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Source: *Mountain Research and Development*, Vol. 17, No. 2 (May, 1997), pp. 99-116
Published by: International Mountain Society
Stable URL: http://www.jstor.org/stable/3673825

MOUNTAIN RESEARCH AND DEVELOPMENT, VOL. 17, NO. 2, 1997, PP. 99-116

LAND-COVER CHANGE AND FOREST INSTITUTIONS: A COMPARISON OF TWO SUB-BASINS IN THE SOUTHERN SIWALIK HILLS OF NEPAL

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ABSTRACT Land-cover change was studied in two adjacent sub-basins of the Kair Khola watershed in the Chitwan District of Nepal using air photographs and Geographic Information Systems (GIS). It was determined that between 1978 and 1992 dramatic forest conversion occurred in both sub-basins. However, the form of conversion differed significantly. In one sub-basin dense forest was most often converted to maize-based agriculture, while in the other dense forest most often became degraded forest. A village-level investigation of forest governance was undertaken to determine whether community and institutional arrangements explain the differences in land-cover change or whether they are the result of human response to physical and topographic influences alone. It was found that in both sub-basins there are similar institutional structures that are inadequate to control the overexploitation of forest resources and this common attribute, coupled with topographic differences, is responsible for the different forms of land-cover change in the area. Some policy recommendations based on these findings are presented.

RÉSUMÉ *Changement de couverture végétale et institutions forestières : Comparaison de deux sous-bassins dans les collines Siwalik méridionales du Népal.* Le changement de couverture végétale a été étudié dans deux sous-bassins adjacents du bassin hydrographique du Kair Khola dans le district de Chitwan au Népal, à l'aide de photographies aériennes et de systèmes d'informations géographiques. Il a été déterminé qu'entre 1978 et 1992 une conversion spectaculaire de la forêt s'est produite dans les deux sous-bassins, mais sous une forme sensiblement différente. Dans l'un des sous-bassins, la forêt dense s'est le plus souvent convertie en agriculture basée sur le maïs, alors que dans l'autre elle s'est le plus souvent convertie en forêt dégradée. Une étude de la gestion de la forêt au niveau des villages a été entréprise afin de déterminer si les dispositions communautaires et institutionnelles pouvaient expliquer les différences entre les changements respectifs de couverture végétale, ou si ces différences résultaient uniquement de la réponse humaine aux influences physiques et topographiques. L'étude a montré qu'il existait dans les deux sous-bassins des structures institutionnelles similaires, inadéquates pour la lutte contre la surexploitation des ressources forestières ; cette caractéristique commune, de concert avec les différences topographiques, est à la base des différentes formes de changement de couverture végétale dans la région. Des recommandations en matière de politique, basées sur les résultats de l'étude, sont présentées.

ZUSAMMENFASSUNG *Vegetationswandel und Forstverwaltungen: ein Vergleich zwischen zwei benachbarten Tälern im südlichen Siwalk Gebirge in Nepal.* In zwei benachbarten Tälern des Kair Khola Wassereinzugsgebiets im Chitwan Distrikt in Nepal wurden mit Hilfe von Luftbildern und dem Geographischen Informationssystem (Geographic Information System, GIS) Vegetationsveränderungen untersucht. Die Untersuchung ergab, daß zwischen 1978 und 1992 dramatische Wandel in der Bewaldung beider Täler stattfanden. Allerdings gab es signifikante Unterschiede in der Art der Veränderungen. In einem der beiden Täler wurde der ursprünglich dichte Wald zumeist in Maisanbauflächen umgewandelt, während sich die Waldflächen des anderen Tals qualitativ verschlechterten. Eine Untersuchung der Forstverwaltungen auf Dorfebene wurde durchgeführt um zu ergründen, ob Vereinbarungen innerhalb der Gemeinden oder institutionelle Anordnungen die Unterschiede in den Vegetationsveränderungen erklären können, oder ob diese Unterschiede lediglich auf den Reaktionen der Bevölkerung auf unterschiedliche physikalische und topographische Bedingungen beruhen. Die Untersuchung zeigte, daß in beiden Tälern ähnliche institutionelle Strukturen bestehen, die in beiden Fällen nicht in der Lage sind, der übermäßigen Nutzung der Waldressourcen Einhalt zu gebieten. Gepaart mit den topographischen Unterschieden ist dieser Umstand für die verschiedenartigen Vegetationsveränderungen in dieser Gegend verantwortlich. Basierend auf diesen Untersuchungsergebnissen präsentieren wir einige praktische Empfehlungen.

INTRODUCTION

While the sense of an impending deforestation 'crisis' in Nepal has diminished in recent years (Ives and Messerli, 1989; Gilmour and Fisher, 1991), reports continue to suggest that significant land modification continues, in part due to the tremendous population pressures and demands for additional agricultural land (Chapagain, 1993). Some empirical studies, such as the watershed-level land-cover change research conducted by Thapa and Weber (1990), support the contention that forest-to-agriculture conversion continues in some areas. Other

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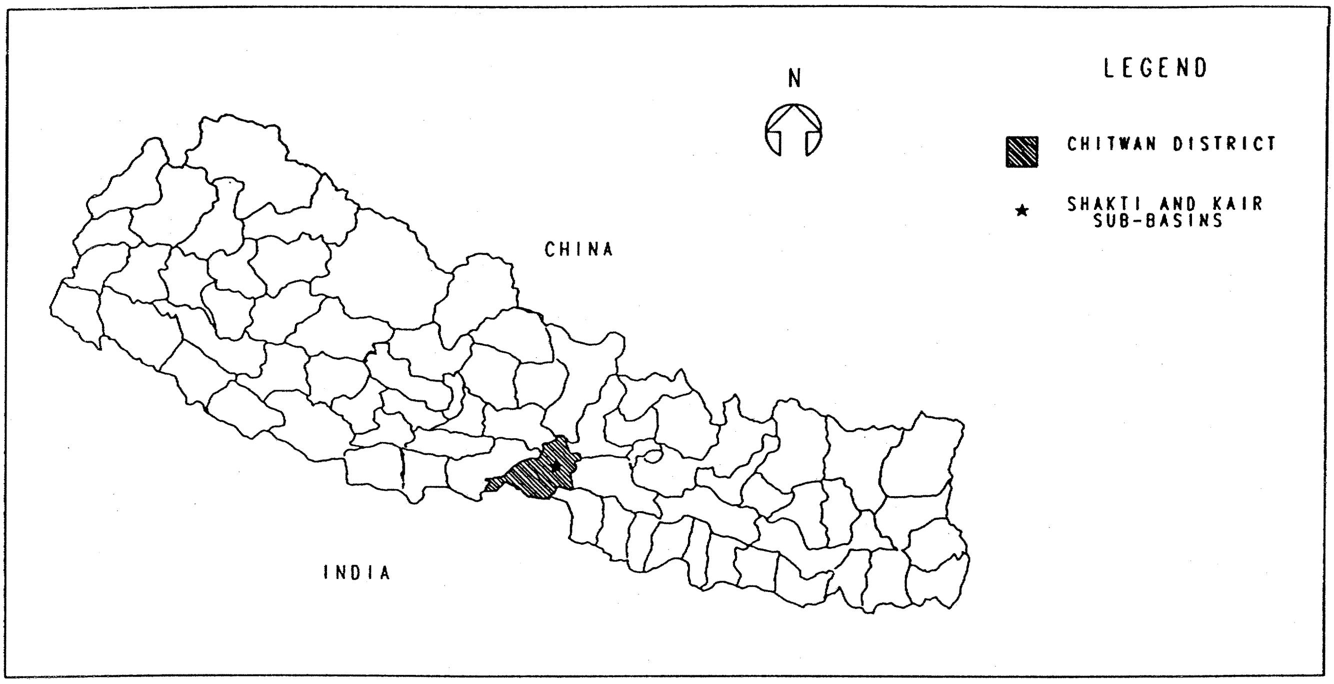

FIGURE 1. Map of Nepal showing the location of the study site.

studies have discovered the contradictory finding of forest regrowth in the presence of population pressure, measured at the watershed level by canopy cover (Schreier *et al.*, 1994) as well as measured at the individual forest level via indicators of forest condition such as basal area and wood volume (Fox, 1993).

