Environmental Effects on Family Size Preferences and Subsequent Reproductive Behavior in Nepal

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This study investigates the relationship between environmental degradation and men and women's family size preferences and subsequent reproductive behaviors in Nepal. We draw on unique environmental data at the local level, household and individual-level survey data and individuals' reproductive behavior over a 3 year time period in Western Chitwan Valley, Nepal. Results from Ordinary Least Squares (OLS) and logistic regression models show that poorer environmental quality and greater reliance on publicly owned natural resources are associated with higher family size preferences and higher rates of pregnancy. The analyses provide support for the ''vicious circle'' argument that environmental degradation can lead to rising population growth via positive effects on fertility. As environmental conditions decline and when households rely on public lands for natural resources, men and women desire larger family sizes and women are more likely to get pregnant in the near future.

KEYWORDS: Environment; fertility; Nepal.

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INTRODUCTION

The purpose of this study is to investigate the effects of environmental quality at the local-level on the reproductive preferences and subsequent behaviors of men and women. Much of the empirical record on the relationship between population and the physical characteristics of the environment is based on macro-level data (Pebley, 1998), such as satellite images of land use and population density. This study advances our knowledge by utilizing multiple measures of local environmental conditions to examine the impact of those conditions on individuals' family size preferences and subsequent fertility behavior.

Our analyses are grounded in a theoretical framework that recognizes the complex and potentially reciprocal relationships between environmental conditions and fertility preferences and behavior. On the one hand, there are good theoretical reasons to expect that poor environmental conditions produce lower demand for children and lower subsequent fertility. On the other hand, there is also an emerging set of theoretical arguments proposing that poor environmental quality may actually lead to higher demand for children and higher fertility. Furthermore, there is also good reason to expect that fertility behavior via population growth and population density may impact environmental conditions (Rosero-Bixby & Palloni, 1998; Axinn & Ghimire, 2002; Foster & Rosenzweig, 2003). Thus, sorting among these competing hypotheses requires careful empirical attention to the possibility of reciprocal relationships between environmental conditions and fertility. Appropriate analytic strategies for examining these hypotheses demand substantial longitudinal measurement.

We take advantage of newly available micro-level, longitudinal measurement of environmental conditions, childbearing preferences, and fertility behaviors to explore these important hypotheses. Data from the Chitwan Valley in rural Nepal provide measures of local level variance in environmental conditions at one point in time and a record of subsequent childbearing preferences and fertility. The same data provide rich measurement of behavior preceding the environmental measures, allowing us to control for previous fertility and associated experiences when evaluating the impact of environmental conditions on subsequent fertility. The results provide empirical evidence regarding the overall impact of environmental conditions on fertility preferences and behavior.

THEORETICAL FRAMEWORK

In general, demand theories of fertility would predict a positive relationship between environmental quality and the desire for children (Becker, 1976). As environmental conditions deteriorate, the demand for children may weaken for two reasons. The first reason is an income effect: In agricultural settings, lower productivity from the land results in lower household income, which in turn decreases the demand for children because households can no longer provide for as many children. Second, declines in environmental quality make commonly used natural resources more scarce (e.g., wood for fuel) and, all things being equal, the value of children's labor for household activities like collecting wood would decline.

However, environmental degradation has also been argued to lead to an increase in the demand for children. The ''vicious circle'' argument postulates just such a negative relationship for rural, subsistence-based economies. O'Neill, MacKellar, and Lutz (2001) provide a concise review of the vicious circle argument and empirical evidence for the feedback effects between the key factors of this model: environmental degradation, high fertility, poverty and the low status of women and children. In short, as natural resources are depleted, people must travel further to collect resources such as wood for fuel or grasses for fodder. Poverty conditions make it very difficult to obtain alternative sources of domestic energy, such as gas stoves. The low status of women and children further ''devalues the increasing time and effort that they must devote to daily gathering of wood and other environmental products'' (O'Neill, MacKellar, & Lutz, 2001). The value of children's labor for obtaining these needed natural resources rises, and men and women thus desire larger family sizes and bear more children. The more children people have, the higher the population density and the more environmental conditions may deteriorate (Rosero-Bixby & Palloni, 1998), which in turn motivates people to have large families; hence, the ''vicious circle'' between environmental quality and population growth.

In particular, if households obtain natural resources for consumption from open access lands—that is, public or common lands where families do not absorb the full cost of consuming natural resources—then the value of children as household producers is likely to be higher as these natural resources become more scarce. In examining the vicious circle argument, Filmer and Pritchett (2002) used data from the 1991 Pakistan Integrated Household Survey and found that households living in areas with greater problems with wood supply or in areas that were further away from a wood source had a higher probability of a birth in the past 5 years. The evidence

supporting a vicious circle argument, though, was not consistent across geographic areas in Pakistan or across multiple indicators of resource scarcity.

