Agricultural Change and Migration in a Rural Agrarian Setting

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Abstract

Many rural agrarian societies are experiencing dramatic changes. Farm households are giving way traditional family-based farming practices and are increasingly being reliant on market-based modern technologies. An increasing number of farm households are also engaged in out-migration. However, less is known about the extent to which such agrarian transformations influence individual out-migration. Using ten and a half years of longitudinal panel data from a rural setting of Nepal, this study investigates the impact of labor-saving modern farm technology use on out-migration. We argue that use of labor-saving technologies in agriculture replaces farm labor and positively influences individual out-migration. Using the discrete time event history method to model the monthly hazard of out-migration, our findings suggest that while other farm implements and chemicals did not have a large effect, the use of a tractor significantly predicts subsequent out-migration. This investigation sheds light on population and development issues in the region.

Introduction

Almost all rural agrarian societies around the world have been undergoing remarkable changes in the ways in which farms are operated (Majumdar et al. 2001; Mamdani 1972; World Bank 2008). New technological innovations (such as high-yielding crop varieties, improved animal breeds, chemical fertilizers, pesticides, and mechanization) and the development of new markets have dramatically changed the agricultural sector, leading to a transformation of subsistence-based farming systems in many rural agrarian societies (Majumdar et al. 2001; World Bank 2008). Traditional family-based farming systems are rapidly experiencing greater commercialization; rural subsistence agriculture is shifting towards market-based agriculture, and rural farm households are increasingly reliant on modern farm technologies such as tractors, pumpsets, improved farm implements, and chemicals (such as fertilizers and pesticides) to increase per-unit-area production. In addition, the volume of out-migration from developing countries is quite significant, and an increasing number of agricultural households in developing countries are engaged in migration (Jokish 2002). This migration of labor out of agriculture has been the primary feature of the economic development process (de Haan 1999; Taylor and Martin 2001; de Brauw 2007).

As we will discuss in detail, the increased adoption of these new technologies can impact the agricultural labor force in important ways. Nepal, the setting for this investigation, has experienced dramatic agricultural transformations as well as the migration of labor out of agriculture, and thus serves as an excellent case for studying the possible linkages between these two phenomena. Empirical evidence suggests that the increased use of modern farm technologies can result in the substitution of human labor (Agarwal 1983; Binswanger 1978; Levy 1985; Schutjer and Van der Veen 1977; Boserup 1965; Mamdani 1972; Rauniyar and Goode 1996). Therefore, use of such technologies by farmers in crop production has the potential to replace the need for manual human labor, especially when these technologies are used for labor-intensive tasks. This may have important implications on demographic processes such as migration. The now unneeded human labor creates a mobile labor force which is less attached to the local agrarian structure and is therefore prone to migration. In the absence of other employment opportunities, there is strong reason to expect that the newly released human labor will migrate (Massey et al. 1998).

Unfortunately, although a number of explanations exist as to why people migrate (see Massey et al. 1993; 1998; Massey, Axinn, and Ghimire 2010; Adamo 2009; Gray 2009; Hunter 2005; Myers 2002; Bilsborrow 1992, 2002), little is known about the influence of such agrarian transformations on migration patterns. To fill this important research gap, this study attempts to investigate the following question: *To what extent does the use of labor-saving modern farm technologies influence individual out-migration, net of all other important factors*?

This research is important for both theoretical and practical reasons. Theoretically, we examine the effect of a new group of factors—labor-saving farm technologies—on rural out-migration in agrarian settings of developing countries. On a practical level, this research will have substantial relevance for understanding these relationships in many other parts of the world, where living conditions are similar to those in our study setting of Nepal. Located between India and China, the Nepalese population is a mixture of the ethno-racial groups originating in these two countries. Although there are important differences between the countries of Asia, the population of Nepal lives under social, cultural, and economic conditions similar to those of most parts of Asia, especially China, India, Pakistan, and Bangladesh. Because of the similarities between Nepal and much of the non-Western world, our findings from Nepal—although particular to that setting—will have substantial relevance for understanding these relationships in many other parts of the world.