These studies are important, for they begin to fill two significant land-cover and land-use information gaps. First, they provide empirical evidence of land-cover change in the Middle Hills of Nepal. Second, they present empirical examinations of the human dimensions driving this land-cover change and support a growing literature arguing that the influence of population pressure and physical constraints can be mediated by established institutional arrangements (Brookfield, 1984; E. Ostrom, 1990; Fox, 1993; Agrawal, 1995). Institutions, in this paper, are defined as the set of working rules and practices that govern particular forests as well as the set of actors responsible for their development, maintenance, and enforcement (Thomson, 1992: viii). However, institutions can reduce the negative consequences of population pressures and physical world constraints only if they are relatively well developed and established. In Nepal, for example, Schreier *et al.* (1994) report afforestation activities—such as the methods of organization, and the rules governing afforestation and their enforcement—as primary reasons for the increase in forested areas in their study. Fox (1993) indicates that the improvements in forest condition indicators he discovers are due to changes in agricultural practices coupled with improved forest management. All of these types of activities fall under our definition of institutional arrangements.

This paper has four objectives. The first is to contribute to the small but growing set of empirical studies that analyze land-cover change in watershed sub-basins of Nepal using available air photographs and Geographic Information System (GIS) technology. As Schreier *et al.* (1994: 139) note: "...there are few quantitative evaluations to document land-use dynamics [in developing countries]." This effort adds one more such quantitative evaluation. In addition, the majority of land-cover change studies that have been conducted in Nepal (including the three described above) have focused largely on the Middle Hills (see Gilmour and Fisher, 1991: xviii). This study shifts focus to the southern section of the Siwalik Hills physiographic province: two sub-basins at the boundary between the Siwalik Hills and the Terai plains that have undergone tremendous migration and population pressure over the last 40 years.

The second objective of this paper is to establish a multi-scale approach to the study of land-use change. Both a GIS meso-scale land-cover change analysis—of approximately 70 km^2—and a micro-scale or local institutional analysis of forest governance are undertaken. By designing such a multi-scale approach at the outset (see Root and Schneider, 1995), more dependable conclusions on the factors driving land-cover change can be made.

The third objective is to extend the work of Fox, Schreier *et al.*, Thapa and Weber, and others by turning to a deeper analysis of forest institutions found within the two sub-basins of study. This work will add to the growing literature documenting the influence of forest institutions (e.g., Becker and Ostrom, 1995; Schweik, 1996; Agrawal, 1996) on human choices and actions as they relate to land-cover change. The fourth objective is to provide some forest policy recommendations based on our findings.

The paper is structured as follows. First, a meso-scale

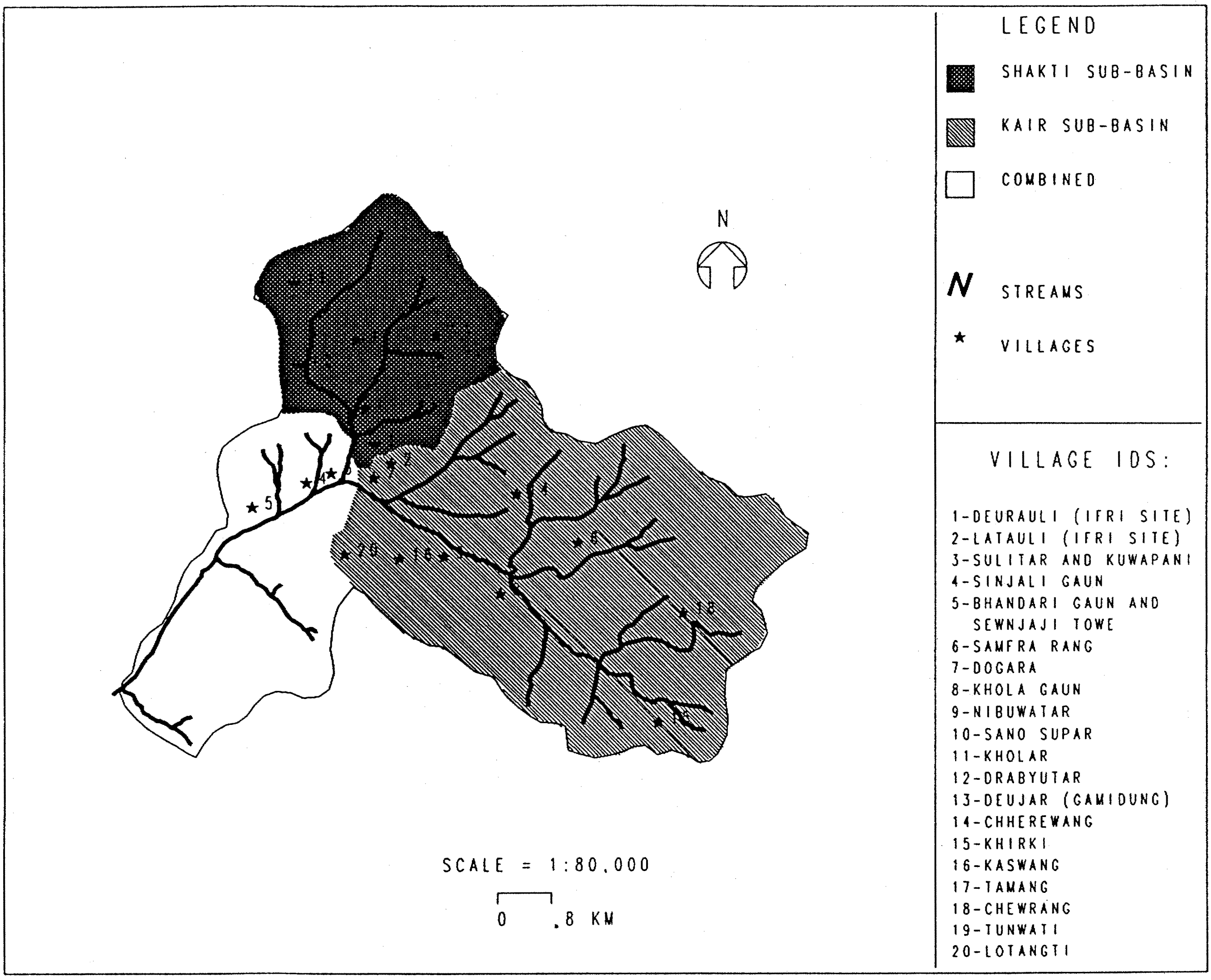

FIGURE 2. The Shakti and Kair sub-basin boundaries.

land-cover change analysis of two adjacent sub-basins in the Chitwan District of Nepal (Figures 1 and 2) using two sets of air photographs taken in 1978 and 1992 is undertaken. The findings for each sub-basin are then compared to answer this question: Are land-cover change patterns similar or different? An answer to this will help identify whether similar or different forest-related management issues exist in the region. Second, a micro-scale analysis of forest institutions at the juncture of the two sub-basins is conducted to investigate further possible solutions to the puzzles discovered in the pattern of land-cover change. Findings of the micro-institutional analysis are then 'scaled-up' by adding a complementary 'rapid institutional assessment' of the other forested areas farther within the two sub-basins. Finally, a discussion of our findings is reported and policy recommendations are made.

A MESO-LEVEL ANALYSIS OF LAND-COVER CHANGE IN THE SIWALIK HILLS: A COMPARISON OF THE KAIR AND SHAKTI SUB-BASINS

THE STUDY AREA

This research focuses on two adjacent sub-basins of the Kair Khola watershed—the Shakti sub-basin and the Kair sub-basin—in the Chitwan District of Nepal (see Figures 1 and 2). The criteria used to select this site for study were as follows:

1. The sub-basins are relatively compact areas and are representative of typical Nepalese upland and lowland farming systems in the agroecological region.
2. The sub-basins represent the Siwalik hill region, one of the distinct physiographic zones in the country.
3. Air photographs, maps, and other secondary information about the area—taken at different points in time—were available.

FIGURE 3. Land use within Shakti and Kair sub-basins in 1978 (as interpreted from 1978 Land Utilization Map).