A key part of the vicious circle argument is the low status of women and children and the reliance of households on the labor of women and children to obtain natural resources. In fact, existing evidence shows that women and children are primarily responsible in many rural, subsistence-based economies for collecting fuel wood, fodder and water and conducting much of the work on family farms (Dasgupta, 1993). In Nepal, where this study is set, age and gender differences in who collects natural resources are pronounced. For example, in the hill areas of Nepal, children devote more than two-thirds of their time in household activities to the collection of natural resources (such as fuel wood, water, grass and leaf fodder) while adult women spend 40 percent of their time in such activities (Kumar & Hotchkiss, 1988). In-depth, time-use studies of six villages in different geographic areas of rural Nepal found that while women and men spent about the same average number of hours per day on agricultural activities (2.74 vs. 2.73 h, respectively), women spent more time than men on fuel and water collection (1.05 vs. 0.31 h, respectively) (Acharya & Bennett, 1981: 158). Another study in the hill areas of Nepal, using data from the 1982–1983 Nepal Energy and Nutrition Survey, found that any increases in time spent collecting environmental goods came mainly from women's time (Cooke, 1998). Because women disproportionately bear the costs of obtaining natural resources for household use, the impact of environmental degradation on fertility should be stronger among women than men.

This paper examines whether there is empirical support for the vicious circle explanation of links between environmental degradation and fertility. The study setting is in the rural area of Western Chitwan Valley, Nepal, where the majority of households are still directly reliant on local natural resources for production needs. Over three-quarters of households raise livestock and 98 percent of these households spend time collecting fodder, with an average of 150 min spent in a roundtrip to collect fodder (Matthews, Shivakoti, & Chhetri, 2000: 69). We examine the effect of environmental quality on family size preferences and fertility behavior using multiple data sets that were specifically designed to test population and environment relationships at the micro-level. We draw on (1) tree and shrub counts (species and number) from the three main forests in the study site; (2) household-level measures of natural resource consumption and living standards; (3) individual-level measures of family size preferences and socio-demographic characteristics; and (4) three years of monthly household registry data on pregnancy. The four data sets allow for measurement

of different facets of environmental quality, including abundance, household consumption and collection activities, and perceptions of local environmental degradation, and men's and women's reproductive preferences and subsequent behaviors. The result is an unprecedented opportunity to examine systematically the relationship between variations in local environmental quality and variations in the childbearing preferences of women and men and their subsequent reproductive behaviors.

STUDY SETTING

Western Chitwan Valley is in South-Central Nepal and is roughly 240 km^2 (92 square miles). The valley is bounded by the Rapti River and the Royal Chitwan National Park on the south, Barandabar Forest on the east, and the Naranyani River (and various small forest areas) on the west and north. The largest town Narayanghat and the East–West highway, located along the north-east boundary of Chitwan Valley, have helped to introduce a host of social and economic changes throughout the study site since the early 1980s. As communities have changed in terms of the proximity to urban areas, public services (e.g., schools) and private enterprises (e.g., markets), so too has the local environment as lands are converted away from common use forests, pastures and agricultural activities to non-agricultural uses (Shivakoti et al., 1999; Matthews, Shivakoti, & Chhetri, 2000).

The management and control of natural resources is a relevant part of people's consumption of natural resources and the larger relationship between population pressure and environmental degradation. The three main forest areas in this study site, while under some degree of national protection, are still much used by communities as sources of fuel wood and fodder. In fact, about three-quarters of the neighborhoods in this study harvested and grazed animals in the surrounding forest areas of Chitwan Valley (Matthews, Shivakoti, & Chhetri, 2000), and more than three-quarters of households that collect wood do so from public lands. Even in a patrolled, government-managed forest, where communities are allowed very limited forest resource extraction, there was evidence of livestock damage (such as trampled flora) in all of the 62 plots examined (Matthews, Shivakoti, & Chhetri, 2000). The same study also documented that tree and shrub diversity decreased with distance from the interior toward the forest edge, where human use of resources is more widespread.

With respect to fertility preferences and behaviors, Nepal has undergone a steady decline in fertility since the 1970s and the norms underlying family size appear to be changing. The total fertility rate has fallen from

5.1 births for the period 1984–1986 to 4.1 for the period 1998–2000 (4.4 in rural areas and 2.1 in urban areas) (Ministry of Health [Nepal], New ERA & ORC Macro, 2002: 57–58). Men and women's ideal family size in Nepal is relatively small: the mean ideal number of children is 2.6 among ever-married women and 2.8 among ever-married men, with a difference of less than one child on average by urban and rural residence (Ministry of Health [Nepal], New ERA & ORC Macro, 2002: 123). Only 15 percent of ever-married women and 18 percent of ever-married men have an ideal family size of 4 or more children (Ministry of Health [Nepal], New ERA & ORC Macro, 2002: 122). Thus, preferences are for small families, but in rural areas these preferences are not being realized to the extent they are in urban areas.

DATA AND METHODS

The data for this study were collected in Western Chitwan Valley beginning in 1996. First, a systematic sample of 151 neighborhoods in Chitwan Valley was selected. The neighborhoods were chosen by mapping all the households in Western Chitwan Valley and selecting an equal probability, systematic sample of 151 clusters of five to fifteen households. In rural Nepal these are meaningful spatial units where individuals interact with one another on a daily basis and were chosen to represent an extremely local level of social context.

Building on this household-based selection of clusters, boundaries were established around the neighborhoods, which gave every unit of land in Chitwan one and only one chance of falling within the sample. Twenty additional neighborhoods were purposively selected to ensure variance on key dimensions of social change and ethnicity, bringing the total sample of neighborhoods to 171. A combination of Global Positioning System (GPS) readings and a topographic survey map of Chitwan Valley were used to determine exact latitude and longitude locations of each neighborhood in the study, and these locations were entered into a Geographic Information Systems (GIS) database.

