The Impact of Community Context on Land Use in an Agricultural Society

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As an initial step toward new models of the population-environment relationship, this paper explores the relationship between community context and local land use in an agricultural setting. In this type of setting, we argue that aspects of the community context, such as schools and transportation infrastructure, impact important environmental characteristics, such as land use. We provide hypotheses which explain the mechanisms producing these effects. We then use data from a study of 132 communities in rural Nepal to test our hypotheses. These analyses show that community characteristics are strongly associated with land use in this agricultural setting. The results point toward changes in communities as critical determinants of environmental quality. These findings are consistent with the notion that changes in community contexts may also condition the population-environment relationship.

Concerns over environmental degradation have prompted increasing research into the determinants of environmental quality. Much of this work

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examines determinants of environmental quality at a very high level of aggregation, often at regional or even global levels (Bilsborrow, DeLargy, 1991; Bongaarts, 1996; Cohen, 1995; Ehrlich, Ehrlich & Daily, 1993; Heilig, 1997; Myers, 1991; Rees, 1996). Instead, we focus on the determinants of environmental quality at the local community level, with the aim of generating new insights into those determinants. At this level, we believe changes in the social and economic infrastructure of a community can have an important impact on environmental quality. This is likely to be particularly true in agricultural societies, where community changes often reorganize agricultural production to affect the physical environment. If so, understanding community influences on environmental quality is essential to a clearer, micro-level understanding of the population-environment relationship because community characteristics may also influence population processes (Casterline, 1985; Entwisle, Casterline, & Sayed, 1989).

We focus on one specific dimension of environmental quality: land use. In a predominantly agricultural setting community changes can have both direct and indirect effects on land use. Increasing community infrastructure may have direct effects on land use because these infrastructure are placed on common or agricultural lands, thereby converting them to other uses. These changes may also have indirect effects on land use by reducing the agricultural labor force, reorganizing agricultural production, or increasing the population of consumers. Together these mechanisms are likely to produce a substantial interaction between the characteristics of the community context and land use.

We use data from 132 neighborhoods in South Central Nepal to examine this relationship. These unique data provide microlevel measures of both the neighborhood context and local land use. Our analyses reveal important local level determinants of land use in this agricultural setting.

POPULATION AND ENVIRONMENT AT THE COMMUNITY LEVEL

Much of the demographic research community's work on environmental quality has focused on the impact of population parameters on environment quality (Bilsborrow & DeLargy, 1991; Blaike & Brookfield, 1987; Cohen, 1996; Ehrlich, Ehrlich & Daily, 1993; Heilig, 1997). The impact of population growth and population re-distribution have probably received the greatest attention. However, demographers are also increasingly sensitive to the idea that environmental quality may have an important impact on population parameters. Here the impact of environment on out-migration and mortality have probably received the most attention

(Hill, 1990; Hamilton, Seyfrit, & Bellinger, 1997; Perz, 1997). Together, these two streams of research suggest an important reciprocal relationship between population parameters and environmental quality, where each affects the other. But the precise microlevel nature of this reciprocal relationship has proved difficult to identify.

One reason the reciprocal relationship between population and environment remains difficult to identify is because both causal effects are probably conditioned by the impact of local contextual characteristics. Certainly recent research on important population parameters is consistent with the conclusion that contextual characteristics shape these parameters, at least in part (Entwisle & Mason, 1985; Entwisle, Casterline & Sayed, 1989; Casterline, 1985; Sastry, 1996). Research on these topics has also shown that local-level contextual characteristics can be particularly important determinants of population parameters (Axinn & Fricke, 1996; Entwisle, Casterline & Sayed, 1989). We believe it is also likely that local-level contextual characteristics shape environmental quality, at least in part.

Understanding the impact of local contextual characteristics on environmental quality is a crucial step toward identifying the reciprocal relationships between population and environment. As Figure 1 shows, the

