It is important to note that the community forestry program was unable to cover over 50% of the forested area, located mostly in the southern high mountains. This remains the situation even after more than two decades of external interventions with continuous donor support. A central challenge to extending the community forestry program to the southern mountains is the difficulty in identifying traditional users and their use patterns (prerequisites for community forest hand over). Moreover, the settlements of forest-accessing people are generally dispersed and/or widespread. Organizing collective action has probably been difficult because of unrestricted access of the local people to these forests. The district forest office has committed its limited human and financial resources to the implementation of community forestry and leasehold forestry programs, rather than to forest management (i.e., protection). Although the overall condition of the high elevation forests remained relatively stable during the study period, the uncontrolled use and lack of maintenance has led to rapid degradation of some of these forests in recent years (field observation by A.P.G.). The deteriorating trends of these forests was also evident from the higher rates of forest deterioration compared to improvements above 2300 m, as found in this study, and the substantial (45%) increase in shrub area of the watershed in between 1989 and 2000 (Gautam 2002).

There is some mismatch between the institutional and forest cover information used in this research, which demands certain degree of caution in the interpretation of the results. As mentioned in Table 1, the boundaries of forest governance types were delineated on 1995 topographic maps with land-cover information obtained from the interpretation of aerial photographs of 1992, while the changes in forested area were compared between 1976 and 2000 based on land use information obtained from digital analysis of satellite images. As the land-cover information in 1976 and 1992 did not exactly match both spatially and statistically, this might have caused some errors in the results. However, as those errors are randomly distributed in all governance types, this is expected to have minimal influence on the trends of changes seen under various governance types.

Conclusions and Policy Implications

The findings on the trends of forest cover change presented in this paper corroborate the findings of some earlier studies (Virgo and Subba 1994, Jackson and others 1998, Gautam and others 2002) that the deforestation trend in some parts of the Middle Hills has reversed during the past few decades, largely as a result of forestation programs and people's involvement in forest management. The findings on the relationship between forest cover change and various ecological and economic factors are generally in tune with the findings from the institutional analysis, and suggest that local forestry institutions play an important role in the balance of forest cover changes. The positive change in forest cover provides evidence of ecological sustainability of the resource in the watershed and also signifies, to some extent, the success of forest conservation efforts by the local communities and the agencies involved.

The findings of this study indicate that a joint effort by forest user groups and local agencies improves the prospects for successful forest conservation at the local level, particularly in urban and semiurban areas. The current forest policy and forestry legislation in Nepal, however, does not acknowledge this possibility as there is no provision for coordinated action between a FUG and other local agencies (e.g., VDC or municipality). The Forest Act of 1993 recognizes a community FUG as a semiautonomous entity responsible for the management and use of the local forest according to a management agreement between the FUG and local district forest office. The finding of this study highlights the necessity of revising existing forest policy to allow cooperation between FUGs and municipalities towards local forest conservation.

The finding that semigovernment forests managed by self-organized informal user groups improved and gained forest more rapidly than formal community forests suggests that a formal handover of forest ownership is not necessarily a strong determinant of successful forest conservation. However, it should be strongly emphasized that in our study area the de facto rights of the local communities were recognized by the concerned government authorities. Thus, while a government policy recognizing the conservation efforts of local communities is essential for successful conservation of local forest patches, there is also a need for recognizing informal conservation efforts of local users before initiating the official forest hand over process, rather than adopting a blueprint approach for a country or the region.

Community-based forestry institutions (both formal and informal) played important roles in improving forest condition in some parts of the watershed. However, the existing models of community forestry and leasehold forestry programs were unsuccessful at reaching more than 50% of the total forest area, most of which was located in southern high mountains. One of the major factors responsible for this outcome could be inability of the existing community-based forest management policy and operational procedures to acknowledge the large difference in biophysical, socioeconomic, and demographic conditions between the lower hills and the elevated mountains in the Middle Hills. This gap in forest policy has raised concern over the future of high-elevation forests, which cover extensive areas in the Middle Hills as a whole and have generally higher biological and commercial value compared to the forests in the lower hills (Jackson and others 1993, Dinerstein 1998). Although more research is needed before making any recommendation on an appropriate governance regime for the high mountain forests, the findings of this study reinforce our conclusion that existing policy needs to be revised to make it more responsive to contextual factor and to not adhere to a blueprint approach.

The study examined the association of some major ecological and economic factors and institutional policies on changes in forest cover in the Kabhrepalanchok District of the Middle Hills of Nepal. Such studies, supplemented with more location-specific in-depth studies based on primary data on forest condition and use pattern, would greatly help refine our understanding of the association between forest dynamics and community-based institutions. Further research on community-based forest management in Nepal should continue, with central questions being: (1) how have positive changes in forest cover benefited local users, and (2) how sustainable are the existing community-based forestry institutions in the long run.

Acknowledgments

Financial support for this research was provided by DANIDA through a doctoral research grant to Ambika Gautam under the Integrated Watershed Development and Management program of the Asian Institute of Technology, ANUTECH Pty Ltd., Australia, through the Nepal Australia Community Resource Management Project, and a MacArthur postdoctoral research grant made available to Ambika Gautam through The Workshop in Political Theory and Policy Analysis at Indiana University. We thank the Center for the Study of Institutions, Population, and Environmental Change at Indiana University for sharing Landsat satellite imagery from 1976. The authors would also like to thank Dr. Charles M. Schweik, University of Massachusetts, and two anonymous reviewers for valuable comments on an earlier version of this paper.

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