Flora count data were collected by hand in early 1996 in 127 plots systematically selected in the three main forests bordering Western Chitwan Valley. These counts are direct measures of the environmental quality of the forests that surround Chitwan Valley. Locations of the flora plots were also entered into a GIS database to identify the nearest forest plot (in km) for each survey respondent's neighborhood. We use a measure of abundance—a count of the number of trees and shrubs in the forest plot nearest

to a respondent's neighborhood—as an indicator of availability of natural resources for fuel and fodder (see Kent & Coker, 1992). We assume that the characteristics of the nearest forest plot represent the resource scarcity within public lands that people in those neighborhoods on average encounter. If the vicious circle argument holds true in this setting, we would expect that people living near forest areas with fewer trees and shrubs are motivated to have larger families than people living near forest areas with a greater abundance of shrubs and trees. The total count of trees and shrubs in each plot was divided by 10 such that a unit change represents what a difference in 10 trees and shrubs would have on fertility preferences and outcomes. Table 1 shows descriptive statistics for all independent and dependent measures in this study. The range of flora abundance in the nearest forest plot to a person's home ranged from 1 shrub or tree to 289, and the mean number was 43 shrubs and trees (Table 1).

A household agricultural survey was also conducted in mid-1996 to obtain information about the agricultural practices, living standards, consumption of environmental goods (such as fuel wood and fodder) and perceptions of environmental change in Chitwan Valley. The household survey had a response rate of 100 percent. Survey data are for all 1,805 households from the 171 neighborhoods in the study sample. Given that the vast majority of households in this rural setting collect fodder (98 percent of households in 1996) and wood for fuel (92 percent) (Matthews, Shivakoti, & Chhetri, 2000: 769), we construct environmental measures from these data that focus on these two natural resources. The first set of measures is the time it takes on average to collect fodder or fuel wood in one roundtrip (these questions were only asked of households that collected fodder or fuel wood). We expect that the longer it takes to collect these natural resources, the more likely people are to want large families and to continue childbearing. Table 1 shows that the average time reported for a roundtrip to collect wood and fodder (among households that collect these resources) was 5½ h for wood and nearly 2 h for fodder. The number of animals the family feeds and the distance to the sites for fodder or fuel wood likely drive the length of time it takes to collect these resources.

We also draw on people's reports of how long on average it took the household to collect fodder or fuel wood three years prior to the survey to create a measure of change over time in these crucial labor activities. Dichotomous variables of whether or not collection time increased by 1 h or more over the past three years are used in the models as a proxy for environmental degradation, assuming that as fodder and fuel wood resources are depleted, people have to search farther for these materials. A threshold of 1 h or more was set to indicate a marked change in work

TABLE 1

Descriptive Statistics for Married Men and Women, Chitwan, Nepal 1996–1999

Variable	MEN				WOMEN			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Coombs scale	6.46	2.63	2	23	6.69	2.47	1	25
Became pregnant in 36 months following baseline survey[a]	–	–	–	–	0.28	0.45	0	1
Environmental measures								
Number of trees and shrubs in nearest forest plot/10	4.25	4.02	0.1	28.9	4.25	4.17	0.1	28.9
Time to collect wood in 1 roundtrip (hours)	5.48	2.75	1	9	5.45	2.79	1	9
Time to collect wood now is 1 + hours more than 3 years ago	0.09	0.29	0	1	0.09	0.29	0	1
Time to collect fodder in 1 roundtrip (hours)	1.94	1.19	1	9	1.89	1.15	1	7
Time to collect fodder now is 1 + hours more than 3 years ago	0.03	0.16	0	1	0.02	0.14	0	1
Household collects wood from public land	0.88	0.33	0	1	0.85	0.36	0	1
Household collects fodder from public land	0.21	0.41	0	1	0.20	0.40	0	1
Any kids in household collect wood	0.09	0.29	0	1	0.11	0.32	0	1
Individual-level controls								
Age 18–24	0.11	0.32	0	1	0.27	0.44	0	1
Age 25–34	0.57	0.50	0	1	0.48	0.50	0	1
Age 35–40	0.31	0.46	0	1	0.25	0.43	0	1
Age at first marriage	20.26	3.65	9	37	16.47	2.79	7	33
Years from first marriage to first birth	2.71	2.35	0	17	2.54	2.08	0	17
Years of school before first marriage	7.56	5.21	0	22	3.71	4.65	0	19
Parents have any education	0.27	0.51	0	2	0.35	0.55	0	2
Ever used contraception	0.67	0.47	0	1	0.61	0.49	0	1
Total number living children	2.67	1.31	1	9	2.83	1.38	0	1
Number of living male children	1.37	0.98	0	7	1.44	0.95	0	1
Ever had a child die	0.18	0.38	0	1	0.21	0.41	0	1
High caste Hindu	0.42	0.49	0	1	0.47	0.50	0	1