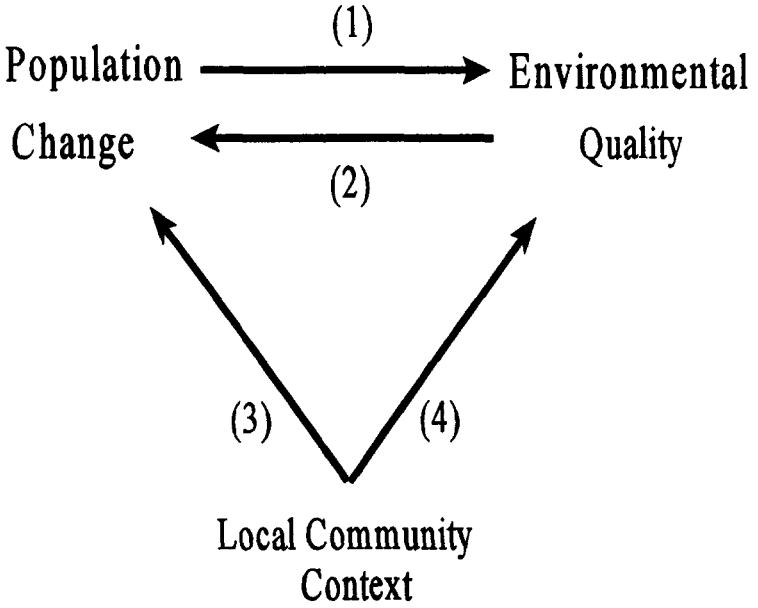

FIGURE 1.

reciprocal relationships between population and environment (denoted by arrows 1and 2) are imbedded within a common set of contextual determinants. Many of the same contextual characteristics that influence population parameters (denoted by arrow 3) may also influence environmental quality (denoted by arrow 4). If this is so, then precise specification of the reciprocal relations between population and environment at the microlevel will require a clear understanding of the impact of contextual characteristics on both population processes and environmental changes.

Below we delineate the reasons why contextual characteristics are likely to influence environmental quality. Then we provide empirical estimates of this relationship. First, however, we provide a brief description of the setting for this study.

SETTING

The setting for this study is the Western Chitwan Valley located in South-Central Nepal. Chitwan is a wide flat valley nestled in the Himalayan foothills at approximately 450 feet above sea level. Until the early 1950s Chitwan was covered by virgin forests, infested with malaria carrying mosquitos, and home to many dangerous fauna, ranging from poisonous snakes to Bengal Tigers. Beginning in the mid-1950s, with assistance from the United States, the Nepalese government began a program of clearing the forest, eradicating malaria, and distributing land to settlers from the higher Himalayas. Approximately one-third of the original forest was preserved as Chitwan National Park, which remains home to several endangered species today. Our study examines land use patterns in a 200 square mile area of Western Chitwan that was cleared and settled (see Figure 2).

Rich soils, flat terrain, and the promise of new opportunities drew many farmers into the area, but the valley remained a remote, isolated frontier until the late 1970s. The first all weather road into Chitwan was completed by 1979. This road linked Chitwan's largest town, Narayanghat, to the eastern portion of Nepal's East-West highway and, therefore, to cities in Eastern Nepal and India. Two other important roads followed. One west, linking Narayanghat to the western portion of Nepal's East-West highway. Another north, linking Narayanghat to Kathmandu, Nepal's capital city. Because of Narayanghat's central location, by the mid-1980s this once isolated town was transformed into the transportation hub of the country. This change produced a rapid proliferation of government services, business, and wage labor jobs in Narayanghat that spread through Chitwan in in-

