Community Context and Road Development in Rural Nepal

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ABSTRACT

The rising amount of attention paid to climate change and other dramatic shifts in Earth's natural processes have sparked an increase in research devoted to better understanding human-environmental interactions. Using data from the Chitwan Valley Family Study, I examine the potential effects that various community characteristics—such as the proximity to the nearest school, market, and police station—have on road development in neighborhoods in rural Nepal. Results suggest that these contextual variables, coupled with the geographical distance to the site's only urban center, affect neighborhoods independently over the time span stretching from 1996-2006. Generally, I hypothesize that as proximity to public infrastructure, such as schools, increases, the greater the change in the amount of neighborhood area that is devoted to roads. Here this increase in roads over time indicates a key change in environmental quality as well as an important change in the wider social and political setting.

INTRODUCTION

This paper expands upon the popular notion of human-environment interactions by exploring the relationship between community characteristics and land use. Here I study the relationship between roads and community context, with community context referring to neighborhood characteristics such as distance from urban centers proximity to non-family services. I consider land use as both a lens through which to better understand changing social values as well as a proxy for environmental quality. According to Logan and Molotch, land use and urban development reflect "human volition, cultural folkways and political activities" within a particular space, and are *not* the result of calculated, rational decision-making (Logan and Molotch, 1987, p. 8-9). Therefore, patterns of land use and urban development can "reflect social meanings, institutional values, and political goals within a geographical context" (Lo, 2010, p.529). Essentially, the way that communities are spatially organized can indicate what things the society deems most or least valuable, and the change over time of the physical structure of a place suggests changes in value of such characteristics. In the case of rural Nepal, an increase in the amount of land area devoted to roads in neighborhoods near schools or markets might signify an increase in the worth society places on access to education or a wage-labor job.

Conversely, land use is also a fundamental element of environmental quality. Changes in land use are a substantial contributor to greenhouse gas emissions, affect local microclimates, and result in habitat fragmentation which often compromises biodiversity. Often these changes in land use have unintended and unexpected ecological consequences; activities such as clearing vegetation and biomass for human use and rerouting natural hydrological systems to better benefit crop cultivation can harm the local environment and limit the uses land can support in the future (DeFries, Asner & Foley, 2006). Changes in land use are especially relevant in areas

where land, most notably agricultural land, is converted to make way for urban development including buildings, mills, and roads. Land use primarily affects environmental quality in two ways: (1) the direct effects that these various uses have on the local environment, and (2) the way that land use affects the organization and actions of everyday life. For example, an increase in urban development often means an increase in impervious surfaces such as tin roofs and concrete or dirt roads. Rainfall is unable to penetrate these surfaces and, rather than seeping back into the groundwater table, is washed across the surface as run-off. Run-off contributes to erosion, especially the loss of nutrient-rich topsoil, and flooding. Additionally, land use greatly affects the day-to-day interactions of its inhabitants and helps to shape the social patterns of a community.

It is likely that land use change and population processes occur reciprocally—people routinely alter the physical environments in which they live, and in turn the natural world affects the lives and behaviors of the people it sustains. Most analyses dealing with land use and population focus on the notion of "population pressure" (Ghimire and Mohai 2005; Bilsborrow and DeLargey 1991;Bongaarts 1996; Boserup 1965; Carr 2004; Cohen 1995; Ehrlich et al. 1993; Fox 1987, 1993; Jolly and Torrey 1993; Malthus 1798; Mortimore 1993; Wolman 1993). Population pressure is defined as the strain put on the land as the population density per unit land increases and greater resources are needed to support the people living there. This cycle often leads to agricultural intensification and the eventual degradation of the land. Conversely, land use affects human populations in numerous ways. Scholars such as Malthus (1798) have acknowledged the presence of this connection almost 200 years ago. Changes in land use, especially in an agricultural setting, help determine the social structure of communities and families. Even changes in the techniques used to work the land can bring about noteworthy

societal changes (Ghimire and Hoelter, 2007). It is important to remember, though, that local context greatly affects causal factors in both directions (Axinn and Barber, 2003).

POPULATION AND ENVIRONMENT AT THE COMMUNITY LEVEL

Most of the research conducted on the relationship between land use and various population processes primarily focuses on large scale, institutional changes rather than changes at the individual, household, or local community levels. Actions made on the micro-level by individuals or communities can have substantial impacts on the larger environment and society, and "because global environmental trends often have their genesis in interactions that take place on a fine spatial scale" (Yabiku, 2006, p. 446). However, it is important to analyze the relationship between community context and land use at the micro-level if our aim is to provide a better, more comprehensive understanding of how contextual social changes can affect and are reflected by the local environment.