Additionally, our study can shed light on important policy issues affecting lesser developed countries, where increasing agricultural output and slowing population growth are important policy goals (Schutjer and Stokes 1982). More specifically, increasing food productivity and relieving population pressure on the land are two important challenges that are facing Nepal (Ashby and Pachico 1987). The two central focuses of our study are directly related to these policy issues, as the use of modern farm technologies may help increase agricultural production, and any subsequent migration due to labor replacement may help relieve population pressure on the land.

Background

Nepal is an agrarian society; over 80% of people rely on farming as their mainstay. As in other agrarian settings of many developing countries, farming in Nepal is mainly subsistence and is commonly performed by using human and animal labor. While population growth has been rapid, food production has been unable to keep up with this growth (CBS 2002; Chitrakar 1990; APP 1995). This mismatch in population growth and food production is an important factor that necessitates the use of modern agricultural technologies as well as a relief mechanism for land that is overcrowded.

As introduced above, the rural agrarian setting is experiencing a dramatic transition away from subsistence farming with a very low level of mechanization and no use of chemical fertilizers or pesticides to a more commercialized farming system with increasing dependency on capital-intensive inputs such as chemical fertilizers, as well as technology advancements through mechanization (Pariyar, Shrestha, and Dhakal 2001; Ministry of Agriculture and Cooperative 2003; APP 1995). For example, land preparation, which has been traditionally performed by animal and human labor, is being gradually replaced by the use of tractors. Farmers are also increasingly using other improved farm implements such as corn shellers, threshers, sprayers, and chaff cutters. Corn shellers are used for loosening grains from corn cobs; threshers are used to separate grains from wheat straw or rice straw; sprayers are used to apply chemicals such as pesticides and herbicides; and chaff cutters are used to chop straw or dried fodder for livestock. Farmyard manure (FYM) or compost has been commonly used as soil nutrient replenishing material, but recently the use of chemical fertilizers has been increasing. Some farmers use chemical fertilizers in combination with compost. The use of pesticides (both insecticides and herbicides) is not especially common, with the exception of more commercialized crops such as vegetables. The rising usage of these technologies and chemicals is a core component of the changes that are revolutionizing agriculture in Nepal.

In addition to this agricultural transformation, the country is also experiencing an increasing volume of out-migration from rural areas to cities, and to international destinations. During the 1950's, the country experienced substantial migration from the hill regions to the Terai, a lowland region next to the Indian border. From the 1970's through the present, the country has exhibited high geographical mobility from rural to urban areas. Aside from these internal migration patterns, there has been a recent rise in international out-migration. Although it is difficult to estimate precisely the number of Nepalis who have migrated outside the country, the number is significantly greater than one million and is probably much higher, representing as much as 15% of the population, and a much higher percentage for young people and men in particular. In 1997, the number of international migrants was estimated at 100,000 scattered across 25 countries (excluding India), and the amount of remittances received by the country was about NRs 29 billion (Seddon, Adhikari, and Gurung 2001). The number of migrants has increased since 1997, and has reached over 200,000 international migrants annually to more than 105 countries (Sharma and Gurung 2009). This substantial out-migration has resulted in a shortage of labor within Nepal, particularly male labor, and has affected some malespecific farm work like plowing and digging (Adhikari 2001). Below we provide a conceptual link between agrarian change and migration.

Use of Labor-saving Modern Farm Technologies and Migration: A Conceptual Link

As discussed above, subsistence farming was traditionally performed using human and animal labor. Land preparation, which was commonly performed by animal and human labor, is being gradually replaced by the use of tractors, which plays a considerable role in the reduction of manual labor (Bartsch 1977; Agarwal 1983; Binswanger 1978; Levy 1985; Schutjer and Van der Veen 1977). According to Agarwal (1983), the use of a tractor required only one-fifth of the labor that was needed when using bullocks. Farmers are also increasing the use of other improved farm implements such as corn shellers, threshers, sprayers, and chaff cutters. Altogether, these improved farm implements diminish the need for human labor. For example, Binswanger (1978) reported that mechanical threshing of wheat reduced about 71 man-hours per hectare of land in India.