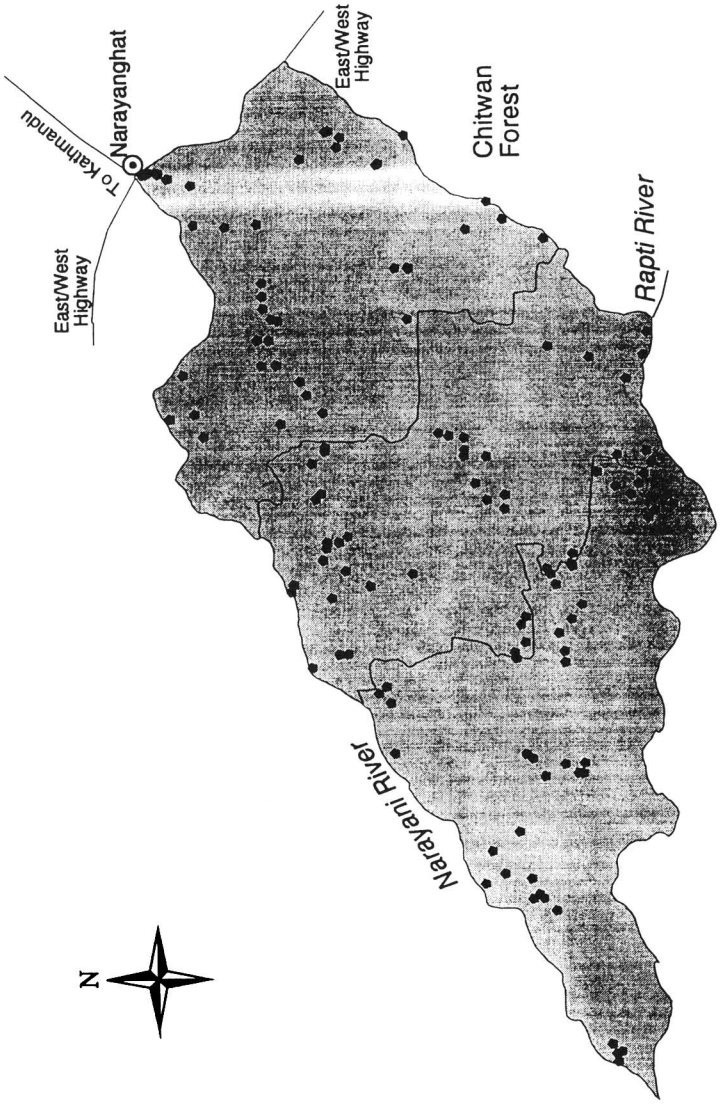

FIGURE 2. Chitwan Valley study area.

verse proportion to distance from Narayanghat (Pokharel & Shivakoti, 1986). These changes also continued to stimulate the government's investments in agriculture in the region, including heavy investments in irrigation, mechanization, improved seeds, pesticides, fertilizer, and new methods of production and marketing (Shivakoti & Pokharel, 1989). The population of this valley continued to grow as well, with both in-migration and natural increase making significant contributions to this growth (His Majesty's Government, 1987; Tuladhar, 1989).

Together these forces dramatically altered the social and economic organization of Chitwan within the lifetimes of its residents. Bus service through the valley has given residents access to the wage labor opportunities and commerce of Narayanghat. Commercial enterprises, such as grain mills and new retail outlets, have scattered throughout Chitwan. A wide range of government services, from schools, to agricultural cooperatives, to police posts, have also sprung up. These changes constitute a significant transformation of the local context for the hundreds of small farming communities in Western Chitwan Valley. In the paragraphs that follow we outline the likely impact of this transformation on land use.

COMMUNITY CONTEXT AND LAND USE

Land use is a fundamental measure of how the environment is organized in this setting. Changes in land use are reflected in the relative magnitude of the land area devoted to agricultural and non-agricultural activities. The important categories of land use in this valley include land devoted to agriculture, land devoted to residences and other enterprises, and land devoted to public (common) forest and pasture. Over time, as the population has increased, the economy grown, and government infrastructure spread, land use in Chitwan has been transformed in many important ways, especially in the conversion of agricultural land to land for housing and other private (nonagricultural) enterprises and the reduction of public forest and grazing lands. Public lands are sometimes converted into land for agriculture, but more often converted directly into land for housing for the poor or new public services. This change is particularly important because public forest and grazing lands are a critical resource for farmers. Virtually every farmer in Chitwan has several animals (Axinn & Axinn, 1983) and these common lands constitute the main source of fodder for farmers' animal herds. The conversion of common lands represents the degradation of the region's flora resources, which, over time, is also likely to have many negative consequences for the undomesticated populations of animals and birds which populate the region.

Below we describe the reasons why one might expect to find a strong relationship between the spread of new social and economic infrastructure to communities and changes in land use. We have divided these reasons between those which imply direct effects on land use and those which imply indirect effects via other mechanisms.

Direct Effects on Land Use

Direct effects of changes in the community context on land use are most likely via the placement of new public services on common lands. This process results in the conversion of common forest and pasture land into land covered by buildings. All manner of new community infrastructure, including schools, health services, agricultural cooperatives, and government offices, are often established on community common lands. Common lands are often the only land available for new public establishments. The expense of purchasing other lands, since they are owned, may constitute a substantial obstacle to the establishment of new public services, particularly in poor countries like Nepal. Thus communities may be faced with the choice of foregoing new services or giving up common land in order to have them. Communities that chose to make the trade have fewer common lands as a result.

The expansion of business and commerce may also have direct effects on land use, but here the impact is more likely to be concentrated on conversion of agricultural land into land covered by buildings. Local residents are less likely to tolerate the placement of new commercial enterprises on common lands, especially because these enterprises are expected to generate profits, thereby providing owners the means to purchase privately held lands. To the extent owners purchase private agricultural lands in order to establish their new commercial enterprises, this process will result in the conversion of agricultural land into land covered by buildings.

We explore the relationship between several different types of community changes and land use, in order to determine the differential impact of new public services and new private enterprises. The specific public service changes we will examine are the placement of schools, dairy cooperatives (milk collection points established by the government), and police stations. The private enterprise changes we examine are placement of grain mills and bazaars (market places). We also explore the impact of distance from Narayanghat (the only urban center in the valley) and bus services. Both of these dimensions of access to urban markets are expected to have important indirect effects on land use, as described below.