STUDY SITE

The Western Chitwan Valley is located in South-Central Nepal, and provides an ideal location for studying the interaction between environmental conditions and social changes. Bounded by the Royal Chitwan National Park and Rapti River to the south, Nepal's East-West Highway and Barandabar to the East, and the Narayani River to the west and north, the Chitwan Valley was isolated and covered in thick tropical vegetation until the late 1950s. Home to the One-Horned Rhinoceros (*Rhinoceros unicornis*) and Bengal Tiger (*Panthera tigris tigris*), this area of Nepal was sparsely inhabited by humans until the Nepalese government opened the area for settlement in the mid-1950s. With the help of United States Agency for International Development (USAID), the Nepalese government cleared vast swaths of forest, eradicated malaria, and encouraged settlers to cultivate land which would eventually become their own property

(Barber, 1997). Many of these settlers came from mountainous areas where the land had already been seriously degraded by intensive agricultural practices, and landslides and floods had all but destroyed most of the available farmland (Barber, 1997; Yabiku, 2006). As these settlers from various ethnic groups made their way to the valley's flat land and fertile soil, Chitwan grew rapidly in population. Despite this surge in inhabitants, Chitwan remained largely isolated until the first all-weather road connecting it to large cities in India and Eastern Nepal was completed in 1979. More specifically, this road stimulated the growth of Chitwan's largest town, Narayanghat, into a key transportation hub in South-Central Nepal. The road brought with it a massive influx of governmental and health services, wage-paying jobs, markets, and modern modes of transport (Shivakoti et al, 1999). Social change was rapidly underway.

COMMUNITY CONTEXT AND LAND USE

Land use is a key indicator of the way that a community and the everyday lives of those living within the community is organized (Shivakoti et al, 1999). In this setting, the proportion of land dedicated to each various use illustrates the relative importance of each of these activities in the neighborhood. Traditionally, changes in land use are most often manifested in the proportion of land designated for crop cultivation as compared to land designated for non-agricultural activities (Shivakoti et al, 1999).

Police. Perceived violence in a neighborhood might impact the likelihood of that community investing in costly public infrastructure such as roads. Nepal has been the site of political unrest—including bombings and gun battles— with most of the violence concentrated in rural areas such as those found in the study sample. Therefore I hypothesize that neighborhoods closer in walking distance to police stations are less likely to be targeted by

violence for fear of governmental repercussions if caught. Conversely, as the distance between neighborhoods and the closest police station increases, the more likely violence is to occur in those neighborhoods. Because of the propensity for violence in neighborhoods farthest from police stations, I hypothesize that it is less likely that these neighborhoods will invest in roads and other costly infrastructure.

Urban Center. Because Chitwan is largely an agricultural setting, changes in land use most often reflect a switch in use from an agricultural system to a non-agricultural system. Proximity to urban opportunities such a markets can prompt individuals and families to either change their agricultural practices or even abandon agriculture altogether.

Market. Individuals living in neighborhoods closer in proximity to a marketplace are more likely to buy products that they are not able to makes themselves. These products can be manufactured goods that must be transported over great distances or goods that the consumer chooses to buy rather than grow or make himself. As the demand for products traded in the market increases, so does the desire for more roads, which facilitates an important mode of transport. Additionally, because people are buying and selling a greater proportion of goods in the market, there is less need to be self-sufficient. Families require less land to support them either because they can specialize in a particular output to sell in the market (which demands less land than growing multiple crops) or they rely on the market for a greater proportion of their food and other products (meaning that they produce a smaller proportion of total things consumed). This decrease in the value of agricultural land relative to roads leads to the expectation that I will find an increase in roads over time in areas near a market.

School. Another important force shaping road development in rural Nepal is the effect of land use change, particularly roads, on the value of private property. Land near a road, especially those parcels adjacent to a road, are more economically valuable than land that is more isolated. Land closer to a road is a much more desirable location for building new structures such as schools than land farther from roads. Even if a landowner never plans on actually selling any of his property, the financial assurance that the land potentially provides is comforting and desirable to those landowners. This leads to the expectation that as proximity to non-family services like schools increases, the relative value of land increases when it is converted into roads as opposed to if it is left unchagned from its original use.

Overall Prediction for Changes in Land Use

I hypothesize that neighborhoods closer in proximity to governmental and non-family services will undergo the greatest increase in road development from 1996 to 2006. Access to urban opportunities like schooling and markets increases as proximity to these services increases; therefore I expect square footage of roads to increase over time in neighborhoods close to these institutions. Second, I predict that neighborhoods close to police stations will experience an increase in road development over time because communities are more likely to invest the capital in road infrastructure if there is not a substantial risk of these roads being destroyed as a result of political conflict in neighborhoods farther from police stations. Lastly, I hypothesize those neighborhoods closer in proximity to the urban center should experience a significant increase in square footage of road area.