The use of chemical fertilizers is also increasing, although some farmers use these chemicals in conjunction with the traditional application of farmyard manure (FYM). FYM is applied by hand, green manure is applied right in the field by cutting green plants and plowing them into the soil, and chemical fertilizers are applied by hand or using a scoop and basket (Bartsch 1977). In some countries, fertilizer drills, seed drills, and row planters are used to apply chemical fertilizers. In Nepal, manual application by hand is a commonly used technique. Comparative studies on the labor requirements of various methods of manure application are scarce. Moreover, the available evidence is not conclusive. In Swaziland, the use of chemical fertilizer is considered to be a labor-intensive technology, where it is frequently used as basal-dose and top-dressing (Rauniyar and Goode 1996). Arnon (1987) also reported that the application of fertilizers may increase labor demand due to the need for more frequent and intensive weeding (see also Bartsch 1977 for similar findings in India).

Although these studies have not compared the labor requirements between chemical fertilizer application and traditional application of manure, it seems that the application of FYM would demand a much higher level of human labor when compared to the use of chemical fertilizers. This is because a household is required to keep livestock to produce manure for field, which demands a regular supply of labor for the care and management of animals. Additionally, the barn has to be cleaned and compost has to be prepared. Prepared compost then must be carried out to the field in baskets or carts and has to be applied in each and every field. This process requires a significant amount of labor when compared to buying, storing, and applying chemical fertilizer in the field.

The application of herbicides and insecticides can also replace manual labor. (Herbicides are used for controlling weed growth in crop fields, and insecticides and pesticides are used for controlling insects and diseases.) The manual weeding of unwanted plants is a common practice in Nepal’s Chitwan Valley. In their work on India, Rani and Malavia (1992) reported that one acre of land required 12.42 days for manual weeding by women. When herbicides were applied to control weeds, the time required decreased to 0.42 days per acre. Although the use of pesticides (along with insecticides and herbicides) is not that common in the Chitwan Valley except in commercialized crops such as vegetables. Whenever used, such chemicals can significantly reduce the labor requirements for weeding as well as the work required to "rough out" diseased plants by hand.

For the reasons outlined above, there is enough preliminary evidence to anticipate that labor-saving modern farm technologies will displace labor and may thus have important implications for demographic processes such as migration. Massey et al. (1998) argue that the mechanization of agriculture decreases the need for manual labor and thus releases labor out of agriculture. The displaced labor creates a mobile labor force that is less attached to the local agrarian structure and is likely to migrate. Given this potential explanation, in this study, we test the following hypothesis: *The use of modern labor-saving technologies such as tractors, improved farm implements, chemical fertilizers, and pesticides in crop production by households encourages migration of individuals from those households.*

Methods

Setting. As already introduced, the setting for this study is the western Chitwan Valley situated in the southern plain of central Nepal. Before the 1950's, the valley was primarily covered with dense forests and was infamous for malarial infestation. During the 1950's, the government, with U.S. assistance, initiated a rehabilitation program in the valley by clearing the dense forests. Since then, the valley has witnessed a rapid inflow of internal migrants. People were attracted by the free distribution of land for agricultural purposes at the beginning of the settlement, and the development of modern amenities and services in recent decades. Currently, the valley is inhabited mostly by in-migrants, especially from *pahad,* i.e., the Hill and the high Hill and other adjacent Terai districts including India. Further, Chitwan's central location and relatively well-developed transportation network have been catalytic forces for transforming it into a hub for business and tourism. This has resulted in a rapid proliferation of government services, businesses, and wage labor opportunities in the district (Shivakoti et al. 1999).

Farming is still the main source of livelihood for people in the valley. Although agriculture is experiencing modernization, it remains mostly subsistence in nature. A large majority of farmers practice mixed-farming with highly integrated crop-livestock production systems. A survey conducted in 1996 indicated that over 82% of households were farming households. About three-fourths of them kept cattle, buffalo, sheep, and goats (Bhandari 2006).