Indirect Effects on Land Use

Community context also plays an important role in deciding the ultimate use of land by the families living in Chitwan. In a rural setting like Chitwan, where community members are primarily engaged in farming, community-level changes in the local context will produce adjustments to farming practices. For example, if a new school is opened, parents who did not send their children before may start sending their children to the school, thereby reducing the availability of labor for farming. Reduction of the agricultural labor force may lead some families to abandon farming for alternative income generating activities, further reducing the need to maintain either agricultural or common lands. Proximity to the wage labor opportunities concentrated in urban areas (Narayanghat) is likely to hasten this process of abandoning agriculture. In the Chitwan setting, both distance to Narayanghat and access to bus service determine this proximity. Thus we expect proximity to urban wage labor opportunities, the expansion of schools, and access to other wage labor alternatives (mills and markets) to encourage families to abandon agriculture and thereby contribute to the conversion of agricultural and common lands into alternative uses.

The establishment of community infrastructure on community common lands, as described above, may also affect the organization of agriculture, thereby producing additional indirect effects on land use. The new infrastructure on common lands will affect family decisions about cattle herd size because common land affects the availability of open grazing space for these animals. Decisions to reorganize farming away from pastoralism will also reduce the need for common forest and grazing lands, removing some of the costs of further converting these lands. Thus placement of public services on common land is likely to reorganize agriculture in a direction that stimulates the continued conversion of common land into alternative, nonagricultural uses.

Of course, community changes may also have indirect effects on land use via population changes. With expansion of community facilities, more people may be motivated to move into an area, thereby reducing the amount of land available for cultivation. This forces intensification of cultivated area or extensification through cultivation in marginal areas, which otherwise were fallow or unused. Better health care infrastructure is likely to have strong positive effects on natural increase by lowering mortality. Until the very recent past, mortality has been quite high throughout Nepal (His Majesty's Government, 1987). When Narayanghat was transformed by the completion of all weather roads the government also invested heavily in health care infrastructure in the town. These investments resulted in a

proliferation of private health care clinics there as well. Proximity to Narayanghat, in terms of both distance and access to bus service, provides Chitwan residents access to health care likely to substantially reduce mortality. Declines in mortality will produce natural increase in local communities which generates the same population growth related pressures on land as in-migration. Thus both in-migration and natural increase may generate the continued conversion of common lands and agricultural lands into other uses.

Note that these indirect effects via population changes are described by arrows 3 and 1 in Figure 1. Community effects on demographic processes, such as mortality, have been documented elsewhere in the literature (Sastry, 1996). To the extent population changes influence land use, these changes may represent a indirect consequence of changes in community infrastructure that is included in our estimate of the total impact of community change on land use.

Overall Prediction for Changes in Land Use

We hypothesize that the communities in Chitwan which have experienced the most change in the local context are also likely to have the lowest proportion of land devoted to either agriculture or common pasture and forests. Our reasoning regarding the mechanisms producing these effects identifies three important dimensions of contextual change. The first is access to urban opportunities, in terms of either distance to Narayanghat or proximity to public transportation. The second is concentrations of private enterprise, such as grain mills or market places. The third is levels of public infrastructure, such as schools, dairy cooperatives, or police posts. We predict each of these contextual characteristics will produce a higher percentage of land area covered by household residences, roadways, and public buildings as compared to communities without these facilities. Thus we expect to see a smaller percentage of all neighborhood land area devoted to common forests and pastures or agriculture in communities with these facilities nearby.

DATA AND METHODS

The data to test our hypotheses come from a study of 132 neighborhoods scattered throughout Western Chitwan Valley. For the purposes of this study a neighborhood was defined as a geographic cluster of five to fifteen households. The first 120 neighborhoods were chosen as an equal

probability, systematic sample of neighborhoods in Western Chitwan. The sample was chosen from three distance strata: close to Narayanghat, far from Narayanghat, and in between. Twelve neighborhoods were added to provide adequate representation of ethnic minorities (Tharu & Newar) in each distance strata. The characteristics of this sample closely resemble the characteristics of the entire Chitwan Valley (Barber, Shivakoti, Axinn, & Gajurel, 1997).

Boundaries of the land surrounding these neighborhoods bisect the areas between the selected neighborhoods and adjoining neighborhoods. This boundary procedure gives every unit of land in Chitwan one and only one chance of falling into our sample. This procedure also means neighborhoods in more densely settled areas are characterized by smaller land areas than neighborhoods in more sparsely settled areas. Therefore we always take total land area into account when constructing our measures of land use.