DATA COLLECTION AND METHODS FOR LAND-COVER CHANGE ANALYSIS

Topographic maps, sets of black-and-white air photographs for 1978 and 1992, and land utilization maps, land system maps, and land capability maps developed by the Land Resource Mapping Project (LRMP) of the two sub-basin areas were obtained from Topographic Survey Branch, Department of Land Survey, Kathmandu, Nepal. These maps and photographs served as the foundation for the development of GIS coverages for the two time periods.

The available air photographs were taken at a fairly small scale (1:50,000) and, therefore, the following general land-cover categories are utilized (based largely on the category definitions of the LRMP's land utilization maps):

1. Maize- and Rice-based Agriculture

Agriculture is classified into two broad groups: irrigated (rice-based) and rain-fed (maize/millet-based) areas. Valley floor areas and terraced areas lying at the base of the slopes are classified as irrigated rice land, whereas hill slope cultivation areas without level terraces are considered rain-fed maize-based crop land.

2. Dense and Degraded Forest

A dense forest area is defined as a plant community comprised predominantly of trees and other woody vegetation with closed or nearly closed canopy–a canopy cover so thick in dark tone that only small portions of the ground can be observed on the air photographs. Degraded forest is defined as a plant community comprised predominantly of trees and other woody vegetation but exhibiting a thin canopy cover. Additionally, we considered shrubs, short trees, open forest floor, gullies, and visible lopped trees as degraded areas.

3. Mixed Land-use

In the study area, there are a number of thin forest patches where upland crops appear to be growing underneath or between the natural forest trees. In these areas, signs of agriculture expansion into the natural forest are

FIGURE 4. Land use within Shakti and Kair sub-basins in 1992 (as interpreted from 1992 air photographs).

apparent. For practical purposes, these were classified as "mixed land-use." This category was produced in response to field visits and, hence, is only used to categorize the 1992 data.

PREPARATION OF MAP MANUSCRIPTS AND GIS DEVELOPMENT

Land cover areas within each sub-basin were interpreted for both 1978 and 1992 using the air photographs and a stereoscope. To assist in the analysis, land-utilization maps developed from the same set of 1978 photographs were used to cross-check our category interpretations (LRMP, 1982). In addition, once interpretation was completed by one team member, the other team members double-checked the classifications to increase accuracy. As often as possible, features were identified only from center regions of photographs to minimize errors resulting from distortion.

The delineated forest, agriculture, and mixed areas were then digitized as polygon coverages into a PC Arc-Info™ GIS. Two primary land-use coverages were produced. Figures 3 and 4 represent land-cover patterns of the two adjacent sub-basins in 1978 and 1992, respectively. Slope-class GIS coverages were also developed for each sub-basin based on land capability maps of the area (LRMP, 1982). Four slope categories were defined—0–5°, 6–20°, 21–30°, and >30°—which characterize moderately sloping, moderate-to-steeply sloping, steeply sloping, and very steeply sloping hills and mountains, respectively. Finally, streams and settlement centroids were digitized as individual GIS coverages.

Once the preliminary GIS coverages were developed, they were printed and taken to the field for verification. The maps were explained to local farmers who provided valuable information on where the maps were misclassified. This exercise was extremely beneficial in diagnosing problems in our land-cover interpretations for both sub-basins. Modifications to land-cover category boundaries were drawn carefully on the maps in the field only after three team members agreed upon the change. The existing GIS coverages were then modified based on these revisions.

FIGURE 5. 1978 dense forest that in 1992 is maize/millet agriculture, Shakti and Kair sub-basins, Chitwan, Nepal.

GIS Arc-Info™ 'overlay' functions were utilized to develop Shakti and Kair sub-basin land-use change coverages for the 1978–1992 time period. Each land-use category in the 1978 coverage (Figure 3) was overlaid on the other alternative categories of land uses in the 1992 coverage (Figure 4). This technique provided an easy method to identify land-use changes that occurred over the 14-year period. Figure 5 provides an example of such an overlay product. A series of 16 such maps were developed that could then provide, for each land-use category, quantitative measures of area in hectares.

LAND-COVER CHANGE RESULTS

Areas of change for both sub-basins produced by the GIS overlay process are presented in Table 1. The table reveals that in both sub-basins, a significant amount of the dense forest of 1978 has been converted to some other land-cover designation in 1992. In the Shakti sub-basin, 35 percent of the dense forest in 1978 has been converted either to degraded forest (+22%), mixed upland (+9%), or lowland rice (+4%) land-cover categories. For the Kair sub-basin, there has been a 22 percent decline in dense forest over the past 14 years. In contrast to Shakti, the majority of this conversion appears to have been into maize-based agriculture (+18%), followed by nominal changes (+2% or less) in other land-use categories. As Schreier *et al.* (1994) note, these conversions are not uni-directional. For example, in both sub-basins some of the 1978 designated agricultural land now exists as degraded forest or even dense forest.

Two important conclusions can be made from this analysis. First, once the multi-directional land-cover gains and losses are accounted for, the Shakti and Kair sub-basins both exhibit a significant net loss in dense forest cover. Second, a major contrast between the land-cover change in the two sub-basins is identified: dense forest in Kair sub-basin has been converted largely into maize-based upland agriculture, whereas in Shakti sub-basin dense forest has been converted mainly into degraded forest. This discovery raises two additional questions:

TABLE 1
Land-cover change in Shakti and Kair sub-basins (1978–1992)

	Shakti			Kair		
Land-use	1978	1992	Percent change	1978	1992	Percent change
Maize based (MM)	343.4 (24%)	313.5 (22%)	–2%	604.1 (16%)	1294.2 (34%)	+18%
Lowland Rice Based (LR)	34.4 (2%)	81.8 (6%)	+4%	161.6 (4%)	179.8 (5%)	+1%
Dense Forest (DS)	885.1 (61%)	410.9 (29%)	–32%	2,384.8 (63%)	1,576 (41%)	–22%
Degraded Forest (DG)	180.3 (13%)	496.3 (35%)	+22%	642.3 (17%)	714.6 (19%)	+2%
Mixed Maize and Degraded Forest (MD)	N/A	121.1 (9%)	+9%	N/A	73.3 (2%)	+2%
Totals	1443.2	1423.6		3792.8	3837.9	

Note: Numbers represent hectare values of land category within the sub-basin. Percentages are percent of total land area within sub-basin. (Hectare area totals differ because of minor digitizing errors between the 1978 and 1992 coverages).

1. What is the situation on the ground—the human dimension related to land use—that has led to such dramatic land-cover change (primarily forest conversion or degradation) in both sub-basins?
2. Why does the Shakti sub-basin reflect such a large extent of dense forest degradation while the Kair sub-basin reflects primarily forest-to-agriculture conversion? What differences exist at the village-level that explain this discovery?

A dual micro- and meso-level analysis can help to answer these questions.

FOREST CHANGE IN THE KAIR AND SHAKTI SUB-BASINS: WHAT ACCOUNTS FOR THE DIFFERENCES?

Answers to the above questions can be best determined through an analysis of the forest-use practices that are found at the community or village level within these sub-basins. Moreover, it requires an understanding of the incentives farmers face when making decisions related to forest use.

THE IAD FRAMEWORK

The framework presented in Figure 6 is helpful to guide such an analysis. This Institutional Analysis and Development (IAD) framework is utilized by a wide variety of scholars in many disciplines on a wide variety of topics (Ostrom *et al.*, 1994: 25–50). IAD depicts the human actor facing a forest-use setting. It characterizes the human decision-making process that occurs over a particular time period, in a specified geographic location, and within a particular community or set of actors. Applied to this study, it describes one or more farmers who reside in any village or location within the Shakti or Kair sub-basin. At any point in time, each villager exists in an *action arena* (in the center of Figure 6), a situation where there exists a set of incentives and constraints that determine the alternative actions—possible forest-use strategies—he or she may undertake. The actions forest users take, acting in parallel, create *patterns of interactions* that produce *outcomes*: either conversion of forest-covered areas to some other land-cover type (e.g., agricultural fields) or modification to a forest-covered area in the form of thinned or increased vegetation (Turner and Meyer, 1994).