Data. This study uses household-level data from multiple surveys collected by the Chitwan Valley Family Study (CVFS). The CVFS examines the influence of rapidly changing social contexts on demographic processes including timing of marriage, childbearing, contraceptive use, and migration. The research is also designed to investigate the reciprocal relationships between family formation (marriage, childbearing, and migration) and environmental outcomes such as land use. For the study at hand, we use the 1996 household census, baseline agriculture survey, and the ongoing monthly household registry data collected for 126 months (10.5 years) since 1996. These multiple survey components included all households that were present in the sample neighborhood or cluster (see Barber et al. 1997 for details) and utilized the same study population over time.

The 1996 household census collected information on the age and gender of each household member. An individual was considered a household member if he or she ate and slept most of the time in a given household during the previous six months. The 1996 baseline agriculture data recorded information on farming activities. Of particular interest to this study, the survey recorded information on the use of various farm inputs and technologies such as tractors, pumpsets, chemical fertilizers, pesticides (insecticides and herbicides), and other farm implements in crop production, as well as additional information about the size of cultivated land, land ownership, and livestock holding. The data were collected using a face-to-face interview technique featuring a carefully designed, interviewer assisted, structured schedule.

The ongoing monthly household registry monitors demographic events such as marriage, childbearing, migration, and deaths for every month since 1996. This study utilizes the first-time out-migration by an individual as the outcome variable, which was updated from the household registry over a period of 126 months (10.5 years). While some of individual level controls come from the interview interviews conducted 1996, other controls such as the number of non-family community services and the distance to the largest market center of Narayangarh come from neighborhood-level data (see Axinn, Barber, and Ghimire1997 for details).

Measure of Migration

Measures used in the study are defined in Table 1, along with their means and standard deviations. Migration is defined as any departure *from the neighborhood* lasting one month or more for any reason that includes moving within and outside Nepal. We selected an interval of one month rather than a year or some other duration to capture seasonal migrations. This is measured as the first time a migration was made by an individual.

Measure of Technology Use

Use of modern farm technologies such as tractors, pumpsets, other farm implements, chemical fertilizers, and pesticides in crop production by a farm household in 1996 are the major explanatory variables used. Importantly, the independent variables were measured in 1996 and the dependent variable migration was measured over a period of 126 months after 1996. This provides the unique opportunity to perform causal analysis to examine the effect technology use in crop production on subsequent migration.

Tractor use. In this study, the use of a tractor was measured with the following survey item: "Did your household use a tractor to plough the land for planting [name of crop]?" The response was coded as "1" if that household used a tractor and "0" if otherwise.

Use of modern farm implements. Ownership of modern farm implements (such as a thresher, chaff cutter, sprayer, corn sheller, etc.) has been considered an indicator of improved technology use on the farm. To measure this variable, respondents were asked the following question: "Does your household have a thresher, chaff cutter, sprayer, corn sheller, or any other kind of farm tools?" The response was recorded as "1" if a household owned any of these implements and "0" if otherwise.

Use of chemical fertilizers and pesticides/herbicides. Use of chemical fertilizers and pesticides/herbicides was measured by asking: "Did you use chemical fertilizer in the past three years?" A similar question was asked for pesticide/herbicide use. The answer was recorded as "1" if a household used the chemical fertilizer or pesticide and "0" if otherwise. These two variables were used separately in the analysis as a dichotomy.

Control Variables

Our interest here is in measuring the *independent* effects of the uses of labor-saving farm technologies on out-migration while holding constant the effects of social and economic variables that are more typically included in migration models. Therefore, in this study we control for the effects of variables that fall under human capital, social capital, and physical capital as previously used by researchers in this setting to study migration (Massey, Axinn, and Ghimire 2010). We also include individual characteristics such as age and gender along with indicators of ethnicity.

Measures of *human capital* include: (a) whether the respondent was enrolled in school (yes/no), (b) the number of years of schooling, (c) whether the respondent currently had a wage job (yes/no), and (d) whether he or she currently had a salaried job (yes/no). These measures were derived from responses to a series of questions on the Life History Calendar during individual interviews.