Measures of Land Use

We identified many distinct categories of land use within the land areas defining each neighborhood. These categories consist of multiple types of common land (grazing, forest, and plantation), multiple types of agricultural land (up-land, irrigated low-land, unirrigated low-land, private grazing land, and private plantations), and multiple types of other uses. These other uses include both private uses, such as household residences and other buildings, and public uses, such as roads, canals, and temples. A team of field workers mapped the land area of each neighborhood using compasses and tape measures. These measurements were computerized and used to calculate the land area of each neighborhood, by land use type. The neighborhoods themselves range from 4,049 square feet to 2,764,242 square feet, with a mean of 697,839 square feet and a standard deviation of 568,471 square feet.

For the purposes of this analysis we used these data to construct two measures of land use. The first measure is the fraction of the total land area devoted to any common agricultural use (grazing, forest, or plantation). This measure is the land area devoted to these uses divided by the total land area of the neighborhood. The second measure is the fraction of the total land area devoted to any agricultural use, including common agricultural use. Thus the numerator of the second measure includes the land uses in the numerator of the first measure with all other agricultural uses and divides by the total land area of the neighborhood. Table 1 provides descriptive statistics for these two measures.

TABLE 1

Descriptive Statistics for Measures of Land Use and Community Context

	Mean	Standard Deviation	Minimum	Maximum
Land Use				
Percent Common Land	1.67	6.37	0	42.70
Percent Agricultural	70.92	26.36	0	94.58
Community Context				
Access to Opportunities				
Miles to Urban Center	7.82	4.18	.02	17.70
Minutes to Nearest Bus	12.35	15.45	0	75
Private Enterprise				
Minutes to Nearest Market	12.39	16.83	0	120
Minutes to Nearest Mill	11.23	11.09	0	90
Public Infrastructure				
Minutes to Nearest School	8.99	6.61	0	30
Minutes to Nearest Dairy	19.46	14.41	0	90
Minutes to Nearest Police Station	64.45	39.48	2	240

Note that a very high fraction of the land area in most neighborhoods is devoted to agricultural uses. Although the neighborhoods are small, this is not surprising since virtually every household in Chitwan was engaged in agriculture through the early 1980s (Axinn & Axinn, 1983; Shivakoti & Pokharel, 1989). Also note that the fraction of land area devoted to common agricultural uses is very low for most neighborhoods. The fraction devoted to such common uses was probably higher in the past, but by the time these data were collected (1996) the region had already experienced substantial social and economic reorganization contributing to the conversion of common agricultural lands into other uses.

Measures of Community Context

The exact latitude and longitude location of each neighborhood was calculated from 1:25,000 maps based on aerial photographs of the valley. These locations were then entered into a Geographic Information System (GIS) which calculated the distance between each neighborhood and

Narayanghat, the valley's only urban center. These distances form our measures of miles to the urban center (see Table 1).

Other measures of the community context were gathered using the Neighborhood History Calendar method. The specific techniques involved in this method are described in detail elsewhere, so we do not repeat those here (Axinn, Barber, & Ghimire, 1997). We used Neighborhood History Calendar methods to collect data on the proximity of each of our 132 neighborhoods to a wide variety of services and infrastructure. The measure of proximity we use here is the number of minutes neighborhood residents report they must walk to reach each of the services in question. In these analyses we explore the impact of minutes to reach the nearest bus, mill, market place, school, dairy cooperative, and police station on variations in land use. Descriptive statistics for these measures of community context are presented in Table 1.

We divided our measures of community context into three categories. The category labeled "access to opportunities" includes our measure of distance to the urban center and our measure of minutes to reach the nearest bus stop. Each of these measures is an important determinant of residents' access to the wage labor, commercial, government service, and health care opportunities concentrated in the valley's only urban center, Narayanghat. The category labeled "private enterprise" includes our measure of minutes to nearest mill and minutes to nearest market place (called "bazaar" in Nepalese). Mills and markets are common examples of private commercial ventures that are likely to be established on privately held agricultural land, thereby contributing to the conversion of agricultural lands into alternative uses. The category labeled "public infrastructure" includes our measures of minutes to the nearest school, dairy, and police station. "dairy" is short hand for government run dairy cooperatives which are milk collection points for farmers in the valley. Each of these public services is quite likely to be placed on publicly held common lands.

One difficulty that often arises when examining the impact of these types of community services is that changes in these services tend to occur together (Casterline, 1985). Table 2 displays the bivariate correlations among all of our measures of community context. All of these correlations are positive, but none is as high as .50. In fact, the largest correlation is for minutes to the nearest mill and minutes to the nearest dairy (.47). Most of the other correlations are substantially less and all are quite mild. Thus, our aim will be to provide estimates of the independent effects of each of these dimensions of community context on land use patterns.

