Popul Environ (2006) 27:445–461
DOI 10.1007/s11111-006-0030-5

Land Use and Marriage Timing in Nepal

Scott T. Yabiku

Received: 8 February 2006 / Accepted: 11 September 2006 /
Published online: 17 October 2006

Abstract I examine the relationship between patterns of land use and marriage timing in the Chitwan Valley, a rural area in south-central Nepal. In this setting, I conceptualize a relevant dimension of land use as the portion of land in each neighborhood devoted to agriculture. Using discrete-time event history models, I examine the relationship between the proportion of land devoted to agriculture and the rate of marriage among 811 never-married individuals aged 15–20 years. Agricultural land has a positive association with marriage rates. As potential intervening mechanisms between agricultural land and marriage rates, I propose nonfamily organizations, school and work activities, and local marriage markets. A portion of the relationship between land and marriage rates appears to be mediated through the accessibility of nonfamily employers. Respondents' actual employment activities, however, fail to mediate the effects of agricultural land or nonfamily employers. The precise mechanisms linking land use to marriage remain unclear.

Keywords Marriage · Family formation · Land use · Nepal

Introduction

The relationships between land use and family behaviors are implicit in many social science theories. Several scholars note how the family was influenced by the shift from agricultural work, which was located near the family household, to industrial work, which potentially was located far away from households (Davis, 1984; Thornton & Fricke, 1987). This shift changed children's independence, relationships between men and women, and the role of nonfamily institutions and individuals, which spurred subsequent changes in marriage and fertility (Davis, 1963, 1984; Thornton & Fricke,

S. T. Yabiku (✉)
School of Social and Family Dynamics, Arizona State University, Box 873701, Tempe, AZ 85287-3701, USA
e-mail: scott.yabiku@asu.edu

1987). Marx and Engels' writings on the family and social change also discuss how parent–child relationships were transformed by the shift from an agricultural to an industrial society (Marx & Engels, 1978, pp. 487–488). Caldwell's (1982) theory of wealth flows is another framework that incorporates land use and the mode of production. When families are engaged in labor-intensive activities that require little investment in human capital—such as agriculture—large numbers of children are valuable for the labor they contribute. If societies change to production that requires less manual labor and more skilled labor, children require substantial investments in human capital, and large numbers of children quickly become expensive.

Because they are fundamental changes in the organization of society, these shifts in the mode of production can be slow, incremental, and sometimes visible only across long periods of time. Nevertheless, theories predict that changes in a society's organization of production should be linked to individual, micro-level family behaviors. Land use is of key importance in societies that are undergoing these transformations from purely agricultural to a mix of agricultural, industrial, and service economies. As agricultural land diminishes to make room for features of the built environment, such as roads, housing, businesses, and infrastructure, these shifts in land use form both new constraints and new opportunities that can influence family behaviors.

Many studies of population–environment relationships have linked environmental conditions to individual outcomes. It is important to examine human–environment relationships on a local level because global environmental trends often have their genesis in interactions that take place on a fine spatial scale (Rindfuss, Walsh, Turner, Fox & Mishra, 2004; Skole, 2004). An, Mertig, and Liu (2003) found that perceptions of resource availability are associated with individualism and intentions to leave the parental home in a Chinese nature preserve. Several studies show that migration behavior is influenced by the local environment, including land availability (Bates & Rudel, 2004; Bhandari, 2004) and climatic conditions (Henry, Schoumaker, & Beauchemin, 2004). And Thapa, Bilsborrow, and Murphy (1996) found that the level of women's agricultural labor is affected by the type and amount of a household's land. Focusing on family behaviors, several studies have examined the links between land use and fertility (Anderton & Barrett, 1990; Bentley, Goldberg, & Jasienska, 1993; Clay & Johnson, 1992; VanLandingham & Hirschman, 2001). Fewer studies, however, have examined how environmental measures are associated with marriage patterns. Because marriage is a proximate determinate of fertility in many societies (Bongaarts, 1978), the timing of marriage is an important demographic event that can also influence family size. Furthermore, changes in marriage patterns are intertwined with other important societal shifts, including educational attainment, employment, and women's independence.

Previous studies examining land use and marriage have looked at historical patterns in areas such as the United States and Ireland (Guest, 1981; Kent, 2002; Landale, 1989; Landale & Tolnay, 1991; Strassmann & Clarke, 1998). Contemporary transitions in land use, however, are occurring much more quickly in developing societies today, and how these transitions influence marriage remains understudied. In this paper, I examine the relationship between patterns of land use and marriage timing in the Chitwan Valley, a rural area in Nepal that is rapidly developing industrial and nonfarm activities. The data used for this analysis are combinations of sources: survey data from individuals living in 151 neighborhoods and ground-mapped measures of land use in each of those 151 neighborhoods. I use these land

use data to test how the proportion of land devoted to agriculture is related to marriage rates in a prospective panel study of 811 unmarried individuals in 1996.

Background

While there are a variety of ways to conceptualize land use patterns, in Chitwan the most relevant categories of land use tend to be divided into agricultural land, non-agricultural floral land, private buildings, public infrastructure, and nonusable land, i.e., geographic areas covered by rivers and ponds (Axinn & Ghimire, 2003). The development of agricultural land has important environmental consequences. As nonagricultural floral land is transformed into agricultural land, there may be increasing pressures on resources such as water, which agricultural land can consume in large quantities. This can result in diversions and disruptions of existing water use patterns, thus leading to environmental degradation. Transforming floral lands into agricultural land also can cause erosion, which can negatively impact other floral lands, other agricultural lands, and human-inhabited areas (Awasthi, Sitaula, Singh, & Bajacharaya, 2002).