We used two *social capital* variables in the analysis: (a) if a household had a network tie, measured by the presence of others with migratory experience in the household; and (b) neighborhood prevalence, measured by the relative number of persons within the neighborhood who have migrated in the past, also called the migration prevalence ratio.

Measures of *physical capital* include access to markets, ownership of farmland, livestock ownership, ownership of house plot, and house quality. These measures come from the 1996 household agriculture and consumption interview.

Demographic controls include age, gender, and household size. Age is categorized into four birth cohorts. Gender is a dichotomy (male vs. female). Household size is the number of individuals living together at the time of 1996 census. Ethnicity is measured as: 1) high caste Hindus; 2) lower caste Hindus; 3) Newars; 4) hill Tibeto-Burmese (Tamang, Gurung, and Magar); and 5) terai Tibeto-Burmese (Tharu, Derai and Kumal).

(Control variables will be discussed in detail)

Analytic Strategy

The panel data from the Chitwan Valley Family Study offers a unique opportunity to examine the effects of labor-saving modern technologies on out-migration while simultaneously controlling for other social and economic factors known to influence mobility. We use discrete time event history methods to model the monthly hazard of out-migration by particular individuals, with person-months serving as the unit of analysis (Massey, Axinn, and Ghimire 2010). We follow individuals within each household month-by-month for 126 months beginning in February 1997 and each month regress the 0-1 migration outcome on independent variables.

We control for duration by counting the number of months transpired since February 1997, along with a squared term, and then estimate the model using the GLIMMIX macro of SAS, following an estimation strategy advocated by Barber et al. (2000). This strategy produces a multilevel hazard model that accounts for the clustering of individuals in our sample by community (see Barber et al. 2000; Yabiku 2004).

(This section will be discussed in detail)

Results and Discussion

(This section yet to be written)

Summary and Conclusion

(This section yet to be written)

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Table 1. Definitions, means and standard deviations of variables used in the analysis of farm technology use and first time migration in the Chitwan Valley, Nepal

Independent Variables	Definition	Mean	SD
Major Independent Variables			
Tractor use	1 if used tractor, 0 otherwise	0.77	0.42
Farm Implements	1 if used any farm implements, 0 otherwise	0.17	0.38
Chemical Fertilizer	1 if used chemical fertilizer, 0 otherwise	0.84	0.37
Pesticides	1 if used pesticides, 0 otherwise	0.24	0.43
Theoretical controls			
Human capital			
Enrolled in school	1 if currently enrolled, 0 otherwise	0.17	0.38
Years of schooling	Years enrolled prior to 1996	5.87	5.82
Currently has wage job	1 if now has wage job, 0 otherwise	0.36	0.48
Currently has salaried jo	1 if now has salaried job, 0 otherwise	0.08	0.27
Social capital			
Household has network tie	1 if household has migrant, 0 otherwise	0.59	0.48
Neighborhood prevalence	Proportion of migrants in neighborhood	0.23	0.10
Physical capital			
Market access	Minutes walk to nearest market (logged)	1.97	1.19
Farmland	1 if household owns land, 0 otherwise	0.94	0.23
Livestock	Number of standardized units	2.97	2.24
House plot owned	1 if house plot owned, 0 otherwise	0.94	0.24
Home quality	Index ranging from 4-18	8.99	3.31
Demographic controls			
Gender			
Female	1 if female, 0 if male	0.53	0.50
Age (Birth cohort)			
15-24 (1972-1981)	1 if yes, 0 otherwise	0.38	0.48
25-34 (1962-1971)	1 if yes, 0 otherwise	0.24	0.43
25-44 (1952-1961)	1 if yes, 0 otherwise	0.19	0.39
45-59 (1936-1951)	1 if yes, 0 otherwise	0.19	0.40
Household size	Number of individuals in the household	6.74	3.37
Ethnicity			
High Caste Hindu (Ref)	1 if yes, 0 otherwise	0.49	0.50
Low Caste Hindu	1 if yes, 0 otherwise	0.10	0.30
Hill Tibeto-Burmese Newar	1 if yes, 0 otherwise	0.14	0.35
Newar	1 if yes, 0 otherwise	0.06	0.23
Terai Tibeto-Burmese	1 if yes, 0 otherwise	0.21	0.41

Table 2. Multilevel hazard model (in odds ratios) predicting first time out-migration in the Chitwan Valley of Nepal, 1997-2007.