TABLE 2

Pearson's Correlation Coefficients for Measures of Land Use and Community Characteristics

	% Common Land	% Agriculture	Miles to Urban Center	Minutes to Bus	Minutes to Mill	Minutes to Market	Minutes to School	Minutes to Dairy
% Agriculture	.43							
Miles to Urban Center	.09	.43						
Minutes to Bus	.13	.26	.28					
Minutes to Mill	.22	.21	.08	.29				
Minutes to Market	.23	.26	.16	.31	.30			
Minutes to School	.22	.15	.18	.36	.41	.23		
Minutes to Dairy	.41	.11	.18	.23	.47	.41	.32	
Minutes to Police Station	.33	.24	.15	.07	.19	.23	.12	.21

Analytic Strategy

Since the history of Chitwan indicates many social and economic changes began in the urban center, Narayanghat, and spread through the valley in inverse proportion to distance from this town, we control for distance to the urban center in each of our models. This variable provides an estimate of the impact of proximity to the urban center and also controls for other, unobserved aspects of change, that may be closely associated with distance from Narayanghat. We add each of our other measures of community context to this basic model one at a time in order to provide estimates of the total impact of each specific dimension of the context. Then, we estimate a combined model that includes all of our measures of community context in a single equation. Since our two measures of land use, proportion of land devoted to common uses and proportion of land devoted to agriculture, are both continuous measures, we use ordinary least squares estimation procedures to estimate our multivariate models.

RESULTS

Table 3 displays our estimates of the impact of community characteristics on the percentage of land allocated to common agricultural uses. Neither of our measures of access to the opportunities in Narayanghat have any significant impact on this dimension of land use. Both miles to this urban center and minutes to reach the nearest bus fail to have any significant effect on common land.

In contrast, each of our measures of proximity to private businesses has a strong, statistically significant influence on the percentage of land allocated to common purposes. The more minutes from the neighborhood to the nearest market or the nearest grain mill, the higher is the proportion of the neighborhood's land area that is devoted to common forests or grazing. These significant positive effects may be the direct result of placement of these enterprises on common land, or, more likely, the indirect result of changes in the organization of agricultural production that are affected by these enterprises.

Proximity to public infrastructure also has a strong, statistically significant impact on the fraction of land devoted to common forest or grazing. The more minutes to the nearest school, dairy cooperative, or police station, the higher is the fraction of the neighborhood's land area that is devoted to common agricultural uses. Since these types of public services are often placed on common land, for lack of affordable alternatives, it is quite

TABLE 3

OLS Regression Estimates of the Impact of Community Characteristics on Percent of Local Land Devoted to Common Pasture or Forest (t-ratio in parentheses)

Model	I	II	III	IV	V	VI	VII
Community Characteristics							
Access to Opportunities							
Miles to Urban Center	.08	.08	.10	.08	.01	.06	−.05
	(.61)	(.59)	(.80)	(.57)	(.13)	(.46)	(.41)
Minutes to Nearest Bus	.05						.01
	(1.26)						(.19)
Private Enterprise							
Minutes to Nearest Market		.08**					.01
		(2.52)					(.20)
Minutes to Nearest Mill			.12**				−.02
			(2.45)				(.40)
Public Infrastructure							
Minutes to Nearest School				.20**			.08
				(2.37)			(.95)
Minutes to Nearest Dairy					.18***		.15***
					(5.04)		(3.63)
Minutes to Nearest Police Station						.05***	.04**
						(3.82)	(3.07)
R-squared Adjusted	.01	.04	.04	.03	.16	.09	.20
N	132	132	132	132	132	132	132

*p < .05, **p < .01, *** p < .001 one-tailed.

likely these estimates represent direct effects of the placement of new public services. Of course, the public services may also have indirect effects on land use, via either the reorganization of agriculture or population processes, or via other mechanisms.

Model VII in Table 3 provides a simultaneous estimate of the impact of all our measures of community context on the fraction of land in common pasture and forests. In this model we see that the significant impact of private businesses and schools disappears. Only the impact of minutes to the nearest dairy and minutes to the nearest police station remain statistically significant. The placement of these two types of public services has a strong, independent influence on the fraction of community lands devoted to common uses that explains the impact of other community changes. Of course all these community changes are positively correlated (see Table 2), but government run dairy cooperatives and police facilities may be particularly likely to be placed on common lands. In fact, of all the dimensions of community context we have measured here, decisions about the placement of police stations are the most likely to have been made by government officials outside of the neighborhood rather than residents themselves. Given the government's lack of resources for purchasing land for these types of services, it seems extremely likely such services will continue to be placed on community common lands. Note from the final column in Table 3 that our model including both minutes to dairies and minutes to police stations explains approximately a fifth of the variance in fractions of community land devoted to common pasture and forests.