In addition to environmental impacts, these changes in land use have implications for family formation behaviors of people living in Chitwan, which has a history of rapid social change. Until the end of the 1950s, the area was largely uncultivated jungle (Guneratne, 1996). There was limited agriculture in Chitwan in the early 19th century, but following the Anglo-Nepal War of 1814–1816 the ruling Nepalese regime depopulated the area and let it revert to jungle. The Chitwan area then served as a buffer to potential British expansion from the south and west; it also served as prime royal hunting grounds (Guneratne, 1996; Müller-Böker, 1999). By the end of the 19th century, the area became highly infected with malaria and was known as the Valley of Death (Guneratne, 1996). The majority of the inhabitants in the area were of the Terai Tibetoburmese ethnic group, such as the Tharu, Derai, and Kumal, who largely avoided agriculture and lived through subsistence wage labor opportunities (Guneratne, 1996). Up until the period of Indian independence, these wage labor opportunities in the 20th century came largely from British employers and military who needed short term, manual labor, opportunities which were very close because Chitwan borders India (Guneratne, 1996). In the early 1950s, there were severe farmland shortages throughout the country, and the government of Nepal, with assistance from the United States Agency for International Development (USAID), deforested large areas of Chitwan (Axinn & Yabiku, 2001). This turned the former jungle area into some of the most fertile farmland in Nepal, and migration to the valley from all across the country accelerated. By the 1980s, the first all-weather roads linking Chitwan to the capital city Kathmandu and India were finished, which further increased population growth and development. In short, the Chitwan Valley transformed from malaria-infected jungle to prime farmland in less than 30 years.

Now an established farming community, most of Chitwan is land devoted to agriculture. Of the neighborhood land sampled in the study, 80% was agricultural land in 1996. Agricultural land in Chitwan generally falls into two types: khet, which is used for growing rice, and bari, which is used for growing other crops such as maize and millet. In 1996, 57% of total land was khet, while 23% was bari. Another major category of land use in Chitwan is also covered with flora, yet is not agricultural land. This comprised 4% of total land area. These kinds of land are public

and private grasslands and plantation lands. The last two categories of land use are nonfloral lands: land devoted to private buildings and public infrastructure such as roads and canals (15% of all land), and a small fraction of unusable land, such as rivers, riverbanks, and ponds (less than 1% of all land area).

In Chitwan, the percent of land devoted to agriculture is likely to be associated with marriage timing for multiple reasons. First, as agricultural land decreases, it may decrease the proportion of young people who can obtain agricultural labor, thus impeding family formation. As agricultural land decreases and technological farming innovations spread, usually less labor is needed to obtain the same levels of productivity (Boserup, 1981; Ehrlich, Ehrlich, & Daily, 1993). As the amount of farmland decreases, it may also constrain family formation if newly formed households are unable to obtain land of their own.

Some historical studies of land use and marriage have used the ecological constraints hypothesis to explain why marriage rates go down when land availability is scarce (Kent, 2002; Strassmann & Clarke, 1998). The ecological constraints hypothesis borrows from studies of birds and mammals that suggest these animals delay reproduction when resources are hard to obtain (Strassmann & Clarke, 1998). Strassmann and Clarke (1998) applied this framework to a historical study of marriage in Ireland in the early 20th century. In support of the ecological constraints hypothesis, they found that young men tended to stay celibate longer when their families' farms had smaller landholdings, and young men from landless families tended to emigrate at high rates. Kent (2002) also analyzed marriage and ecological constraints in Ireland, but found that the concept of philopatry—the tendency of species to remain in their area of birth—was also needed to explain the relationship. In any case, both analyses point to the importance of land in marriage timing. Landale (1989) also examined links between land availability and marriage using historical data, focusing on the United States in 1900. Her findings are consistent with an ecological constraints hypothesis: as farmland became more expensive, men were less likely to have married. Her analysis also includes a measure of manufacturing capital as a proxy for the availability of nonfarm jobs. These jobs represent alternatives to farm labor. As manufacturing capital investment in an area increased, marriages were delayed.

A second reason why decreasing agricultural land may be associated with lower marriage rates is that the agricultural land is replaced with a built environment containing organizations that can change the family's organization of information, authority, and production. When parents have less control over young people, it is more difficult for parents and elders to encourage the family patterns they practiced, such as earlier marriage and high fertility (Thornton & Lin, 1994). These organizations include schools, markets, health posts, transportation infrastructure, and employment centers.

Schools increase human capital, but they also introduce additional authority figures (teachers) who compete with family elders (Thornton & Fricke, 1987; Yabiku, 2005). In a setting of rapid social change, schooling can quickly cause children to have more education than their parents, an imbalance that decreases parental authority. In Chitwan, healthcare used to be provided by elders and folk healers, but the rise of health posts and clinics introduces doctors as authority figures, which may reduce parental authority (Yabiku, 2004). Markets and stores are places where young people can develop consumption aspirations for products and goods, which may buttress nonfamily behaviors such as delayed marriage. Nonfarm employment

also provides independence to young people. In contrast to family-organized agricultural labor, nonagricultural, nonfamily employment is usually located farther away from the family home (Davis, 1984). Thus individuals have potentially more independence and freedom from parents. Ghimire, Axinn, Yabiku, and Thornton (2006) found that when young people in Chitwan had nonfamily employment, they had a higher degree of autonomy in choosing their spouse. Chitwan is historically an arranged marriage society, but nonfamily activities are weakening exclusive parental control in spouse selection. Nonagricultural employment also likely introduces young people to new peers and a broader spectrum of individuals (Bongaarts & Watkins, 1996). These new peers can bring new ideas about family formation that compete with traditional family norms.

Third, changes in land devoted to agriculture may affect individuals' perceptions of environmental opportunities. Previous research shows that individuals' perceptions are shaped by physical features of their surrounding environment (Wilcox, Quisenberry, & Jones, 2003). The role of environmental perceptions in marriage decisions is supported by previous work showing the importance of perceptions (MacDonald, 1999). Perceived resource availability was associated with people's migration behaviors in a Chinese wildlife preserve (An, Mertig, & Liu, 2003). And Abernethy (1999, p. 23) argues that when people believe resources are scarce, it leads to ''delayed marriage and long intervals between births.'' In Chitwan, if the land devoted to agriculture becomes smaller, then individuals may perceive that there are long-term shifts in the future nature of obtaining a livelihood. Instead of focusing on the family formation patterns that are most valuable in agricultural societies, such as marriage and high fertility (Caldwell, 1982), individuals may be drawn to other experiences, such as schooling and employment. These are activities that do not require family formation, and schooling's student role is often viewed as incompatible with spouse or parent roles (Tambashe & Shapiro, 1996; Thorton, Axinn, & Teachman, 1995). Thus perceptions of a decreasing agricultural environment may lead individuals to pursue alternative activities that are likely to delay marriage.