Central to any analysis guided by IAD is a focus on the sets of incentives, constraints, and possible actions that actors—forest users within each sub-basin—are forced to choose between. These sets are determined by the existing composition of three entities shown in Figure 6: (1) attributes of the physical landscape where the forest resides; (2) attributes of the communities that rely on the forest and its many products; and (3) the institutional arrangements that govern the neighboring forest resources.

Physical Attributes

Physical attributes are existing abiotic and biotic characteristics of forested areas that villagers utilize. Abiotic features of neighboring forests include topographic elements such as slope gradient and aspect, elevation, and soil type. Biotic features characterize the vegetation and animal population that exists within the neighboring

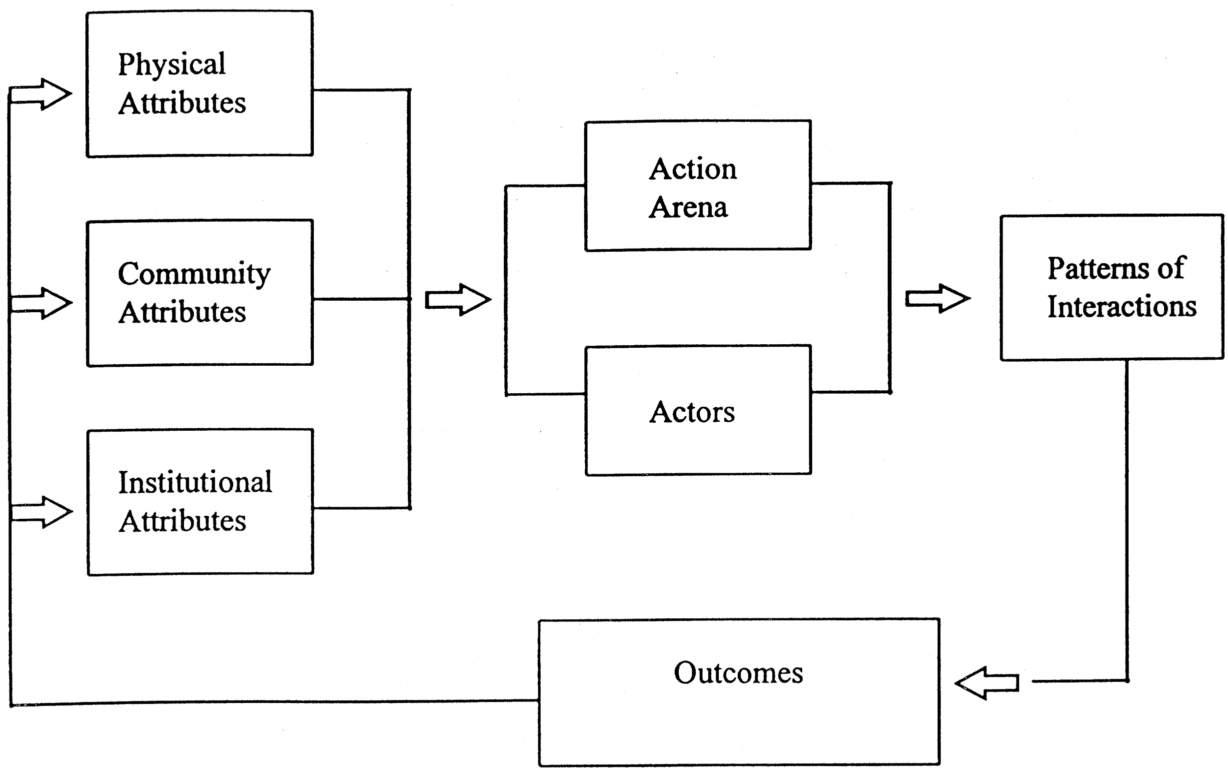

FIGURE 6. A framework for institutional analysis (adapted from Ostrom, *et al.*, 1994: 37).

forests. These physical attributes provide opportunities and constraints on farmers as they make their land-use decisions.

Community Attributes

Community attributes describe a large set of variables that characterize the human population that utilizes and manages forest resources. The economic condition of villagers is one such variable often cited as a factor that forces villagers to over-utilize forest resources. Families who lack sufficient economic means may be forced to over-utilize adjacent forest areas in order to maintain their livelihood (Repetto and Gillis, 1988; Rudel, 1993). In the Nepali context, farmers may require additional land to feed their families. Moreover, forest products are often required for cooking fuel, heating, animal feed, and construction (Thapa and Weber, 1990; Metz, 1990; Shrestha, 1993). Access to markets is a related economic variable that has been identified as an influential factor in extreme forest consumption (Poffenberger, 1990; Agrawal, 1995). The general logic is that ability to transport forest products swiftly to market increases the temptation to over-harvest. This presumption is still open to debate. Ascher's (1995) general discussion, for example, suggests that in some cases access to markets has the opposite influence: it provides other income-generating alternatives to community members.

Harvesting technologies and agricultural practices are also reported as influential factors that lead to forest conversion or modification. Harvesting technology, such as mechanization, has been found to have a positive influence on the rate of deforestation in developing countries (Poffenberger, 1990; Ascher, 1995). The type of agricultural practices also influences the rate of deforestation in a given area. In some hill areas of Nepal, a practice of shifting cultivation is present (Thapa and Weber, 1990; Subedi, 1994) where forest areas are cleared and a rotation cultivation schedule is established, leaving some areas fallow for a number of years (Thapa and Weber, 1990; Shrestha, 1993).

Behavioral norms and other elements that generally fall under the term 'culture' (e.g., ethnic traditions) are other community attributes that may influence the use of forest resources in a region. The level of homogeneity of the people within a sub-basin—the extent to which they share a common religious, ethnic, or caste background (Ascher, 1995: 84) or similar economic condition—may influence what established social norms and accepted behaviors exist within a community. These characteristics can influence how humans relate to one another and play a role in determining the set of socially accepted actions a villager may take in regard to forest product use.

Finally, the literature on the effects of population growth on human action and deforestation has been mixed. Some researchers suggest that increasing population produces land scarcities—forcing those with little or no land to convert forested regions to agricultural land (Messerschmidt, 1987; Shah and Schreier, 1991; Rowe *et al.*, 1992; Abernathy, 1993). Others report instances where population pressures have induced creativity in crafting institutional arrangements that slow, halt, or even enhance environmental conditions (Brookfield, 1984; Thapa and Weber, 1990; Fox, 1993; Agrawal, 1995). Depending on the particular circumstance, either of these arguments could be correct. These institution-related studies are intriguing, for they suggest another whole realm of possible actions that may help to temper the effects of population growth on natural resources.

Institutional Arrangements

Forests generate a diversity of products, many of which can be considered common-pool resources (CPRs). A CPR is a good that exhibits two properties: (1) subtractability and (2) difficulties of exclusion (Ostrom and Ostrom, 1977). Subtractability describes many forest products. If one person harvests a tree, this tree is not available for others to harvest, or to supply ecosystem services such as soil protection. In addition, it is often difficult to exclude or restrict people from extracting a variety of forest products.

Community and physical attributes create pressures and modify the incentives that influence villager decision making and actions related to forest CPR use. But these attributes coexist with the existing institutional arrangements that govern a particular forested region. Institutional arrangements describe the set of 'working rules' and practices that influence human decision making and behavior by altering the existing incentive structure related to the use of forested areas. (Ostrom, 1992). Working rules describe the types of actions that prohibit, require, or permit various forest resource-related activities (Ostrom, 1986). Grounded upon theoretical models and empirical studies, Ostrom (1990) has outlined a set of eight institutional or working rule 'design principles' that appear to exist in cases of long-enduring or well-sustained CPRs. Each are briefly expanded upon below and are based largely on Ostrom's (1990) discussion.

Boundary rules define the individuals or households who possess rights to access and withdraw resources from a forest within an established and understood geographic area. Residents of an entire village, for example, may enjoy full access rights to a given forest circumscribed by some political or physical boundary, such as a river. In other instances, only a subset of the residents may be allowed access to the area. The first design principle states that if individuals of a community have clearly defined access rights to a CPR, the resource will be better sustained.