Table 4 provides our estimates of the impact of community characteristics on the fraction of community lands devoted to any agricultural use. Here we find a much different pattern of results than we did for our models of common pasture and forest lands. Access to opportunities, as measured by miles to the nearest urban center, has a very large and statistically significant influence on percentage of land devoted to agriculture. The further a neighborhood is from the urban center, Narayanghat, the higher the percentage of that neighborhood's land which is devoted to agriculture. Proximity to bus services also has a significant effect on agricultural land use, so that neighborhoods further from bus service have a higher fraction of land devoted to agriculture. Thus, these two measures of access to urban opportunities have important independent influences on agricultural lands. Neighborhoods near Narayanghat, or near the bus services that run to Narayanghat, have much better access to the wage labor and commercial opportunities which have blossomed in that urban area. This access is likely to motivate some farmers to abandon agriculture and take up alternative economic pursuits. This process is likely to result in the conversion of agricultural land to other uses.

TABLE 4

OLS Regression Estimates of the Impact of Community Characteristics on Percent of Local Land Devoted to Agriculture (t-ratio in parentheses)

Model	I	II	III	IV	V	VI	VII
Community Characteristics							
Access to Opportunities							
Miles to Urban Center	2.45***	2.52***	2.63***	2.64***	2.68***	2.55***	2.37***
	(4.78)	(5.09)	(5.34)	(5.21)	(5.27)	(5.15)	(4.65)
Minutes to Nearest Bus	.26*						.16
	(1.88)						(1.08)
Private Enterprises							
Minutes to Nearest Market		.31**					.24*
		(2.50)					(1.76)
Minutes to Nearest Mill			.43*				.38*
			(2.30)				(1.71)
Public Infrastructure							
Minutes to Nearest School				.29			−.10
				(.91)			(.28)
Minutes to Nearest Dairy					.06		−.25
					(.41)		(1.49)
Minutes to Nearest Police Station						.12*	.09*
						(2.26)	(1.75)
R-squared Adj	.20	.21	.21	.18	.17	.20	.23
N	132	132	132	132	132	132	132

*p < .05, **p < .01, *** p < .001 one-tailed.

Consistent with this interpretation, we also find that proximity to markets and grain mills has a statistically significant impact on the percent of land devoted to agriculture. The further a neighborhood is from markets and mills, the higher the fraction of that neighborhood's land that is used for agriculture. These features of the local context may have direct effects on land use, since private enterprises are more likely to be placed on private lands than they are on public lands. To the extent this has happened, nearby private enterprises which were placed on lands formerly devoted to agriculture contribute directly to the conversion of agricultural land to other uses. Of course, nearby private enterprise may have contributed to the conversion of agricultural lands in the same ways as access to the wage labor and commercial opportunities in Narayanghat. Nearby mills and market places may stimulate some farmers to abandon agriculture in order to pursue alternative income generating activities. This mechanism is likely to lead to the further conversion of agricultural lands to alternative uses.

As we described earlier, population processes may also be an important intervening mechanism linking community context to changes in land use. For example, access to Narayanghat also means access to health care infrastructure which is likely to reduce mortality (Sastry, 1996). In this high mortality setting any reduction in mortality is likely to produce population growth, and growth, in turn, is likely to stimulate the conversion of land out of agriculture and into housing. Of course, this explanation seems more likely to be consistent with access to the urban opportunities of Narayanghat than with the proximity to private businesses.

Among the public infrastructure we have measured, neither schools nor dairies have any significant influence on the fraction of land devoted to agriculture. Recall both had a significant impact on the common land remaining in neighborhoods. On the other hand, minutes to the nearest police station does have a significant impact on the fraction of land devoted to agriculture. The further a neighborhood is from police posts the higher is the fraction of land devoted to agriculture. Although this public service is not likely to be placed directly on agricultural lands, it may have important indirect effects on land use. The security that police provide may encourage farmers to invest in nonagricultural enterprises. This could lead to the conversion of land out of agriculture. Or, the presence of police posts may directly stimulate nonagricultural enterprises, such as services for the police themselves. This might also lead to the conversion of land out of agriculture.

Model VII in Table 4 provides a simultaneous estimate of the impact of all our measures of community context on the fraction of land in agriculture. The impact of miles to Narayanghat remains strong and statistically

significant. The impact of minutes to the nearest bus service is no longer significant, but all the other factors which were significant in previous models continue to exert a statistically significant influence on the fraction of land in agriculture in this combined model. That is, distance to the urban center, minutes to the nearest market, minutes to the nearest mill, and minutes to the nearest police station each make an independent contribution to the fraction of land remaining in agriculture. In fact, together these factors explain nearly a quarter of the total variance in land area devoted to agriculture in Chitwan (see Table 4). Thus multiple dimensions of contextual change contribute to the conversion of land out of agriculture in the communities in this predominantly agricultural valley.