Decreasing agricultural land may also alter the local marriage market. Marriage rates can be influenced by the pool of available partners (Bhat & Halli, 1999; Lichter, McLaughlin, Kephart, & Landry, 1992; Lloyd & South, 1996). Research shows that migration out of Chitwan was more likely to occur when households had less access to farmland (Bhandari, 2004). This finding is replicated in other contexts. Work by Bates and Rudel (2004) and Barbieri and Carr (2005) in rural Ecuador suggested that when farmland is scarce or expensive, the young migrate to urban areas. Less farmland, therefore, could lead to fewer young people of marriageable age, which could depress marriage rates.

It is important to note that the relationships between land use and changes in family behaviors, such as marriage, are likely to be contingent on the specific local context. In Chitwan, less farmland is hypothesized to be associated with decreased rates of marriage. In other contexts, however, these relationships may be very different. For example, research shows that fertility is positively correlated with the demand for child labor (Basu & Van, 1998; Cain & Mozumder, 1981; Rosenzweig & Evenson, 1977). If there are lucrative opportunities for young children in urban manufacturing jobs or ''sweatshops,'' then the demand for children may be just as high in urban areas, with little agricultural land, as in rural areas, with much agricultural land and labor-intensive farm activities. In both these settings, marriage and

fertility rates could be equally high. On the other hand, consider a community that has kept the same amount of agricultural land, but has changed the use of this land from crops to livestock. Since livestock is less labor intensive than crops (Carr, 2004; Walker, Moran, & Anselin, 2000), in this case fertility and marriage rates might decrease.

In sum, in the Chitwan Valley the amount of agricultural land is likely to be related to marriage timing because it alters the organization of individuals' families and life courses. I expect a positive relationship between the percent of a neighborhood's land devoted to agriculture and the rate of young people's marriages. An important intervening link between land use and individual marriage decisions may be the presence of nonfamily organizations and services, which may give children independence from family elders. As agricultural land decreases, it is replaced with the built environment, such as roads, schools, health posts, businesses, and markets. While all of these features alter the social organization of the family and may affect marriage timing, some are likely to be especially important. Nonfamily employers are alternatives to agricultural work. As described below, I test these models of land use and marriage timing with data from the Chitwan Valley Family Study.

Data and Methods

The Chitwan Valley Family Study is a multifaceted data collection that began in 1996. Several components comprise the data, each with a separate focus. Using a probability sample of neighborhoods, the individual interview in 1996 measured 5,271 individuals in 171 neighborhoods between the ages of 15 and 59 (Barber, Shivakoti, Axinn, & Gajurel, 1997). The respondents' spouses were also interviewed, regardless of age. The individual interview collected a variety of social demographic, life history, and attitudinal questions. Upon completion of the individual interview, a household registry system began. This registry system collected monthly data on vital and life events, such as births, marriages, deaths, and migration. The registry system involved a subset of 151 of the 171 original neighborhoods (the selection of the 151 was random). The registry system involved monthly monitoring of households, provided by one informant per household. If a respondent was temporarily away due to migration, a remaining household member still reported on the migrant's registry events. This is an important feature of the registry system. Otherwise, there would be high risks for sample attrition based on migration, which has been shown to be correlated with agricultural opportunity (Bhandari, 2004), a key measure in this analysis.

A second component of the data is the land use mapping. In 1996, field workers mapped the entire area of neighborhoods and classified its use into various categories. In 2000, this mapping was repeated. The main land use categories are agricultural, nonagricultural floral, private buildings, and public infrastructure. These categories can be further broken down into specific classes. For example, agricultural land includes rain fed khet, irrigated khet, and bariland. For the purposes of this paper, however, I focus on aggregated categories. Neighborhoods were defined as free-standing clusters of 5–15 households. Defining the concept of the neighborhood is difficult (McKenzie, 1921), but the definition used in the study tried to approximate the daily realities of individuals' lives. An effective definition of community should have both a geographic and social aspect (Simmons, Walker, Wood, Arima,

& Cochrane, 2004). Chitwan is largely a rural area, in which small groups of housing structures are clustered together and surrounded by farmland. These groupings contain individuals who see and interact with each other on a very frequent basis. The definition of neighborhood used in the study, therefore, is not artificial; the neighborhood clusters are local, immediate social groups that are relevant to the people living there. This is in accordance with the advice of Pan and Bilsborrow (2005, p. 236), who write that neighborhood and community definitions should be ''based on functionality, social interaction, and the dependent variable of interest.''

A third component of the data is the neighborhood history calendars (Axinn, Barber, & Ghimire, 1997). This data source measures how far, in minutes walking distance, each neighborhood was from various nonfamily organizations and services that reflect daily social life, such as schools, health posts, bus stops, markets, and employers. These are important organizations in a setting such as Chitwan, which is undergoing rapid social change. Many activities that once were the exclusive domain of the family are increasingly performed outside the family within nonfamily organizations. In Chitwan, minutes walking is a more appropriate measure of access than geographic distance because few people have cars, and walking is the main method of transportation to these local services.

Marriage Timing

Marriage timing is the dependent outcome of interest. Because marriage is an event that may be censored—i.e., not all respondents may have experienced the event—event history analysis is appropriate (Allison, 1995). I use discrete-time event history to estimate the effect of covariates on the rate of marriage among people aged 15–20 years who were never married as of 1996. Instead of examining all unmarried respondents as of 1996, the analysis is restricted to this narrow age cohort to minimize the sample bias that is created by the removal of married people from the sample. For example, the sample of unmarried 30-year-olds in 1996 is likely to be a select group who has a greater preference for being single since most 30-year-olds have married by this time. In contrast, a minority of the 15–20 age cohort in 1996 has married, and a sample based on the unmarried in this cohort has less selection bias.