Use rules define how, how much, when, and where forest products may be harvested and may restrict the use of certain technologies. For instance, use rules may specifically state when and where particular forest products may be harvested, and when and where they may not. The second design principle argues that in instances where CPRs are long-enduring, use rules are well-tailored to local conditions and complement rules established for resource improvement. In many situations, inequalities between resource users may exist in terms of formal or informal rights to various forest products. In these circumstances, when inequalities in resource use are inconsistent with other situational variables—such as the amount of forest improvement labor people may have contributed, or the distance people have to travel for forest products—there may be a breakdown of the legitimacy of defined use rules. This breakdown then leads to situations where the resource is subject to more pressure.

Collective-choice rules describe how the above use rules are designed to meet local conditions. The knowledge of time and place information (Hayek, 1945) has a dramatic influence on what may constitute an appropriate and useful rule. Non-user decision makers and policy makers, who often reside and work in locations distant from the actual setting, will often lack information on the day-to-day local circumstances and thus may develop rule prescriptions that do not adequately address the problems in the field. The third design principle suggests that in instances where CPR users—the local community members who are subject to the use rules being developed—play a role in the design of these rules, the rules will be better crafted to address harvesting and maintenance issues particular to the local setting. Further, rules governing natural resources often require modification, revision, and flexibility to allow adjustments in response to changes in ecological or economic circumstances (McKean, 1996). Collective-choice arrangements that include local community participation are more apt to develop appropriate responses and design effective rule configurations over time.

Rules, however, are only effective if they are enforced. The fourth design principle states that when the monitoring of forest use rules is actively pursued, forest users are more likely to follow the established rule prescriptions. One recent study of forest use in India reports that the communities that have established strong monitoring arrangements as part of their forest governance structure were more likely to possess non-degraded forest resources (Agrawal, 1992). A well-established monitoring mechanism helps to ensure that community members perceive use rules as legitimate and increases the likelihood that forest users will conform to institutional arrangements. Monitors, in the successful circumstances that Ostrom (1990) analyzes, are either the forest resource users themselves or are people accountable to those users.

The ability for individuals within a community to comply with a set of rules governing a resource depends not only on an adequate monitoring regime but also on the likelihood that an appropriate punishment will follow. Ostrom's fifth design principle asserts that in instances where successful resource management has occurred, there will be some complementary set of punishments that are linked to types and frequencies of infractions. In these successful cases, community members will possess some basic understanding of this set of graduated sanctions and will generally expect them to be enforced, either by other resource users themselves or by officials held accountable to the resource user community.

In instances where a particular forest area is subject to some set of institutional arrangements, conflicts will invariably arise. Rules, often grounded in language, can be subject to multiple and competing interpretations. These multiple interpretations lead to confusion or conflict among members of the resource community. Ostrom's sixth design principle argues that successful CPR governance requires some rapid, low-cost mechanism to resolve such conflicts when they arise.

The seventh design principle maintains that in order for institutional design to be responsive to changing local circumstances, forest users must be given some recognition to organize and devise their own set of working rules. Without some mechanism wherein the resource users are allowed some say in their own circumstances, it will be much more difficult to maintain a community that conforms to established governance arrangements. In circumstances where governmental authorities are involved in the governance of forest resources, it is important that they recognize and support community-level mechanisms designed to promote institutional discourse.

The multiple-CPR characteristic of forests creates additional complexities. First, the forests in the Shakti and Kair sub-basins may provide a wide variety of useful species and products utilized by humans, but they also provide new land for agriculture. Second, these forests cover a large geographic area where multiple groups of users are actively utilizing the resource. Ostrom's eighth design principle contends that complex CPRs have a greater likelihood of being sustained if they are governed by nested enterprises—multiple, overlapping jurisdictional boundaries—that operate under multi-tiered sociopolitical systems (Ostrom, 1990).

Ostrom (1990: 181) calls for additional empirical research to support or refute these principles. Clearly, our temporal GIS analysis leads to the conclusion that many forests within the Shakti and Kair sub-basins are not 'long-enduring.' A great amount of forest conversion or modification has taken place over the 1978–1992 period. However, an analysis of forest institutions in light of these principles, coupled with an analysis of community and physical attributes, can help to understand why this is the case, as well as help to answer the questions related to the differences in land-cover change between the two sub-basins.

DATA COLLECTION FOR SUB-BASIN FOREST INSTITUTIONAL ANALYSIS

The data collection for our IAD-based institutional analysis can be described in three parts: (1) a detailed micro- or village-level collection of data about forests and forest institutions utilized by communities at the juncture of the two sub-basins; (2) a rapid, on-the-ground institutional assessment of forested areas deeper within each sub-basin; and (3) a gathering of supplementary information on community attributes. Physical attribute data for each sub-basin were provided by the GIS and analog maps.

1. The International Forestry Resources and Institutions (IFRI) Research Program

At approximately the same time the GIS analysis was under way, a team of Nepali researchers (two social scientists, one social forester, a botanist, and a forester) joined the effort and together we set out to conduct a study on Kair and Shakti sub-basin forest institutions guided by the International Forestry Resources and Institutions (IFRI) research program developed at Indiana University. This research program is a multi-country, long-term effort to monitor physical forest conditions as well as the socioeconomic, demographic, and institutional factors that affect the sustainability of forest resources (Ostrom and Wertime, 1995). A common database has been developed by researchers at Indiana University in cooperation with Collaborative Research Centers (CRCs) currently established in Bolivia, Uganda, and Nepal. The team lives in the study villages for a number of weeks and collects data using a variety of qualitative research methods including participatory rural appraisal techniques, interviews, and direct observation. Data are later recorded in a structured relational database. The types of data collected include the following information: village composition and community attributes, the governance structure of neighboring forested areas, the users of the forests, the forest products utilized, an inventory of rules existing for forested areas and for important forest products or species, and physical measurements using randomly sampled forest plots of the forest areas themselves.

Ideally, information on the community and institutional structure of all Shakti and Kair sub-basin communities would be gathered. But limited resources allowed for only one complete IFRI study to be conducted. For this reason, villages and forests at the juncture of the two sub-catchments were selected for study (Figure 2). Two upland villages, Deurauli and Latauli, exist on either side of the sub-basin boundaries. The Deurauli village falls in the Shakti sub-basin and Latauli falls just inside the Kair sub-basin.

2. A Rapid Institutional Appraisal of Forest Institutions in Deeper Areas within the Two Sub-basins

The detailed micro-level IFRI data on villages from the two sub-basins provide insight into the institutional arrangements and incentive structures facing villagers at these locations, but this information alone cannot be used to scale-up inferences to the sub-basin level. For this reason a second, complementary 'rapid institutional appraisal' of other forested areas within each sub-basin was conducted to determine whether the IFRI findings in Deurauli and Latauli were representative of the other forested areas found in each sub-basin. This rapid assessment involved walking deep within each sub-basin and holding informal discussions with villagers about the institutional arrangements that govern the forests they utilize. The villages visited include Kholar, Drabyutar, and Samfra Rang in the Shakti sub-basin and Nibuwatar, Gamidung, and Tindovane in the Kair sub-basin (Figure 2). Given the often-hidden nature of institutions (Ostrom, 1992: 23), this exercise could easily be misleading. But our goals were modest: we wished only to see if villagers deeper in the catchment—supplied with no information on our Latauli and Deurauli findings—would report similar or different institutional rules affecting the forests they utilize. If their comments were similar to what were identified via the IFRI data collection, they provide support for the inferences that can be made from the IFRI

TABLE 2
Comparison of physical attributes of the Shakti and Kair sub-basins (Differences highlighted in bold)

Physical attribute	Shakti	Kair
Forest Vegetation Composition	Dominated by *Shorea robusta* climax forests	Dominated by *Shorea robusta* climax forests
Drainage area	**1424 hectares**	**3838 hectares**
Slope	**99% of area classified as steeply sloping terrain;**	**72% of area classified as steeply sloping terrain;**
	Gradient much greater than Kair sub-basin.	**Gradient much less than the Shakti sub-basin.**
Maximum elevation	**1877 meters**	**1646 meters**

TABLE 3
Land-area slope classes of Shakti and Kair sub-basins

		Land area			
Slope class		Shakti sub-basin		Kair sub-basin	
degree	percent	hectares	percent	hectares	percent
0-5*	< 8.7	0	0	152	3.97
6–20	< 36.4	19	1.31	912	23.76
21–30	< 57.7	498	34.98	773	20.13
> 30	> 57.7	907	63.71	2001	52.14
Total	1424	100	3838	100	

Source for slope class: Land system maps (72 A/9 and 72 A/10, LRMP, Nepal)
< 5 = Alluvial plains and fans, flat to moderately sloping
< 20 = Moderate to steeply sloping hill and mountain
< 30 = Moderate to steeply sloping mountain terrains
> 30 = Steeply to very steeply sloping mountain terrains

data. Information that contradicts the IFRI findings indicates what cannot be inferred: it helps to prevent conclusions that are false at a sub-basin level from the micro-level study.