DATA AND METHODS

My project analyzes data from the Chitwan Valley Family Study (CVFS), which were collected in Western Chitwan beginning in 1996. My sample includes 151 neighborhoods chosen systematically and with equal probability from the study site (Barber et al. 1997). Each neighborhood is defined as a cluster of 5-15 homes with a delineated boundary separating each neighborhood from surrounding areas. This ensures that each area of land in Chitwan may fall into the sample only one time. Next, twenty additional neighborhoods were purposely added to the sample to provide variance on ethnicity and fundamental indicators of social change, bringing the total sample size to 171 neighborhoods. Neighborhoods are divided into three separate strata based on their geographic distance to Narayanghat, the largest metropolitan area in Chitwan: close to Narayanghat, farther from Narayanghat, and farthest from Narayanghat. Neighborhoods such as these are meaningful spatial units in rural Nepal because they represent the area in which individuals interact on a daily basis. They provide an important measure of local context in this study (Axinn, Barber & Biddlecom, 2005). The neighborhoods chosen in this sample accurately represent the Chitwan Valley as a whole (Barber et al, 1997). The neighborhoods range in size from the smallest measuring 3,809 ft^2 to the largest measuring 3,223,438 ft^2. The mean neighborhood size in the sample is 812,523.67 ft^2 and the standard deviations 701,887.81 ft^2.

Measures of Land Use

For measures of land use, a research team first surveyed each neighborhood using tape measures and compasses in 1996. These measurements were then computerized and used to determine the amount of square feet of land in each neighborhood devoted to each particular land

use. Categories of land use include common land (public and private grazing land), agricultural land (high lands and rain fed and irrigated low lands), forests (for collecting fuel wood and fodder), and land devoted to other uses (schools, roads, canals etc.). Measurements were taken following the exact same neighborhood boundaries again in 2000 and 2006.

Here I specifically focus my attention on the square footage of roads in each neighborhood, and specifically the change in the amount of land devoted to roads over time for the decade ranging from 1996 to 2006. To analyze this change over time I have created three new measures: the difference in road area from Time 1 (1996) to Time 3 (2006), the difference in road area from Time 1 (1996) to Time 2 (2000), and the difference in road area from Time 2 (2000) to Time 3 (2006) in each particular neighborhood.

Measures of Community Context

The community context variables measuring proximity to the nearest market, school, and police station were collected in 1995 by way of the Neighborhood History Calendar method, a data collection strategy designed to document event histories at the community level over time. This method is advantageous because it directly collects contextual data rather than relying on aggregation of individual level data, allows researchers to differentiate between similar contexts that may have evolved differently over time, and allows the community level contextual history to be easily coupled with individual level data to create dynamic multilevel models (Axinn, Barber & Ghimire, 1997). The Neighborhood History Calendar was used to gather data about the proximity of each neighborhood to various governmental and non-family services. Historically these services (i.e. healthcare, schooling) were performed within the household; however, as this setting experiences rapid social change, more people are turning the non-family organizations for

these services (Yabiku, 2006). To measure proximity I use walking distance in minutes, or the number of minutes it takes a person to walk from his or her neighborhood to the nearest of each of these services. This measurement is appropriate in this setting because few people have cars and most people rely on walking as their primary mode of transportation. In this paper, I focus on how three particular community context variables affect neighborhood road development: minutes it takes to walk to the nearest market, police station, and school.

Additionally, in this model I control for distance (in miles) to Narayanghat, Chitwan's only urban center. Because most governmental and non-family services originated in this urban center and subsequently radiated out from this point, I want to control for any unexpected or unseen effects related to proximity to the urban center (Shivakoti et al, 1999). This measure also approximates the affect of proximity to the urban center on the amount of roads per neighborhood (Shivakoti et al, 1999).

To find the distance of each neighborhood to Narayanghat, the geographic coordinates of each neighborhood were determined by examining maps (1:25,000) based on aerial photographs. These positions were then submitted into a Geographic Information System (GIS) in order to determine the number of miles between each neighborhood and the city center (1999).

One disadvantage that occurs when trying to evaluate the effects of these non-family services is that they often take place simultaneously (Casterline, 1985; Shivakoti et al, 1999). Table 1 displays the bivariate correlations among the community context variables and change in amount of land use from 1996-2006. All of the correlations are slight; the highest correlation is between minutes to the nearest market and minutes to the nearest police station and measures .20.