In the discrete-time event history models, the person-period of risk is the person-month. For every month in which the individual is single, the dependent variable is coded 0. When an individual marries, the dependent variable is coded 1, and the individual no longer contributes person-months of exposure. Because 90 months of registry data after 1996 are available thus far, individuals who do not marry are censored after 7.5 years. I focus on the respondents' transition to their first marriage because remarriage in the Chitwan context is relatively rare. The 15–20 age cohort will be 23–28 years old after 7.5 years. Based on the retrospective marital history of other Chitwan respondents in 1996, only 5% of respondents aged 23–28 had been married more than once. Thus there will be an insufficient sample size to provide a meaningful analysis of second marriages.

Percent Agricultural Land

Although there are many ways to categorize land use, a dimension likely to influence marriage timing in Chitwan is the percent of land devoted to agriculture. This measure is calculated as the amount of khet and bariland divided by the total land in

the neighborhood. Because this measure was skewed, with many individuals living in neighborhoods with high percentages of land devoted to agriculture, a logarithmic transformation was applied. This transformation accentuates the differences in percent agricultural for the neighborhoods with a low percentage of agricultural land, which is justifiable: the difference between 70% and 90% of agricultural land is likely to be less important than the difference between 5% and 30%. While the former two cases would both be considered largely agricultural, the latter two cases may be different: one which is virtually nonagricultural (5%) and one which is moderately agricultural (30%). The economies of scale involved with agriculture also point to substantial, fundamental differences in land use when comparing neighborhoods that are 5% and 30% as opposed to 70% and 90% agricultural land.

Because land use was measured in 1996 and 2000, the percent of agricultural land is treated as a time-varying variable. Linear interpolation and extrapolation are used to calculate values between 1996 and 2000 and from 2000 to 2003 (results were similar in analyses that treated land use as static and used only the 1996 measure).

Nonfamily Organizations

Historical studies of land use and marriage in the United States at the beginning of the 20th century suggested that opportunities for rural manufacturing jobs helped to delay marriage (Landale, 1989). Similar processes may be operating in Chitwan, which is a largely rural farming area that is beginning to develop industrial and service activities through the presence of nonfamily organizations. Because neighborhood nonfamily organizations may be important intervening links between land use and marriage timing, I include measures of how far away, in terms of minutes walking distance, are various nonfamily organizations and services. I focus on schools, health posts, markets, bus stops, and employers. Schools are defined as any place of instruction for youth. Health posts are any places of care and healing, such as hospitals, clinics, or doctor's offices. A market was defined as any place of at least two contiguous stores or places offering goods for sale. Bus stops were any places an individual could ride a vehicle for pay, which included buses, cars, or even tractors that were regularly operated for transportation. An employer was defined as a place that paid 10 or more people for work. The minutes walking distance in 1996 to the nearest of each of these nonfamily organizations or services was measured with the neighborhood history calendars.

Nonfamily Work and Schooling Activities

Nonfamily work was defined as work that took place outside the home. Work was measured in three categories: salaried jobs, wage labor, and family-owned businesses located outside the home. Each of these is measured with a dichotomous variable coded 1 if the respondent had the type of work in 1996, and 0 otherwise. Schooling is captured with two measures: schooling enrollment and schooling attainment. It is important to separately measure these dimensions of schooling because their relationships with marriage timing often differ (Blossfeld & Huinink, 1991; Raymo, 2003; Thornton, Axinn, & Teachman, 1995; Yabiku, 2005). Enrollment, or the state of being in school, often has a negative effect on marriage rates because the student role conflicts with the spouse role, and young people are often expected to have finished schooling before they marry. Educational attainment, however, often

increases marriage rates because individuals with more education are viewed as more attractive partners once they exit schooling. Enrollment is measured with a dichotomous variable, and attainment is measured with a continuous variable. All work and schooling variables are measured in 1996 and are static variables. Data on work and schooling after 1996 are not available.

Local Marriage Markets

The local marriage market for each respondent was calculated as the percent of single opposite-sex individuals in the neighborhood of similar age. For example, for a 20-year-old man, the local marriage market was represented by the percent of 19–21 year-old women in the neighborhood who were single. The local marriage market variable is time-varying.

Controls

Controls in the analyses include gender, age, ethnic group, and migration status. Gender is coded as a dichotomous variable where females are coded 1, males are coded 0. Age is simply the respondent's age at the beginning of the registry data collection in 1996. Because there is often a quadratic age-pattern to marriage, age-squared is also included in the models. Dummy indicators for ethnic group are included as controls. There are many diverse ethnic groups in the Chitwan Valley, but they can be categorized into five main groups: Upper Caste Hindus, Lower Caste Hindus, Newars, Terai Tibetoburmese, and Hill Tibetoburmese (Axinn & Yabiku, 2001).

Migration status is an especially important control in the analysis. In- and out-migration in rural areas can rapidly transform land use patterns and the rate at which these transformations occur (Perz & Skole, 2003; Rudel, Bates, & Machinguiashi, 2002). It may be that individuals with higher preference for delayed marriage may seek out and move to areas that have less agricultural land and more nonfamily organizations and activities. Thus the relationship between agricultural land and marriage timing could be overestimated. Migration variables can measure part of this process and test if these selection processes are occurring. I use two migration variables. The first is a static variable that indicates if the resident was born in his or her 1996 neighborhood. The second variable is time-varying and indicates, for each month, if the respondent is living away from his or her neighborhood.

Another concern in the analysis is how to parameterize the duration of the hazard. In contrast to a Cox proportional hazards model, in a discrete-time event history model it is necessary to specify the functional form of the hazard (Allison, 1995). Duration is modeled with the respondents' age and age-squared as well as dummies for calendar months. Because Hindus view some months as more auspicious than others for marriage, there are periodic monthly variations in marriage timing. Thus I include 11 dummy indicators to include the twelve calendar months, which allows for periodic month effects in the shape of the hazard.

Lastly, multilevel modeling techniques are used to address the clustered nature of the data. Respondents are clustered into 151 neighborhoods, and thus there is nonindependence between respondents (Raudenbush & Bryk, 2002). Ignoring the clustered structure of the data may lead to biased test statistics, most often in the form of deflated standard errors and increased Type I error. I use a random intercept

model to address this clustering. These models allow the intercept to vary randomly across the 151 neighborhoods. Multilevel hazard models have been used successfully in previous analyses of clustered data in the Chitwan Valley (Axinn & Yabiku, 2001; Barber, Murphy, Axinn, & Maples, 2000; Yabiku, 2004, 2005).