TABLE 1

Continued

Variable	MEN				WOMEN			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Low caste Hindu	0.13	0.33	0	1	0.11	0.31	0	1
Newar	0.05	0.22	0	1	0.06	0.24	0	1
Hill Tibetoburmese	0.14	0.35	0	1	0.16	0.36	0	1
Terai Tibetoburmese	0.21	0.40	0	1	0.19	0.39	0	1
Household-level controls								
Has toilet	0.56	0.50	0	1	0.57	0.50	0	1
Has electricity	0.37	0.48	0	1	0.35	0.48	0	1
Index of consumer durables	1.11	1.03	0	5	1.11	1.03	0	5
Index of housing quality	8.52	3.94	4	17	8.45	3.78	4	17
Own home	0.62	0.48	0	1	0.65	0.48	0	1
Own any bari land	0.43	0.50	0	1	0.44	0.50	0	1
Own any khet land	0.42	0.49	0	1	0.45	0.50	0	1
Sample size	948				1218			

Sample: Currently married men and women age 18–40 years old with at least 1 living child.
[a]Sample is limited to 739 married women age 18–40 years old with at least 1 living child and who were not sterilized as of 1996.

burden and to avoid small degrees of change (e.g., differences of several minutes) that are more likely attributable to recall error alone. Nine percent of people reported an increase of 1 h more to collect wood in the past three years and 2–3 percent reported such a dramatic increase in time for collecting fodder (see Table 1).

Another set of measures, also constructed separately for fodder and fuel wood, is if the source is common land—that, is publicly owned land—-which includes both internal common lands and the surrounding forests. These measures are directly aimed at exploring the hypothesis that if households rely on public sources for environmental goods—a cornerstone of the vicious circle argument—they will respond to environmental degradation by increasing their family sizes since they do not bear the full cost of depleting these natural resources. While the GIS-linked data provide a measure of relative availability of forest resources, these self-report data provide information about actual utilization of resources from forests and other public lands. Among people in households that collect wood and fodder, the vast majority rely on public lands for fuel wood (85–88 percent) while private lands are the main source for fodder collection—only one-fifth of people relied on public lands for fodder collection (see Table 1). The indicators capture the basic yet crucial distinction between reliance on public vs. private lands for natural resources.

Children's labor is also a key component of the vicious circle argument. Given the predominant reliance on public lands for fuel wood collection and the longer average length of time it takes to collect fuel wood (vs. fodder), we use the household survey data to construct a dichotomous measure of whether children age 15 or younger in the household collect wood (again, this question was asked only of households that collected wood). We would expect that households that are reliant on child labor for collecting this key natural resource are also going to be more inclined to larger family sizes and higher subsequent fertility. Approximately 10 percent of men and women lived in households where young children collected wood (Table 1).

Two dependent variables are examined: family size desires of men and women and whether or not women had a pregnancy in the three years following when the environmental and household measures were made. For the measure of family size desires and the individual-level control variables, we use data from a survey of individuals conducted in 1996. This survey followed from the household survey described above and consisted of interviews with every household member 15–59 years old. A total of 5,271 men and women were interviewed and the overall response rate was 97 percent.

We use a continuous measure for family size preferences, the Coombs scale, which is sensitive to variations from individuals' first choices of family size and has been shown to be consistently predictive of future childbearing behavior (Coombs, 1974). Each respondent is asked: ''People often do not have exactly the same number of children they want to have. If you could have exactly the number of children you want, how many children would you want to have?'' The respondent is then asked, ''If you could not have exactly (the number the respondent gave) children, would you want to have (one number lower) or (one number higher)?'' The answer to that question is then used in a third question: ''If you could not have that number, would you want to have (the next lower number not mentioned) or (the next higher number not mentioned)?'' The final range for the Coombs scale is 1–25 children, with 1 representing a very low underlying desired family size and 25 representing a very high underlying desired family size. We use Ordinary Least Squares (OLS) regression models for the multivariate analyses of family size because the outcome is a continuous variable.

Data on pregnancy are from the household registry system, an ongoing, monthly data collection activity that records fertility, contraceptive use, mortality, marriage and migration events in study households (see Shrestha, Shrestha, & Biddlecom (2002) for a detailed description of the registry system). The pregnancy outcome is measured as a dichotomous variable of whether or not a woman became pregnant in the 36 months following the environmental and household surveys. We use logistic regression models to estimate the effects of environmental quality on subsequent pregnancy. The models can be expressed as:

$$\ln\left(p/(1-p)\right) = \alpha + \Sigma\left(\beta_k\right)\left(X_k\right),$$

where p is the probability of becoming pregnant, $p/(1-p)$ is the odds of becoming pregnant, α is the constant term, β_k represents the effects parameters of the independent variables and X_k represents the independent variables in the model. The analytic samples for this study are married women and men ages 18–40 years old at the time of the individual survey in 1996 and who had at least one living child. The sample is further restricted to women who had never been sterilized as of 1996 for the models predicting pregnancy in the 36 months subsequent to the baseline measures.

Control variables for these models of reproductive preferences and behaviors, based on extensive prior investigation of fertility behavior in this setting, are birth cohort, age at first marriage, years of school before first marriage, parental education, prior childbearing and contraceptive

experiences, and ethnicity (Axinn & Barber, 2001; Axinn & Yabiku 2001). We also use the 1996 household survey data to construct a number of household living standards measures to test whether the relationship between environmental conditions and fertility preferences and behaviors remains after accounting for the economic status of the household.