3. A Supplementary Data Collection on Community and Physical Attributes of Each Sub-basin

Finally, additional supplementary data were gathered to provide even more support for our inferences regarding land-cover change in each sub-basin. Specifically, community attribute data were collected from the 1991 census and these were verified by conducting an informal census in discussions with villagers within these sub-basins. Additional GIS analyses and analog maps (LRMP, 1982) provide further data on the physical attributes of the two sub-basins separately.

SIMILARITIES AND DIFFERENCES IN SUB-BASIN PHYSICAL ATTRIBUTES

Table 2 provides a summary of similarities and differences between the physical attributes of the two sub-basins. While a local- or micro-level analysis of our IFRI vegetation data has revealed variations in the spatial distribution of some important product species (Schweik, 1996), the forests at Deurauli and Latauli are broadly similar in terms of their species composition—*Shorea robusta* climax forests (IFRI, 1994). Further analysis at a meso-scale using Land Utilization Maps (LMRP, 1982) coupled with visual evaluation during our sub-basin ground-truthing efforts lead us to conclude that, in general, forest vegetation is quite similar throughout both sub-basins. General species composition differences, therefore, do not appear to be a factor in sub-basin land-cover change.

An analysis of the topography, however, reveals significant differences between the two sub-basins. First, the Kair sub-basin has a drainage area more than two and one-half times the size of the Shakti sub-basin (Table 2). Second, the Shakti sub-basin exhibits a significantly larger percentage of area classified as steep or very steeply sloping terrain (Tables 2 and 3). Third, a comparison of elevation between the two sub-basins reveals another important difference: while the average elevations in the valley and middle areas of each basin are quite similar, the upper part of Shakti sub-basin rises to 1,877 m, whereas the Kair sub-basin does not extend above 1,646 m (Table 2). Coupling this with the slope information, few areas in the Shakti sub-basin exhibit less than a 20° slope, and yet the sub-basin exceeds the maximum elevation of Kair sub-basin at least by 231 meters. This suggests that the land gradient of the Shakti sub-basin is much greater than that of the Kair sub-basin.

TABLE 4
Comparison of community attributes of villages within the Shakti and Kair sub-basins
(Differences highlighted in bold)

	Shakti sub-basin: Deurauli, Drabyutar, Kholar, and Sano Supar villages	Kair sub-basin: Chherewang, Deujar, Kaswang, Khirki, and Latauli villages
Ethnic Composition	89% Chepang 6% Magar 5% Other	92% Chepang 8% Tamang
Percentage Employed in Agriculture	83%	91%
Literacy Rate	39%	31%
Dominant Harvesting Technologies	Axes and Sickles	Axes and Sickles
Dominant Cropping Patterns	Rice paddy where water is available, maize, millet, potato and other crops elsewhere. Shifting cultivation present.	Rice paddy where water is available, maize, millet, potato and other crops elsewhere. Shifting cultivation present.
Access to Market	Difficult access; motorable road access at southern corner of sub-basin	Slightly less difficult access; motorable road along river throughout 1/3rd of the sub-basin
Population Growth	**Increasing, but a much lower percentage growth than the Kair (See Table 5a)**	**Increasing, but a much higher percentage growth than the Shakti (See Table 5b)**

Note: Villages chosen because their census names successfully cross-checked with the name villagers provided in the field.

SIMILARITIES AND DIFFERENCES IN SUB-BASIN COMMUNITY ATTRIBUTES

Table 4 presents a summary of community attribute information that we were able to cross-reference between the 1991 census data and field results. The sub-basin villages are strikingly similar in several respects. First, all of these villages exhibit a nearly homogeneous structure made up almost entirely of *Chepang* people—an ethnic group that is indigenous to the Siwalik Hills. Second, a large proportion of villagers in both sub-basins is actively employed in subsistence agriculture activities. Third, villages within the two sub-catchments have similar literacy rates.

The more detailed IFRI study of two of the villages in the sub-basins supports the above conclusions and provides additional insight (IFRI, 1994). Most villagers own some small parcels of land, but over half report that their land does not satisfy their own subsistence requirements. Only a small minority of households in each village are considered wealthy, defined as having 'large land and livestock holdings' (IFRI, 1994). In both villages, the primary products removed from forests are leaves and grasses for animal fodder and wood for cooking, heating, and construction material. Further, the IFRI study and additional ground-truthing efforts reveal similar harvesting methods—specifically using axes and sickles—throughout both sub-basins. Finally, little variation exists in the types of agricultural practices in each sub-basin. Terraced fields exist throughout each catchment and, wherever water supplies are accessible, farmers grow rice. In other more xeric areas, crops such as maize, millet, and potatoes are cultivated. The villagers in both Latauli and Deurauli reported that the practice of slash-and-burn, shifting cultivation by hill residents, people primarily of *Chepang* heritage, was in their view the most significant threat to the existing forest resources (IFRI, 1994). The rapid institutional assessment conducted in February 1996 supports this statement: over the course of only a few days, several large fires burning within forests of both sub-basins were witnessed (Figure 7). Further, many significantly sloped areas exhibiting patterns of fallow or abandoned land were observed; this is a common signature of this type of agricultural practice (Subedi, 1994) (Figure 8).

There is only a slight difference between the two sub-basins regarding villager access to external markets. The one motorable road—open only half the year—follows the primary river within the Kair sub-basin. However this advantage is slight, for the road extends only up to the village of Tindovane, and there still are many areas within the Kair sub-basin that are quite distant from this road.

Population growth is one important community attribute that differs between the two sub-basins. Census data of the area are available only for 1991, so we undertook an informal household survey of villages within each sub-basin while the GIS ground-truthing fieldwork was conducted. The percentage growth of the number of households for a large sample of villages within the Shakti and Kair sub-basins is presented in Tables 5A and 5B, respectively; they reveal a significant growth in household numbers in both sub-basins over the 14-year period, but clearly, the Kair sub-basin has witnessed a much larger percentage growth (72%).