Results

Table 1 presents descriptive statistics for the measures used in the analysis. Of the 811 unmarried individuals aged 15–20 in 1996, almost two-thirds (64%) married during the following 7.5 years. In terms of land use, respondents lived in neighborhoods in which, on average, 70% of the total land area of the neighborhood was devoted to agricultural land. Recall that this land includes rain-fed khet, irrigated khet, and bariland. This indicates that most respondents lived in largely agricultural areas of the Chitwan Valley.

The distance to neighborhood nonfamily organizations and services showed variation in accessibility by the type of organization. Schools were the most accessible organizations, and respondents averaged less than a ten minute walk to the nearest school. Bus stops and markets were also nearby, with these organizations averaging about a 12 min walk away. Health posts and employers were the next farthest away; these organizations averaged a 20 min walk by foot. Note that it is not

Table 1 Descriptive statistics for $N = 811$ unmarried individuals

	Mean	St. Dev.
% Respondents who married during study	.64	.48
% Neighborhood land agricultural[a]	.70	.23
Nonfamily organizations (minutes by foot to nearest)		
School	8.88	6.40
Health post	19.71	7.96
Bus stop	12.06	3.97
Market	12.60	7.11
Employer	20.53	20.12
Nonfamily activities in 1996		
Salaried job	.06	.24
Family-owned business outside home	.01	.11
Wage labor	.35	.48
Years schooling completed	7.15	2.76
Enrolled in school	.70	.46
Local marriage market		
% Opposite sex single in neighborhood[a]	.36	.42
Migration		
Born in 1996 neighborhood	.66	.47
Currently living outside 1996 neighborhood[a]	.12	.32
Female	.48	.50
Ethnicity		
Upper Caste Hindu	.55	.50
Lower Caste Hindu	.09	.29
Newar	.08	.27
Hill Tibetoburmese	.12	.33
Terai Tibetoburmese	.15	.36
Age[a]	21.97	2.73

[a] Time-varying variable; values are from last observed month (marriage or censoring)

necessarily the nearest organization that is hypothesized to influence individual behavior. If a neighborhood is only 15 min from the nearest employer of 10 people or more, then there is a good chance there are also employers within 20, 25, and 30 min. Contrast that neighborhood to a neighborhood whose nearest employer is 50 min away by foot. Thus the distance to the nearest organization is simply a way to measure the respondent's neighborhood's general context of nonfamily organizations and not one particular organization.

Seventy percent of the sample was enrolled in school in 1996, and they had attained about 7 years of education, on average. The most common type of nonfamily employment was wage labor (35%). Salaried jobs (6%) and jobs at family-owned business outside the home (1%) were much less common. The marriage market variable indicated that, at time of marriage or censoring, in respondents' neighborhoods about one-third of similarly aged opposite sex residents were single. Migration experiences were frequent: two-thirds of respondents were born in the neighborhood in which they were interviewed in 1996, and 12% were living away from their neighborhood at time of marriage or censoring.

The sample was nearly equally divided by sex, with slightly more men than women (52% male, 48% female). In terms of ethnic composition, the largest group was the Upper Caste Hindus at slightly more than half the sample (55%). They were followed by the Terai Tibetoburmese at 15% of the sample. These ethnic representations are expected, and they mirror the general composition of the Chitwan Valley. Although the sample was age 15–20 years in 1996, age of the respondents averaged nearly 22 years at time of marriage or censoring. This is because respondents were followed for up to 7.5 years after the 1996 interview.

Table 2 presents the discrete-time estimates of the relationship between agricultural land use and marriage timing. The results are presented as odds ratios, which are the exponentiated coefficients of the logistic regression model used to estimate the discrete-time hazard. An odds ratio greater than one represents a positive effect on the marriage rate: it is an effect that causes individuals to marry sooner. In contrast, an odds ratio less than 1 is a negative effect on the marriage rate that delays individuals' marriages. An odds ratio of 1.00 is a null effect.

In model 1, the only predictors are percent agricultural land (logged) and controls. Model 1 indicates a significant relationship between agricultural land and the rate of marriage. When more land in a respondent's neighborhood was devoted to agricultural use, unmarried respondents tended to marry more quickly. Migration did not appear to be related to marriage timing. Migration selectivity into the neighborhood (whether or not the respondent was born in the neighborhood) was not significant ($P = .74$). Migration out of the neighborhood had a slight negative effect, suggesting that respondents who were living outside their neighborhoods after 1996 had lower preferences for marriage, but this was not significant ($P = .28$). While migration selectivity cannot be completely measured, these two variables suggest that migration is not introducing large selection effects with regards to marriage. The coefficients for age and age-squared indicate a quadratic age-pattern to marriage, as expected. Once transformed back to their original metrics by logging them and solving for the maximum, these results point to a peak in marriage rates at about 26.5 years, which is consistent with prior research in this context. Among the remaining controls, the coefficient for female (which is coded as female = 1, male = 0) is positive, indicating that women marry more quickly than men. This is expected because women tend to marry men who are older than themselves.