All data on prior marital, childbearing and contraceptive experiences were collected using a life history calendar that used timing cues to prompt accurate recall and dating of these events (see Axinn, Pearce, & Ghimire, 1999). We use three birth cohorts: 1972–1978 (age 18–24 at the time of the survey), 1962–1971 (age 25–34 at the survey), and 1956–1961 (age 35–40 at the survey). The measure of the youngest birth cohort, 1972–1978, is the reference group and is omitted from the models. Age at first marriage is a control variable for the tempo of family formation. Prior childbearing experiences—measured as the number of living children, the number of sons, and whether or not a child has died—and prior contraceptive use (measured as a dichotomous variable of ever used any contraceptive method) are also included to prevent environmental effects from being spuriously related to fertility preferences and subsequent behaviors. For neither men nor women does the correlation between prior contraceptive use and the measures of environmental conditions exceed 0.10 (results not shown).

A measure of parental education was included as a control for family background effects that have been argued to influence people's subsequent fertility behaviors in Nepal (Axinn & Barber, 2001). The three-category variable we use is equal to 0 if neither the respondent's mother nor father attended school, 1 if either parent attended school and 2 if both parents attended school. Given the relatively recent spread of mass education in rural areas of Nepal like Chitwan Valley, adults of reproductive age who grew up with at least one parent who ever attended school are in the minority (28 percent of women and men compared to 72 percent who had neither parent attend school).

A series of dummy variables for ethnicity are also included as controls because prior studies in this setting have shown that family formation patterns differ widely by ethnicity (Axinn & Barber, 2001; Axinn & Yabiku, 2001; Acharya & Bennet, 1981). The five main ethnic groups in this area of Nepal are high caste and lower caste Hindus (originally from India and practice Hinduism), Newars (of Tibetan origin and practice a mixture of Hinduism and Buddhism), Tibeto-Burmese (of Tibetan origin and practice Buddhism), and the terai Tibeto-Burmese (a group that is indigenous to Chitwan Valley).

Lastly, a series of indicators of the household's standard of living was included in the models. These variables are: (1) presence of any kind of toilet facility, (2) connection to electricity or not, (3) an index of consumer durables, (4) an index of housing quality, (5) whether the household owns the house plot, (6) whether the household owns any khet land (low wetlands that are the most agriculturally productive), and (7) whether the household owns any bari land (dry uplands that are the least agriculturally productive).

RESULTS

Table 2 presents the OLS coefficients of the full models for the environmental measures and effects on married men and women's desired family size (measured using the Coombs scale). Note that the models presented in Table 2 evaluate the total impact of one dimension of environmental quality at a time controlling for a comprehensive set of previous experiences. The multivariate controls include multiple measures of each individual's previous childbearing and contraceptive use experience in order to reduce the chance that effects of fertility on environmental quality are responsible for the observed associations between environmental quality and fertility. This first set of models focuses on the relationship between various dimensions of environmental quality and total family size preferences.

The results provide some support for the vicious circle argument that environmental degradation is positively associated with preferences for larger families. Women's desired family size increases if the time to collect fodder increased over the past three years, net of how long on average it takes currently to collect fodder and net of all control variables (Model 2 in Table 2). None of the other environmental measures were significantly associated with women's desired family size.

For men, the longer the average time to collect fodder, the higher men's desired family size, net of any perceived change in time to collect fodder over the past three years and net of all control variables (Model 2 in Table 2). The source for natural resources is also a crucial aspect of the vicious circle argument about the impact of environmental degradation on population. Among households that collect fodder (rather than buy it), gathering fodder from public lands such as forests and internal common lands vs. private lands has a strong positive effect on men's desired family size (Model 4 in Table 2). No other measures had a statistically significant effect on desired family size. Neither the direct count of trees and shrubs nor

TABLE 2

Ordinary Least Squares Models of Men's and Women's Desired Family Size [Coombs Scale] on Environmental Conditions and Household and Individual Characteristics, Chitwan, Nepal 1996

Variable	Model 1		Model 2		Model 3		Model 4	
	Men	Women	Men	Women	Men	Women	Men	Women
Environmental measures								
Time to collect wood in 1 roundtrip (hours)	0.01	−0.03						
	(0.04)	(0.03)						
Time to collect wood now is 1+ hours more than 3 years ago	0.22	0.13						
	(0.30)	(0.23)						
Time to collect fodder in 1 roundtrip (hours)			0.27**	−0.05				
			(0.11)	(0.08)				
Time to collect fodder now is 1 + hours more than 3 years ago			−0.29	1.27**				
			(0.58)	(0.49)				
Wood is from public land (ref = private land)					0.10	−0.12		
					(0.35)	(0.24)		
Fodder is from public land (ref = private land)							0.65*	0.16
							(0.30)	(0.23)
Individual-level controls								
Age 25–34 (ref = age 18–24)	−0.22	0.06	0.06	−0.09	−0.21	0.08	0.08	−0.07
	(0.35)	(0.21)	(0.41)	(0.24)	(0.35)	(0.21)	(0.41)	(0.24)
Age 35–40	0.07	0.19	0.39	−0.07	0.08	0.17	0.41	−0.07
	(0.41)	(0.29)	(0.48)	(0.31)	(0.41)	(0.28)	(0.48)	(0.31)
Age at first marriage	−0.02	0.05	−0.01	0.06+	−0.02	0.05	−0.01	0.06+
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)

TABLE 2

(Continued)