CONCLUSION

In this paper we begin the process of reorienting studies of environmental quality toward the microlevel. Specifically, we explore the determinants of environmental quality at the community level. We limit ourselves to a single dimension of environmental quality: land use. However, in agricultural societies land use is a critical dimension of environmental quality. The conversion of public forest or other common lands into agricultural or other uses removes habitats for non-domesticated birds and animals, reduces the natural flora diversity, and depletes a natural resource that humans might have used for other purposes (such as grazing). Conversion of agricultural lands to alternative, nonagricultural uses increases pressure to intensify production on remaining agricultural land, or extensify production to previously uncultivated lands, in order to maintain constant food supplies. The process of extensification further reduces the availability of public forests and other common lands. The process of intensification increases the presence of other environmental hazards, such as chemical fertilizers, chemical pesticides, and irrigation (Pimental & Pimental, 1991). Thus changes in land use are likely to produce a broad range of environmental changes in this type of setting.

At the community level, we predict important effects of community characteristics on local land use patterns. The evidence we provide from rural Nepal is consistent with this prediction. Characteristics of local communities such as access to urban areas, the proximity of private enterprises, and the proximity of public services have a significant impact of the fraction of local land devoted to common forests or pastures and the fraction of local land devoted to any agricultural uses. However, our results also indicate some important differences in the relationships be-

tween different dimensions of the community context and various dimensions of land use.

Public services have a particularly important impact on the fraction of local land devoted to common forests or pasture. Our measures of proximity to urban areas had no significant impact on the fraction of land preserved for common uses. Our measures of proximity to private enterprises did have a significant effect on common land, but this effect was not independent of the impact of our measures of proximity to public infrastructure. Only proximity to government dairy cooperatives and police posts had significant effects on common land that were independent of the other community characteristics included in our model. The strong impact of these services on common land is reasonable in this setting because public services, especially police stations, are particularly likely to be placed directly on common lands. In fact, in a poor country like Nepal, where government does not have the money to purchase private lands to place new government services, the spread of government services is quite likely to come at the expense of common forest and pasture lands.

Access to urban opportunities and proximity of private enterprises, on the other hand, have a particularly strong influence on the fraction of local land devoted to agricultural uses. Distance between the community and the urban center, proximity to the nearest market place, and proximity to the nearest mill each have independent effects that significantly reduce the fraction of local land in agricultural uses. Proximity to schools and dairies does not have similar effects, though the proximity to police stations does. The impact of access to urban opportunities and private enterprise also seems reasonable in this setting. New private enterprises, such as mills and retail outlets, are quite likely to be placed on agricultural lands, directly contributing to the conversion of land out of agriculture. Proximity to these enterprises, as well as the wage labor and commercial opportunities in the urban center, are likely to motivate some farmers to abandon farming for alternative income generating activities. This process is also likely to stimulate conversion of agricultural lands into alternative uses. Apparently proximity to police posts has an independent effect stimulating this conversion as well.

Previous research has already demonstrated important connections between the local community context and population processes (Axinn & Fricke, 1996; Entwisle, Casterline, & Sayed, 1989; Sastry, 1996). The combination of these prior findings and the results of the study reported here raise the possibility that some community-level connections between population processes and environmental quality are the product of changes in local community characteristics. Of course the relationships between com-

munity characteristics and land use we document here may have been produced by intervening changes in population. However, we also have many good reasons to expect community characteristics to affect land use that are independent of population processes. These reasons include the direct conversion of common lands for placement of public services, the direct conversion of agricultural lands for placement of private enterprises, and indirect effects of community changes on land use via the reorganization of agriculture and competing income generating alternatives. Given these many possibilities, and the strong relationships between community characteristics and land use we document, it seems prudent to give careful attention to the role of community characteristics when evaluating the relationship between population processes and land use at the community level.

Land use is only one dimension of environmental quality, but based on our examination of land use the model of micro-level relationships between population processes and environmental changes we advocate demands explicit consideration of the impact of community characteristics on all environmental changes (see Figure 1). Our findings also lead us to advocate models which explicitly differentiate among community characteristics. We found public infrastructure is closely tied to the availability of common land while private enterprise and access to urban centers is closely tied to the availability of agricultural land. Differences in the impact of community changes on the environment are quite likely to depend on the precise characteristics of the changes themselves. Thus, discovery of the systematic uniformities in the relationship between dimensions of community change and dimensions of the environment also demands careful attention to the precise characteristics of specific community changes.

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