Therefore, I will attempt to evaluate the independent impacts that each of these measures have on change in square footage of roads over time.

[Table 1, About Here]

Analytic Strategy

Because square footage of roads in this center is a continuous variable, I use the Ordinary Least Squares (OLS) Regression statistical test in order to approximate the effect of my multivariate model on the change in amount of roads per neighborhood over time.

RESULTS

Table 2 provides the descriptive statistics for both the land use and community context variables used in this study. Under my hypotheses, I expected to see an increase over time, or at least no difference, in the amount of land devoted to roads in every neighborhood. However, in all time periods the minimum value of change in amount of roads is a negative number, which suggests that there are neighborhoods in all three time periods experiencing a decrease in the amount of land area devoted to roads.

From 1996-2000 the quantity of land devoted to roads increased on average by a mean value of 3,052 ft^2. Conversely, from 2000-2006 land area in each neighborhood devoted to roads actually decreased on average by a mean value of -754.78 ft^2, which is contrary to what I had predicted would happen. Compared to the standard deviation this number is extremely small, yet it is notable because this result is not what I would have expected. The overall difference in land area covered by roads (1996-2006) is an average of the mean values found for the two aforementioned periods, showing that neighborhoods on average grew by mean value of 2,297

ft^2. Although the average land area allocated for roads increased across the entire time period, some neighborhoods underwent a decline in road area, which is an occurrence that does not support any of my original hypotheses. In total, road area in 107 and of the 171 neighborhoods evaluated in this paper actually decreased from 1996-2006.

[Table 2, About Here]

Change in Area Devoted to Roads 1996-2000

Table 3 displays the results of the multivariate OLS model run for each of the three variables measuring change over time: 1996-2000, 2000-2006, and 1999-2006. The distance to the urban center, Narayanghat, has a strong, significant effect on the amount of land devoted to roads in neighborhoods from 1996-2000. Neighborhoods closer to Narayanghat have a significantly greater amount of roads in 2000 than they did in 1996. For each mile closer to Narayanghat, the area of land occupied by roads in a particular neighborhood increased by 479.32 ft^2 on average.

Neither minutes to the nearest market nor minutes to the nearest police station have any significant impact on the amount of land dedicated to roads over the time period 1996 to 2000.

In contrast, minutes to the nearest school has a significant t-value (t=2.07), which is interesting because it suggests that proximity to the nearest school does have an impact on the development of roads—but not in the direction that I had originally predicted. Rather, this result indicates that as walking distance from the nearest school increases, so does the amount of land dedicated to roads. One possible explanation for this result is that neighborhoods farther away from the nearest school have fewer roads initially, making the construction of new roads necessary in order for students to attend the school.

Change in Area Devoted to Roads 2000-2006

From 2000-2006, the variables measuring minutes to the nearest market, police station, and school have no significant influence on road development. However, like the result measuring proximity to schools discussed above, distance to Narayanghat has a very high t-value (1.99). This finding suggests that as walking distance to the urban center increases, so does the square footage of roads per neighborhood. This statistic is interesting not only because it is different from what I had hypothesized, but is opposite from what happened during the first time interval. Whereas land area devoted to roads increased as proximity to Narayanghat increased from 1996-2000, land area allocated for roads increased as neighborhoods got farther away from Narayanghat in the period from 2000 to 2006. The parameter estimate for distance to the urban center actually changes sign, resulting in a 346.98 ft^2 decrease in road area per neighborhood on average for each mile closer to the urban center. One potential explanation for this result is that because the square footage of land devoted to roads increased so much in neighborhoods closer to Narayanghat from 1996-2000, these neighborhoods no longer required any more roads. Rather, neighborhoods farther from the urban center may have had fewer roads initially, thereby making the construction of new roads in these areas useful for accessing non-family services that were previously out of reach.

Change in Area Devoted to Roads 1996-2006

The results from 1996-2006 are essentially just the averages of the values from both of the aforementioned time periods. This fact helps to explain why distance to the urban center has no significant impact over the entire time period of 1996-2006. The parameter estimate for the first time interval is negative and the parameter for the second time interval is positive, which

combine to result in a non-significant statistic that masks the fluctuations of this variable over time.

[Table 3, About Here]

CONCLUSION

In this paper I explored the relationship between local community context and neighborhood road development over time. I hypothesized that as walking distance to governmental and non-family services such as markets, schools, and police stations decreased, the amount of land area devoted to roads in each neighborhood would increase over time. Proximity to Narayanghat during the time period from 1996-2000 produced the most significant effect on the change in amount of land area dedicated to roads.