Variable	Model 1		Model 2		Model 3		Model 4	
	Men	Women	Men	Women	Men	Women	Men	Women
Years of school before marriage	−0.02	−0.03	−0.02	−0.04	−0.02	−0.03	−0.02	(−0.04)
	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)
Parents have any education	0.30	−0.17	0.04	−0.03	0.27	−0.16	0.01	−0.04
	(0.23)	(0.16)	(0.25)	(0.18)	(0.23)	(0.16)	(0.25)	(0.18)
Ever used contraception	−0.19	−0.14	0.14	−0.23	−0.19	−0.15	0.17	−0.20
	(0.23)	(0.17)	(0.26)	(0.19)	(0.23)	(0.17)	(0.26)	(0.19)
Total number living children	0.49***	0.52***	0.40**	0.61***	0.50***	0.52***	0.39**	0.60***
	(0.11)	(0.08)	(0.12)	(0.09)	(0.11)	(0.08)	(0.12)	(0.09)
Number of living male children	0.03	0.08	0.12	0.15	0.01	0.09	0.11	0.14
	(0.13)	(0.10)	(0.15)	(0.11)	(0.13)	(0.10)	(0.15)	(0.11)
Ever had a child die (ref = never)	−0.05	0.57**	0.15	0.67**	−0.06	0.58**	0.16	0.72**
	(0.27)	(0.20)	(0.30)	(0.22)	(0.27)	(0.20)	(0.30)	(0.22)
Low caste Hindu (ref = high caste)	1.03**	−0.07	1.24**	−0.44	1.07**	−0.11	1.19**	−0.39
	(0.34)	(0.27)	(0.39)	(0.31)	(0.34)	(0.26)	(0.39)	(0.31)
Newar	0.61	−0.49	0.56	−0.52	0.62	−0.53	0.50	−0.47
	(0.53)	(0.38)	(0.64)	(0.45)	(0.53)	(0.38)	(0.64)	(0.45)
Hill Tibetoburmese	0.63^{+}	0.16	0.44	0.11	0.69*	0.14	0.34	0.11
	(0.33)	(0.25)	(0.35)	(0.27)	(0.33)	(0.24)	(0.35)	(0.27)
Terai Tibetoburmese	1.48***	0.73**	1.74***	0.52^{+}	1.49***	0.71**	1.69***	0.46^{+}
	(0.31)	(0.23)	(0.35)	(0.26)	(0.31)	(0.23)	(0.35)	(0.26)
Household–level controls								
Toilet (ref = no toilet)	0.30	0.19	0.31	−0.01	0.31	0.17	0.34	−0.01
	(0.25)	(0.19)	(0.28)	(0.21)	(0.25)	(0.19)	(0.28)	(0.21)

TABLE 2

(Continued)

Variable	Model 1		Model 2		Model 3		Model 4	
	Men	Women	Men	Women	Men	Women	Men	Women
Electricity (ref = no electricity)	−0.14	−0.30	0.10	−0.52*	−0.15	−0.28	0.02	−0.55*
	(0.32)	(0.23)	(0.33)	(0.24)	(0.30)	(0.22)	(0.33)	(0.24)
Index of consumer durables	−0.03	−0.05	0.11	−0.10	−0.03	−0.06	0.17	−0.08
	(0.12)	(0.09)	(0.13)	(0.09)	(0.12)	(0.09)	(0.12)	(0.09)
Index of housing quality	−0.02	−0.05	−0.06	0.02	−0.01	−0.05	−0.06	−0.01
	(0.04)	(0.03)	(0.05)	(0.03)	(0.04)	(0.03)	(0.05)	(0.03)
Own home (ref = do not own home)	0.37	0.13	0.84*	−0.001	0.38	0.14	0.65*	0.02
	(0.28)	(0.22)	(0.37)	(0.28)	(0.28)	(0.22)	(0.36)	(0.28)
Own any bari land	0.18	0.01	0.12	0.23	0.13	0.04	0.13	0.27
	(0.22)	(0.17)	(0.25)	(0.19)	(0.22)	(0.17)	(0.25)	(0.19)
Own any khet land	−0.02	0.20	−0.23	0.17	−0.02	0.19	−0.33	0.21
	(0.22)	(0.17)	(0.25)	(0.19)	(0.22)	(0.17)	(0.25)	(0.19)
Intercept	4.84***	4.54***	3.58***	4.15***	4.73***	4.53***	4.13***	3.95***
	(0.89)	(0.67)	(1.03)	(0.78)	(0.92)	(0.68)	(0.99)	(0.76)
N	638	839	510	692	643	851	512	697
Adjusted R-squared	0.13	0.18	0.16	0.21	0.13	0.18	0.16	0.20

Sample: Currently married men and women age 18–40 years old with at least 1 living child.
Note: Standard errors are in parentheses.
$^{+}p < .10$,* $p < .05$,** $p < .01$,*** $p < .001$.

the indicator of any children in the household collecting wood was statistically significant for either men or women (results not shown in Table 2).