Independent Variables	Model 1	Model 2	Model 3	Model 4
Major Independent Variables				
Tractor use	1.18 (2.68)**	-	-	-
Farm Implements	-	1.06 (0.84)	-	-
Chemical Fertilizer	-	-	0.99 (-0.17)	-
Pesticides	-	-	-	0.97 (-0.47)
Theoretical controls				
Human capital				
Enrolled in school	1.14 (2.01)*	1.15 (2.12)*	1.15 (2.08)*	1.15 (2.08)*
Years of schooling	1.03 (5.66)***	1.03 (5.45)***	1.03 (5.58)***	1.03 (5.60)***
Currently has wage job	1.02 (0.38)	1.01 (0.23)	1.01 (0.18)	1.01 (0.18)
Currently has salaried job	1.60 (5.57)***	1.60 (5.57)***	1.60 (5.57)***	1.60 (5.57)***
Social capital				
Household has network tie	0.94 (-0.18)	0.98 (-0.05)	0.99 (-0.03)	1.00 (-0.01)
Neighborhood prevalence	1.24 (4.43)***	1.24 (4.34)***	1.24 (4.37)***	1.24 (4.39)***
Physical capital				
Market access	1.04 (1.25)	1.04 (1.23)	1.04 (1.24)	1.04 (1.25)
Farmland	1.09 (0.83)	1.09 (0.77)	1.09 (0.79)	1.09 (0.79)
Livestock	0.97 (-1.95)+	0.97 (-2.13)*	0.97 (-1.99)*	0.97 (-2.02)*
House plot owned	0.70 (-3.81)***	0.69 (-3.91)***	0.69 (-3.86)***	0.69 (-3.88)***
Home quality	0.99 (-1.65)+	0.99 (-1.42)+	0.99 (-1.35)+	0.99 (-1.29)
Demographic controls				
Gender				
Female	0.78 (-4.93)***	0.79 (-4.9)***	0.79 (-4.87)***	0.79 (-4.86)***
Age (Birth cohort)				
15-24 (1972-1981)	2.53 (11.71)***	2.56 (11.84)***	2.55 (11.80)***	2.55 (11.79)***
25-34 (1962-1971)	1.31 (3.51)***	1.33 (3.67)***	1.33 (3.64)***	1.33 (3.63)***
25-44 (1952-1961)	0.88 (-1.60)	0.89(-1.36)	0.89(-1.39)	0.89(-1.40)
45-59 (1936-1951)	-	-	-	-
Household size	1.01 (1.33)	1.01 (1.20)	1.01 (1.30)	1.01 (1.31)
Ethnicity				
High Caste Hindu	-	-	-	-
Low Caste Hindu	1.22 (2.16)*	1.19 (1.87)	1.19 (1.83)+	1.19 (1.84)+
Hill Tibeto-Burmese	1.28 (2.99)**	1.27 (2.93)**	1.27 (2.90)**	1.27 (2.90)**
Newar	0.78 (-2.15)*	0.78 (-2.21)*	0.78 (-2.18)*	0.78 (-2.19)*
Terai Tibeto-Burmese	0.84 (-1.87)+	0.82 (-2.16)*	0.82 (-2.14)*	0.82 (-2.15)*
Duration				
Month	0.99 (-6.06)***	0.99 (-6.11)***	0.99 (-6.10)***	0.99 (-6.10)***
Month squared	1.00 (1.04)	1.00 (1.06)	1.00 (1.07)	1.00 (1.06)
ICC				
Deviance				
Person Months				

+*P*<.10, * *P*<.05, ** *P*<.01, ****P*<.001 all probabilities are one-tailed
Figures in parenthesis are t-values