SIMILARITIES AND DIFFERENCES IN SUB-BASIN INSTITUTIONAL ATTRIBUTES

Table 6 summarizes our comparison of the forest institutional composition between the Shatki and Kair sub-

TABLE 5A

Shakti sub-basin household growth 1978–1992 (data collected through discussions with villagers)

Village	# Households 1978	# Households 1992	Percentage household growth	Upland/ lowland
Deurauli*	19	25	37%	U
Drabytar	6	8	33%	L
Kholar	35	40	14%	U
Samfra rang	6	16	160%	L
Sano Supar	20	25	25%	U
Tammang	10	13	30%	L
Tunwati	7	1	86%	U
Total	103	14	39%	

*Site of IFRI study

TABLE 5B

Kair sub-basin household growth 1978–1992

Village	# Households 1978	# Households 1992	Percentage household growth	Upland/ lowland
Chewrang	15	20	33%	U
Chherwang	20	40	100%	U
Deujar	25	30	20%	U
Dogara (Ganidung)	30	60	100%	L
Kaswang	3	7	125%	L
Khola Gaun	20	25	25%	U
Latauli*	1	10	900%	U
Lotangti	8	11	38%	U
Nibuwatar	9	22	140%	L
Paimarang	16	22	38%	U
Tindovane	2	10	400%	L
TOTAL	149	257	72%	

*Site of IFRI study

TABLE 6

Levels of institutional design of forests within the Shakti and Kair sub-basins (1978–1992)

Design principle	Shakti	Kair
1. Clearly defined boundaries	Weak	Weak
2. Congruence between use-rules and local conditions	Weak	Weak
3. Collective-choice arrangements	None	None
4. Monitoring mechanisms	Weak	Weak
5. Graduated sanctions	Weak	Weak
6. Conflict-resolution mechanisms	Established	Established
7. Minimal recognition of rights to organize	None	None
8. Nested enterprises	Weak	Weak

basins. This table indicates three levels or categories of institutional development. 'Established' institutions are ones that are well defined and appear to be well understood and accepted by the sub-basin communities. 'Weak' institutions are ones that exist in some manner, but are not very well constructed and/or have significant problems in their current design. The 'none' category describes a design principle that does not exist in the area. Our general conclusion from Table 6: no institutional differences between sub-basins appear to exist that help explain the disparity between sub-basins in their land-cover change patterns. But the common institutional structure that is discovered—where Ostrom's (1990) design principles hold up or break down—does help immensely in understanding why such dramatic forest conversion and modification has occurred in both sub-basins. For this reason, it is important that these common findings related to Ostrom's CPR design principles are reported in further detail.

Political boundaries are at the heart of past and present governance of relevant forest areas. Both sub-basins fall within the Chitwan District, and the forests within these sub-basins have been under the jurisdiction of the District Forest Office (DFO) for the 1978–1992 time period. The DFO manages these forest areas through range-post offices at the Village Development Committee (VDC)—the smallest political unit in the Nepalese administration system. The entire Shakti and the western tip of the Kair sub-basin fall within one VDC boundary; the rest of the Kair sub-basin falls within a second VDC boundary.

In the case of both sub-basins for this period of study, the DFO has managed its forests around VDC boundaries. The formal policy is that only VDC members were provided access and harvesting rights from forests within their VDC. This policy has continued through the political overhaul to democracy in 1990 until new decentralization-type initiatives were established by the National Forest Act in 1992 (Pardo, 1993). Conversations with villagers from Deurauli, Latauli, and beyond reveal that there is an understanding of the formally established access rights organized by VDCs, but that there are other customary access rights, based largely on wealth and ethnicity, that contradict these formal rights defined by the DFO (Schweik, 1996). While these customary access rights appear to be understood and followed by people from various villages, it is the contradictions between the formal DFO defined rights and the customary rights identified in the field that lead to the conclusion that clearly defined boundaries—Ostrom's design principle one—were only weakly established in the area during this 1978–1990 period.

Design principle two—the existence of use rules well-tailored to local conditions—was also only weakly established during this 14-year period. Villagers understand that they have *de jure* rights to utilize grasses and deadwood from the VDC forests to support their daily subsistence requirements and they clearly take advantage of their right to these products. However, two use rules are DFO policy but are clearly not followed by sub-basin villagers: (1) a 'no live tree harvesting' rule that requires DFO permission before any live tree is felled and (2) a 'no encroachment' rule that prohibits conversion of forest land to some other land use. Both the GIS analysis and the infractions that were witnessed during the field visits confirm the breakdown of these rules. A second reason supports the 'weakly established' classification for design principle two. In order to abide by these rules, the villager faces significant transaction costs in order to gain harvesting permission: the villager must travel miles over difficult terrain to reach the DFO range-post, bring the range-post personnel back to the location that is to be harvested, risk the possibility of being turned down for the request, and thus bring the attention of officials to their activities. The benefits of these actions have not outweighed the costs of being caught breaking the rules. Since 1992, this situation has improved slightly, for permission is now required from VDC officials instead of DFO officials, and VDC officials are geographically closer to sub-basin locations.

Design principle three—the establishment of collective-choice arrangements where most villagers affected by operational rules can participate in modifying the rules—did not exist during this time period. The DFO has been the primary authority in developing the operational rules that oversee the forest land within the two sub-basins. DFO officials are appointed by the Nepalese government, and users of the forest have no voice in selecting officials assigned to these positions. The post-1992 creation of the VDC Forest Users Committee is a step in the right direction. This committee has recently passed one operational rule—a timber harvesting rule that requires the villager to gain VDC permission prior to harvest—but a number of infractions of this rule with no VDC enforcement were witnessed in the field.

Design principle four—effective monitoring mechanisms—was only weakly established in both sub-basins. The monitoring of the 'no live tree harvesting' and 'no encroachment' rules during the 14-year period traditionally has been done by DFO forest guards who are based out of local range-posts. Two range-posts organized by VDC are responsible for monitoring the sub-basin forest resources. Both are located on the plains to the south of the sub-basins: one approximately 14 km south of the Shakti sub-basin and the other about 16 km south of the Kair sub-basin. Some monitoring by DFO guards was observed by the research team but the activity occurred primarily in the lowland areas of the sub-basin—closer to market areas, closer to the one existing road, and closer to the DFO range-post. From discussions with sub-basin villagers, interaction with these forest guards is infrequent—only once or twice a year. Further, some villagers reported their use of gifts to avoid being charged with a rule violation. More recently (post-1992) in an attempt to improve rule monitoring, the VDC Forest Protection Committee has implemented a policy that involves the monitoring of villagers by the villagers themselves. When an infraction occurs, villagers are to bring the issue to the committee for a ruling. The burning we witnessed in the field, and villager reports of continued encroachment and timber felling, lead us to conclude that this new monitoring mechanism has not improved the situation.

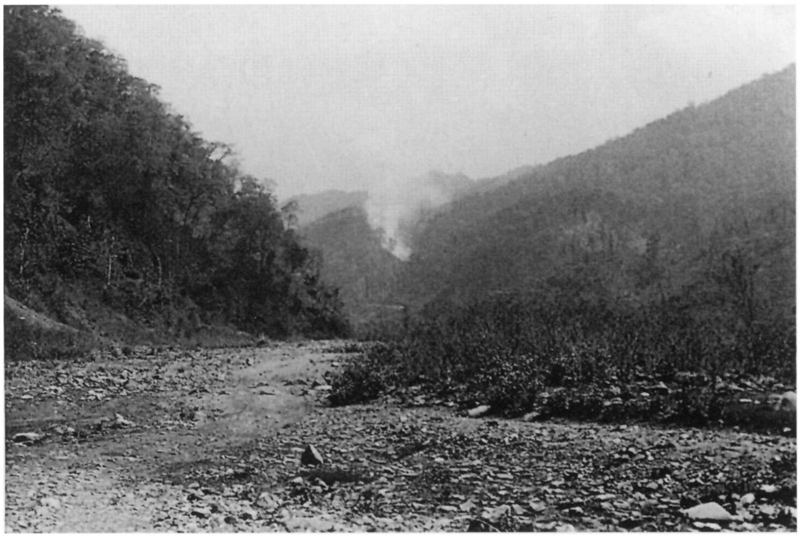

FIGURE 7. An example of slash-and-burn agricultural practices in the Kair sub-basin (February, 1996).

FIGURE 8. Recently burned and fallow slopes in the Shakti sub-basin (February, 1996).

The fifth design principle—established graduated sanctions—was also weakly established in both sub-basins. Formally, forest users in either sub-basin who are caught breaking an operational rule face penalties of increasing severity depending on the seriousness of the infraction, the history of previous infractions, and the context in which the offense occurred. People caught cutting live timber or encroaching on forested areas by the DFO guards are subject first to verbal chastisement and possibly a fine. Further or serious infractions will lead to additional fines and/or possible incarceration. In one lowland area, the IFRI team witnessed DFO guards removing a home recently built on encroached forest land. Thus, some sanctioning clearly occurs when monitoring is undertaken, but there was no evidence of it in the more distant and less accessible upland communities such as Deurauli and Latauli or beyond. From villager reports, sanctioning is mostly by the guards in the field and they are sometimes tempted by gifts offered by villagers to reduce the penalty. Few case-by-case records are maintained on these decisions. The sanctioning practices designed by the VDC Forest Protection Committee follow a similar graduated approach. First and second-time violators for timber harvesting or forest encroachment are verbally chastised, required to make public apologies, and then fined. Third-time offenders are reportedly taken to the DFO for possible trial. However, no records exist in the VDC office, few fines have been reported, and no third-time infractions have occurred. It appears that the decision to sanction is dependent on each individual situation and VDC officials, like the DFO guards, are subject to bribes. In short, graduated sanctions exist but are not consistently enforced.