In short, the more dependent households are on public lands for natural resources and as households have to search farther for natural resources, the larger the family size desires of men and women. The evidence supports the vicious circle argument that resource scarcity and reliance on public lands has a positive effect on fertility preferences and behaviors. However, measures of the abundance of trees and shrubs, time to collect fuel wood, source of fuel wood and whether any young children in the household collected fuel wood were not significantly associated with family size desires. Based on evidence that women are primarily responsible for fuel wood collection activities in Nepal and spend more time engaged in such work than men (Cooke, 1998), we expected poor environmental quality to have particularly strong effects on women's desired family size. However, the results do not suggest large gender differences in the ways that the environment shapes fertility preferences.

We should also note that the effects of the control variables are relatively stable across the different models. Statistically significant individual-level control variables are the total number of living children (positively associated with desired family size, as expected), ever having had a child die (a positive association with desired family size) and some differences by ethnic group. Only two of the control variables for a household's standard of living were significantly associated with desired family size: having electricity (a negative association) and owning the dwelling (a positive association).

Table 3 presents the results from our estimates of the effects of the environmental measures in 1996 on the likelihood of a woman becoming pregnant in the subsequent 36 months. Once again, the models we estimate control for a wide range of factors that precede our measures of environmental quality. Furthermore, the prospective panel measures of pregnancy following our measures of environmental quality help to insure that the temporal order of our measures matches the temporal order in hypotheses regarding the impact of environmental quality on fertility outcomes. These models, therefore, are well suited to an evaluation of the total effects of environmental quality on subsequent fertility decision-making. Note that this set of models is limited to married women of childbearing ages.

Again, there is some empirical support for the vicious circle argument. Women from households that relied on public lands for fuel wood collection in 1996 were much more likely to have had a pregnancy in the subsequent 36 months compared to women from households relying on private lands (see Model 3). Moreover, women from households where the time to

TABLE 3

Logistic Regression Models of Women's Subsequent Pregnancy on Environmental Conditions and Household and Individual Characteristics, Chitwan, Nepal 1996–1999

Variable	Model 1	Model 2	Model 3	Model 4
Environmental measures				
Time to collect wood in 1 roundtrip (hours)	−0.05 (0.04)			
Time to collect wood now is 1 + hours more than 3 years ago	0.54^{+} (0.31)			
Time to collect fodder in 1 roundtrip (hours)		0.09 (0.11)		
Time to collect fodder now is 1 + hours more than 3 years ago		0.04 (0.76)		
Wood is from public land (ref = private land)			1.07* (0.44)	
Fodder is from public land (ref = private land)				0.11 (0.31)
Individual-level controls				
Age 25–34 (ref = age 18–24)	−0.85** (0.27)	−1.27*** (0.33)	−0.78** (0.27)	−1.27*** (0.32)
Age 35–40	−2.45*** (0.54)	−2.89*** (0.57)	−2.50*** (0.54)	−2.91*** (0.57)
Age at first marriage	0.06 (0.04)	0.07 (0.05)	0.05 (0.04)	0.07 (0.05)
Years of school before first marriage	−0.09** (0.03)	−0.10** (0.04)	−0.08* (0.03)	−0.10** (0.04)
Parents have any education	0.01 (0.22)	−0.02 (0.24)	0.04 (0.22)	−0.01 (0.24)
Ever used contraception (ref = never used)	0.39 (0.24)	−0.90** (0.28)	−0.34 (0.24)	−0.90** (0.28)
Total number living children	0.10 (0.12)	0.19 (0.14)	0.09 (0.12)	0.19 (0.14)
Number of living male children	−0.49*** (0.15)	−0.23 (0.16)	−0.49*** (0.15)	−0.24 (0.16)
Ever had a child die (ref = never had a child die)	0.21 (0.29)	0.24 (0.33)	0.21 (0.30)	0.23 (0.33)
Low caste Hindu (ref = high caste Hindu)	−0.10 (0.37)	−0.59 (0.43)	−0.01 (0.37)	−0.60 (0.43)
Newar	0.35 (0.54)	−0.07 (0.77)	0.52 (0.55)	−0.001 (0.76)
Hill Tibetoburmese	0.44 (0.35)	0.26 (0.38)	0.54 (0.35)	0.23 (0.38)
Terai Tibetoburmese	0.47 (0.32)	0.26 (0.37)	0.48 (0.32)	0.25 (0.37)

TABLE 3

(Continued)

Variable	Model 1	Model 2	Model 3	Model 4
Household-level controls				
Toilet (ref = no toilet)	−0.09 (0.26)	0.02 (0.29)	−0.14 (0.25)	0.02 (0.29)
Electricity (ref = no electricity)	0.19 (0.36)	0.13 (0.38)	0.19 (0.35)	0.11 (0.37)
Index of consumer durables	−0.21 (0.13)	−0.09 (0.14)	−0.22 (0.14)	−0.07 (0.14)
Index of housing quality	−0.004 (0.05)	0.02 (0.05)	0.05| (0.05)	0.02 (0.05)
Own home (ref = do not own home)	0.17 (0.30)	1.03* (0.42)	0.21 (0.29)	0.96* (0.41)
Own any bari land (ref = do not own bari land)	0.07 (0.24)	−0.09 (0.27)	0.07 (0.23)	−0.10 (0.27)
Own any khet land (ref = do not own khet land)	0.19 (0.23)	−0.08 (0.26)	0.10 (0.23)	−0.10 (0.25)
Intercept	−0.60 (0.93)	−1.90^{+} (1.15)	−2.01* (0.99)	−1.57 (1.09)
N	518	420	525	424

Sample is limited to married women age 18–40 years old with at least 1 living child and who were not sterilized as of 1996.
Note: Standard errors are in parentheses.
$^{+}p < .10$,* $p < .05$,** $p < .01$,*** $p < .001$.

collect fuel wood increased by at least 1 h were also more likely to have a pregnancy in the following 36 months, although the effect is marginally significant ($p < .10$, see Model 1). Similar to the results for fertility preferences, environmental degradation and reliance on public lands for natural resources have positive effects on fertility behavior. This association between negative environmental conditions and higher fertility is the key element of the vicious circle argument. Yet the measures of the abundance of trees and shrubs and whether any young children in the household collected fuel wood were not significantly associated with the likelihood of a woman's subsequent pregnancy (results not shown in Table 3).