Table 2 Relationships between agricultural land and rate of marriage

	1	2	3	4	5
% Neighborhood Land Agricultural (logged)	1.151* (2.137)	1.109 (1.497)	1.154* (2.213)	1.153* (2.132)	1.123 (1.678)
Nonfamily organizations (minutes by foot)					
School		1.003 (.286)			1.005 (.534)
Health post		.996 (–.910)			.997 (–.820)
Bus stop		1.007 (1.445)			1.006 (1.184)
Market		.998 (–.401)			.997 (–.711)
Employer		1.007* (2.260)			1.007* (2.161)
Nonfamily activities in 1996					
Salaried job			1.207 (.958)		1.202 (.930)
Family-owned business outside home			1.310 (.638)		1.322 (.657)
Wage labor			1.380** (3.316)		1.384** (3.318)
Years schooling completed			1.008 (.394)		1.012 (.629)
Enrolled in school			.701** (–3.258)		.707** (–3.150)
% Opposite sex single in neighborhood				1.123 (1.036)	1.151 (1.250)
Migration					
Born in 1996 neighborhood	.967 (–.332)	.970 (–.298)	.993 (–.069)	.965 (–.343)	.990 (–.093)
Living outside 1996 neighborhood	.865 (–1.090)	.863 (–1.104)	.845 (–1.253)	.866 (–1.078)	.845 (–1.250)
Female	2.396** (9.719)	2.380** (9.615)	2.331** (9.015)	2.359** (9.316)	2.289** (8.585)
Ethnicity					
Lower Caste Hindu[a]	1.286 (1.485)	1.261 (1.361)	1.127 (.687)	1.293 (1.508)	1.133 (.706)
Newar[a]	.884 (–.641)	.890 (–.601)	.907 (–.510)	.888 (–.611)	.917 (–.446)
Hill Tibetoburmese[a]	1.371* (2.090)	1.333 (1.856)	1.313 (1.816)	1.377* (2.100)	1.289 (1.632)
Terai Tibetoburmese[a]	1.158 (.932)	1.067 (.399)	1.003 (.021)	1.172 (.994)	.955 (–.266)
Age	2.347** (3.653)	2.341** (3.642)	2.326** (3.608)	2.364** (3.683)	2.343** (3.636)
Age-squared	.984** (–2.967)	.984** (–2.945)	.984** (–2.963)	.984** (–2.958)	.984** (–2.937)
N (person-months)	48861	48861	48861	48861	48861

[a] Upper Caste Hindu is reference group

Coefficients are odds ratios, with *z*-statistics in parentheses; *$P < .05$, **$P < .01$, ***$P < .001$, two-tailed tests

Note: Intercept and monthly dummies for baseline hazard were estimated, but not displayed

Compared to the reference group (Upper Caste Hindu), Hill Tibetoburmese married at higher rates.

In model 2, I introduce measures of distance to nonfamily organizations. The distance to schools, health posts, bus stops, and markets is not significantly associated with marriage rates. The distance to the nearest employer has a significant, positive effect on the rate of marriage. The odds ratio of 1.007 means that for each minute of walking distance to the nearest employer of 10 or more people, the rate of marriage is predicted to increase by .7%. This may not appear to be a sizable effect, but it must be remembered that odds ratios are multiplicative; thus the effects are multiplied for each one-unit change. As an example, compare two individuals, one who lives in a neighborhood that has an employer (0 min walk) and one who lives 40 min from the nearest employer. The values of 0 and 40 min are about 1 standard deviation below and above the mean; thus these are reasonable values for the data. The difference in marriage rates between these two individuals is 32.2%: the individual who lives 40 min away from the employer is predicted to marry at a rate that is 32.2% higher than the individual who lives in the neighborhood with an employer (1.007 raised to the power of 40 equals 1.322).

In addition to the significant effect of distance to employers in model 2, also of note is the change in the coefficient for agricultural land. Although the effect of agricultural land is still positive, it is no longer significant at the .05 level. It has decreased from 1.151 in model 1 to only 1.109 in model 2. Although the effect is not reduced to null (1.00), it appears that some of the effect of agricultural land might be attributed to the presence of nearby employers.

Model 3 examines the influence of work and schooling activities. The only significant employment measure is wage labor, which significantly increased the rate of marriage. This is contrary to expectations, which hypothesized that employment would delay marriage. An explanation might be selectivity into this type of employment. Wage labor jobs do not require much education, and the type of individuals who take these jobs may have low educational and career aspirations. The coefficients for education show that years schooling completed is not related to marriage, but enrollment has a strong negative association with marriage rates. Individuals who were enrolled in school in 1996 married at rates 30% lower than nonenrolled individuals. This result is consistent with the explanation that enrollment creates role conflict between student and spouse roles, which tends to delay marriage. It is important to note in model 3 that the coefficient for agricultural land remains significant, and it is little changed compared to the model without nonfamily activities (model 1). Thus while an individual's wage labor and school enrollment is related to marriage timing, these factors appear unrelated to the amount of agricultural land in the neighborhood.

Model 4 introduces a measure of the local marriage market: the percent of single opposite sex individuals of similar age in the neighborhood. If decreasing agricultural land leads to an out-migration of young people (Bates & Rudel, 2004; Bhandari, 2004; Carr, 2004), then local marriage market conditions may help to explain the relationship between agricultural land use and marriage timing. While in the expected direction (positive), the availability of potential spouses in the neighborhood is not significant. Furthermore, the coefficient for agricultural land in the neighborhood is essentially unchanged from the original model (model 1).

Lastly, in model 5 all predictors are estimated in the same model. The effects of predictors in model 5 are similar to what they were in previous models. The effect of

agricultural land remains insignificant, most likely due to the continued presence of distance to employers in the model. The effects that were significant in prior models (distance to employers, individual wage labor, and individual school enrollment) remain significant, and their coefficients are largely unchanged, suggesting that these factors are mostly independent of each other. Note that while the coefficient for agricultural land is not significant ($P = .09$), it is not reduced to a null effect (1.00). This suggests that while predictors in the final model mediate some of its relationship with marriage timing, there likely exists other unmeasured factors that mediate this relationship.

Discussion

In this paper, I have examined how the portion of a neighborhood's land used in agriculture is related to individual behavior in marriage. After establishing a positive relationship between agricultural land use and marriage rates, I attempted to explain this relationship with measures of distance to nonfamily organizations, individuals' work and schooling activities, and local marriage market conditions.

Distance to the nearest employer explained part of the relationship between land use and marriages rates. This finding is similar to analyses of land use in other settings. There are strong parallels between Chitwan and Landale's (1989) analysis of agricultural opportunity and marriage in the turn of the century United States. In both settings, the availability of agricultural land shared a positive association with marriage rates, and the presence of rural nonfarm employment alternatives was negatively associated with marriage.

At first glance, the finding in the Chitwan context appears to support the ecological constraints hypothesis and the explanation that as agricultural land decreases, it is replaced with nonfarm employment opportunities. Since these opportunities often require more schooling, young people stay in school longer and delay marriage. This explanation, however, was not supported by subsequent models that included measures of young people's employment activities: employment was positively associated with marriage, and whether or not someone was employed did not explain the relationship between land use and marriage.