Conflict-resolution mechanisms—design principle six—have been well established and more recently an additional dispute-resolution mechanism at the VDC level has been added. The villagers, however, report that conflicts rarely occur. Both in IFRI field interviews and our rapid institutional assessment, very little was reported related to conflicts over forest product use or forest management. This, at least in part, can be attributed to (1) the existence of very few use rules, (2) a fairly abundant supply of forest products and forest land existing in the sub-basins, and (3) the lack of consistent monitoring of rules by the DFO forest guards and, more recently, VDC Forest Committee members and the villagers themselves.

Design principle seven—a minimal recognition of villagers to organize—has been addressed only in legislation and was not in practice in this region. Over this study period, there was a national initiative by government officials to provide rights to villagers to establish their own forest governance structures, but few such actions were taken at the local level. The more recent national policy encouraging the development of VDC-level Forest Protection Committees and handing forest ownership to them is a step in this direction; however, formal transfer of forest authority has not occurred in either sub-basin, although after 1992 VDC committees were recognized. Even more recently, in 1994, DFO officials from both responsible range-posts stated that they fear such a move may backfire and produce an increase, rather than the desired reduction, in villager harvesting and encroachment (IFRI, 1994).

The eighth and final design principle argues that in complex forest-governance settings, governance activities should be organized in nested, multiple layers. During the 1978–1992 period, the existing forest governance hierarchy involved three levels: (1) the forest range-post for each VDC (the lowest level); (2) the Forest Office at the District level (e.g., Chitwan); and (3) the National Level DFO in Kathmandu. More recently, there is the additional partially-recognized VDC Forest Protection Committee which overlaps with the geographic jurisdiction of the DFO range-post officials. However, the entire Shakti sub-basin falls under the same VDC-level jurisdiction and the question remains whether this arrangement provides enough involvement at the village level to allow for the design of rules well-crafted to local village conditions. For this reason, the 'nested enterprises' design principle is classified as weakly established for the area.

DISCUSSION AND CONCLUSIONS

Let us return to the two questions posed earlier and answer them directly, beginning with the second question first. Why does the Shakti sub-basin reflect such a large extent of dense forest degradation while the Kair sub-basin reflects primarily forest-to-agriculture conversion? The physical, community, and institutional analysis yields the following conclusion: the institutional and community attributes within the two sub-basins are very much the same. We, therefore, attribute the land-cover change differences indicated by our GIS analysis to the sub-basin physical differences that force farmers toward alternate dominant land-use practices. A large portion of the Shakti sub-basin exhibits a slope greater than 30°, and therefore it cannot be easily converted to permanent terraced farming land (Subedi, 1994: 13). Thus, there is a continuing practice of shifting cultivation where forested land is cleared either partially or fully, farmed for a number of years, then left fallow to rejuvenate the soil (Subedi, 1994). The air photograph analysis clearly reveals this dominant practice in the Shakti sub-basin and it has been confirmed in the field (Figure 8). In contrast, during the 1978–1992 period, the Kair sub-basin still had available moderately sloping forested land capable of conversion to terracing. This also explains the one major community attribute difference: villagers have migrated to other areas in the Kair more appropriate for terracing.

What is the situation on the ground—the human dimensions related to land use—that have led to such dramatic land-cover change in both sub-basins? It is the similarities in community and institutional attributes in both sub-basins that lead to these two types of land-cover conversions. Villagers in each sub-basin exhibit similar community attributes—for example, agriculture-based livelihoods and similar caste composition—and these attributes create an incentive that encourages dense forest transformation. The similar institutional composition that exists within each sub-basin does nothing to counterbalance these harvesting incentives. Weakly established use-rules coupled with few mechanisms to allow villagers to organize and devise operational rules more tailored to their conditions are part of the problem. But a larger part of the problem is that the existing monitoring and sanctioning mechanisms are largely ineffective in establishing countervailing disincentives in order to control extensive forest conversion in both sub-basins. The type of land-cover change is different; the indirect reasons for the conversion are the same.

Let us now conclude with some reflections related to forest policy in the area, given our understanding of the local circumstances. This analysis clearly shows that the current institutional structure in both sub-basins has not been successful in controlling forest encroachment. The DFO officials would require an army of guards to patrol such large and remote areas effectively. Given tight fiscal resources, an increase in guards is an unrealistic solution. A more appropriate step toward solving the monitoring problem might be to develop incentive structures that encourage monitoring by the community members themselves. The movement toward VDC control is a step in the right direction, but the DFO must formally hand over control to the VDCs. If DFO officials are concerned that the VDC officials and villagers will abuse their new power and over-harvest resources even more than they already do, the DFO should carefully select one VDC community—a pilot project perhaps—that appears to exhibit the most interest, sincerity, and immunity from other political pressures. The DFO should assist and encourage the development of a local governance structure—a local Forest Protection Committee made up of local leaders—

with a capacity to work through a difficult phase of institutional design. The monitoring efforts of the DFO would then shift from the current primary emphasis on forest surveillance to monitoring the operation of the Forest Protection Committee. Encouragement should be given to design of an equitable committee constitution and fair collective-choice mechanisms. This will not come easily or quickly (Ostrom, 1990: 210). Humans are fallible and mistakes will be made. A primary goal should be to devise mechanisms that allow for institutional adjustment when flaws are identified.

Once the formation of such a committee is complete, one of the first tasks should be a careful review of monitoring and sanctioning mechanisms devised by the Committee. The temptation is great—whether a DFO guard or VDC official—to accept gratuities; a one-on-one confrontation with a rule-breaking farmer far up in the hills can often lead to temptation. In such nested-enterprise systems, strong deterrents must be devised and DFO and VDC officials and other village leaders must develop a culture and a commitment where corrupt activities are not accepted and where appropriate sanctions are imposed on offenders.

Finally, one other particularly difficult monitoring-related issue must be carefully addressed. Mechanisms must be devised that encourage villagers to report rule infractions by other villagers. Our multiple field visits revealed a 'see-no-evil' mind-set both within villages and between villages. The burning of forested areas is clearly visible both day and night from areas many kilometers distant (Figure 7), and yet villagers do not report the violation. It is an accepted practice *not* to report on one's proximate and distant neighbors. This is quite understandable behavior: why would anyone want to initiate conflict with the neighbors with whom they interact on a day-to-day basis? Yet, in many CPR situations in many other countries (Tang, 1992), and specifically in Nepal (Benjamin *et al.*, 1994; Lam, 1994), such negative incentives have been overcome, and monitoring mechanisms have been devised whereby the farmers themselves have been able to monitor one another successfully. It is by no means an easy task, but one that DFO and VDC officials and village leaders must address head-on.

ACKNOWLEDGEMENTS

The authors are very appreciative of the financial and intellectual support received from the Ford Foundation, New Delhi, and specifically from Dr. John Ambler and Dr. Ujjiwal Pradhan. Dr. Elinor Ostrom of Indiana University has provided valuable insight and direction at every stage of this project. We are also grateful to Dr. Ganesh Shivakoti, Ashutosh Shukla, Dean Tej Bahadur K.C., and IAAS faculty and staff who have provided on-going encouragement and support. Our IFRI field data could not have been collected without the hard work of Rajendra Shrestha and his IFRI team, Bharat Sharma, Mukunda Karmacharya, Vaskar Thapa, and Sudil Gopal Acharya. Ajay Pradhan, Patty Dalecki, and Robert and Joanne Schweik provided helpful comments on earlier drafts. Finally, we are deeply grateful to DFO officials and the residents of the Shakti and Kair sub-basins for their openness and willingness to discuss community natural resource issues.

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