The proximity to the nearest school also had a dramatic effect on the amount of roads per neighborhood for the time period ranging from 1996- 2001. However, this result was opposite that which I had hypothesized. Rather than neighborhoods experiencing an increase in road area when the walking distance to the nearest school decreased, road area was more likely to experience growth as distance to the nearest school increased. One possible reason for this outcome is that new roads are required for students to get to school in neighborhoods that are farther away from a school, and it might be more likely that these neighborhoods have less road infrastructure initially. Distance to the nearest school has traditionally been a substantial determinant of whether or not parents decide to send their children to school in Chitwan, but because the maximum time it took to walk to the nearest school was only 20 minutes in 1995, distance might not have been a factor influencing school attendance in this case. Had the range of this variable been larger, say from a couple minutes to multiple hours, perhaps proximity to

the nearest school would have played a more important role in determining whether or not a child would attend school, consequently affecting the number of roads necessary or desired by a community.

There exists a marked difference in the results from the first time period I studied (1996-2000) as compared to that of the second time period (2000-2006). One potential explanation for this occurrence is that Nepal has been the site of political unrest for roughly the last decade. Violence from this Maoist insurgency escalated more or less around 2000: the separation date for the two time periods I examine in this paper. It is possible that this conflict affected the development of new infrastructure such as roads, or perhaps it changed various attitudes of the people living in these communities. Rather than focusing on changes in local context like proximity to urban opportunities like markets and schools, this conflict may have forced people to concentrate on needs like mitigating damage to their property and avoiding violence.

Examining local community context and the impact that these factors have on land use is an important step in furthering the body of research concerning human-environment interactions. Community context greatly affects both the way that humans affect their surroundings as well as how the environment shapes daily human activity. In this case, the effects that these contextual variables have on road development is important in determining what factors may or may not contribute to an increase in roads in rural areas like Chitwan. As non-family services proliferate and take over roles historically provided within the household, the likelihood of change in land use toward more urban development increases. Increases urban development like roads can have many beneficial outcomes such as increased access to wage labor jobs and other economic or educational opportunities. But it can also have potentially negative consequences: degraded soils, increased runoff, and flooding. Therefore, a better understanding of some of the fine

determinants of change in land use can lead to more sustainable development in rural areas like Chitwan.

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TABLE 1

Pearson's Correlation Coefficients for Land Use and Community Characteristics

	Sq. Feet Roads '96-'06	Miles to Urban Center	Minutes to School	Minutes to Market	Minutes to Police Station
Land Use					
Sq. Feet Roads per Neighborhood	1.00	-.04	.09	-.04	.01
Community Characteristics					
Miles to Urban Center		1.00	.15	.14	.10
Minutes to Nearest School			1.00	.18	.09
Minutes to Nearest Market				1.00	.20
Minutes to Nearest Police Station					1.00

TABLE 2

Descriptive Statistics for Measures of Land Use and Community Context

	Standard Deviation	Mean	Minimum	Maximum
Land Use				
Sq. Feet Roads per Neighborhood in 1996	27,202	36,186	1,080	171,305
Sq. Feet Roads per Neighborhood in 2000	26,601	39,238	0	154,470
Sq. Feet Roads per Neighborhood in 2006	25,800	38,483	0	148,947
Change in Roads—1996-2006	11,415	2,297	-36,946	46,196
Change in Roads—1996-2000	9,944	3,052	-29,369	37,598
Change in Roads—2000-2006	8,755	-754.78	-40,051	38,277
Community Characteristics				
Miles to Urban Center	3.93	8.24	.02	17.7
Minutes to Nearest School	5.81	8.80	0	20
Minutes to Nearest Market	15.66	11.91	0	120
Minutes to Nearest Police Station	37.88	64.92	2	240

TABLE 3

OLS Regression Estimates of the Impact of Community Characteristics on Square Feet of Land Devoted to Roads (t-ratio in parentheses)

Time Periods	1996-2000	2000-2006	1996-2006
Community Characteristics			
Miles to Urban Center	-479.32*	346.98	-132.34
	(-2.46)	(1.99)	(-.58)
Minutes to Nearest School	273.65	-57.36	216.29
	(2.07)	(-.48)	(1.39)
Minutes to Nearest Market	-31.46	-11.10	-42.56
	(-.63)	(-.25)	(-.73)
Minutes to Nearest Police Station	3.61	.09	3.69
	(.18)	(.00)	(.16)
R-squared Adjusted	.03	.00	-.01
N	171	171	171

*p<.05, one-tailed