These puzzling results suggest several alternative explanations. First, distance to the nearest employer may represent other unmeasured characteristics in addition to employment opportunities. Young people living near employers are exposed to nonfarm modes of production, and this may raise their educational, consumption, and employment aspirations—these ideational influences could delay marriage without the young person actually taking a job at these places of employment. Second, there may be selection issues driving the result that nonfamily employment activities increased marriage rates. Consider the cohort age 25–30 years in 1996; this is the cohort born prior to the analysis sample, which was age 15–20 years in 1996. Among the 25–30 year-old age group in 1996, years of completed schooling varied substantially depending on the type of employment: salaried workers averaged 7.7 years, wage laborers averaged 2.4 years, and workers at family-owned business averaged 7.3 years. Clearly, wage labor is taken by individuals with less education and likely other unmeasured correlates for earlier marriages. In the analysis sample, respondents who took employment this early (age 15–20 years) are likely to be different than respondents who took jobs later. Since work activities were measured

only in 1996, when respondents were age 15–20 years, it is not possible to test if employment later, when the respondents were in their 20s, may delay marriage.

Another unanswered question is the role of environmental perceptions. Perceptions of environmental change and opportunity were theorized to be mechanisms linking land use to marriage, but it was not possible to include measures of these mechanisms in the analysis. Previous work suggests these perceptions play an important role in family formation (Abernethy, 1999; MacDonald, 1999). Furthermore, research from Nepal shows that there is significant variation in perceptions of environmental quality and degradation, and these worsening perceptions are linked to the creation of the built environment (Barber, Biddlecom, & Axinn, 2003). Thus it is likely important to examine not only how actual land use is associated with family formation decisions, but how perceptions also influence these processes.

In sum, this paper shows overall associations between land use and marriage timing that invite additional investigation. Accessibility of nonfarm employment opportunities appear to explain part of this relationship, but the respondents' measured employment activities failed to support this hypothesis. Thus the specific mechanisms linking agricultural land to marriage decisions remain unclear. Exploring these mechanisms will help to further our knowledge of how population processes are affected by environmental conditions.

References

Abernethy, V. D. (1999). A darwinian account of the fertility opportunity hypothesis. *Population and Environment, 21*, 119–148.

Allison, P. D. (1995). *Survival analysis using the SAS system: A practical guide*. Cary, NC: SAS Institute Inc.

An, L., Mertig, A. G., & Liu, J. (2003). Adolescents leaving parental home: Psychosocial correlates and implications for conservation. *Population and Environment, 24*, 415–444.

Anderton, D. L., & Barrett, R. B. (1990). Demographic seasonality and development: The effects of agricultural colonialism in Taiwan, 1906–1942. *Demography, 27*(3), 397–441.

Awasthi, K. D., Sitaula, B. K., Singh, B. R., & Bajacharaya, R. M. (2002). Land-use change in two Nepalese watersheds: GIS and geomorphometric analysis. *Land Degradation & Development, 13,* 495–513.

Axinn, W. G., & Ghimire D. J. (2003). Population and land use: Social change, fertility and the transition to a built environment. Working Paper. Ann Arbor: Institute for Social Research.

Axinn, W. G., & Yabiku, S. T. (2001). Social change, the social organization of families, and fertility limitation. *American Journal of Sociology, 106*(5), 1219–1261.

Axinn, W. G., Barber, J. S., & Ghimire, D. J. (1997). The neighborhood history calendar: A data collection method designed for dynamic multilevel modeling. *Sociological Methodology, 27*, 355–392.

Barber, J. S., Biddlecom, A. E., & Axinn, W. G. (2003). Neighborhood social change and perceptions of environmental degradation. *Population and Environment, 25*, 77–108.

Barber, J. S., Shivakoti, G. P., Axinn, W. G., & Gajurel, K. (1997). Sampling strategies for rural settings: A detailed example from Chitwan valley family study, Nepal. *Nepal Population Journal, 6*(5), 193–203.

Barber, J. S., Murphy, S., Axinn, W. G., & Maples, J. (2000). Discrete-time multilevel hazards analysis. *Sociological Methodology, 30*, 201–235.

Barbieri, A. F. B., & Carr, D. L. (2005). Gender-specific out-migration, deforestation and urbanization in the Ecuadorian Amazon. *Global and Planetary Change, 47*, 99–110.

Basu, K., & Van, P. H. (1998). The economics of child labor. *The American Economic Review, 88*(3), 412–427.

Bates, D. C., & Rudel, T. K. (2004). Climbing the 'Agricultural Ladder': social mobility and motivations for migration in an Ecuadorian colonist community. *Rural Sociology, 69*(1), 59–75.