In general, these models perform as expected across other determinants of fertility behavior. The control variables that are statistically significant are in the expected directions: older women are much less likely than younger women to become pregnant, years of schooling has a negative effect on the likelihood of subsequent pregnancy, and, a special hallmark of son-preference in Nepal, the more male children a woman has, the less likely she is to become pregnant again (net of the total number of living children). The only measure of household wealth to have a significant effect on the likelihood of pregnancy is home ownership, again having a positive effect on family formation as it did on family size preferences.

There is the possibility that the correlation between the location of a neighborhood and unobservable factors in individual fertility preferences and behaviors could lead to an underestimation of standard errors and an incorrect rejection of the null hypothesis. We re-estimated the OLS models of family size preferences to account for within neighborhood clustering using the PROC MIXED procedure in SAS (results available upon request). The same statistically significant relationships for both the environmental and control variables hold in the multi-level models as in the OLS models with no hierarchical structure specified. Other analyses of contraceptive use using these same data in Nepal have found no evidence that individuals' hazard rates of contraceptive use within a neighborhood are highly correlated (Barber et al., 2000).

CONCLUSION

This study is one of the few that focuses on the impact of environmental degradation on population outcomes using micro-level measures of both the environment and population. We examined the effect of multiple indicators of environmental conditions—flora abundance, time to collect natural resources and perceived changes in collection time, reliance on

public lands and child labor for collecting natural resources—on men and women's family size desires and women's subsequent pregnancy. The results provide some support for the ''vicious circle'' argument that environmental degradation can lead to rising population growth via positive effects on fertility. As environmental conditions decline and when households rely on public lands for natural resources, men and women desire larger family sizes and women are more likely to get pregnant in the near future. These environmental effects are net of individual-level characteristics such as birth cohort, total number of living children, and ethnicity as well as household-level measures of the standard of living.

A number of the environmental measures we used failed to show any significant association with the dependent variables or did not have consistent effects for both the fertility preference and behavior outcomes. Like Filmer and Pritchett's (2002) study of the vicious circle argument in Pakistan, there is empirical evidence to support this explanation of the relationship between environmental degradation and fertility preferences, but the evidence is not consistent. Certainly measurement error exists with these indicators of environmental degradation, and this is one reason why we examined a range of indicators from different sources of data. However, one direction for further research is to test this argument with other measures of the environment; for example, direct count data of the environment can be used to construct diversity-abundance measures that incorporate both species diversity and the relative abundance of species. Moreover, careful empirical attention to the institutional variation in management (and, thus, relative access to) the forest areas and internal public lands in the study site for natural resource use would shed further light on the vicious circle argument and the larger implications that population pressure has on environmental quality over time.

With the availability of panel data that incorporate both environmental and individual and household-level information over time, further research could improve upon this study by directly addressing the potential problem of omitted-variable bias. Our analyses could not address the possible bias introduced by correlation between changes in individual and household-level characteristics with changes in environmental conditions. The availability of longitudinal measurement enables one to difference equations to account for the risk of omitted-variable bias.

The nature of population and environment research inevitably lends itself to discussion of policy and programmatic interventions. At the very least, demographers can contribute to ongoing debates on the environment by highlighting the connections (or lack thereof) to population processes (Pebley, 1998). In the rapidly changing social and economic setting of

Chitwan Valley, Nepal, the spread of public services and private enterprise have led to a switch in local land use away from common forests or pasture (Shivakoti et al., 1999). Despite the shrinking availability of public land for natural resource consumption, many households still remain dependent on fuel wood collection, and most continue to gather wood from public forests or common lands.

Evidence from other studies in Nepal suggests that forestry policies should target physical forest stocks rather than fuel wood markets in regions where households are primarily dependent on collecting wood (Amacher, Hyde, & Kanel, 1996, 1999), as is the case in Western Chitwan Valley. Indeed, the empirical analyses here showed that reliance on and accessibility to these public lands (as measured by perceived change in time to collect fodder and fuel wood) has a strong impact on the reproductive preferences and behaviors of women and men.

The study results suggest that easing the burden of collecting fuel wood and fodder either through technological substitutes for fuel wood (e.g., more efficient stoves) or through the replenishment of physical forest stocks may also lead to lower family size desires, lower fertility, and, perhaps, lower population growth (barring dramatic changes in in-migration patterns). And given the lack of strong evidence showing gender-specific differences in the effect of environmental degradation on fertility outcomes, programmatic challenges to the ''vicious circle'' of environmental degradation and population growth may be successful even without building in different emphases for women vs. men.

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