Bentley, G., Goldberg, T., & Jasienska, G. (1993). The fertility of agricultural and non-agricultural traditional societies. *Population Studies, 47*, 269–281.
Bhandari, P. (2004). Relative deprivation and migration in an agricultural setting of Nepal. *Population and Environment, 25*(5), 475–499.
Bhat, P. N. M., & Halli, S. S. (1999). Demography of brideprice and dowry: Causes and consequences of the Indian marriage squeeze. *Population Studies, 53*(2), 129–148.
Blossfeld, H.-P., & Huinink, J. (1991). Human capital investments or norms of role transition? How women's schooling and career affect the process of family formation. *American Journal of Sociology, 97*(1), 143–168.
Bongaarts, J. (1978). A framework for analyzing the proximate determinants of fertility. *Population and Development Review, 4*, 105–132.
Bongaarts, J., & Watkins, S. C. (1996). Social interactions and contemporary fertility transitions. *Population and Development Review, 22*(4), 639–682.
Boserup, E. (1981). *Population and technological change: A study of long-term trends*. Chicago: University of Chicago.
Cain, M., & Mozumder, A. B. M. K. A. (1981). Labour market structure and reproductive behavior in rural South Asia (pp. 245–287). In G. Rodgers & G. Standing (Eds.), *Child work, poverty and underdevelopment*. Geneva: International Labour Organization.
Caldwell, J. C. (1982). *Theory of fertility decline*. New York: Academic Press.
Carr, D. L. (2004). Proximate population factors and deforestation in tropical agricultural frontiers. *Population and Environment, 25*(6), 585–612.
Clay, D. C., & Johnson, N. E. (1992). Size of farm or size of family: Which comes first? *Population Studies, 46*, 491–505.
Davis, K. (1963). The theory of change and response in modern demographic history. *Population Index, 29*, 345–366.
Davis, K. (1984). Wives and work: The sex role revolution and its consequences. *Population and Development Review, 10*, 397–417.
Ehrlich, P. R., Ehrlich, A. H., & Daily, G. C. (1993). Food security, population and environment. *Population and Development Review, 19*, 1–32.
Ghimire, D. J., Axinn, W. G., Yabiku, S. T., & Thornton, A. (2006). Social change, premarital nonfamily experience and spouse choice in an arranged marriage society. *American Journal of Sociology, 111*, 1181–1218.
Guest, A. M. (1981). Social structure and U.S. Inter-State Fertility Differentials in 1900. *Demography, 18*, 465–486.
Guneratne, A. (1996). The tax man cometh: the impact of revenue collection on subsistence strategies in Chitwan Tharu society. *Studies in Nepali History and Society, 1*(1), 5–35.
Henry, S., Schoumaker, B., & Beauchemin, C. (2004). The impact of rainfall on the first out-migration: A multi-level event-history analysis in Burkina Faso. *Population and Environment, 25*, 423–460.
Kent, J. P. (2002). On the decline of marriage in rural Ireland 1851–1911: The role of ecological constraints and/or developing philopatry. *Population and Environment, 23*, 525–540.
Landale, N. S. (1989). Agricultural opportunity and marriage: The U.S. at the turn of the century. *Demography, 26*(2), 203–218.
Landale, N. S., & Tolnay, S. E. (1991). Group differences in economic opportunity and the timing of marriage: Blacks and Whites in the rural south, 1910. *American Sociological Review, 56*(1), 33–45.
Lichter, D. T., McLaughlin, D. K., Kephart G., & Landry, D. J. (1992). Race and the retreat from marriage: A shortage of marriageable men? *American Sociological Review, 57*(6), 781–799.
Lloyd, K. M., & South, S. J. (1996). Contextual influences on young men's transition to first marriage. *Social Forces, 74*(3), 1097–1119.
MacDonald, K. (1999). An evolutionary perspective on human fertility. *Population and Environment, 21*, 223–246.
Marx, K., & Engels, F. (1978). Manifesto of the communist party. In R. C. Tucker (Ed.), *The Marx-Engels Reader* (2nd ed., pp. 469–500). New York: Norton.
McKenzie, R. D. (1921). The neighborhood: A study of local life in the city of Columbus, Ohio. II. *American Journal of Sociology, 27*, 344–363.
Müller-Böker, U. (1999). *The Chitwan tharus in Southern Nepal: An ethnoecological approach*. Stuttgart: Steiner.

Pan, W. K. Y., & Bilsborrow, R. E. (2005). The use of a multilevel statistical model to analyze factors influencing land use: A study of the Ecuadorian Amazon. *Global and Planetary Change, 47*, 232–252.

Perz, S. G., & Skole, D. L. (2003). Social determinants of secondary forests in the Brazilian Amazon. *Social Science Research, 32*, 25–60.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models* (2nd ed.). Thousand Oaks: Sage.

Raymo, J. M. (2003). Educational attainment and the transition to first marriage among Japanese women. *Demography, 40*(1), 83–103.

Rosenzweig, M. R., & Evenson, R. (1977). Fertility, schooling and economic contribution of children in rural India: And econometric analysis. *Econometrica, 45*(5), 1065–1079.

Rindfuss, R. R., Walsh, S. J., Turner, B. L. II, Fox, J., & Mishra, V. (2004). Developing a science of land change: Challenges and methodological issues. *Proceedings of the National Academy of Sciences, 101*(39), 13976–13981.

Rudel, T. K., Bates, D., & Machinguiashi, R. (2002). A tropical forest transition? Agricultural change, out-migration, and secondary forests in the Ecuadorian Amazon. *Annals of the Association of American Geographers, 92*(1), 87–102.

Simmons, C. S., Walker, R. T., Wood, C. H., Arima, E., & Cochrane, M. (2004). Wildfires in Amazonia: A pilot study examining the role of farming systems, social capital, and fire contagion. *Journal of Latin American Geography, 3*(1), 81–95.

Skole, D. L. (2004). Geography as a great intellectual melting pot and the preeminent interdisciplinary environmental discipline. *Annals of the Association of American Geographers, 94*(4), 739–743.

Strassmann, B. I., & Clarke, A. L. (1998). Ecological constraints on marriage in rural Ireland. *Evolution and Human Behavior, 19*(1), 33–55.

Tambashe, B. O., & Shapiro, D. (1996). Family background and early life course transitions in Kinshasa. *Journal of Marriage and the Family, 58*(4), 1029–1037.

Thapa, K. K., Bilsborrow, R. E., & Murphy, L. (1996). Deforestation, land use, and women's agricultural activities in the Ecuadorian Amazon. *World Development, 24*, 1317–1332.

Thornton, A., & Fricke, T. E. (1987). Social change and the family: Comparative perspectives from the West, China, and South Asia. *Sociological Forum, 2*, 746–779.

Thornton, A., & Lin, H.-S. (1994). *Social change and the family in Taiwan*. Chicago: University of Chicago Press.

Thornton, A., Axinn, W. G., & Teachman, J. (1995). The influence of educational experiences on cohabitation and marriage in early adulthood. *American Sociological Review, 60*, 762–774.

VanLandingham, M., & Hirschman, C. (2001). Population pressure and fertility in pre-transition Thailand. *Population Studies, 55*(3), 233–248.

Walker, R., Moran, E., & Anselin, L. (2000). Deforestation and cattle ranching in the Brazilian Amazon: External capital and household processes. *World Development, 28*(4), 683–699.

Wilcox, P., Quisenberry, N., & Jones, S. (2003). The built environment and community crime risk interpretation. *Journal Of Research in Crime and Delinquency, 40*, 322–345.

Yabiku, S. T. (2005). The effect of non-family experiences on age of marriage in a setting of rapid social change. *Population Studies, 59*(3), 339–354.

Yabiku, S. T. (2004). Marriage timing in Nepal: Organizational effects and individual mechanisms. *Social Forces, 83*, 559–586.